Technical Report

Standardized Approach for Computing Market Risk Capital Charges on Interest Rate Exposures In Debt Securities: The Philippine Case

Johnny Noe E. Ravalo Ph.D.

Prepared for

Governor Amando M. Tetangco, Jr.
Deputy Governor Nestor A. Espenilla, Jr.
Bangko Sentral ng Pilipinas (BSP)
Republic of the Philippines

Submitted for review to

USAID/Philippines OEDG

April 11, 2007

EMERGE
A GRP project supported by USAID

Economic Modernization through Efficient Reforms and Governance Enhancement (EMERGE)
Unit 2003, 139 Corporate Center, 139 Valero St., Salcedo Village, Makati City 1227, Philippines
Tel. No. (632) 752 0881 Fax No. (632) 752 2225

Preface

This report is the result of technical assistance provided by the Economic Modernization through Efficient Reforms and Governance Enhancement (EMERGE) Activity, under contract with the CARANA Corporation, Nathan Associates Inc. and The Peoples Group (TRG) to the United States Agency for International Development, Manila, Philippines (USAID/Philippines) (Contract No. AFP-I-00-03-00020-00, Delivery Order 800). The EMERGE Activity is intended to contribute towards the Government of the Republic of the Philippines (GRP) Medium Term Philippine Development Plan (MTPDP) and USAID/Philippines' Strategic Objective 2, "Investment Climate Less Constrained by Corruption and Poor Governance." The purpose of the activity is to provide technical assistance to support economic policy reforms that will cause sustainable economic growth and enhance the competitiveness of the Philippine economy by augmenting the efforts of Philippine pro-reform partners and stakeholders.

Governor Amando M. Tetangco, Jr. of the Bangko Sentral ng Pilipinas (BSP) requested this technical assistance on October 12, 2006. The results of the analysis would primarily be used by Deputy Governor Nestor A. Espenilla, Jr. who is in charge of the Supervision and Examination Sector (SES) of the BSP. The analysis was undertaken by Dr. Johnny Noe E. Ravalo from January to April 2007.

The views expressed and opinions contained in this publication are those of the author and are not necessarily those of USAID, the GRP, EMERGE or the latter's parent organizations.

Standardized Approach for Computing Market Risk Capital Charges on Interest Rate Exposures In Debt Securities: The Philippine Case

Johnny Noe E. Ravalo Ph.D.

Prepared for:

Deputy Governor Nestor A. Espenilla Jr.
Supervision and Examination Sector
Bangko Sentral ng Pilipinas

Economic Modernization Through Efficient Reforms and Governance Enhancement
(Project EMERGE) U.S. Agency for International Development
Contract No. AFP 1-00-00-03-00020 Task Order 800
Task 4.1.2.4d Determination of Appropriate Risk weights for BSP's Standardized Approach to the Computation of Market Risk Capital Charges and Establishment of Financial Performance Benchmarks by Industry

USAID
FROM THE AMERICAN PEOPLE

1. Introduction

The Basel Committee on Banking Supervision (BCBS) issued in April 1993 a consultative document (BCBS11(a)) that proposed to introduce a capital charge for market risk in all positions, both on and off-balance sheet.[1] This was the logical and anticipated extension of the 1988 Accord whose credit risk focus invariably also included situations where the risk of default was driven by market risk. Thus, the 1993 proposal not only extended the financial risks covered by the supervisory framework but also established some separation at three levels:

a) in the oversight of credit and market risks,
b) between specific and general market risk,[2] and
c) between the trading book and the regular banking book.

This separation was not to define independent domains since the BCBS itself made clear that "*the Committee ... set out to develop a framework for integrating into the 1988 Accord an approach to [sic] assessing explicit capital charges for market risk*." In furtherance of this, the Committee's market risk initiative was driven by two related objectives.

> *. . . first, the framework for estimating the amount of such capital charges and the manner in which such capital charges could be satisfied should constitute a minimum prudential standard relative to the potential for losses that might be incurred for a given portfolio of open positions in debt and equity securities in the trading portfolio and in foreign exchange; second, the framework should be one in which the capital charges for each class of instruments (i.e. debt, equities and foreign exchange) would be roughly equivalent in economic terms so as not to create artificial incentives favouring one class of instrument over others.*

For the general market risk component, the BCBS introduced its "building block approach" which essentially allowed for the direct summation of risk charges from separate components. One such component is the interest rate exposure to debt instruments which was to be addressed either by a standard approach or an alternative method that eased critical assumptions made under the standard method. This review focuses exclusively on the standard method.

After a relative short period of discussions, the proposal was formalized by BCBS in January 1996. Effective end of 1997, market risk supervision was incorporated into the 1988 Accord.

---

[1]The document is "The Supervisory Treatment of Market Risk", BCBS publication #11. April 1993.

[2]As defined by BCBS11(a),

> *Specific risk is the risk of loss caused by an adverse price movement of a security (or a derivative product linked to it) due principally to factors related to the issuer of the security. Specific risk has some parallels with, but is broader than, credit risk in the sense that it exists whether the position is long or short. General market risk is the risk of loss caused by an adverse market movement unrelated to any specific security. This dual approach has been chosen because it provides a sound conceptual and practical basis for permitting offsetting of matched (i.e. long and short) positions.*

2. The Standard Model for Debt Instruments

The standard model calculates the general market risk charge arising from the impact on debt instruments of interest rate volatility. In principle, rising interest rates are the primary concern since it is these that cause mark-to-market (MTM) losses.[3]

2.1 Model Details

The specification of the model is fairly straightforward. There are 13 to 15 maturity bands which have been pre-defined. The financial institution (FI) measures the remaining term for each security it maintains a position and slots these positions into the pre-defined time bands.[4] Since the FI may take long or short positions in different instruments within the same time band, these positions are netted out. This effectively leads to a net position for each time band, that is, a bank may be "long" on instruments with 1 to 2 years remaining life together with a short position on instruments with remaining term of 2 to 3 years.

For each of the net position per time band, a risk weight is directly applied to determine the general market risk charge. The risk weight is a product of a pre-defined modified duration for each time band and an assumed shock in yields. The assumed rate shock is represented by the Committee's determination that it covers 2x the standard deviation of yields within the time band.

The theoretical underpinning of the risk weight is that it reflects the proportional change in the price of the security:

$$D \quad = \quad -\lim_{\Delta y \to 0} \frac{\Delta P / P}{\Delta y} \quad = \quad \frac{-\,\partial P / \partial y}{P}$$

$$\frac{\Delta P}{P} \quad = \quad -D\,\Delta y$$

where D is duration and Äy is the assumed change in yield.[5] This is then multiplied to the exposure

---

[3]It is the trading position of the bank that is being evaluated rather than its structural position. Securities that are intended as hold-to-maturity (i.e., similar to the IBODI account) are not subjected to this analysis since changes in yield throughout the life of the security are not going to affect maturity valuation.

[4]This applies to positions in fixed-rate instruments. Floaters are not to be evaluated versus the full remaining life of the instrument but only for the period of time until the next repricing date.

[5]The equations use Macauley duration. However, modified duration is just a transformation:

$$\text{Modified Duration } D^* = D / (1 + y)$$

(continued...)

for that tenor bucket, generating a differential in market value that approximates the loss arising from the price shock. This is not yet on the same footing as a charge for credit risk. To allow for a similar weighing *vis-a-vis* the 8% international threshold, the product between the risk weight and the exposure is grossed up 12½ times (i.e., the mathematical converse of 8%) before it is added to the credit and operational risk charges.

On a stand-alone basis, the generated market risk charge needs to be adjusted further for the strong likelihood of basis risk.[6] The standard model does this by introducing *vertical and horizontal disallowance*. In the case of the former, the total long position and total short position is computed per maturity bucket. A 10% vertical disallowance factor is applied to the lower of either the long or short position. Since the "net open position" is already subjected to the risk weights under the maturity ladder, applying this disallowance to the "covered position" is tantamount to an assumption of a 10% basis risk. To set the market risk charge for this, the disallowance factor is simply multiplied to the lower of the short or long position.

Horizontal disallowance merely expands the same principle espoused by the vertical disallowance. This time, the correlation of concern is not within time bands but in respect of time zones. The standard model defines these zones as:

a) Zone 1 — Up to 12 months remaining life
b) Zone 2 — From 1 to 4 years remaining life
c) Zone 3 — For those with remaining life of more than 4 years

These zones are an aggrupation of the pre-defined time bands and literally suggest that the 13 time bands are sufficiently distinct from the standpoint of supervision. In particular, the distinction operates at two levels: first a strong separation that warrants distinctly different zones and second, a lesser degree of separation that implies that sub-groups of different time bands manifest some similarity that set them apart from other sub-groups but are not similar enough to collapse the component time bands into one collective and wider time band.

The horizontal disallowance factor is set for 40% for zone 1 as well as between adjacent zones. Within-zone disallowance is 30% for zones 2 and 3 suggesting that rates among time bands at the longer end of the term structure move more of a herd when compared with the zone 1 rates. Because of amounts that can be used as offsets and carried forward, the disallowance between

---

[5](...continued)

and since Äy = Ä(1+y), there is no difference in the analytical result. Note however that the representation is valid only for a parallel shift in the yield curve that leads to a very small ("infinitisimal") change in yield.

[6]Basis risk occurs because interest rates are not perfectly correlated with other interest rates. This is true for different positions in the same time band or for rates across tenor buckets. Thus, hedging will always generate a basis or spread risk and yield curve shifts are not parallel across the term structure (unless extremely coincidental ... and highly unbelievable).

zone 1 and 3 is set at 100%.

The model also makes a distinction between interest-bearing instruments on one hand and zero-coupon & deep-discount bonds on the other. BCBS11(a) notes that this distinction is based on the increased price volatility of zeroes/deep-discount bonds relative to regular interest-bearing bonds. This is aligned with the so-called Malkiel bond-pricing relationship one of which states that the interest rate risk is inversely related to the bonds coupon rate.[7] This can likewise be phrased in the context of duration which decreases as coupon rates rise. Thus, the specification in BCBS11(a) calls for time bands which are narrower for zero-coupon and deep-discount bonds versus regular interest-bearing bonds for a given change in interest rate and/or for a given duration. To cover the same term structure as interest-bearing bonds, zero-coupon and deep-discount bonds have more time bands. Larger magnitudes of interest rate shocks are applied are the additional time bands for zero-coupon and deep-discount bonds although duration is held constant at a value of 0.6.[8]

2.2 Key Parameters

In the context of the above specification, there are four (4) model parameters that directly influence the determination of the risk charge.

2.2.1 Modified Duration Values

The duration values are calibrated based on an 8% coupon in an 8% market environment. This is a relevant parameter for three inter-related reasons:

1) it suggests that the instruments are valued at par;
2) the choice of the level (i.e., 8%) affects the calculation of durations; and
3) it is an indication of the link to the credit risk model in Basel 1.

The first is a matter of convenience. While the *sine qua non* for trading instruments is precisely its periodic deviation from par, it would be unrealistic and impractical to consider every possible combination of coupon rate and yield that is manifested in the trading markets. It does, however, materially affect the level of duration. As can be seen in chart 1, instruments trading at a discount will have a duration that is above and to the right of the reference line. The higher the gap between coupon rate and the market rate, the further above and to the right will be the actual duration. The reference line connects five combinations of coupon rates and market rates that are equal and thus in each case, the instrument must be at par. In contrast, lower durations are found for instruments to the left and below the reference line. In these cases, the instrument is trading at a premium i.e.,

---

[7]In other words, prices of higher-coupon bonds are less sensitive to changes in interest rates as compared to bonds with lower coupon rates, *ceteris paribus*.

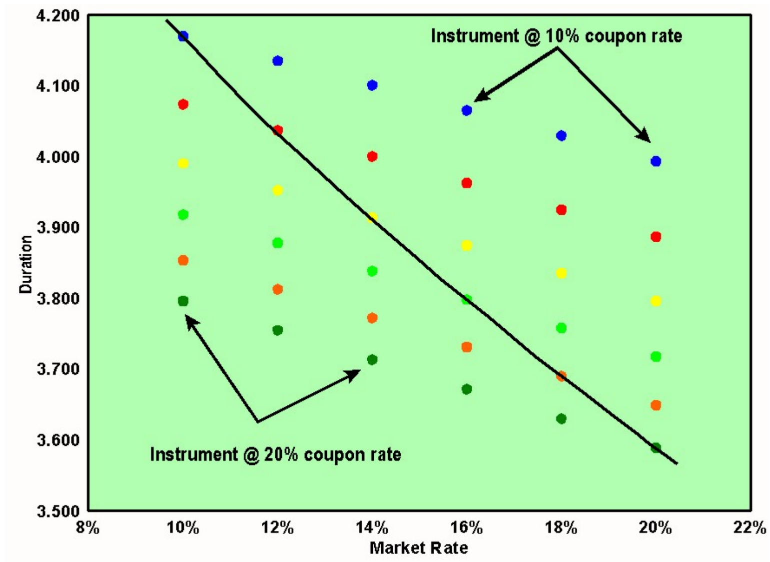
[8]BCBS(a) defines a deep-discount bond as having coupons less than or equal to 3%. It is not clear what was the basis of this threshold.

the coupon rate is higher than the market discount rate, all things being equal.

It is not only the valuation at par that affects the duration figures but the chosen interest rate level itself . In chart 2, we show three different interest rate environments at which instruments all trade at par, i.e., where coupon and market yields are equal. As can be clearly seen from chart 2, higher (lower) duration numbers would have to be used had the coupon & market interest rates been lower (higher) than the 8% prescribed by the standard model.

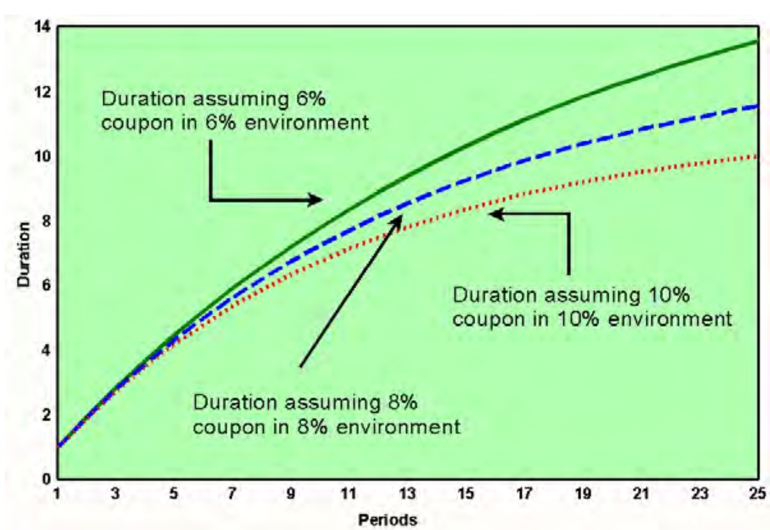
All these lead us to ask what the basis is for assuming an 8% rate for both coupon and yield. Although it is not directly stated in BCBS11(a), it is not unreasonable to believe that the choice was largely driven by the intention — and need — to provide a numerical link between the market risk initiative and the credit risk model that was institutionalized in the 1988 Accord. This is nothing more than a supposition on our part but in the absence of a clear basis, it is not without merit. The strongest indication of this is the observation that 8% is also used as the basis for other charges within the market risk

CHART 1
Coupon Rates, Market Yields and Duration



The above simulates the calculated duration of instruments at various combinations of coupon rates and market yield. Each dot represents an instrument with a remaining life of 5 years, paying annual coupons.

CHART 2
Duration and Pricing at Par



The simulation compares the calculated duration arising from pricing instruments at par in a 6%, 8% and 10% environment respectively.

framework. These would include, for example, the specific risk charge for non-government non-qualifying securities, the specific risk charge for high-yielding securities with equity-like features, the general market risk for net open equity positions and the capital charge for foreign exchange and commodities positions. In each of these cases, the imposition of an 8% risk charge appears completely *ad hoc* but this, on its own, has not prevented it from being repeatedly called upon in the model. Had a higher rate been used lower duration figures would have been used.

2.2.2 The Assumed Magnitude of Interest Rate Shocks

The magnitude of the interest rate shocks for the different time bands has been pre-set by the model. These range from a high of 100 basis points for securities maturing within 1 month to a low of 60 basis points for those securities with remaining life of over 10 years.[9]

These parameters are suppose to be based on empirical regularities. In particular, the Committee notes that the magnitudes are so chosen "*to cover about two standard deviations of one month's yield volatility in most major markets.*" [10] Presumably, however, the Committee would only be concerned with upward perturbations in interest rates since these would cause a valuation loss while downswings in rates would actually create capital gains. In this case, instruments about to mature and trading at par would find the market rate rising to 9%. Conversely, instruments at the far end of the term structure will find their yields rising from 8% to 8.6%. Presuming standard normality, these deviations are supposed to represent about 95.44% of the expected upward swings in market yields.

One must note that the magnitude of the shock decreases as remaining life increases. This is deliberate and the Committee bases this on its observation that in "*most countries, long-term rates are less volatile than short-term rates.*"[11] Thus, the relative shift in short-term rates is 12.5% (i.e., 9% ÷ 8%) while that of long-term rates is only at 7.5% (i.e., 8.6% ÷ 8.0%).[12] It is also of note that the "planning horizon" used is one month. Its relevance stems from the fact that this length of time can be interpreted as what would be needed to close out interest-sensitive positions. This is an aggressive risk mitigation position inasmuch as trading securities are subjected to daily MTM valuation and the capital adequacy position is also recalculated daily.

[9] The lower end of the threshold is reduced to 7.3 years for zero-coupon or deep-discount bonds.

[10] Page 17 of BCBS11(a).

[11] Footnote 17 of BCBS11(a).

[12] It should be noted that the yield curve was presumed flat at 8% and the shocks would then lead to a "tilting" of the curve. This is an important analytical feature because the approximations afforded by D x Äy is technically valid for infinitisimal parallel shifts of the yield curve.

2.2.3 Correlations of Interest Rates Within and Across Time Bands

The third major parameter revolve around the correlations between the rates themselves. As noted previously, this is to cover for basis risk which in this case translates to the possibility of non-parallel shifts in the yield curve.

By their very nature, the chosen values for the disallowance factors — 10% within a time band and 30%, 40% or 100% as applied to zones — need empirical validation at the level of a particular market. These disallowances are designed for the matched or covered positions and the full model must be understood in conjunction with the use of risk weights for open positions. Thus effectively, the additive nature of long and short positions for each time band suggest perfect correlation. All that the disallowances do is to account for some deviation.

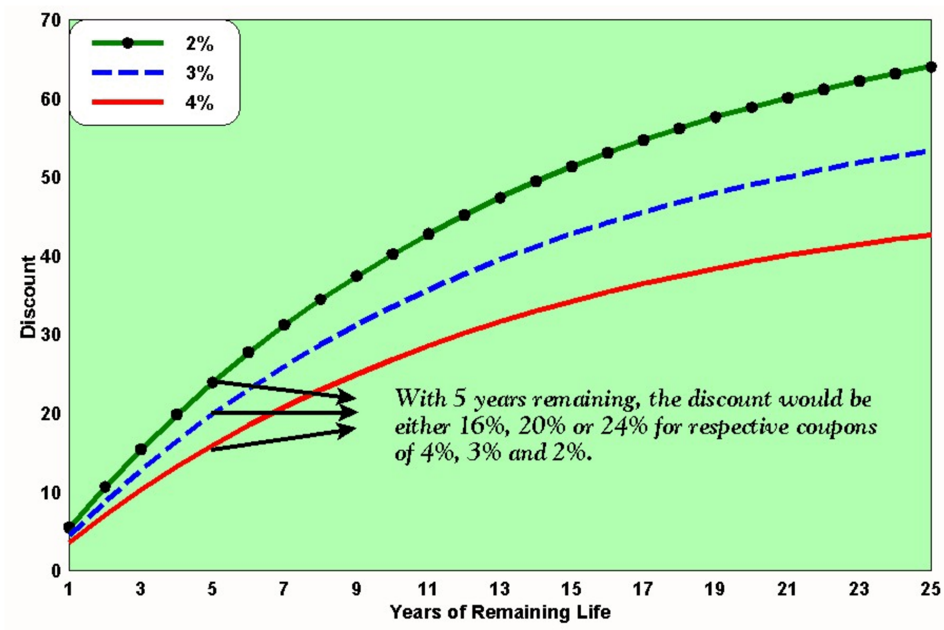
2.2.4 Time bands and Zones

To the extent that the slotting process is bottom-up (i.e., individual securities are grouped based on residual term or time to next repricing), in principle the time bands themselves can be tested to validate their robustness. The practical issue here is that some time bands are wider than others raising a question of whether the groupings are statistically reliable i.e. is a bond with 10½ remaining years until maturity really more alike to a bond with 15 remaining years than one with 9 remaining years? Since duration can be directly estimated from the securities in the sample, the larger policy concern has to do with the difference across time bands in assumed yield change. One observes that even for a relatively small 5 basis point difference in yield change, the impact to one time band is 7.5% (8.6% ÷ 8%) versus 8.125% (8.65% ÷ 8%). From the perspective of financial markets, this difference is highly significant.

There is also the matter between regular interest-bearing bonds on one hand and zero-coupon and deep-discount bonds on the other hand. There should be no issue that interest bearing bonds are being distinguished from zero-coupon bonds. The difference in price volatility between these two is not only well established in theory but also clearly observed in the trading markets.

However, using a 3% coupon rate for defining a "deep-discount" bond is much more *ad hoc*. One can only surmise that this threshold is influenced by having to assume an 8% interest rate environment. Indeed, the discount generated by a 3% coupon will be substantial given a market yield of 8%. For instruments with 12 months remaining life, the discount is 4.6% but this quickly rises to 49.1% for 20 year securities. This is a matter of empirical simulation and is not a source of debate. What is of concern is the level of the threshold itself, i.e., why was it set at 3%? As chart 3 shows, the actual size of the discount would materially deviate if for a relatively small change in the threshold. For a bond with a remaining term of 5 years, for example, the simulation shows that the discount would be roughly 400 basis point apart even for a 100 basis point change in the threshold. This gap increases geometrically as remaining life increases.

CHART 3
Defined Coupon Rate and the Generated Discount



3. Validation Issues

It is well understood that the model was not designed to be perfectly accurate of real-world market conditions since these conditions easily differ across markets and change over time. As an international norm, it was meant to be at least reasonable in order to gain acceptance. The relatively quick passage of the proposal into a formal amendment of the 1988 Accord provides anecdotal evidence that the model specification was generally tolerable and indeed acceptable.[13]

That actual local conditions deviate from the model's specification is not the central issue. The crux of the matter lies with the onus upon national supervisory authorities to determine how significant the deviation exists. This deviation is central to the supervisory process because it directly affects the capital charges that need to be set aside for market risk (i.e., "the numbers") and it impacts upon the viability of the supervisory framework (i.e., the incentive structure that influences market behavior towards price risk). Clearly, one does not need to go very far in identifying the critical assumptions that could stand empirical validation. These include:

---

[13] In contrast, the work on Basel I took over 5 years to morph into Basel II. Even in the new Accord, the market risk model is largely unchanged from the 1996 Amendment.

- duration values which have been referenced to the mid-point of each time band;[14]
- coupon rates and market yields across time bands;
- magnitude of possible upward swings in yields across time bands;
- correlation of the different spot market interest rates; and
- volatility of zero-coupon and deep-discount bonds versus other interest-bearing bonds.

From an empirical exercise standpoint, these can be summarized into two main components:

a) the profile of outstanding traded securities and

b) the profile of the interest rates emanating from these securities.

The former has a direct bearing on the duration values since we can determine where the balance lies within each time-band between the cash flows and the final payment. The later bears upon the parameters for the expected yield shifts as well as the disallowance factors.

By taking time-bands of uniform length, we can likewise conduct some tests that could evaluate any warranted changes in the construction of the time-bands. This will not only improve the quality of the market risk supervisory framework but will also influence the way the Philippine yield curve will be structured. Taking this one step further, it may also provide some inputs which the Philippine Treasury may find useful in defining its "benchmark issues". In this manner, the resulting benchmark yield curve not only generates the needed reference rates but also reflects a term structure that better defines the clustering of market risk across market-responsive tenor buckets.

4. Validating the Model Parameters Using Philippine Government Issues

We report below our initial findings on the relevant parameters of fixed income instruments in the Philippines. This follows the framework we outlined in our technical review of the standard BIS approach and in that review we indicated the need to validate:

- modified duration per tenor bucket;
- magnitude of interest rate shocks;
- correlations of interest rates; and

[14] This is tantamount to an assumption that the remaining life of the outstanding securities is always uniformly distributed within each time band i.e., there is no supply-side risk that can affect pricing.

- structure of the time bands.

To undertake the empirical tests, the Bangko Sentral ng Pilipinas (BSP) requested specific data from the Philippine Dealing and Exchange Corporation (PDEx) based on consummated trades through the PDEx platform. The PDEx provides an organized market for fixed-income instruments where all bids and offers are entered through the Fixed Income Trade Workstation (FITW). The subsequent automatic capture of trade details ensures that the gathered information is reflective of firm market conditions (i.e., “done deals”) and not merely indicative quotes which can be nonetheless withdrawn.

The data subsequently provided by the PDEx:

- covers **454 trading days** from March 29, 2005 to January 31, 2007;
- consists of **18,636 transactions;**
- involving **152 Fixed-Rate Treasury Notes (FXTNs)**, **110 Treasury Bills (TBills), 10 Retail Treasury Bonds (RTBs) and 2 special bond issues**.

At present, only peso-denominated sovereign issues are traded on the PDEx platform. To augment these data, daily benchmark and fixing rates for predefined tenor buckets have also been gathered from the daily broadcasts on the PDEx website.

To maintain trade confidentiality, information about the transacting counterparties was neither sought nor provided. The information gathered were limited to the instrument code (both the International Security Identification Number or ISIN as well as the corresponding local security code), the trade date, the coupon rate where appropriate, the market price at trade date, the computed yield based on the price, the maturity date and the remaining life of the instrument. A screen shot of the spreadsheet file is shown in the following box.

5. Validating the Assumed Duration Values

We test for the Macauley duration of the fixed income instruments for each transaction. However, we exclude TBills and delimit the test to the FXTNs, RTBs and the special issuance. This is simply because the duration of treasury bills will only reflect the remaining term of these instruments, i.e., there are no intermediate coupons or cashflows to weigh. The resulting value merely represents the aging process and this is neither a financial risk issue nor does it provide additional analytical value to the task at hand.

With the exclusion, 17,558 transactions were processed. These included fixed-income instruments whose remaining terms were less than one year when they were transacted and their durations were correspondingly calculated for the remaining term. At the maximum, there were transactions

SCREEN SHOT OF BASIC DATABASE

Microsoft Excel - FI Trades 032805 to 013107_for BSP

A2 = 3/28/2005

1	tradedate	isin	seccode	securityname	couponrate	yield	price	issuedate	maturitydate	BMT	Remaining days to maturity
18614	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.42	105.8881636	2/17/2006	2/17/2009	2.5Y	748
18615	1/31/2007	PIBD0309F143	FXTN 03-14	PIBD0309F143	10.375	5.525	110.6446473	6/15/2006	6/15/2009	2.5Y	866
18616	1/31/2007	PIBD1016I428	FXTN 10-42	PIBD1016I420	9.125	6.825	115.9843627	9/4/2006	9/4/2016	10Y	3504
18617	1/31/2007	PIBD1016I428	FXTN 10-42	PIBD1016I420	9.125	6.825	115.9843627	9/4/2006	9/4/2016	10Y	3504
18618	1/31/2007	PIBD0309G158	FXTN 03-15	PIBD0309G155	8.750	5.55	107.3429545	7/27/2006	7/27/2009	2.5Y	908
18619	1/31/2007	PIBD1016I428	FXTN 10-42	PIBD1016I420	9.125	6.825	115.9873955	9/4/2006	9/4/2016	10Y	3504
18620	1/31/2007	PIBL0607A029	TBILL 07.25.07	PIBL0607A025		3.575	98.291838	1/24/2007	7/25/2007	6M	175
18621	1/31/2007	PIBD0713C432	FXTN 07-43	PIBD0713C438	8.750	6.285	112.307477	3/3/2006	3/3/2013	6Y	2223
18622	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.435	105.8511065	2/17/2006	2/17/2009	2.5Y	748
18623	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.435	105.8511065	2/17/2006	2/17/2009	2.5Y	748
18624	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.435	105.8511065	2/17/2006	2/17/2009	2.5Y	748
18625	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.435	105.8511065	2/17/2006	2/17/2009	2.5Y	748
18626	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.435	105.8511065	2/17/2006	2/17/2009	2.5Y	748
18627	1/31/2007	PIBD0309B134	FXTN 03-13	PIBD0309B132	8.500	5.435	105.8511065	2/17/2006	2/17/2009	2.5Y	748
18628	1/31/2007	PIBD1016I428	FXTN 10-42	PIBD1016I420	9.125	6.8	116.176019	9/4/2006	9/4/2016	10Y	3504
18629	1/31/2007	PIBD0408A078	FXTN 04-07	PIBD0408A072	10.500	4.65	105.3076687	1/8/2004	1/8/2008	11M	342
18630	1/31/2007	PIBL0607A029	TBILL 07.25.07	PIBL0607A025		3.55	98.3035806	1/24/2007	7/25/2007	6M	175
18631	1/31/2007	PIBD1016I428	FXTN 10-42	PIBD1016I420	9.125	6.815	116.060976	9/4/2006	9/4/2016	10Y	3504
18632	1/31/2007	PIBD1016I428	FXTN 10-42	PIBD1016I420	9.125	6.815	116.060976	9/4/2006	9/4/2016	10Y	3504
18633	1/31/2007	PIBD0408G117	FXTN 04-11	PIBD0408G119	11.000	5	108.5367507	7/29/2004	7/29/2008	1.5Y	545
18634	1/31/2007	PIBD2017D012	FXTN 20-01	PIBD2017D011	14.375	6.855	154.6229098	4/24/1997	4/24/2017	11Y	3736
18635	1/31/2007	PIBD0713K450	FXTN 07-45 *	PIBD0713K457	7.125	6.375	104.0498685	11/2/2006	11/2/2013	7Y	2467
18636	1/31/2007	PIBD2026A126	FXTN 20-12	PIBD2026A122	10.250	7.9	122.8979279	9/21/2006	1/19/2026	19Y	6928
18637	1/31/2007	PIBD1015B367	FXTN 10-36	PIBD1015B367	12.375	6.385	137.2892943	2/24/2005	2/24/2015	9Y	2946
18638											
18639											

with remaining tenors of more than 25 years. Going by a 30/360 day-count convention, the transactions were then divided into time buckets of 360 days length with the exception of those maturing in less than a year which were categorized into their standard four time buckets.

Duration values are calculated individually for the 17,558 transactions. To arrive at the duration for a particular tenor bucket, it was presumed that the trade volumes were uniform across all trades within each time band. This is clearly not accurate although the magnitude of the numerical deviation is unknown given the available information. However, proper adjustments can easily be made once the trade value for each of the 17,558 transactions could be further supplied by PDEx. It is worth pointing out, nonetheless, that our simplified structure is functionally equivalent to the assumption made by the BCBS in its standard model where durations are calculated at the midpoint of the time-band.

Table 1A provides a summary of the calculated durations. Taken as a homogenous sample, duration values are available for 18 tenor buckets. Within each of the seven quarters, transactions consistently occur for 13 contiguous tenor buckets from 1-3 months at the short end to 11-12 years at the long end, coupled with other transactions beyond 12 years. Correspondingly durations are available for each of these buckets. There is no clear trend in the duration values for each bucket across several quarters, indicative of the complexities of aging the most heavily traded instruments, coupled with transactions with different and newer instruments. At any given point in time, however, duration can only be calculated for a few tenor buckets. In table 1B, we calculate the durations at the end of each quarter and find the more limited tenors for which daily transactions occur.

In table 1C, we reproduce the calculated durations per quarter and compare these to the BIS-set parameters per tenor bucket. This gives us a dual view of the duration dynamics, in this case intertemporally and across tenors. We find, in particular, that the BIS-set duration overstates the calculated duration of traded fixed income instruments in 11 tenor buckets and subsequently understates it in the remaining seven tenor buckets. As noted earlier, there is a fair amount of volatility from quarter-to-quarter within each tenor bucket. From a policy perspective, however, the issue is one of "significant deviation" (i.e., whether the difference between the calculated duration and the BIS parameter is statistically material) and "trending" (i.e., as you move over time, in what direction is the calculated duration moving *vis-a-vis* the BIS standard).

To answer these issues, comparisons are provided in table 2 where the BIS-imposed durations are juxtaposed *vis-a-vis* the calculated values for the full sample. We can readily verify from the 3rd and 4th moments that the values within each tenor bucket do not follow a normal distribution. The consequence of this is that standard procedures for testing the statistical significance of deviations from the BIS values cannot be readily applied.

As a work-around, we suggest a 3-point criteria for the comparison and possible remedial action:

(1) A conservative policy stance suggests that it is generally acceptable to retain the BIS-instituted duration values which exceed the calculated values. The expectation is that internal models should more accurately determine the duration values. This provides the banks an incentive to move toward these internal models, as approved by the BSP, as they should lower the corresponding capital charge for market risk, *ceteris paribus*.

(2) In the event that calculated duration values exceed the BIS-set standard, a material deviation exists when the former exceeds the latter by an absolute amount of 0.10. In this situation, a review is warranted to correct the undervaluation of the risk weight. Depending on the incentive structure which the BSP may wish to institute, a higher deviation value may be set for BIS-set durations that exceed the actual durations calculated from trade transactions before a policy review is warranted.

(3) The tenor buckets will be set for finite lengths of 360 days based on a 30/360 day count convention. The exception will be for those instruments with a remaining life of less than 360 days in which case the standard buckets of

[a] less than 30 days,
[b] from 31 to 90 days,
[c] from 91 to 180 days

TENOR BUCKET	CALCULATED DURATION LIKELY TO EXCEED BIS	BIS LIKELY TO EXCEED CALCULATED DURATION
< 30 Days	✔	
31 - 90 Days		✔
91 - 180 Days		✔
181 - 360 Days	✔	
1 - 2 Yrs	✔	
2 - 3 Yrs		✔
3 - 4 Yrs		✔
4 - 5 Yrs		✔
5 - 6 Yrs		✔
6 - 7 Yrs	✔	
7 - 8 Yrs		✔
8 - 9 Yrs		✔
9 - 10 Yrs	✔	
10 - 11 Yrs		✔
11 - 12 Yrs		✔
19 - 20 Yrs	✔	
20 - 21 Yrs		✔
25 - 26 Yrs	✔	

[d] 181 to 360 days

will be used. These tenor buckets will serve an analytical basis for possible further policy action, where deemed appropriate.

A cursory review of table 2 shows that the calculated duration values, based on measures of central tendency, are surprisingly close to the BIS parameters. Applying the first two suggested criteria, we note however that the mean and media duration values are materially higher than the BIS-assumed parameters in the following tenor buckets:

[a] 1 to 2 years;
[b] 5 to 7 years;
[c] 7 to 10 years;
[d] 15 to 20 years and;

[e] more than 20 years (using the median value).

In contrast, the BIS parameter in the 10-15 year band is practically the maximum value of the calculated durations, thus putting the mean and median values significantly lower.

Working with our expanded tenor buckets, in table 3 we show that the deviations between the BIS and the calculated parameters can in fact be attributed to the dominant 1-year time bands within the composite tenor bucket. In the case of the 5-7 year and 7-10 year bands, what is causing the calculated duration of traded instruments to exceed the BIS parameters is localized to the bands of 6-7 years and 9-10 years respectively. In addition, we also note the case of instruments with remaining tenor of 20 years where "trending" is the issue since the latest values are significantly higher than those in earlier quarters.

TENOR BUCKET	MAGNITUDE OF DEVIATION		DAYS EQUIVALENT
	CALCULATED > BIS	BIS > CALCULATED	
1 - 2 Yrs	0.14		50 Days
5 - 6 Yrs		0.52	187 Days
6 - 7 Yrs	0.31		112 Days
7 - 8 Yrs		0.43	155 Days
8 - 9 Yrs		0.36	130 Days
9 - 10 Yrs	0.96		346 Days
10 - 11 Yrs		0.68	245 Days
20 - 21 Yrs	0.29		104 Days
25 - 26 Yrs	0.21		76 Days

On the whole, we summarize the material deviations from the BIS standard as follows:

6. Magnitude of Interest Rate Swings

In determining market risk charges, the BCBS assumed the magnitude of interest rate movements that may occur per time band, ranging from 100 basis points for short-term rates and leveling off at 60 basis points at the longest tenor buckets. These represent the "shock" in interest rates that should be anticipated and for which market risk capital charges are required. In contrast to these absolute magnitudes, risk analytics uses the daily change in the logarithmic value of interest rates as the norm. This is based on practical and theoretical reasons and subsequently results in a relative measure of interest rate volatility instead of absolute magnitudes of change. Fortunately, the simplifying presumption made by the BCBS of an 8% environment makes it straightforward to relate one to the other. As noted in our earlier technical review document, the rates for the longer tenors are assumed to be less volatile than short-term rates and therefore the percentage change in interest rate is defined to decrease as the tenor increase.

TENOR BUCKET	ASSUMED CHANGE (In Basis Points)	EFFECTIVE % CHANGE
Less than 1 Yr	100	12.500 %
1 – 2 yrs	90	11.250 %
2 – 3 yrs	80	10.000 %
3 – 5 yrs	75	9.375 %
5 – 7 yrs	70	8.750 %
7 – 10 yrs	65	8.125 %
More than 10 yrs	60	7.500 %

To analyze the change in interest rates, we use the benchmark rates reported daily by the PDEx for 12 representative tenor buckets. This is consistent with their representation as "reference rates" based either on "done deals" on benchmark issues or the interpolated midpoint between bid and offer rates.

Standard statistical tests are performed on these reference rates and, as shown in tables 4A and 4B, it is immediately clear that the daily changes do not follow a normal distribution for any tenor bucket for either 2005 or 2006. Although the median value is almost exclusively valued at zero, the series is also non-stationary with mean and variance statistics that differ with time and tenor. In fact, the data per tenor bucket is consistently leptokurtic or shows a very high concentration of values at central tendency. This is not indicative of normality since the concentration is much higher than what would be consistent with the bell-shaped curve. Furthermore, the occurrence of change is not evenly centered since the short-end rates are generally skewed to the left while the intermediate rates have a tendency to be skewed to the right.

These results highlight why relative volatility would be the more appropriate risk metric instead of absolute values. Since the statistics would not be independent of the time factor, there would be no need to run the same tests on the combined data series.

To determine possible interest rate shocks, we perform the tests using data over the last 100 trading days. This maximizes the "latest" available information while mindful that the time-dependency factor necessitates that the results be updated periodically, both for statistical as well as prudential reasons.

Table 5 reports the test results and again confirms that the sample is distinctly leptokurtic within the vicinity of a median value of zero and a mean value that is consistently slightly negative. Correspondingly, the data series exhibits a consistent skewness toward the left tail across all tenor buckets. This literally suggests that interest rate increases — which cause the decline in market values for which the policy concern arises — are not as extreme as those on the far left of the distribution. From a policy perspective, the issue then becomes probabilistic in nature, i.e.,

a) what probability level should policy prescribe as the critical threshold of likelihood?
b) what would be the expected value of the interest rate change at that critical level?

These questions can only be answered by "fitting" a probability distribution function (PDF) to the dataset. Since the data is non-stationary and deviates from a normal distribution, we recognize that the PDF will be specific to particular data values and will thus have to be periodically re-fitted based on updated observations in the dataset. By itself, this updating requirement does not erode the robustness of the approach. It is no different from the normal backtesting prescription and merely reiterates how dynamic financial market information has become.

We revert to the dataset of the last 100 trading days and use a generalized beta distribution using the min-max values per tenor bucket. To fit the PDF and its corresponding cumulative distribution function (CDF), we calibrate the alpha and beta parameters to minimize the sum of the squared error (SSE) between the actual and the simulated beta values. We prioritize minimizing the SSE in the positive range of interest rate movements (SSE+) since the policy concern rests with rising rates which depress mark-to-market values. Recognizing that trending is an issue exhibited by the data, we take a conservative estimate and deliberately structure the simulated beta probability to be higher than the actual distribution at the right extreme of the CDF. To settle trade-offs between the overall SSE and SSE+, we locate the central tendency of the beta PDF to closely match that of the actual distribution.

Figures 1 to 12 show the fitted distributions while table 6 summarizes the percentage changes at three critical values: (1) at 95% confidence level of the simulated beta distribution, (2) at 2 standard deviations and (3) at the maximum value of the dataset used. Choosing 2 standard deviations from the mean is consistent with the general intent of the BCBS approach while evaluating the interest rate shock at the sample maximum provides a glimpse of the full extent of the volatility which has been experienced in actual market conditions.

In all three cases, the expectation that the longer tenors manifest lower volatility is generally preserved. Using the critical values at 2SD and at the maximum, we note however that short-term rates (i.e., up to one year) are found to be more volatile than the relative shocks anticipated by the

BIS model while other tenors do not show such "excess" volatility. This is consistent with the observation that the yield curve for Philippine treasuries has a tendency to "flip" from the short-end rather than move in parallel shifts. Going a step further, this may in fact reflect the long-standing "practice" of pricing transactions based on *ad hoc* increments over a (scalar) short-term benchmark rate, i.e., the 91-day TBill rate. In such a case, trading activity at the shorter tenors may generate "noise" which would not necessarily filter through the longer-tenors. At face value then, there may be a case for raising the assumed magnitude of interest rate shocks at the short-end beyond the levels prescribed by the BIS model.

The results of the simulated beta distributions, however, make the contrary case. Consistently across all tenor buckets, the volatility estimated at the 5% level of significance is noticeably lower than the BIS thresholds. This suggests that a structural modification is not warranted in the sense that the relative volatilities are amply covered by the current BIS specifications.

There is, however, an operational adjustment that is required and this is to apply either the implied BIS volatilities or the generated volatilities of the estimated beta distribution on the non-stationary data. That is, instead of using 8% as the base interest rate, one would have to use the latest market rate for a particular tenor bucket. This simply follows from the fact that (a) market yields have never been held constant at 8% (see figures 13 to 15) and (b) adjustments are necessary to faithfully mitigate market risk that emanates from non-stationary market rates. The simple effect of these adjustments is that if the prevailing market rate is lower than 8%, a lower charge for market risk is levied *ceteris paribus*. Needless to say, the converse also holds.

The difference between the prior result (particularly the one at 2 standard deviations) and this one is that the latter takes a more deliberate look at the distribution of the data. The implication then is that accounting for the 3rd and 4th moments is relevant, particularly for a notoriously non-stationary data series like interest rates. In effect, the necessity to periodically re-estimate the distribution of the data is not driven by a strict sense of technical elegance but rather by the policy cost (i.e., unwarranted market risk charges) of potentially acting upon the misspecification.

7. Correlation of Interest Rates

The extent to which interest rates are correlated across tenor buckets is the 3rd main parameter of the standard market risk model of the BIS. These correlations factor directly into the disallowance provisions, principally to account for basis risk. In general, basis risk occurs because additional gains or losses arise (thus the increase in risk) in a hedging strategy when the prices of two instruments are not perfectly correlated. In the context of the standard BIS market risk model, the disallowance has been introduced to recognize the likelihood that ideally offsetting positions (a long and a short position of the same amount) do not materialize as interest rates across tenor buckets move in a similar but not equivalent magnitude. In visual terms, the issue simply revolves around the behavior of the benchmark yield curve, specifically the extent to which interest rate shocks are filtered through the tenor buckets as a parallel shift of the yield curve.

The key policy issue then is to test for the validity of the parallel shift of the benchmark curve. This is tantamount to estimating the magnitude of the relative change in the rates of two tenor buckets. If we represent the disallowance factor by the symbol 0<ñ<1, the BIS model effectively assumes that interest rates are pairwise correlated (1-ñ) at the minimum. That is, the offset of long and short positions is limited to the factor (1-ñ) and this creates a basis risk equal to ñ times the exposure.

On this basis, we estimate for the Pearson Product-Moment correlation coefficients using the daily reference rates reported by the PDEx. The full sample of 5544 data points is used for the tests covering 462 observations per tenor bucket. One correlation coefficient is calculated for each of the 66 non-identical pairwise combinations over 12 tenor buckets. Following the transformation proposed by Fischer,

$$z = \frac{\frac{1}{2}\ln\frac{1+r}{1-r} - \frac{1}{2}\ln\frac{1+c}{1-c}}{\frac{1}{\sqrt{N-3}}}$$

where r is the Pearson Product-Moment correlation coefficient and c is the critical threshold. We then test:

Null Hypothesis $H_o: r > c = (1-ñ)$

Alternative Hypothesis $H_1: r < c = (1-ñ)$

where the calculated z-scores are approximately distributed ~N(0,1). We evaluate at 459 degrees of freedom and the relevant critical values at the 5% and 1% levels of significance are 1.645 and 2.33 respectively.

In table 6, the estimated correlation coefficients are color-coded for convenient reference. The green-shaded cells represent the coefficients in zone 1 where the horizontal disallowance is 40%. The yellow-shaded cells represent zones 2 and 3 where a 30% disallowance is imposed. The cells boxed within the blue lines correspond to correlations between adjacent zones (i.e., zones 1 & 2 and zones 2 & 3) where the disallowance is again 40%. The correlation between zones 1 & 3 are within the red border for which the horizontal disallowance is 100%.

The results show that the correlations are above the respective thresholds (1-ñ) within each zone, particularly for zones 2 and 3 where the correlations are consistently higher than 93%. Although these results are encouraging, the issue of basis risk is a question of how the reference curve ***shifts*** and not simply the relationship between tenors that defines its ***slope***. For this reason, we take the correlation of the first difference in the daily rates and present the results in table 7.

The correlations of the first differences are clearly much lower than those of the interest rate levels.

While the reference curve tends to be strongly upward sloping, the data suggests that parallel shifts would not be the norm. In fact, once tested against the BIS-imposed disallowance factors, table 8 shows that the null hypothesis, generally, will be rejected. The blue shades in table 8 indicate that the null hypothesis will be rejected at both the 5% and 1% significance levels while the green-shaded cell is where the null hypothesis is rejected at 1% but not at 5% level of significance. On the other hand, the null hypothesis for the horizontal disallowance between zones 1 and 3 can be accepted because the disallowance is already at 100% to begin with.

At face value, these results are indicative that the BIS disallowance parameters are understated. That is, to generate the “appropriate” market risk charge, larger magnitudes of disallowance are warranted by the available data.

8. Structure of Tenor Buckets

The duration analysis presented in section 2 already alludes to an aggregation issue. The root cause of this is that market activity for the tested fixed income instrument is not evenly distributed across the tenor spectrum. Thus, aggregating into larger time bands would mask the underlying dynamics in specific annual tenor buckets. From a supervisory standpoint, the policy cost of this aggregation may simply outweigh the benefits of convenience. Depending on the supervisory focus then, there is analytical basis for suggesting a more disaggregate classification.

9. Summary of Findings and Initial Recommendations

We return to the idea that the standard BIS model for market risk is derived from the relationship:

$$D = -\lim_{\Delta y \to 0} \frac{\Delta P / P}{\Delta y} = \frac{-\,\partial P / \partial y}{P}$$

$$\frac{\Delta P}{P} = -D\,\Delta y$$

where D is duration and Äy is the assumed change in yield. We supposed in the technical review document that the model was not likely meant to be accurate but only reasonable. Its construction, however, makes it clear that the application of the model is highly dependent on the magnitudes assigned for duration and Äy for each tenor bucket. In effect, the bar of “reasonableness” is itself a question of trading off the costs of misspecification versus the gains of simplicity.

Based on the data made available, we have shown the following:

(1) The duration values set by the BIS model are remarkably close to those calculated for FXTNs, RTBs and special bond issues with remaining terms of less than one year.

(2) The calculated duration of traded fixed-income instruments tends to be significantly higher than the BIS model in three annual tenor buckets: 1-2 years, 6-7 years and 9-10 years. The deviations are significant enough to cause a material underestimation of the hypothesized market risk charge. This results also highlights that danger brought about by aggregating annual tenor buckets into larger time bands.

(3) The calculated durations are also higher for instruments with remaining a remaining term of 19 years or more. However, the trading of these instruments is comparatively limited and adjusting the policy-prescribed duration for the affected time bands may be an over-reaction to the results based on limited data. Similarly, the BIS-set duration is higher than the actual duration of traded fixed-income instruments in the 5-6 year, 7-8 year and 8-9 year tenor buckets. However, these three buckets also suffer from limited data and any downward adjustment in the policy-prescribed duration should probably be postponed until more data are available.

(4) Reference interest rates per tenor bucket are, as expected, a non-stationary series and do not follow a normal distribution. A generalized beta distribution — adjusting for the alpha, beta, minimum and maximum parameters — can be fitted to the actual data with reasonable accuracy.

(5) Using the fitted beta distributions, the implied interest rate volatility at the 5% level of significance is lower than the BIS model for all tenor buckets. However, since the data series are not stationary and the BIS framework requires Äy rather than volatilities, the computed volatilities need to be applied to some absolute interest rate level to generate the required Äy.

(6) Reference interest rates are strongly linearly correlated specially for tenors above one year. However, the changes in interest rate levels across tenor buckets are not strongly correlated in a linear fashion. This suggests that the reference curve would not generally shift in a parallel manner but is prone to so-called “twists” and “flips.” Effectively then, the horizontal disallowance factor assumed by the BIS model significantly understates basis risk.

(7) Vertical disallowance could not be tested given the data made available.

Based on the foregoing, the following are put forward for the consideration of the BSP:

[a] Given the distribution of reported fixed-income transactions across the tenor spectrum, there is considerable policy benefit in maintaining disaggregated tenor buckets in lieu of broad time bands. Specifically, there is good basis to unbundle the 5-7 year and 7-10 year bands to highlight the heavy trading activity in the tenor buckets of 6-7 years

and 9-10 years respectively.

[b] For the moment, there is no compelling reason to unbundle the time bands of 10-15 years, 15-20 years and more than 20 years. However, there is always a policy benefit for BSP to monitor internally the activity at the longer ends of the market, particularly in testing the robustness and consistency of the yield curve.

[c] The policy-prescribed durations for the tenor buckets of 1-2 years, 6-7 years and 9-10 years warrant upward adjustments. Based on the data, the market risk model can raise the prescribed durations to 1.55, 5.00 and 6.80 from 1.40, 4.65 and 5.80 respectively.

[d] The interest rate volatilities implied by the BIS model may be retained. However, to get the appropriate values for Äy, these volatilities should not be applied to 8% but rather to the rates reflective of contemporaneous market conditions. The recently launched PDST reference rates may be suitable for this purpose. Subject to the preference of the BSP, the market rates that should be multiplied to the volatilities may be re-set periodically (i.e., monthly or quarterly) or changed daily similar to mark-to-market valuation. The volatilities themselves may likewise be reviewed periodically and re-fitted to the appropriate beta distribution.

[e] The horizontal disallowance factors that would match the data have been simulated to be as follows:

i) Zone 1 – 100 %
ii) Zone 2 – 70 %
iii) Zone 3 – 70 %
iv) Between Zone 1 & 2 – 100 %
v) Between Zone 1 & 3 – 100 %

Using these parameters, the calculated z-scores are provided in table 9 where in 62 of the 66 cases, the null hypothesis will be accepted at the 5% level of significance that the estimated correlation coefficients in table 7 statistically exceed the critical values. One should note that increasing the disallowance factor for zone 3 would still not lead the 4 remaining coefficients to be accepted at the 5% significance level. Statistics aside, these disallowance factors suggest that basis risk is encompassing. Whether this extreme is a policy position that the BSP will be willing to take needs to be considered carefully. Perhaps the issue may be revisited in 3 to 6 months with the same tests conducted using the PDST data series.

TABLE 1A
CALCULATED MACAULEY DURATIONS PER QUARTER

Tenor	FULL	05Q2	05Q3	05Q4	06Q1	06Q2	06Q3	06Q4	07Jan
<30D	0.0697	0.0698		0.0583		0.0806			
31-90D	0.1843	0.2052	0.1544	0.1028	0.1875	0.1978	0.1796	0.1642	0.1875
91-180D	0.3692	0.3864	0.4281	0.3312	0.3518	0.3903	0.3278	0.3107	0.4324
181-360D	0.7142	0.7477	0.7237	0.7499	0.7231	0.7921	0.7257	0.5825	0.7366
1-2Y	1.5160	1.5024	1.4796	1.4891	1.4577	1.5497	1.6164	1.5095	1.3666
2-3Y	2.1986	2.2178	2.2351	2.1631	2.1893	2.3547	2.2845	2.1285	1.9143
3-4Y	2.9071	2.9155	2.9299	2.8385	2.8091	2.9935	2.9122	3.0177	2.9594
4-5Y	3.6423	3.5237	3.5115	3.5502	3.4730	3.8621	3.7198	3.7493	3.5943
5-6Y	4.0867	3.8974	3.9939	3.9834	4.1604	4.0597	4.0071	4.2771	4.2233
6-7Y	4.9414	4.7404	4.7087	4.7860	4.8376	4.9285	5.0232	5.0096	4.9151
7-8Y	5.3436	4.9359	4.9705	5.1006	5.3370	5.1686	5.1687	5.6022	5.3625
8-9Y	5.4607	5.2983	5.4870	5.4222	5.6480	5.4960	5.6571	5.6998	5.5542
9-10Y	6.7166	5.7935	5.6969	5.7710	6.5596	6.4752	6.5082	6.7938	6.7275
10-11Y	6.7926	5.9760	6.0514	6.2126	6.6424	6.7751	6.8080	6.8479	6.9197
11-12Y	6.4305				6.4305				
19-20Y	9.2145				8.5672	8.9780	9.1086	9.2457	9.4210
20-21Y	9.7437	7.8179		7.9928				10.2139	10.3180
25-26Y	9.9255				8.7081			10.1266	10.4727

TABLE 1B
CALCULATED MACAULEY DURATIONS AT END-OF-QUARTER

TENOR BUCKET	Full Sample	June 30 2005	Sept 30 2005	Dec 29 2005	Mar 30 2006	June 30 2006	Sept 27 2006	Dec 29 2006
< 30D	0.0697							
31 - 90D	0.1843				0.2528			
91 - 180D	0.3692							
181 - 360D	0.7142		0.7614					
1 - 2Y	1.5160		1.4232	1.3051		1.5015	1.5674	
2 - 3Y	2.1986	2.2276	2.1446	2.1028	2.3119	2.3238	2.2408	1.9453
3 - 4Y	2.9071	2.7970	2.7997	2.5226		3.0513	2.8450	2.9878
4 - 5Y	3.6423	3.6571	3.7767		3.8712	3.8380	3.6548	3.7494
5 - 6Y	4.0867		4.1559			4.0144	3.9385	
6 - 7Y	4.9414	4.8077	4.5884			4.9509	5.0653	4.9644
7 - 8Y	5.3436				5.3636	5.2545		
8 - 9Y	5.4607					5.5620		
9 - 10Y	6.7166		5.8166		6.7027			6.7129
10 - 11Y	6.7926						6.8040	
11 - 12Y	6.4305							
19 - 20Y	9.2145						9.0858	
20 - 21Y	9.7437							10.4405
25 - 26Y	9.9255							

TABLE 1C
CALCULATED MACAULEY DURATIONS PER QUARTER vs. BIS STANDARD

Tenor	*BIS*	*05Q2*	*05Q3*	*05Q4*	*06Q1*	*06Q2*	*06Q3*	*06Q4*	*07Jan*
<30D	0.0000	0.0698		0.0583		0.0806			
31-90D	0.2000	0.2052	0.1544	0.1028	0.1875	0.1978	0.1796	0.1642	0.1875
91-180D	0.4000	0.3864	0.4281	0.3312	0.3518	0.3903	0.3278	0.3107	0.4324
181-360D	0.7000	0.7477	0.7237	0.7499	0.7231	0.7921	0.7257	0.5825	0.7366
1-2Y	1.4000	1.5024	1.4796	1.4891	1.4577	1.5497	1.6164	1.5095	1.3666
2-3Y	2.2000	2.2178	2.2351	2.1631	2.1893	2.3547	2.2845	2.1285	1.9143
3-4Y	3.0000	2.9155	2.9299	2.8385	2.8091	2.9935	2.9122	3.0177	2.9594
4-5Y	3.6500	3.5237	3.5115	3.5502	3.4730	3.8621	3.7198	3.7493	3.5943
5-6Y	4.6500	3.8974	3.9939	3.9834	4.1604	4.0597	4.0071	4.2771	4.2233
6-7Y	4.6500	4.7404	4.7087	4.7860	4.8376	4.9285	5.0232	5.0096	4.9151
7-8Y	5.8000	4.9359	4.9705	5.1006	5.3370	5.1686	5.1687	5.6022	5.3625
8-9Y	5.8000	5.2983	5.4870	5.4222	5.6480	5.4960	5.6571	5.6998	5.5542
9-10Y	5.8000	5.7935	5.6969	5.7710	6.5596	6.4752	6.5082	6.7938	6.7275
10-11Y	7.5000	5.9760	6.0514	6.2126	6.6424	6.7751	6.8080	6.8479	6.9197
11-12Y	7.5000				6.4305				
19-20Y	8.7500				8.5672	8.9780	9.1086	9.2457	9.4210
20-21Y	10.0000	7.8179		7.9928				10.2139	10.3180
25-26Y	10.0000				8.7081			10.1266	10.4727

Note: Highlighted values are those which are higher than the BIS-assumed parameter.

TABLE 2
STATISTICS ON CALCULATED MACAULEY DURATIONS

TENOR BUCKET	BIS	TRANSACTED ON PDEx PLATFORM							
		MAX	AVG	MEDIAN	MIN	SD	KURT	SKEW	COUNT
< 30 days	0.00	0.081	0.070	0.074	0.056	0.009	-1.231	-0.671	10
31 - 90 days	0.20	0.244	0.184	0.189	0.083	0.049	-0.885	-0.561	71
91 - 180 days	0.40	0.497	0.369	0.365	0.247	0.083	-1.458	-0.054	112
181 - 360 days	0.70	0.959	0.714	0.699	0.480	0.155	-1.355	0.147	199
1 - 2 yrs	1.40	1.872	1.516	1.540	0.903	0.232	-0.364	-0.623	1,897
2 - 3 yrs	2.20	2.658	2.199	2.233	1.702	0.227	-0.855	-0.098	5,238
3 - 4 yrs	3.00	3.418	2.907	2.933	2.306	0.243	-1.023	-0.185	2,480
4 - 5 yrs	3.65	4.335	3.642	3.663	3.018	0.243	-0.007	0.203	2,886
5 - 7 yrs	4.65	5.564	4.758	4.887	3.590	0.400	0.037	-0.908	2,405
7 - 10 yrs	5.80	7.421	6.355	6.693	4.743	0.645	-0.479	-1.006	1,477
10 - 15 yrs	7.50	7.569	6.791	6.816	5.770	0.184	11.854	-1.029	621
15 - 20 yrs	8.75	9.697	9.214	9.165	8.567	0.169	2.813	0.708	100
> 20 yrs	10.00	10.944	9.791	10.285	7.504	0.922	0.408	-1.406	62

Note: Highlighted values are those which are higher than the BIS-assumed parameter.

TABLE 3
STATISTICS ON EXPANDED TENOR BUCKETS

TENOR BUCKET	BIS	TRANSACTED ON PDEx PLATFORM							
		MAX	AVG	MEDIAN	MIN	SD	KURT	SKEW	COUNT
5 - 7 yrs	4.65	5.564	4.758	4.887	3.590	0.400	0.037	-0.908	2,405
5 - 6 yrs	4.65	4.658	4.087	4.133	3.590	0.185	-0.417	-0.108	517
6 - 7 yrs	4.65	5.564	4.941	4.956	4.213	0.193	2.181	0.153	1,888
7 - 10 yrs	5.80	7.421	6.355	6.693	4.743	0.645	-0.479	-1.006	1,477
7 - 8 yrs	5.80	5.655	5.344	5.372	4.743	0.276	-1.324	-0.463	365
8 - 9 yrs	5.80	5.755	5.461	5.442	5.128	0.140	0.812	-0.278	26
9 - 10 yrs	5.80	7.421	6.717	6.765	5.641	0.214	6.524	-1.652	1,086
10 - 15 yrs	7.50	7.569	6.791	6.816	5.770	0.184	11.854	-1.029	621
10 - 11 yrs	7.50	7.569	6.793	6.816	5.770	0.183	12.159	-1.036	619
11 - 12 yrs	7.50	6.447	6.430	6.430	6.414	0.023	ERR	ERR	2
15 - 20 yrs	8.75	9.697	9.214	9.165	8.567	0.169	2.813	0.708	100
19 - 20 yrs	8.75	9.697	9.214	9.165	8.567	0.169	2.813	0.708	100
Over 20 yrs	10.00	10.944	9.791	10.285	7.504	0.922	0.408	-1.406	62
20 - 21 yrs	10.00	10.443	9.744	10.287	7.504	0.993	0.009	-1.365	46
25 ++ yrs	10.00	10.944	9.925	10.208	8.375	0.691	0.490	-1.001	16

Note: Highlighted values are those which are higher than the BIS-assumed parameter.

TABLE 4A
DESCRIPTIVE STATISTICS OF DAILY CHANGE IN YIELD

2005	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
Mean	-0.0005	-0.0005	-0.0002	-0.0002	-0.0004	-0.0007	-0.0009	-0.0009	-0.0010	-0.0010	-0.0004	-0.0004
Std Error	0.0020	0.0037	0.0015	0.0016	0.0007	0.0009	0.0006	0.0007	0.0006	0.0008	0.0007	0.0005
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000	0.0000
Mode	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std Dev	0.0281	0.0514	0.0207	0.0214	0.0103	0.0118	0.0089	0.0098	0.0078	0.0108	0.0094	0.0073
Variance	0.0008	0.0026	0.0004	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Kurtosis	9.2795	4.4219	3.1422	5.2203	12.3244	10.2901	4.4890	6.7295	2.9762	11.0298	12.8815	2.6257
Skewness	-0.2133	-0.4841	0.5284	0.1114	0.7367	0.2105	0.4909	0.2899	-0.5955	-1.6730	-1.0328	-0.3631
Range	0.2599	0.4066	0.1572	0.1909	0.1144	0.1304	0.0727	0.0907	0.0565	0.1097	0.0997	0.0594
Minimum	-0.1264	-0.2339	-0.0667	-0.0921	-0.0482	-0.0652	-0.0319	-0.0441	-0.0305	-0.0688	-0.0562	-0.0305
Maximum	0.1335	0.1728	0.0905	0.0988	0.0662	0.0652	0.0408	0.0467	0.0259	0.0408	0.0435	0.0290
Sum	-0.0873	-0.0873	-0.0386	-0.0403	-0.0715	-0.1344	-0.1630	-0.1624	-0.1857	-0.1864	-0.0733	-0.0731
Count	190	190	190	190	190	190	190	190	190	190	190	190
95% CL	0.0040	0.0073	0.0029	0.0030	0.0015	0.0017	0.0013	0.0014	0.0011	0.0015	0.0013	0.0010

TABLE 4B
DESCRIPTIVE STATISTICS OF DAILY CHANGE IN YIELD

2006	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
Mean	-0.0010	-0.0009	-0.0012	-0.0013	-0.0018	-0.0019	-0.0021	-0.0021	-0.0019	-0.0019	-0.0017	-0.0014
Std Error	0.0033	0.0045	0.0034	0.0026	0.0020	0.0018	0.0019	0.0021	0.0022	0.0017	0.0017	0.0014
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0015	0.0000	0.0000	0.0000	0.0000
Mode	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std Dev	0.0512	0.0705	0.0534	0.0409	0.0311	0.0289	0.0299	0.0330	0.0341	0.0272	0.0274	0.0223
Variance	0.0026	0.0050	0.0029	0.0017	0.0010	0.0008	0.0009	0.0011	0.0012	0.0007	0.0008	0.0005
Kurtosis	9.3143	8.5558	2.9892	3.0894	3.8299	5.6490	6.3958	9.5997	12.6480	5.4846	6.7265	7.9120
Skewness	-0.1189	0.5300	-0.0033	-0.1332	-0.1232	0.8867	0.5868	-0.5224	1.3291	0.9822	0.0016	0.7906
Range	0.5071	0.6804	0.3719	0.3204	0.2540	0.2491	0.2910	0.3612	0.3795	0.2157	0.2703	0.2094
Minimum	-0.2646	-0.2567	-0.1809	-0.1677	-0.1434	-0.0866	-0.1264	-0.2181	-0.1448	-0.0685	-0.1420	-0.1001
Maximum	0.2426	0.4237	0.1911	0.1527	0.1106	0.1625	0.1646	0.1431	0.2347	0.1472	0.1283	0.1093
Sum	-0.2361	-0.2113	-0.3027	-0.3250	-0.4488	-0.4591	-0.5162	-0.5285	-0.4831	-0.4672	-0.4208	-0.3536
Count	248	248	248	248	248	248	248	248	248	248	248	248
95% CL	0.0064	0.0088	0.0067	0.0051	0.0039	0.0036	0.0037	0.0041	0.0042	0.0034	0.0034	0.0028

TABLE 5
DESCRIPTIVE STATISTICS OF DAILY CHANGE IN YIELD
LAST 100 TRADING DAYS

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
Mean	-0.0055	-0.0047	-0.0063	-0.0061	-0.0037	-0.0031	-0.0030	-0.0025	-0.0026	-0.0025	-0.0026	-0.0028
Std Error	0.0082	0.0102	0.0089	0.0070	0.0035	0.0029	0.0030	0.0024	0.0026	0.0018	0.0028	0.0019
Median	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0035	0.0000	0.0000	0.0000	-0.0013	0.0000	0.0000
Mode	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NA	0.0000	0.0000
Std Dev	0.0815	0.1020	0.0887	0.0696	0.0352	0.0292	0.0302	0.0235	0.0263	0.0176	0.0275	0.0192
Variance	0.0066	0.0104	0.0079	0.0048	0.0012	0.0009	0.0009	0.0006	0.0007	0.0003	0.0008	0.0004
Kurtosis	6.8868	4.4580	2.6927	2.2253	3.3272	1.1635	3.4581	2.8889	1.5051	2.7527	7.1405	4.7685
Skewness	-0.1245	-0.9625	-0.2769	-0.5652	-0.6732	-0.2072	-0.2579	-0.7839	-0.5020	-0.3464	-1.5630	-0.4324
Range	0.6597	0.6834	0.5613	0.4119	0.2318	0.1532	0.2166	0.1580	0.1565	0.1259	0.2030	0.1434
Minimum	-0.3299	-0.4274	-0.2736	-0.2192	-0.1434	-0.0848	-0.1264	-0.1029	-0.0852	-0.0637	-0.1420	-0.0809
Maximum	0.3299	0.2559	0.2877	0.1927	0.0884	0.0684	0.0903	0.0551	0.0713	0.0623	0.0610	0.0625
Sum	-0.5401	-0.4622	-0.6245	-0.6028	-0.3639	-0.3087	-0.2961	-0.2522	-0.2578	-0.2451	-0.2591	-0.2810
Count	99	99	99	99	99	99	99	99	99	99	99	99
95% CI	0.0160	0.0201	0.0175	0.0137	0.0069	0.0057	0.0060	0.0046	0.0052	0.0035	0.0054	0.0038

FIGURE 1
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 1-MONTH RATES

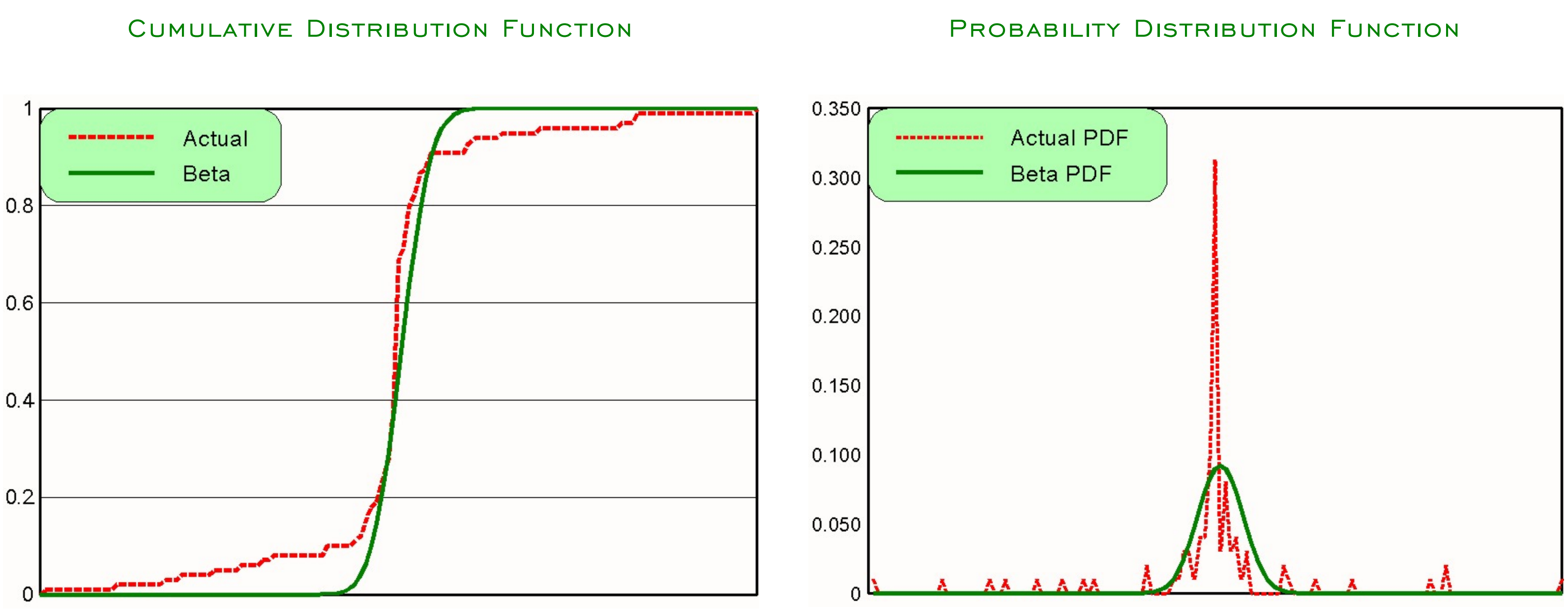


FIGURE 2
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 3-MONTH RATES

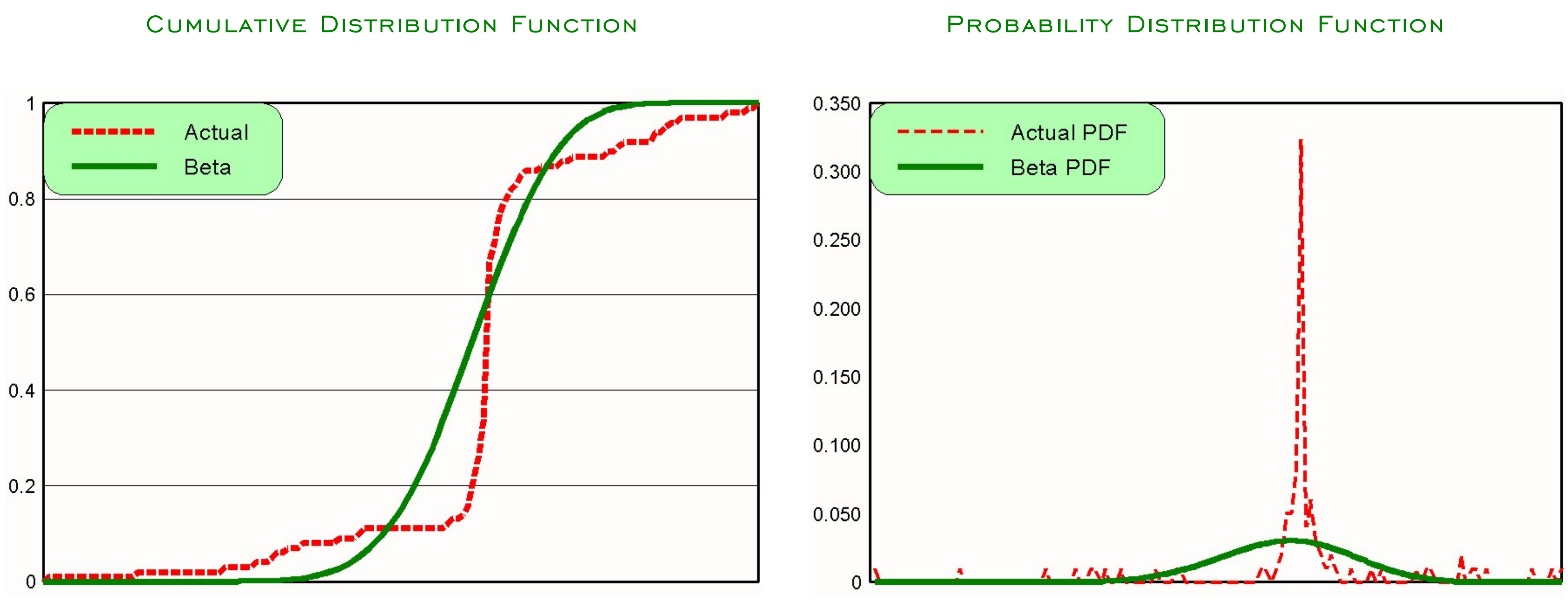


FIGURE 3
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 6-MONTH RATES

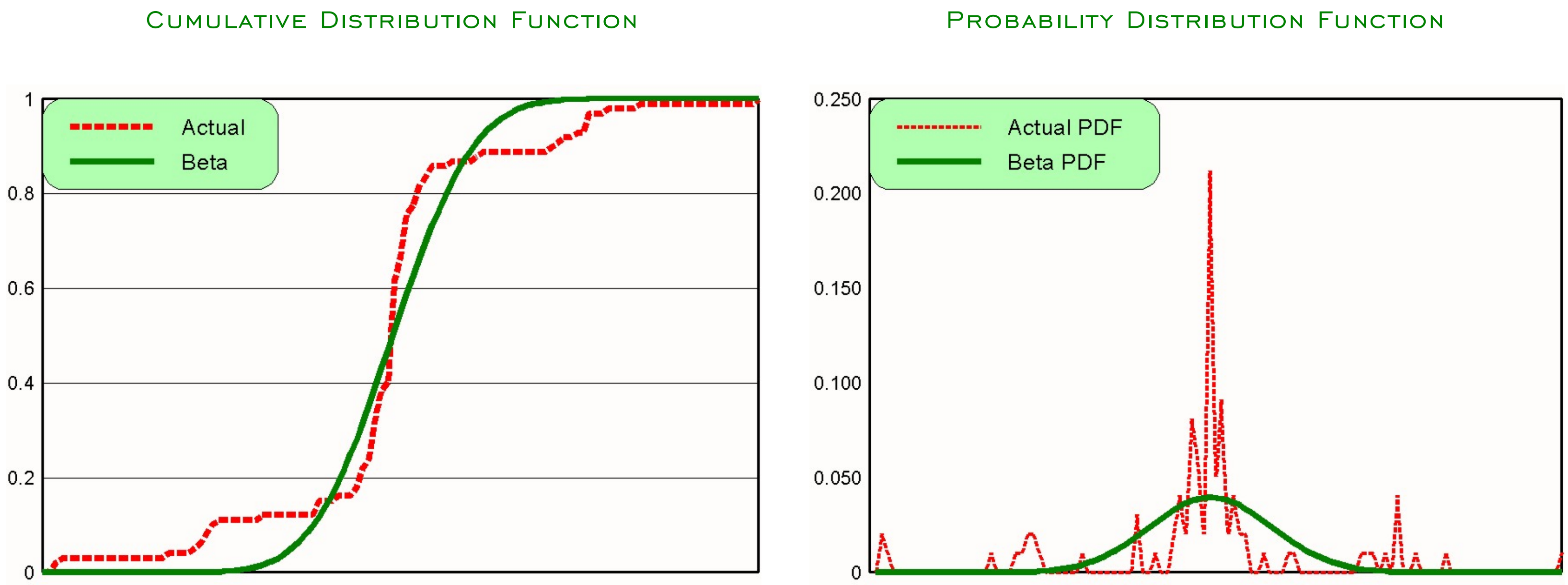


FIGURE 4
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 12-MONTH RATES

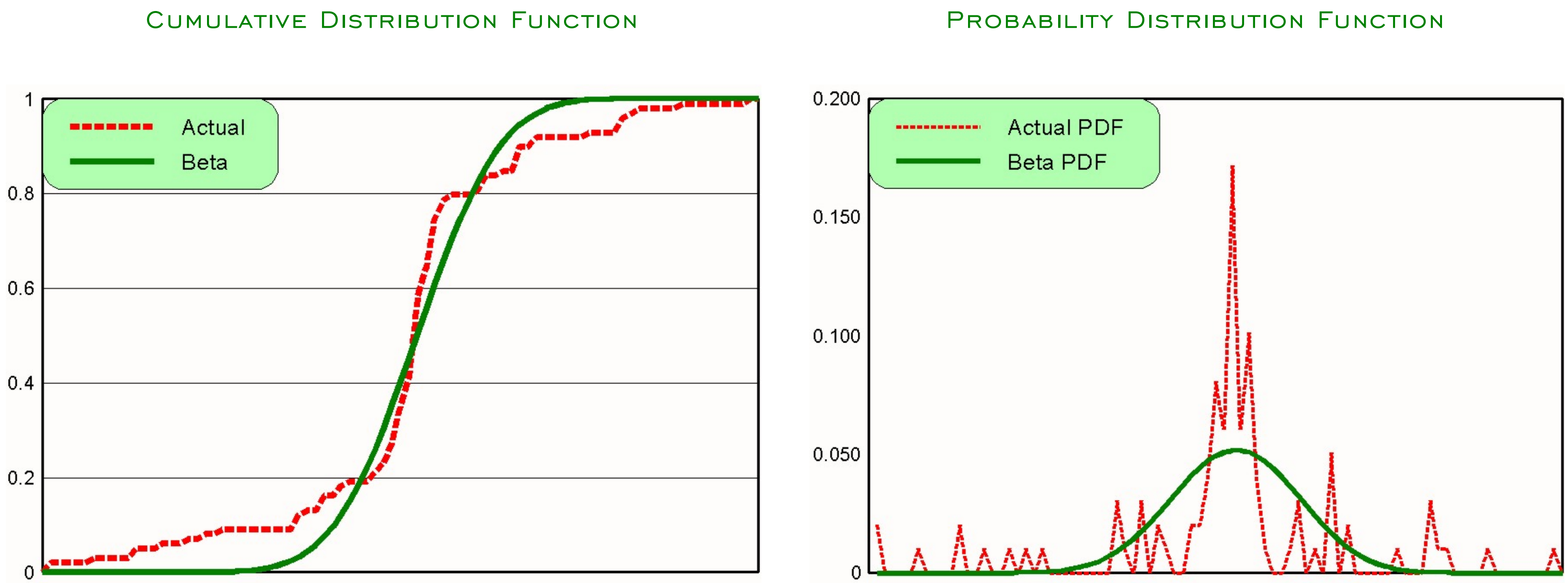


FIGURE 5
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 2-YEAR RATES

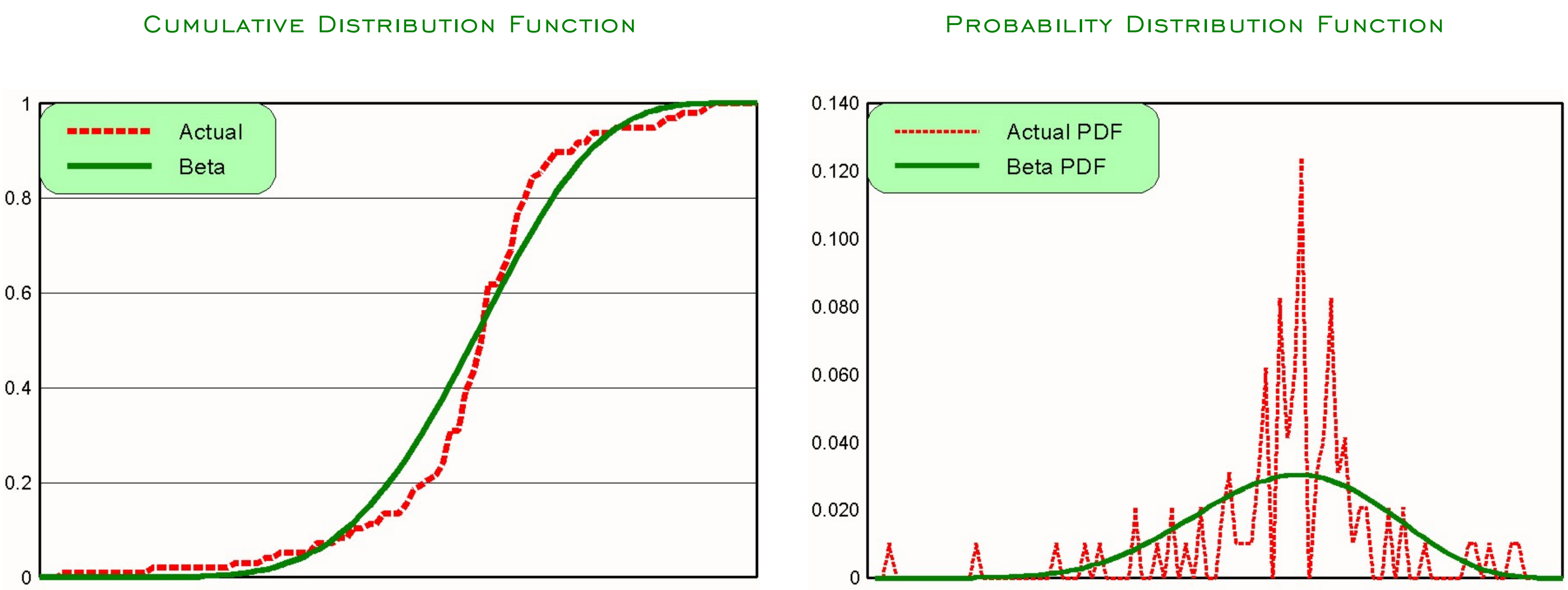
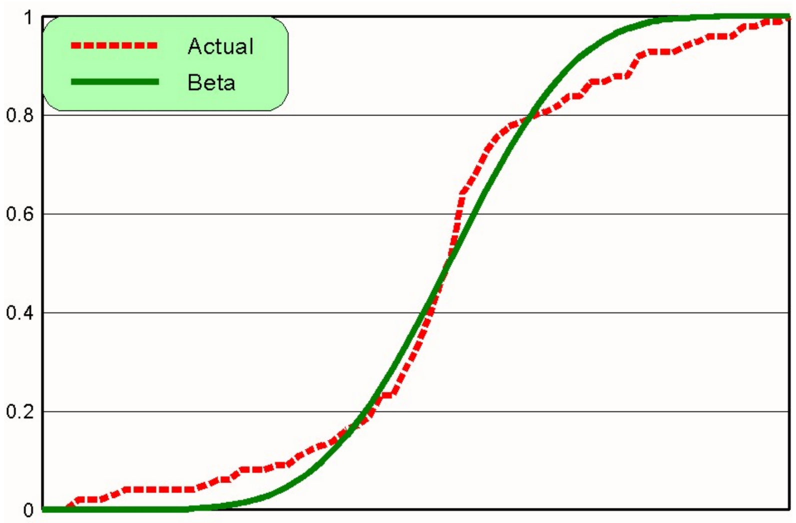


FIGURE 6
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 3-YEAR RATES

CUMULATIVE DISTRIBUTION FUNCTION



PROBABILITY DISTRIBUTION FUNCTION

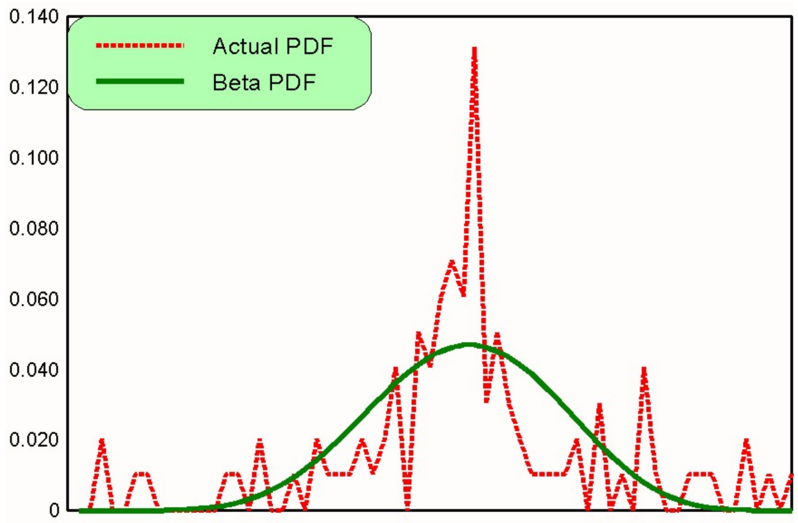


FIGURE 7
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 4-YEAR RATES

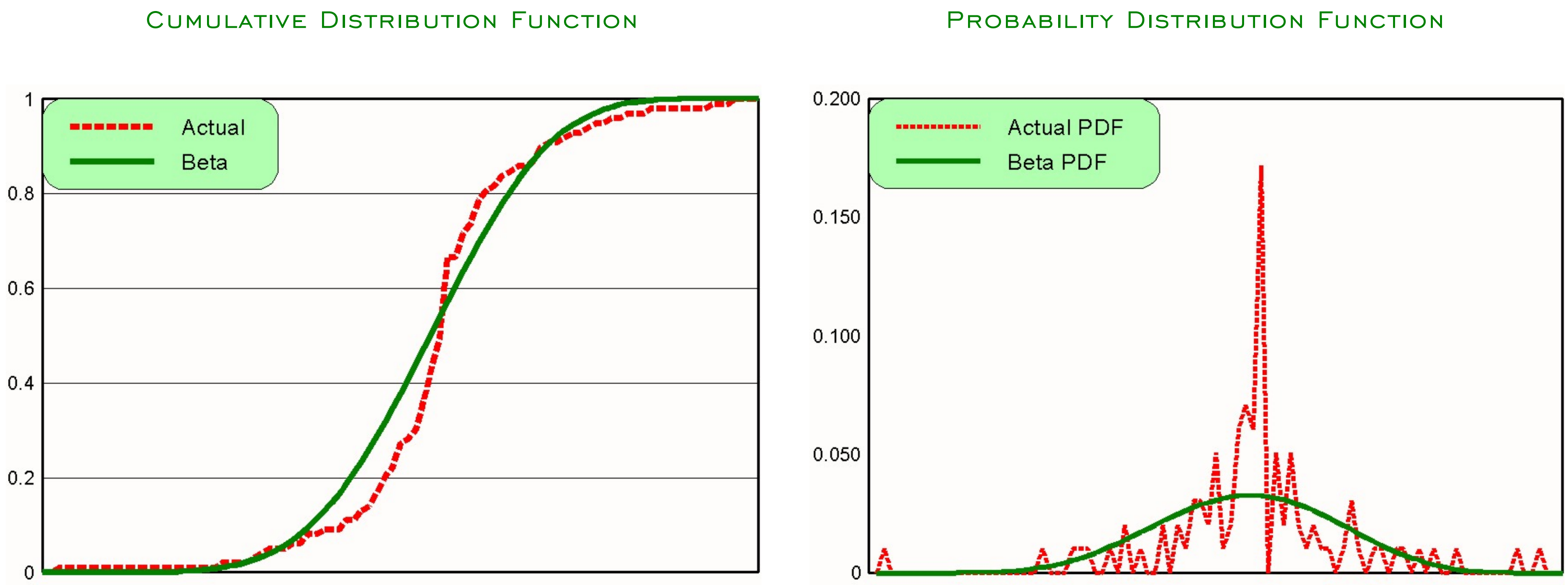
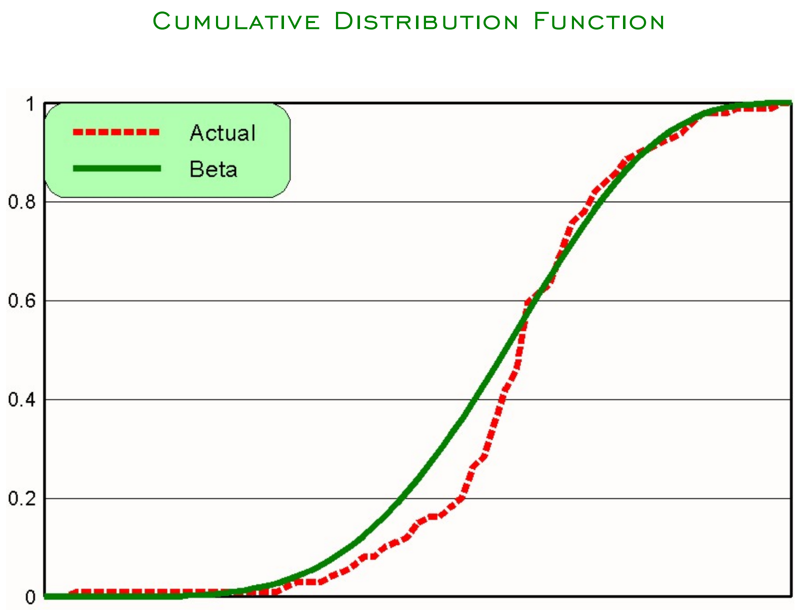


FIGURE 8
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 5-YEAR RATES



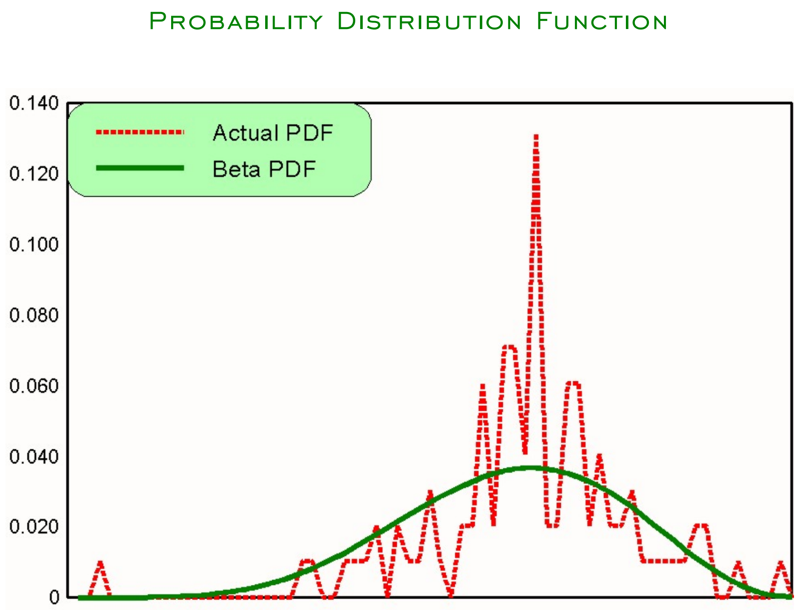


FIGURE 9
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 7-YEAR RATES

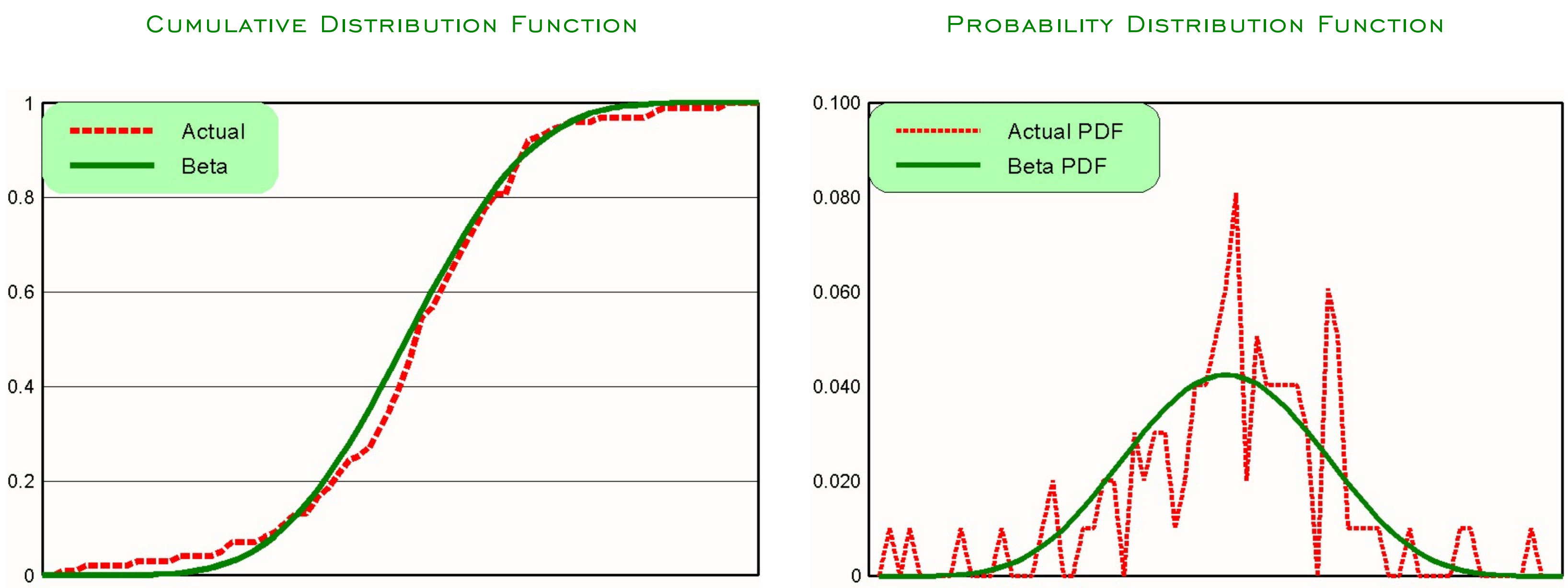
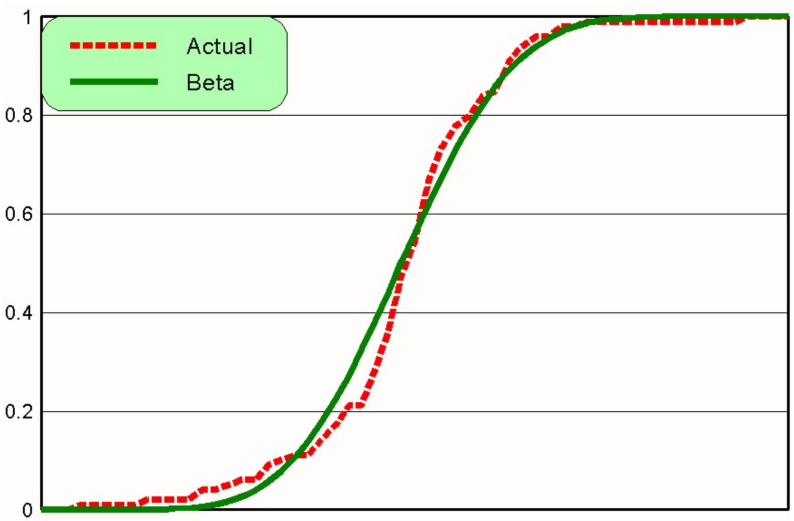


FIGURE 10
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 10-YEAR RATES

Cumulative Distribution Function



Probability Distribution Function

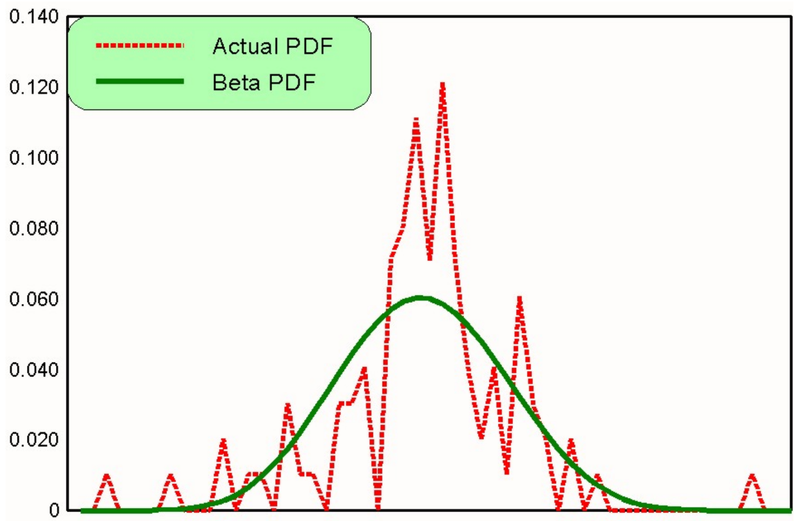
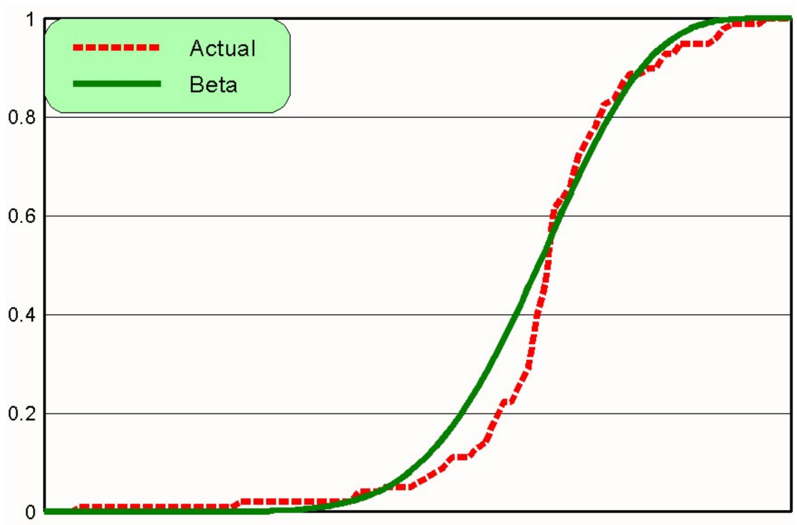


FIGURE 11
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 20-YEAR RATES

Cumulative Distribution Function



Probability Distribution Function

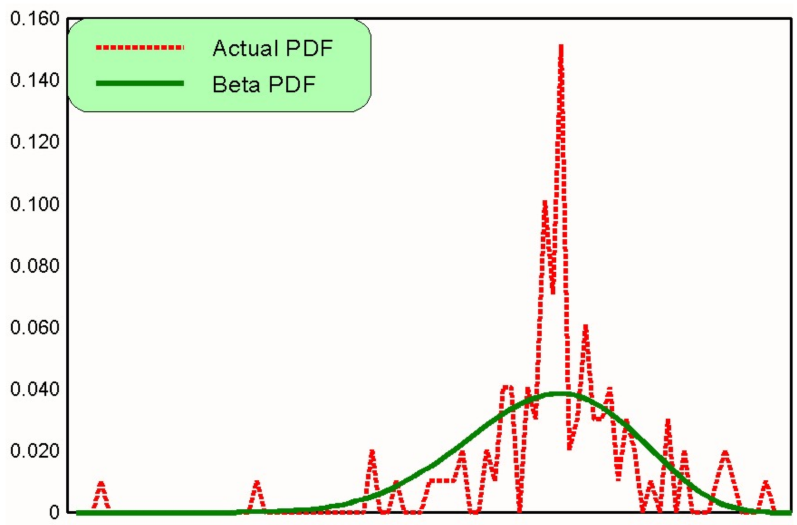
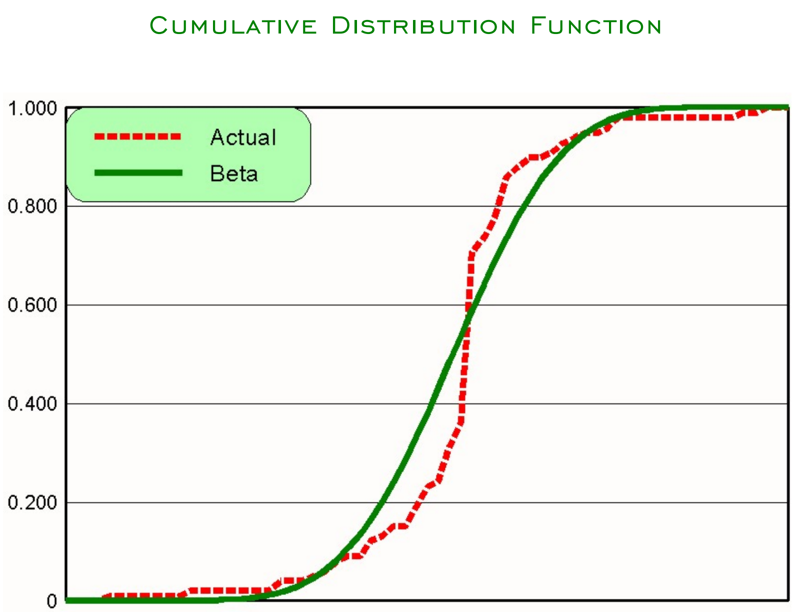


FIGURE 12
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 25-YEAR RATES



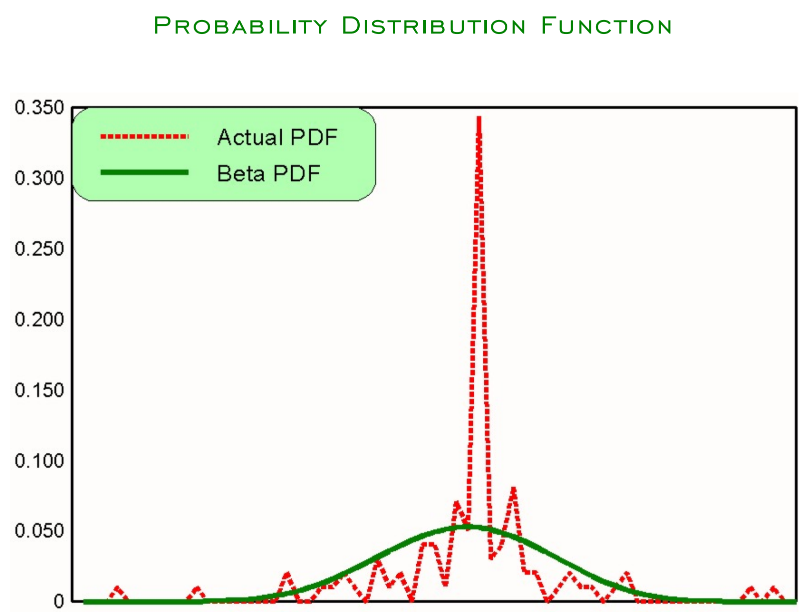


TABLE 6
RELATIVE MAGNITUDE OF INTEREST RATE CHANGES

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
Value at 95% Probability	0.0380	0.0854	0.0803	0.0611	0.0433	0.0297	0.0413	0.0334	0.0330	0.0240	0.0330	0.0252
Percentage Change @95%	3.870%	8.917%	8.364%	6.296%	4.429%	3.014%	4.212%	3.401%	3.357%	2.433%	3.353%	2.552%
Percentage Change @max	39.08%	29.17%	33.33%	21.25%	9.24%	7.08%	9.45%	5.66%	7.39%	6.42%	6.29%	6.45%
Percentage Change @2SD	17.06%	22.05%	18.65%	14.25%	6.89%	5.67%	5.91%	4.55%	5.13%	3.33%	5.37%	3.62%
Implied BIS Change	12.500%	12.500%	12.500%	12.500%	11.250%	10.000%	9.375%	9.375%	8.750%	8.125%	7.500%	7.500%

FIGURE 13
TIME PATH OF PDEX REFERENCE RATES
(March 29, 2005 to January 31, 2007)

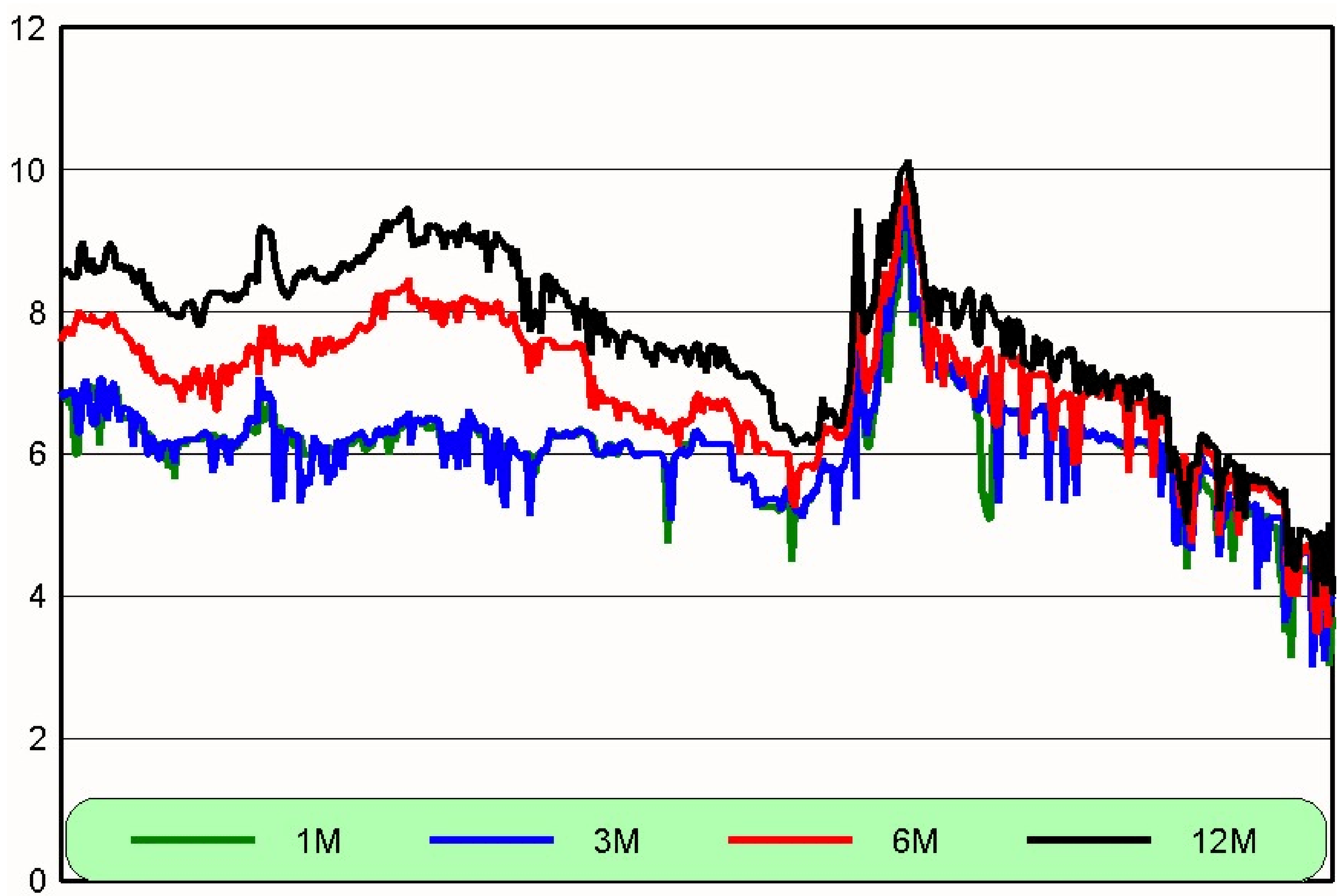


FIGURE 14
TIME PATH OF PDEX REFERENCE RATES
(March 29, 2005 to January 31, 2007)

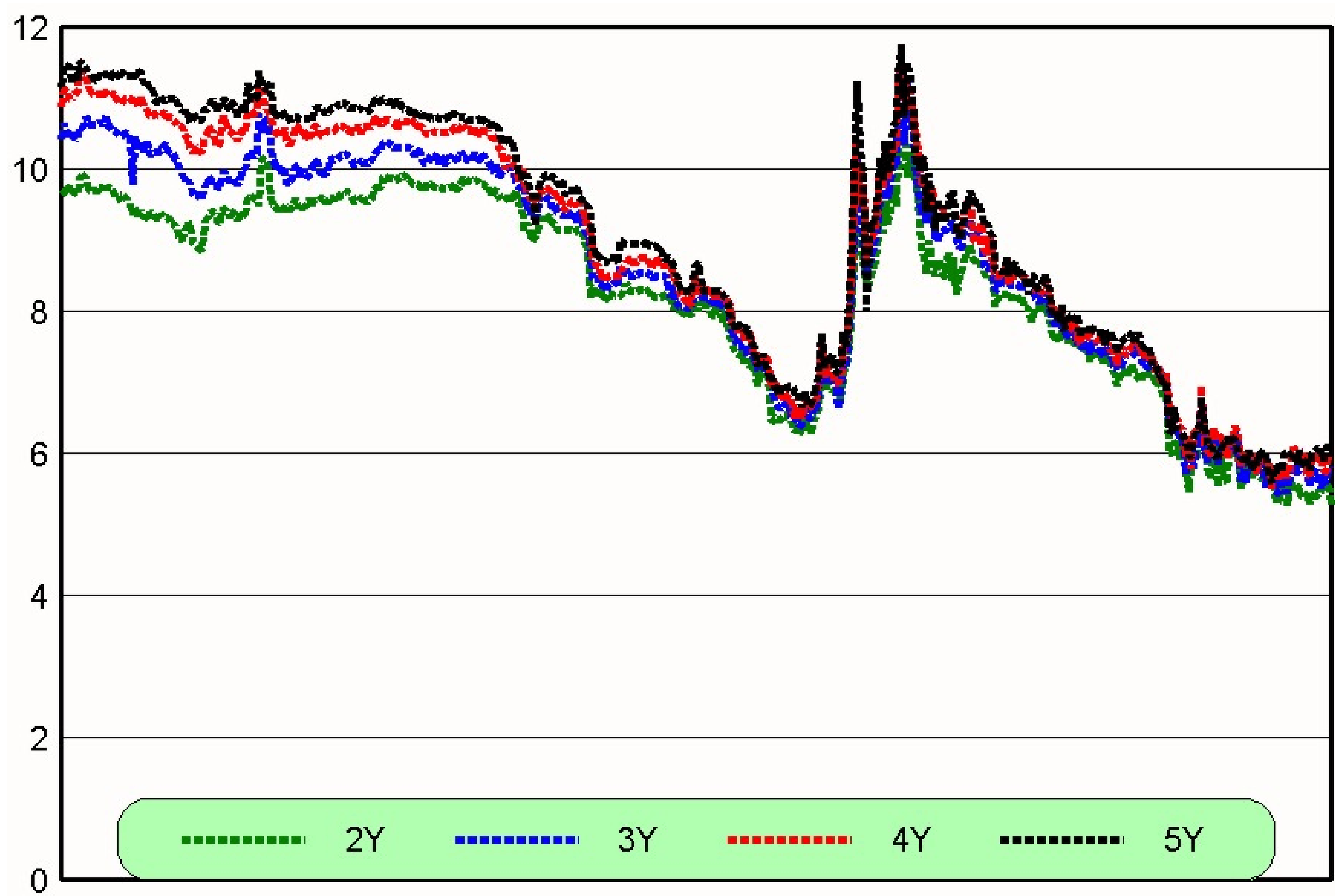


FIGURE 15
TIME PATH OF PDEX REFERENCE RATES
(March 29, 2005 to January 31, 2007)

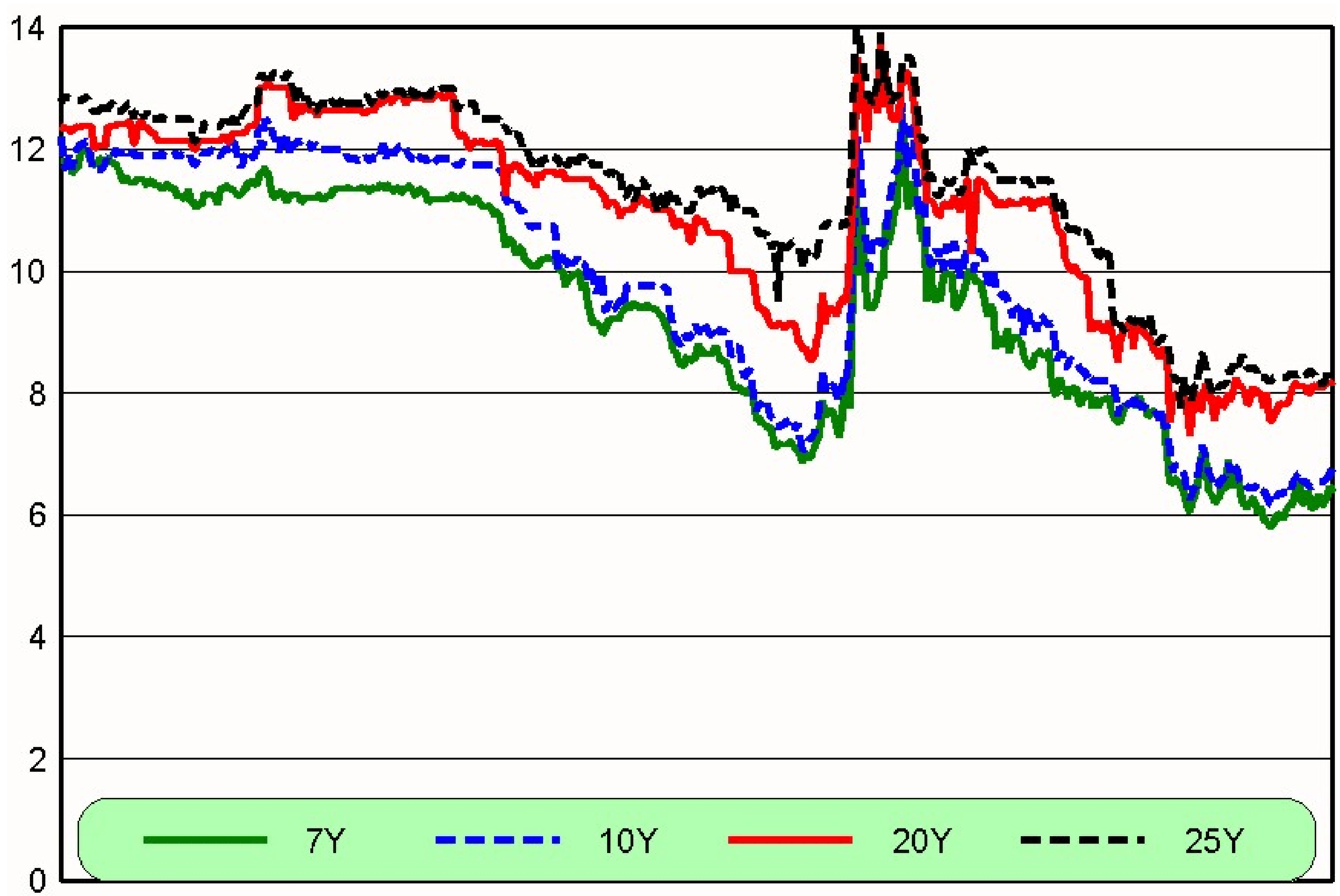


TABLE 6
CORRELATION COEFFICIENTS OF REFERENCE RATES REPORTED BY PDEx

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M	1.0000	0.9116	0.8273	0.7726	0.7027	0.6900	0.6680	0.6509	0.6395	0.6306	0.6635	0.6747
3M		1.0000	0.7985	0.7366	0.6577	0.6455	0.6227	0.6096	0.5956	0.5885	0.6264	0.6352
6M			1.0000	0.9507	0.9021	0.8821	0.8636	0.8517	0.8446	0.8432	0.8486	0.8494
12M				1.0000	0.9669	0.9507	0.9363	0.9293	0.9244	0.9260	0.9314	0.9256
2Y					1.0000	0.9899	0.9821	0.9788	0.9760	0.9760	0.9670	0.9506
3Y						1.0000	0.9950	0.9923	0.9887	0.9853	0.9619	0.9423
4Y							1.0000	0.9957	0.9944	0.9899	0.9578	0.9364
5Y								1.0000	0.9946	0.9911	0.9577	0.9363
7Y									1.0000	0.9917	0.9555	0.9336
10Y										1.0000	0.9678	0.9462
20Y											1.0000	0.9765
25Y												1.0000

TABLE 7
CORRELATION COEFFICIENTS OF FIRST DIFFERENCE OF REFERENCE RATES

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M	1.0000	0.2304	0.1451	0.1500	0.1440	0.2805	0.2542	0.2316	0.2167	0.0743	0.1980	0.2225
3M		1.0000	0.1973	0.2300	0.1378	0.1862	0.0626	0.1963	-0.0427	0.0708	0.1362	0.0927
6M			1.0000	0.4141	0.2952	0.2750	0.2246	0.2348	0.1143	0.1869	0.2494	0.2533
12M				1.0000	0.3701	0.3406	0.2507	0.3079	0.1777	0.2528	0.3193	0.3120
2Y					1.0000	0.4769	0.3955	0.4938	0.3894	0.4042	0.4174	0.4175
3Y						1.0000	0.6490	0.6327	0.4280	0.4479	0.4368	0.4536
4Y							1.0000	0.5887	0.6197	0.4204	0.3868	0.4913
5Y								1.0000	0.4944	0.4765	0.5334	0.4951
7Y									1.0000	0.4261	0.3772	0.4772
10Y										1.0000	0.4314	0.4536
20Y											1.0000	0.5784
25Y												1.0000

TABLE 8
CALCULATED CRITICAL z-SCORES BASED ON FISCHER TRANSFORMATION

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M		-9.824	-11.719	-11.611	-11.744	-8.675	-9.283	5.053	4.718	1.595	4.298	4.847
3M			-10.568	-9.833	-11.880	-10.813	-13.507	4.261	-0.916	1.519	2.935	1.991
6M				-5.412	-8.333	-8.802	-9.955	5.125	2.459	4.053	5.458	5.547
12M					-6.527	-7.250	-9.362	6.817	3.848	5.536	7.088	6.916
2Y						-7.462	-9.619	-3.257	-6.044	-5.667	-5.327	-5.324
3Y							-2.009	1.131	-5.050	-4.523	-4.817	-4.369
4Y								-0.376	0.672	-5.249	-6.108	-3.328
5Y									-6.972	-7.474	-5.835	-6.953
7Y										-8.830	-10.081	-7.455
10Y											-8.691	-8.100
20Y												-4.440
25Y												

TABLE 9
CALCULATED z-SCORES BASED ON SIMULATED DISALLOWANCE

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M		5.026	3.131	3.239	3.107	6.176	5.567	5.053	4.718	1.595	4.298	4.847
3M			4.282	5.017	2.970	4.037	1.343	4.261	-0.916	1.519	2.935	1.991
6M				9.438	6.517	6.048	4.895	5.125	2.459	4.053	5.458	5.547
12M					8.323	7.600	5.488	6.817	3.848	5.536	7.088	6.916
2Y						4.488	2.331	11.593	8.806	9.184	9.523	9.526
3Y							9.941	15.981	9.800	10.327	10.033	10.482
4Y								14.475	15.523	9.601	8.743	11.522
5Y									4.978	4.476	6.115	4.997
7Y										3.120	1.869	4.495
10Y											3.259	3.850
20Y												7.510
25Y												

ANNEX 1
COUPON PROFILE AT ISSUE

COUPON STATISTICS	TENOR AT ISSUE								
	2 Yrs	3 Yrs	4 Yrs	5 Yrs	7 Yrs	10 Yrs	19 Yrs	20 Yrs	25 Yrs
Mean	8.56	9.04	11.08	10.25	10.51	10.88	10.25	9.35	9.73
Standard Error	0.06	0.01	0.02	0.02	0.04	0.07	0.00	0.30	0.19
Median	8.38	8.50	11.00	10.75	8.75	9.13	10.25	8.00	9.38
Mode	8.38	8.50	12.00	8.50	8.75	9.13	10.25	8.00	9.38
Standard Deviation	1.23	0.89	1.05	1.65	2.48	3.19	0.00	2.16	0.76
Variance	1.50	0.80	1.09	2.72	6.17	10.20	0.00	4.68	0.57
Kurtosis	0.20	0.30	9.51	-0.18	-0.23	0.91	ERR	-0.35	1.28
Skewness	0.12	1.35	-2.62	0.07	0.83	1.37	ERR	1.14	1.77
Range	4.50	4.50	7.75	10.88	11.25	16.63	0.00	6.38	1.88
Minimum	6.50	8.50	6.50	5.88	7.13	6.25	10.25	8.00	9.38
Maximum	11.00	13.00	14.25	16.75	18.38	22.88	10.25	14.38	11.25
Count	445	3,657	2,806	5,005	3,088	2,392	98	51	16
Confidence Level	0.1139	0.0290	0.0387	0.0457	0.0876	0.1280	0.0000	0.5934	0.3704

ANNEX 2
YIELD PROFILE AT ISSUE

YIELD STATISTICS	TENOR AT ISSUE								
	2 Yrs	3 Yrs	4 Yrs	5 Yrs	7 Yrs	10 Yrs	19 Yrs	20 Yrs	25 Yrs
Mean	8.13	7.76	9.07	8.41	8.13	7.94	8.59	8.71	9.17
Standard Error	0.05	0.02	0.03	0.03	0.03	0.03	0.05	0.24	0.26
Median	8.25	8.05	9.60	8.38	7.93	7.75	8.75	7.85	9.03
Mode	8.30	5.40	10.00	10.70	6.00	6.50	9.03	7.83	9.03
Standard Deviation	1.00	1.46	1.56	1.77	1.75	1.51	0.50	1.69	1.03
Variance	1.00	2.13	2.44	3.15	3.05	2.29	0.25	2.84	1.06
Kurtosis	1.28	-0.86	-0.25	-1.24	-1.00	-0.30	-0.21	0.17	0.27
Skewness	-1.00	-0.13	-0.81	-0.11	0.36	0.70	-1.07	1.39	0.98
Range	5.30	6.50	7.45	8.15	8.13	7.25	1.80	5.25	3.39
Minimum	4.50	4.38	3.90	3.40	3.50	4.75	7.30	6.86	7.75
Maximum	9.80	10.88	11.35	11.55	11.63	12.00	9.10	12.11	11.14
Count	445	3,657	2,806	5,005	3,088	2,392	98	51	16
Confidence Level	0.0931	0.0473	0.0578	0.0492	0.0616	0.0606	0.0995	0.4627	0.5044

Validation of the BIS Market Risk Model for Debt Instruments: The Philippine Case

Noet E. Ravalo *Ph.D.*

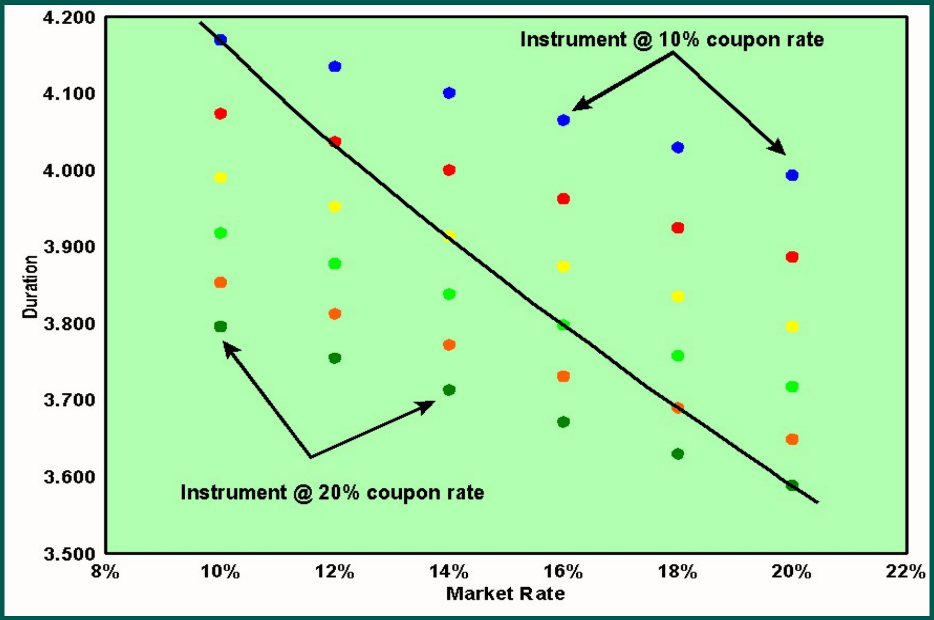
A Presentation to the
Supervision & Examination Section
Bangko Sentral ng Pilipinas

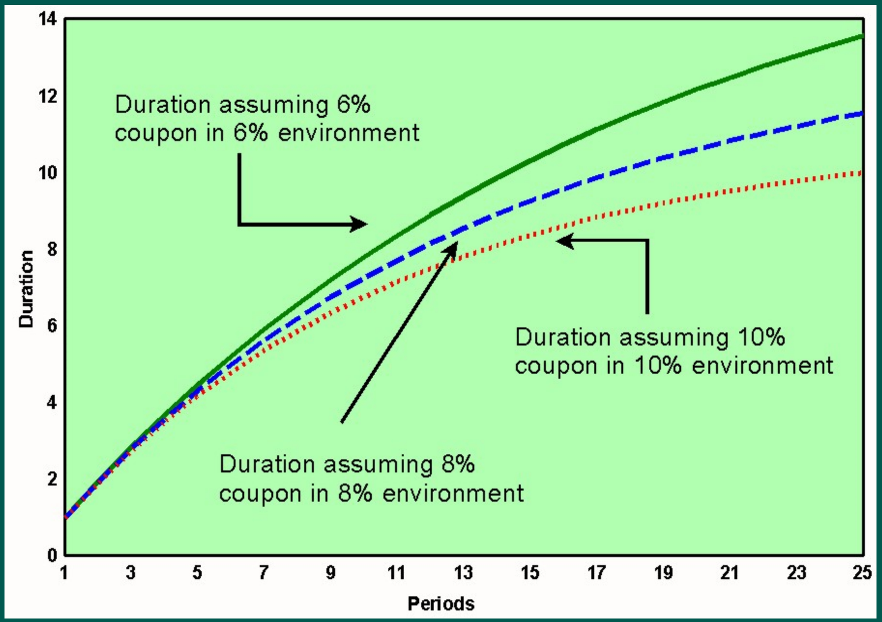
Key Model Assumptions

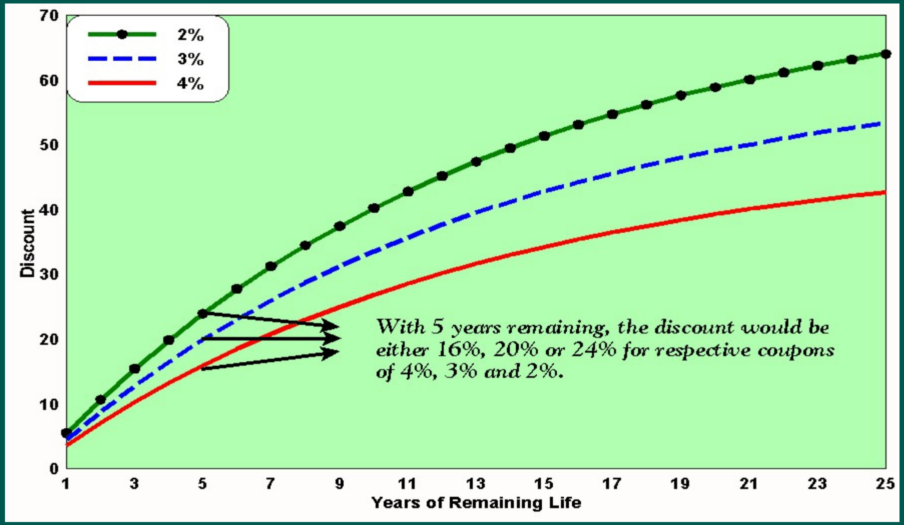
- Assumes 8% coupon rate in an 8% environment
  - ☞ All securities are at par value
  - ☞ All securities have same pricing (8% coupon)
  - ☞ Yield curve is flat at 8%
- Maturity of securities is at mid-point of time band
  - ☞ Defines dist'n of securities (impacts duration)
- On volatility of market yields
  - ☞ There is so-called basis risk
  - ☞ Model designed to cover extremum at 2σ

$\int\partial$ Noet E. Ravalo Ph.D.

Some Basic Simulations







∫∂ Noet E. Ravalo Ph.D.

The Model Construction

Tenor Buckets (A)	Net Open Position (B)	Duration (C)	Extremum Yield Change (D)	Market Risk Charge (E) = B x C x D
1	x01	0.00	1.00	k01
2	x02	0.20	1.00	k02
3	x03	0.40	1.00	k03
⋮	⋮	⋮	⋮	⋮
⋮	⋮	8.75	0.60	⋮
13	x13	10.00	0.60	k13

Vertical Disallowance: Capital charge to account for ***basis risk*** for covered position within a tenor bucket

Horizontal Disallowance: Capital charge to account for ***basis risk*** for covered position within & across zones

Underlying Theory

$$D = \sum_{i=1}^{n} t \left(\frac{\frac{c_i}{(1+y)^i}}{P} \right) = \sum_{i=1}^{n} t w_i$$

Duration is a weighted average maturity of a bond where the weights are the PV of the cash flows as a percentage of the bond's market price

$\int \partial$ Noet E. Ravalo Ph.D.

Underlying Theory

$$D = \sum_{i=1}^{n} t \left(\frac{\frac{c_i}{(1+y)^i}}{P} \right) = \sum_{i=1}^{n} t w_i$$

$$D = -\lim_{\Delta y \to 0} \frac{\Delta P / P}{\Delta y} = \frac{-\partial P / \partial y}{P}$$

At the limit, duration relates P and yield

This is often mistaken to be the slope of the price-yield curve

Underlying Theory

$$D = \sum_{i=1}^{n} t \left(\frac{\frac{c_i}{(1+y)^i}}{P} \right) = \sum_{i=1}^{n} t w_i$$

$$D = -\lim_{\Delta y \to 0} \frac{\Delta P / P}{\Delta y} = \frac{-\partial P / \partial y}{P}$$

$$\frac{\Delta P}{P} = -D \, \Delta y$$

Valid only for infinitisimal changes in yield AND for a parallel shift in yield curve

Items for Validation

- Time buckets — Is aggregation benign?
- Assumed duration values — Are values reasonable?
- Assumed change in yields — Is volatility covered?
- Correlation of yields — What is extent of basis risk?
  - ☞ Within a time bucket
  - ☞ Across time buckets within a zone
  - ☞ Across zones

∫∂ Noet E. Ravalo Ph.D.

Some Related Policy Issues

- **Is price risk arising from Philippine GS *reasonably* covered by current regulation ?**

- **Is there a *policy benefit* to unbundling time bands ?**

- **How should we approach interest rate volatility ?**
  - **What do the results suggest about the yield curve ?**
  - **What implications arise for the derivatives market ?**
  - **To what extent is basis risk apparent ?**
  - **What is the appropriate “haircut” for GS per tenor ?**

Data Provided

- 454 trading days (March 29, 2005 to Jan 31, 2007)
- 18,636 individual transactions
- 152 FXTNs, 110 Treasuries, 10 RTBs, 2 Special Bonds
- 17,558 data points if Treasury Bills are excluded
- In addition, 454 reference rates for 12 benchmark tenor buckets were also sourced

$\int \partial$ Noet E. Ravalo Ph.D.

Tests on Duration

$\int \partial$ Noet E. Ravalo Ph.D.

Actual Duration in the Market

TABLE 1A
CALCULATED MACAULEY DURATIONS PER QUARTER

Tenor	*FULL*	*05Q2*	*05Q3*	*05Q4*	*06Q1*	*06Q2*	*06Q3*	*06Q4*	*07Jan*
<30D	0.0697	0.0698		0.0583		0.0806			
31-90D	0.1843	0.2052	0.1544	0.1028	0.1875	0.1978	0.1796	0.1642	0.1875
91-180D	0.3692	0.3864	0.4281	0.3312	0.3518	0.3903	0.3278	0.3107	0.4324
181-360D	0.7142	0.7477	0.7237	0.7499	0.7231	0.7921	0.7257	0.5825	0.7366
1-2Y	1.5160	1.5024	1.4796	1.4891	1.4577	1.5497	1.6164	1.5095	1.3666
2-3Y	2.1986	2.2178	2.2351	2.1631	2.1893	2.3547	2.2845	2.1285	1.9143
3-4Y	2.9071	2.9155	2.9299	2.8385	2.8091	2.9935	2.9122	3.0177	2.9594
4-5Y	3.6423	3.5237	3.5115	3.5502	3.4730	3.8621	3.7198	3.7493	3.5943
5-6Y	4.0867	3.8974	3.9939	3.9834	4.1604	4.0597	4.0071	4.2771	4.2233
6-7Y	4.9414	4.7404	4.7087	4.7860	4.8376	4.9285	5.0232	5.0096	4.9151
7-8Y	5.3436	4.9359	4.9705	5.1006	5.3370	5.1686	5.1687	5.6022	5.3625
8-9Y	5.4607	5.2983	5.4870	5.4222	5.6480	5.4960	5.6571	5.6998	5.5542
9-10Y	6.7166	5.7935	5.6969	5.7710	6.5596	6.4752	6.5082	6.7938	6.7275
10-11Y	6.7926	5.9760	6.0514	6.2126	6.6424	6.7751	6.8080	6.8479	6.9197
11-12Y	6.4305				6.4305				
19-20Y	9.2145				8.5672	8.9780	9.1086	9.2457	9.4210
20-21Y	9.7437	7.8179		7.9928				10.2139	10.3180
25-26Y	9.9255				8.7081			10.1266	10.4727

$\int \partial$ Noet E. Ravalo Ph.D.

Market versus Model

TABLE 1C
CALCULATED MACAULEY DURATIONS PER QUARTER vs. BIS STANDARD

Tenor	*BIS*	*05Q2*	*05Q3*	*05Q4*	*06Q1*	*06Q2*	*06Q3*	*06Q4*	*07Jan*
<30D	0.0000	0.0698		0.0583		0.0806			
31-90D	0.2000	0.2052	0.1544	0.1028	0.1875	0.1978	0.1796	0.1642	0.1875
91-180D	0.4000	0.3864	0.4281	0.3312	0.3518	0.3903	0.3278	0.3107	0.4324
181-360D	0.7000	0.7477	0.7237	0.7499	0.7231	0.7921	0.7257	0.5825	0.7366
1-2Y	1.4000	1.5024	1.4796	1.4891	1.4577	1.5497	1.6164	1.5095	1.3666
2-3Y	2.2000	2.2178	2.2351	2.1631	2.1893	2.3547	2.2845	2.1285	1.9143
3-4Y	3.0000	2.9155	2.9299	2.8385	2.8091	2.9935	2.9122	3.0177	2.9594
4-5Y	3.6500	3.5237	3.5115	3.5502	3.4730	3.8621	3.7198	3.7493	3.5943
5-6Y	4.6500	3.8974	3.9939	3.9834	4.1604	4.0597	4.0071	4.2771	4.2233
6-7Y	4.6500	4.7404	4.7087	4.7860	4.8376	4.9285	5.0232	5.0096	4.9151
7-8Y	5.8000	4.9359	4.9705	5.1006	5.3370	5.1686	5.1687	5.6022	5.3625
8-9Y	5.8000	5.2983	5.4870	5.4222	5.6480	5.4960	5.6571	5.6998	5.5542
9-10Y	5.8000	5.7935	5.6969	5.7710	6.5596	6.4752	6.5082	6.7938	6.7275
10-11Y	7.5000	5.9760	6.0514	6.2126	6.6424	6.7751	6.8080	6.8479	6.9197
11-12Y	7.5000				6.4305				
19-20Y	8.7500				8.5672	8.9780	9.1086	9.2457	9.4210
20-21Y	10.0000	7.8179		7.9928				10.2139	10.3180
25-26Y	10.0000				8.7081			10.1266	10.4727

Note: Highlighted values are those which are higher than the BIS-assumed parameter.

$\int \partial$ Noet E. Ravalo Ph.D.

Where BIS Understates

TABLE 2
STATISTICS ON CALCULATED MACAULEY DURATIONS

TENOR BUCKET	BIS	TRANSACTED ON PDEx PLATFORM							
		MAX	AVG	MEDIAN	MIN	SD	KURT	SKEW	COUNT
< 30 days	0.00	0.081	0.070	0.074	0.056	0.009	-1.231	-0.671	10
31 - 90 days	0.20	0.244	0.184	0.189	0.083	0.049	-0.885	-0.561	71
91 - 180 days	0.40	0.497	0.369	0.365	0.247	0.083	-1.458	-0.054	112
181 - 360 days	0.70	0.959	0.714	0.699	0.480	0.155	-1.355	0.147	199
1 - 2 yrs	1.40	1.872	1.516	1.540	0.903	0.232	-0.364	-0.623	1,897
2 - 3 yrs	2.20	2.658	2.199	2.233	1.702	0.227	-0.855	-0.098	5,238
3 - 4 yrs	3.00	3.418	2.907	2.933	2.306	0.243	-1.023	-0.185	2,480
4 - 5 yrs	3.65	4.335	3.642	3.663	3.018	0.243	-0.007	0.203	2,886
5 - 7 yrs	4.65	5.564	4.758	4.887	3.590	0.400	0.037	-0.908	2,405
7 - 10 yrs	5.80	7.421	6.355	6.693	4.743	0.645	-0.479	-1.006	1,477
10 - 15 yrs	7.50	7.569	6.791	6.816	5.770	0.184	11.854	-1.029	621
15 - 20 yrs	8.75	9.697	9.214	9.165	8.567	0.169	2.813	0.708	100
> 20 yrs	10.00	10.944	9.791	10.285	7.504	0.922	0.408	-1.406	62

Note: Highlighted values are those which are higher than the BIS-assumed parameter.

$\int \partial$ Noet E. Ravalo Ph.D.

Benefit of Unbundling

TABLE 3
STATISTICS ON EXPANDED TENOR BUCKETS

TENOR BUCKET	BIS	TRANSACTED ON PDEx PLATFORM							
		MAX	AVG	MEDIAN	MIN	SD	KURT	SKEW	COUNT
5 - 7 yrs	4.65	5.564	4.758	4.887	3.590	0.400	0.037	-0.908	2,405
5 - 6 yrs	4.65	4.658	4.087	4.133	3.590	0.185	-0.417	-0.108	517
6 - 7 yrs	4.65	5.564	4.941	4.956	4.213	0.193	2.181	0.153	1,888
7 - 10 yrs	5.80	7.421	6.355	6.693	4.743	0.645	-0.479	-1.006	1,477
7 - 8 yrs	5.80	5.655	5.344	5.372	4.743	0.276	-1.324	-0.463	365
8 - 9 yrs	5.80	5.755	5.461	5.442	5.128	0.140	0.812	-0.278	26
9 - 10 yrs	5.80	7.421	6.717	6.765	5.641	0.214	6.524	-1.652	1,086
10 - 15 yrs	7.50	7.569	6.791	6.816	5.770	0.184	11.854	-1.029	621
10 - 11 yrs	7.50	7.569	6.793	6.816	5.770	0.183	12.159	-1.036	619
11 - 12 yrs	7.50	6.447	6.430	6.430	6.414	0.023	ERR	ERR	2
15 - 20 yrs	8.75	9.697	9.214	9.165	8.567	0.169	2.813	0.708	100
19 - 20 yrs	8.75	9.697	9.214	9.165	8.567	0.169	2.813	0.708	100
Over 20 yrs	10.00	10.944	9.791	10.285	7.504	0.922	0.408	-1.406	62
20 - 21 yrs	10.00	10.443	9.744	10.287	7.504	0.993	0.009	-1.365	46
25 ++ yrs	10.00	10.944	9.925	10.208	8.375	0.691	0.490	-1.001	16

Note: Highlighted values are those which are higher than the BIS-assumed parameter.

∫∂ Noet E. Ravalo Ph.D.

Material Deviations in Duration

TENOR BUCKET	MAGNITUDE OF DEVIATION		DAYS EQUIVALENT
	CALCULATED > BIS	BIS > CALCULATED	
1 - 2 Yrs	0.14		50 Days
5 - 6 Yrs		0.52	187 Days
6 - 7 Yrs	0.31		112 Days
7 - 8 Yrs		0.43	155 Days
8 - 9 Yrs		0.36	130 Days
9 - 10 Yrs	0.96		346 Days
10 - 11 Yrs		0.68	245 Days
20 - 21 Yrs	0.29		104 Days
25 - 26 Yrs	0.21		76 Days

∫∂ Noet E. Ravalo Ph.D.

Deviations for Policy Review

TENOR BUCKET	MAGNITUDE OF DEVIATION		DAYS EQUIVALENT
	CALCULATED > BIS	BIS > CALCULATED	
1 - 2 Yrs	0.14		50 Days
5 - 6 Yrs		0.52	187 Days
6 - 7 Yrs	0.31		112 Days
7 - 8 Yrs		0.43	155 Days
8 - 9 Yrs		0.36	130 Days
9 - 10 Yrs	0.96		346 Days
10 - 11 Yrs		0.68	245 Days
20 - 21 Yrs	0.29		104 Days
25 - 26 Yrs	0.21		76 Days

$\int \partial$ Noet E. Ravalo Ph.D.

Tests on Yield Volatility

$\int \partial$ Noet E. Ravalo Ph.D.

Converting Yield Volatility

BIS: Absolute change → Risk: Relative change

TENOR BUCKET	ASSUMED CHANGE (In Basis Points)	EFFECTIVE % CHANGE
Less than 1 Yr	100	12.500 %
1 – 2 yrs	90	11.250 %
2 – 3 yrs	80	10.000 %
3 – 5 yrs	75	9.375 %
5 – 7 yrs	70	8.750 %
7 – 10 yrs	65	8.125 %
More than 10 yrs	60	7.500 %

$\int \partial$ Noet E. Ravalo Ph.D.

Leptokurtic & Patently Skewed

TABLE 5
DESCRIPTIVE STATISTICS OF DAILY CHANGE IN YIELD
LAST 100 TRADING DAYS

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
Mean	-0.0055	-0.0047	-0.0063	-0.0061	-0.0037	-0.0031	-0.0030	-0.0025	-0.0026	-0.0025	-0.0026	-0.0028
Std Error	0.0082	0.0102	0.0089	0.0070	0.0035	0.0029	0.0030	0.0024	0.0026	0.0018	0.0028	0.0019
Median	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0035	0.0000	0.0000	0.0000	-0.0013	0.0000	0.0000
Mode	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NA	0.0000	0.0000
Std Dev	0.0815	0.1020	0.0887	0.0696	0.0352	0.0292	0.0302	0.0235	0.0263	0.0176	0.0275	0.0192
Variance	0.0066	0.0104	0.0079	0.0048	0.0012	0.0009	0.0009	0.0006	0.0007	0.0003	0.0008	0.0004
Kurtosis	6.8868	4.4580	2.6927	2.2253	3.3272	1.1635	3.4581	2.8889	1.5051	2.7527	7.1405	4.7685
Skewness	-0.1245	-0.9625	-0.2769	-0.5652	-0.6732	-0.2072	-0.2579	-0.7839	-0.5020	-0.3464	-1.5630	-0.4324
Range	0.6597	0.6834	0.5613	0.4119	0.2318	0.1532	0.2166	0.1580	0.1565	0.1259	0.2030	0.1434
Minimum	-0.3299	-0.4274	-0.2736	-0.2192	-0.1434	-0.0848	-0.1264	-0.1029	-0.0852	-0.0637	-0.1420	-0.0809
Maximum	0.3299	0.2559	0.2877	0.1927	0.0884	0.0684	0.0903	0.0551	0.0713	0.0623	0.0610	0.0625
Sum	-0.5401	-0.4622	-0.6245	-0.6028	-0.3639	-0.3087	-0.2961	-0.2522	-0.2578	-0.2451	-0.2591	-0.2810
Count	99	99	99	99	99	99	99	99	99	99	99	99
95% CI	0.0160	0.0201	0.0175	0.0137	0.0069	0.0057	0.0060	0.0046	0.0052	0.0035	0.0054	0.0038

∫∂ Noet E. Ravalo Ph.D.

The Policy Questions to Ask

- **What level of comfort — in probability terms — should be prescribed by policy as the extremum ?**
- **What would be the expected magnitude of the volatility of yield at this threshold ?**

These questions can be answered by fitting a distribution

… The PDF/CDF can also answer other policy questions

$\int \partial$ Noet E. Ravalo Ph.D.

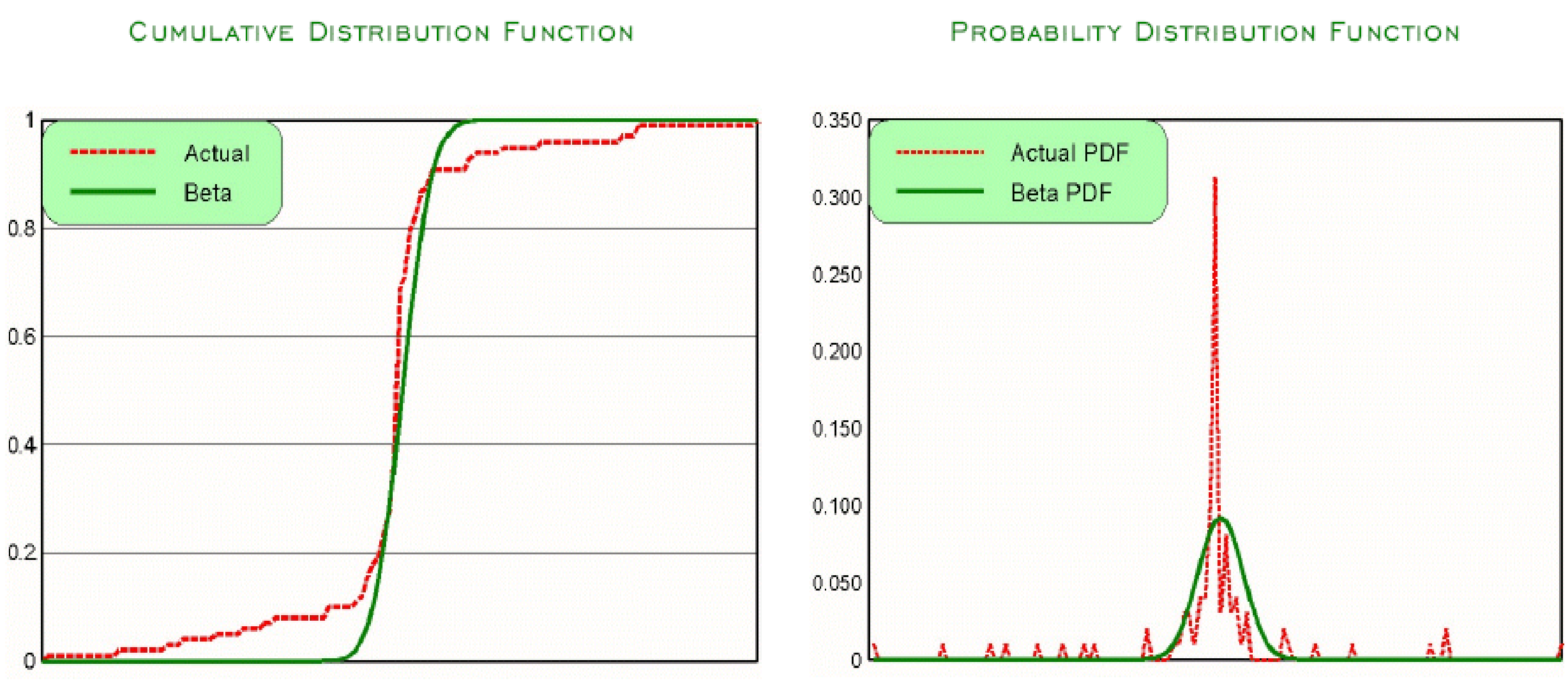
The Mindset We Put Forward

- **Use the generalized beta function, input actual max and min values, then calibrate α and β parameters**
- **Minimize the sum of squared error between the actual and the fitted beta distribution**
- **Prioritize in the + range of the data; Overcompensate so that fitted is "above" the actual distribution**
- **Locate central tendency of fitted beta PDF to match the actual distribution**
- **Update the data and backtest often**

∫∂ Noet E. Ravalo Ph.D.

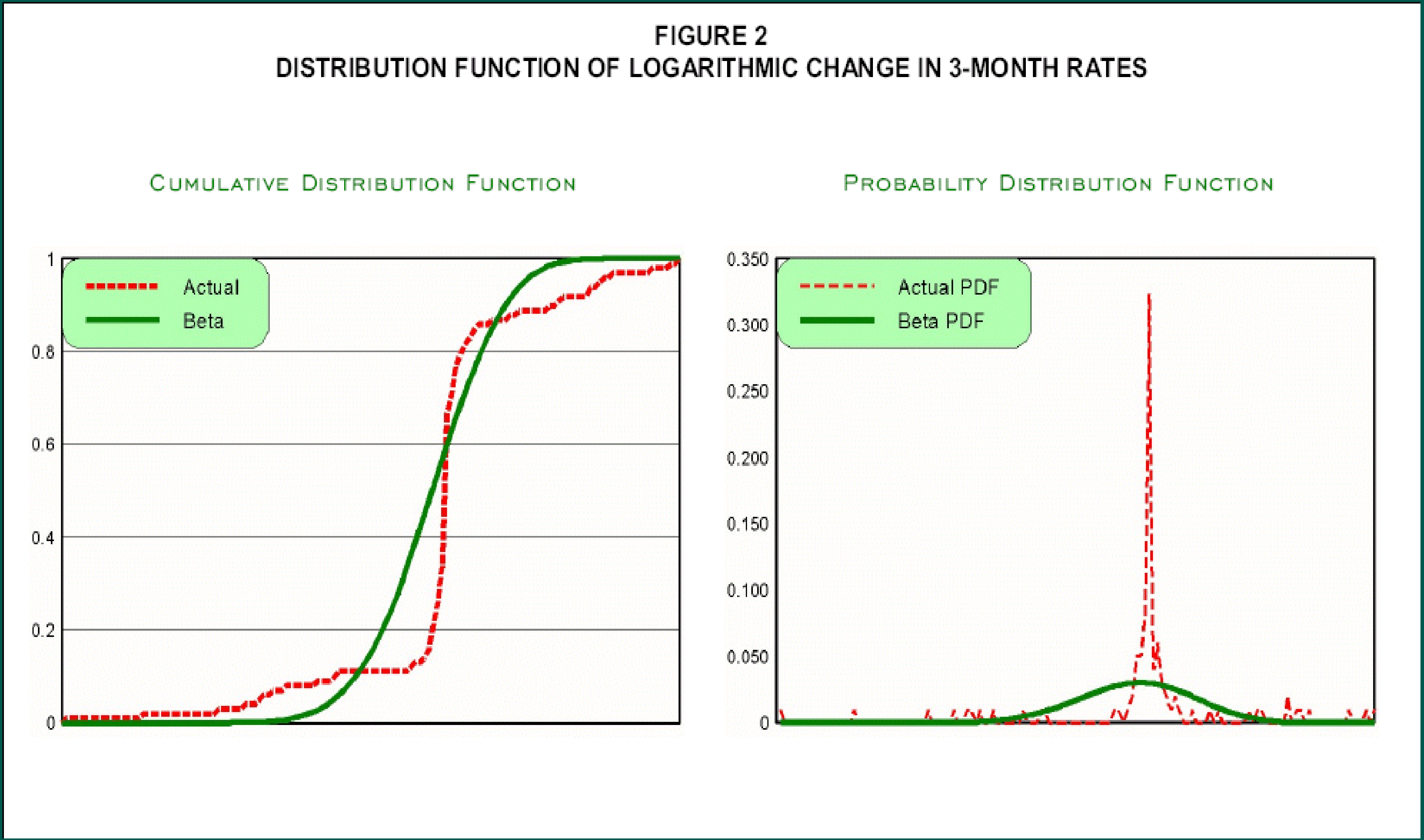
Distribution for 1-Mo

FIGURE 1
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 1-MONTH RATES



∫∂ Noet E. Ravalo Ph.D.

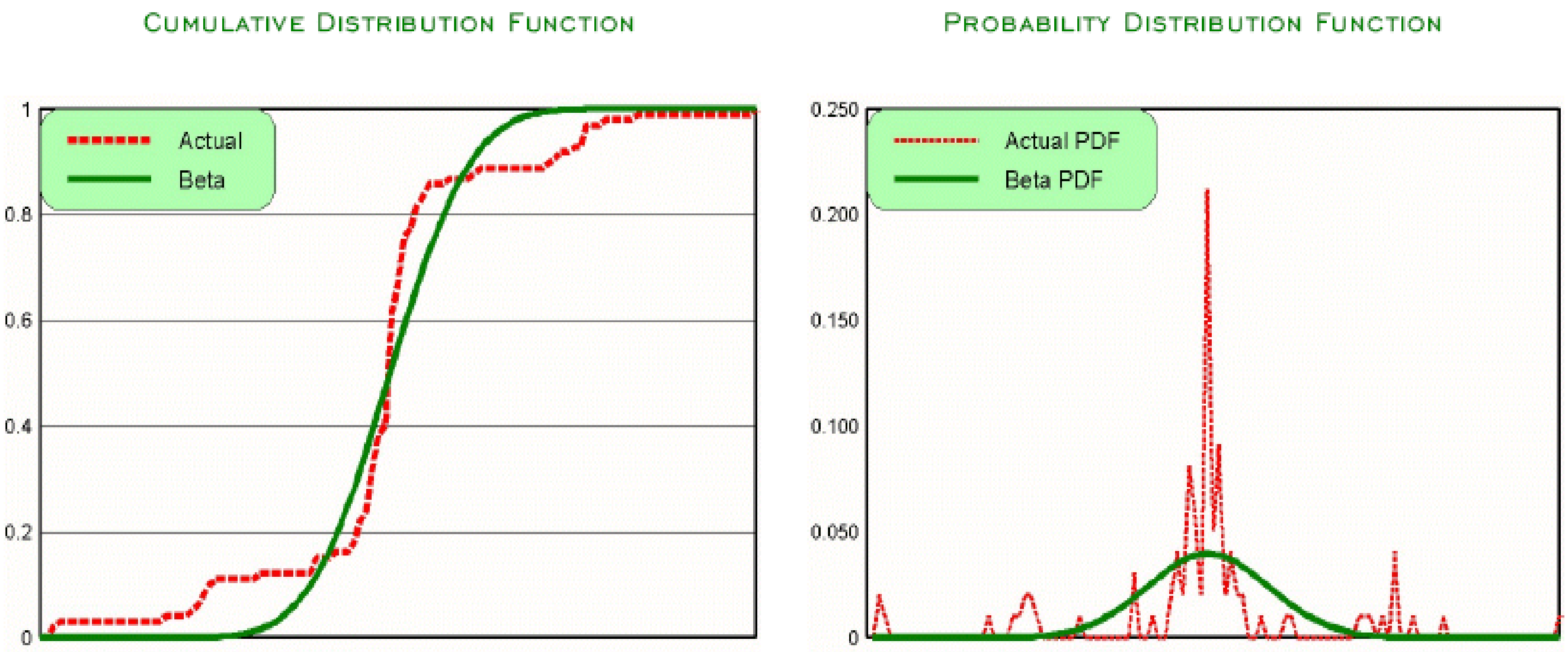
Distribution for 3-Mo



∫∂ Noet E. Ravalo Ph.D.

Distribution for 6-Mo

FIGURE 3
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 6-MONTH RATES

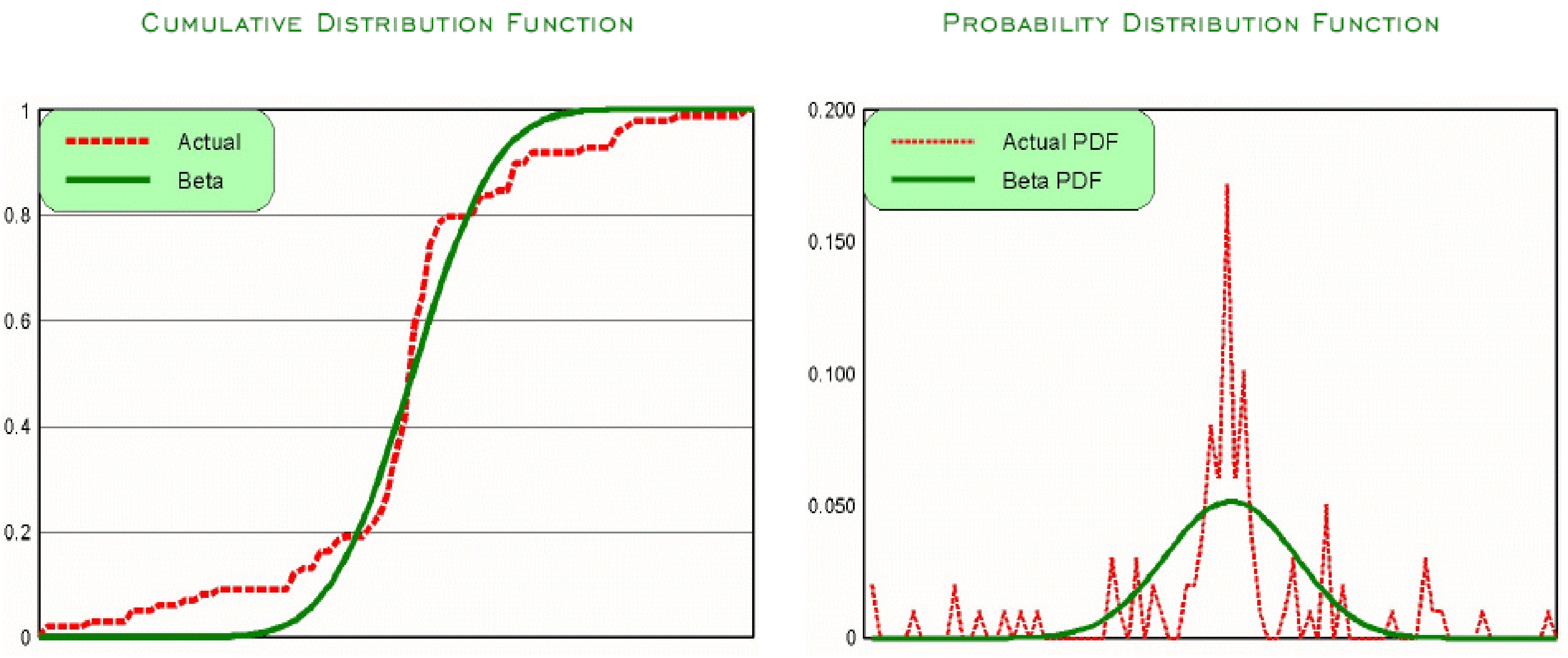


∫∂ Noet E. Ravalo Ph.D.

Distribution for 12-Mo

FIGURE 4

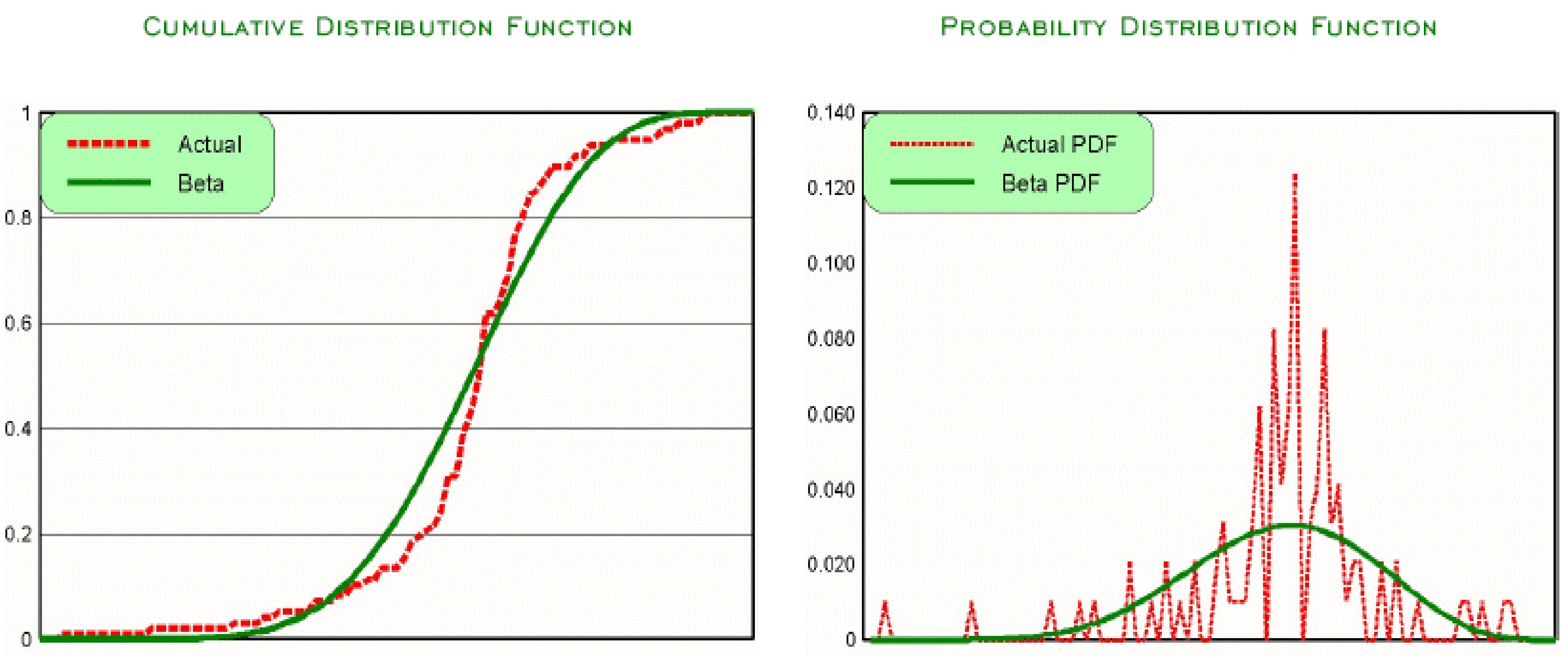
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 12-MONTH RATES



$\int \partial$ Noet E. Ravalo Ph.D.

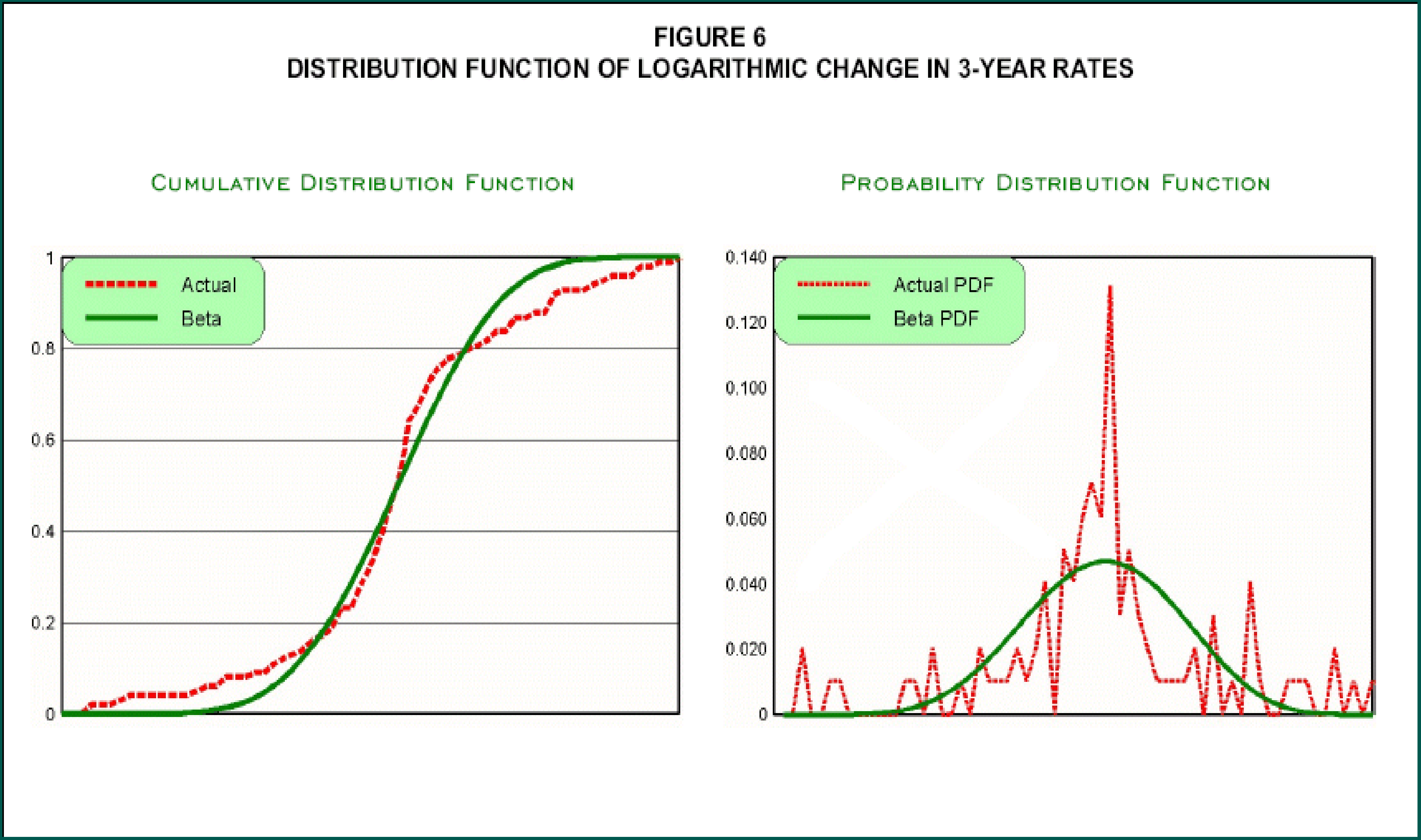
Distribution for 2-Yrs

FIGURE 5
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 2-YEAR RATES



∫∂ Noet E. Ravalo Ph.D.

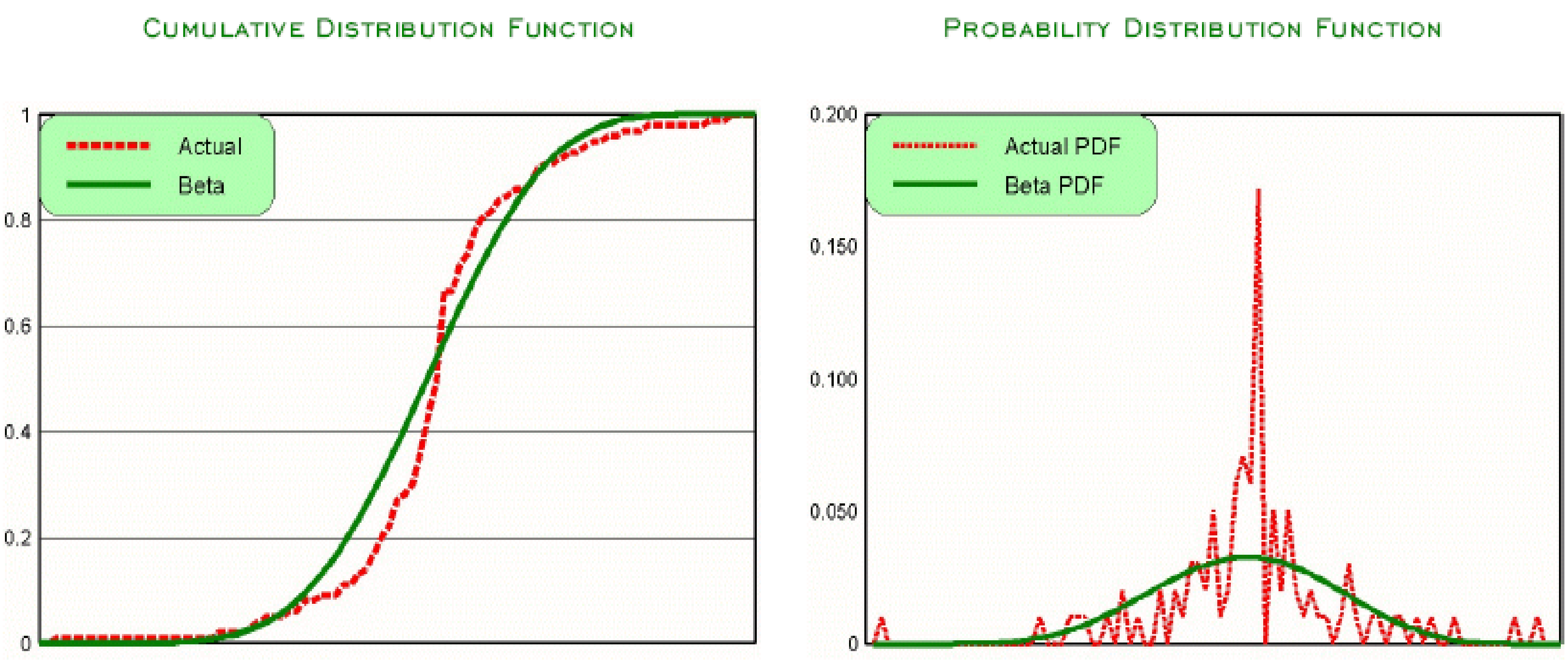
Distribution for 3-Yrs



∫∂ Noet E. Ravalo Ph.D.

Distribution for 4-Yrs

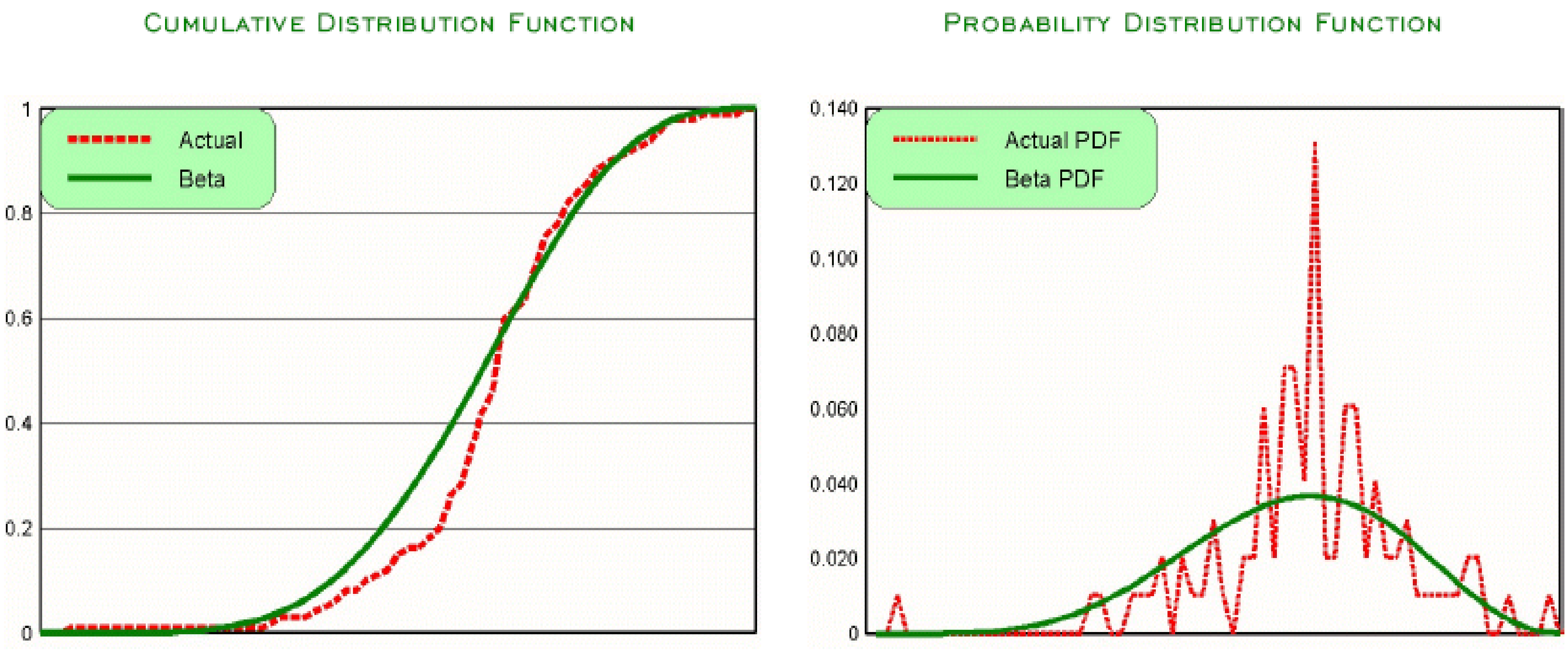
FIGURE 7
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 4-YEAR RATES



∫∂ Noet E. Ravalo Ph.D.

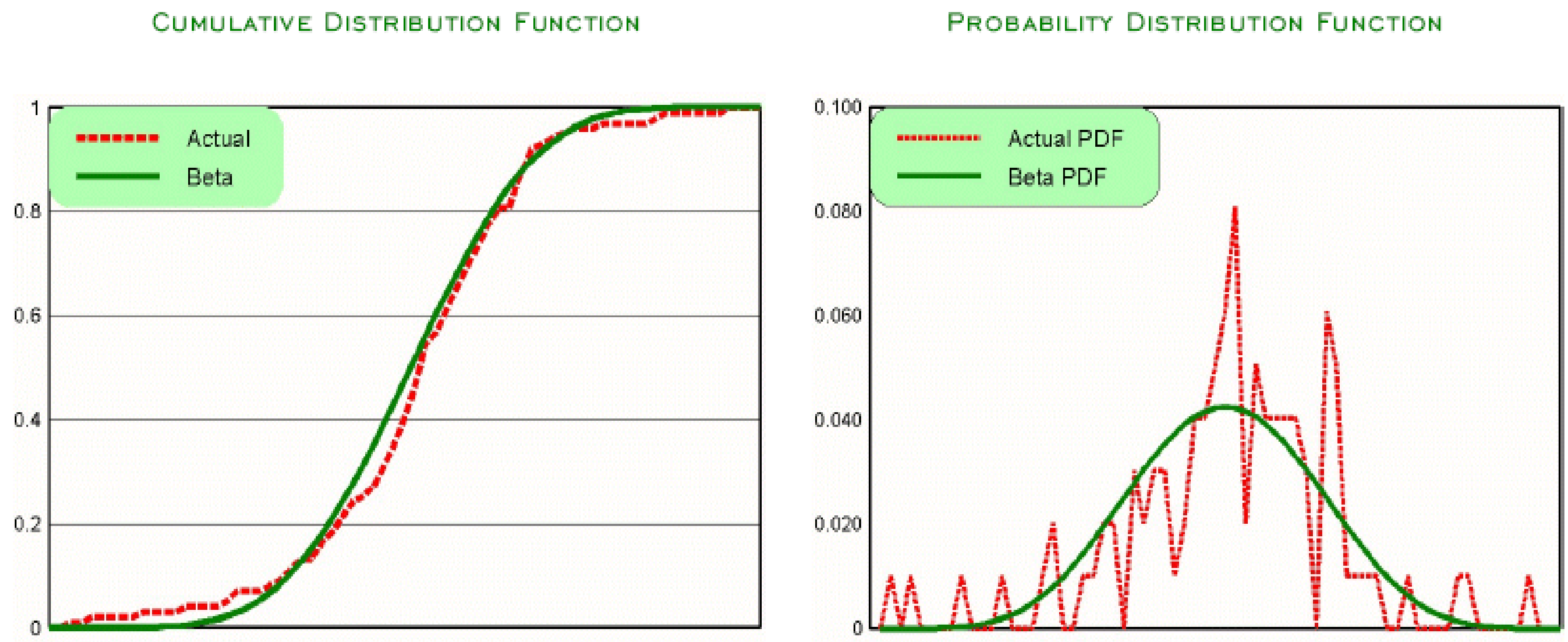
Distribution for 5-Yrs

FIGURE 8
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 5-YEAR RATES



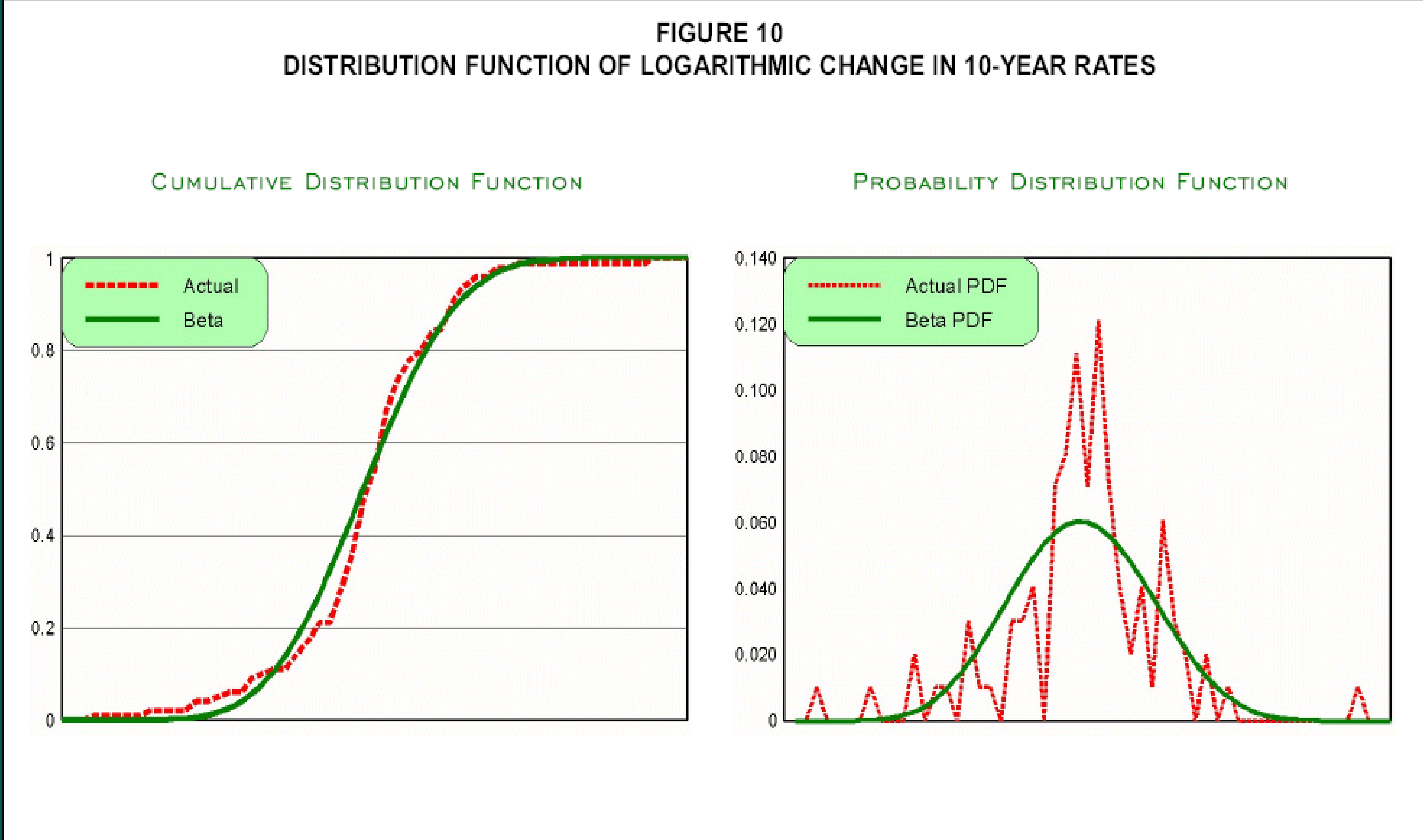
Distribution for 7-Yrs

FIGURE 9
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 7-YEAR RATES



∫∂ Noet E. Ravalo Ph.D.

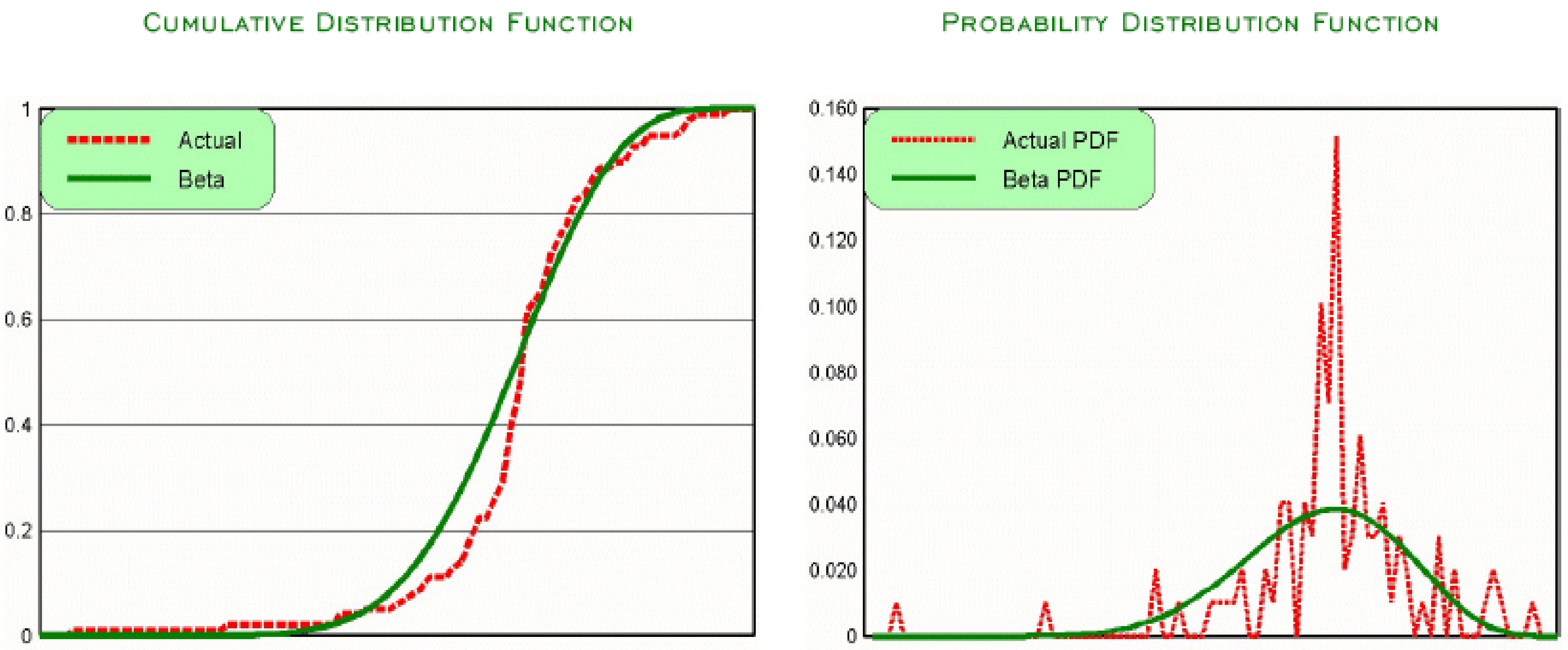
Distribution for 10-Yrs



∫∂ Noet E. Ravalo Ph.D.

Distribution for 20-Yrs

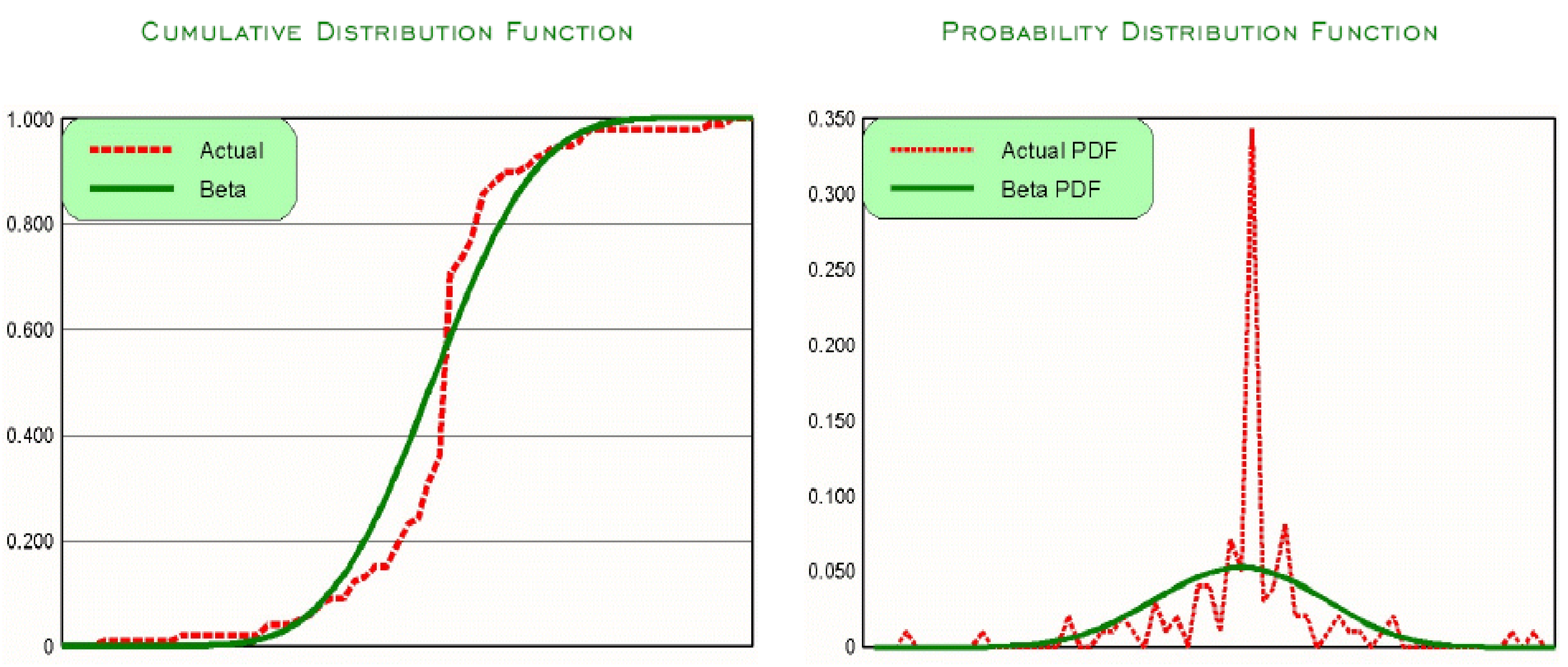
FIGURE 11
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 20-YEAR RATES



∫∂ Noet E. Ravalo Ph.D.

Distribution for 25-Yrs

FIGURE 12
DISTRIBUTION FUNCTION OF LOGARITHMIC CHANGE IN 25-YEAR RATES



∫∂ Noet E. Ravalo Ph.D.

Market versus Model

TABLE 6
RELATIVE MAGNITUDE OF INTEREST RATE CHANGES

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
Value at 95% Probability	0.0380	0.0854	0.0803	0.0611	0.0433	0.0297	0.0413	0.0334	0.0330	0.0240	0.0330	0.0252
Percentage Change @95%	3.870%	8.917%	8.364%	6.296%	4.429%	3.014%	4.212%	3.401%	3.357%	2.433%	3.353%	2.552%
Percentage Change @max	39.08%	29.17%	33.33%	21.25%	9.24%	7.08%	9.45%	5.66%	7.39%	6.42%	6.29%	6.45%
Percentage Change @2SD	17.06%	22.05%	18.65%	14.25%	6.89%	5.67%	5.91%	4.55%	5.13%	3.33%	5.37%	3.62%
Implied BIS Change	12.500%	12.500%	12.500%	12.500%	11.250%	10.000%	9.375%	9.375%	8.750%	8.125%	7.500%	7.500%

Tests on Basis Risk

∫∂ Noet E. Ravalo Ph.D.

Shape of the Yield Curve

TABLE 6
CORRELATION COEFFICIENTS OF REFERENCE RATES REPORTED BY PDEx

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M	1.0000	0.9116	0.8273	0.7726	0.7027	0.6900	0.6680	0.6509	0.6395	0.6306	0.6635	0.6747
3M		1.0000	0.7985	0.7366	0.6577	0.6455	0.6227	0.6096	0.5956	0.5885	0.6264	0.6352
6M			1.0000	0.9507	0.9021	0.8821	0.8636	0.8517	0.8446	0.8432	0.8486	0.8494
12M				1.0000	0.9669	0.9507	0.9363	0.9293	0.9244	0.9260	0.9314	0.9256
2Y					1.0000	0.9899	0.9821	0.9788	0.9760	0.9760	0.9670	0.9506
3Y						1.0000	0.9950	0.9923	0.9887	0.9853	0.9619	0.9423
4Y							1.0000	0.9957	0.9944	0.9899	0.9578	0.9364
5Y								1.0000	0.9946	0.9911	0.9577	0.9363
7Y									1.0000	0.9917	0.9555	0.9336
10Y										1.0000	0.9678	0.9462
20Y											1.0000	0.9765
25Y												1.0000

∫∂ Noet E. Ravalo Ph.D.

Correlation and Parallel Shifts

TABLE 7
CORRELATION COEFFICIENTS OF FIRST DIFFERENCE OF REFERENCE RATES

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M	1.0000	0.2304	0.1451	0.1500	0.1440	0.2805	0.2542	0.2316	0.2167	0.0743	0.1980	0.2225
3M		1.0000	0.1973	0.2300	0.1378	0.1862	0.0626	0.1963	-0.0427	0.0708	0.1362	0.0927
6M			1.0000	0.4141	0.2952	0.2750	0.2246	0.2348	0.1143	0.1869	0.2494	0.2533
12M				1.0000	0.3701	0.3406	0.2507	0.3079	0.1777	0.2528	0.3193	0.3120
2Y					1.0000	0.4769	0.3955	0.4938	0.3894	0.4042	0.4174	0.4175
3Y						1.0000	0.6490	0.6327	0.4280	0.4479	0.4368	0.4536
4Y							1.0000	0.5887	0.6197	0.4204	0.3868	0.4913
5Y								1.0000	0.4944	0.4765	0.5334	0.4951
7Y									1.0000	0.4261	0.3772	0.4772
10Y										1.0000	0.4314	0.4536
20Y											1.0000	0.5784
25Y												1.0000

$\int \partial$ Noet E. Ravalo Ph.D.

Using Fischer Transformation

$$z = \frac{\frac{1}{2}\ln\frac{1+r}{1-r} - \frac{1}{2}\ln\frac{1+c}{1-c}}{\frac{1}{\sqrt{N-3}}}$$

where r is the Pearson Product-Moment correlation coefficient and c is the critical threshold. We then test:

Null Hypothesis	H_o: $r > c = (1-\rho)$
Alternative Hypothesis	H_1: $r < c = (1-\rho)$

$\int \partial$ Noet E. Ravalo Ph.D.

Market versus Model

TABLE 8
CALCULATED CRITICAL z-SCORES BASED ON FISCHER TRANSFORMATION

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M		-9.824	-11.719	-11.611	-11.744	-8.675	-9.283	5.053	4.718	1.595	4.298	4.847
3M			-10.568	-9.833	-11.880	-10.813	-13.507	4.261	-0.916	1.519	2.935	1.991
6M				-5.412	-8.333	-8.802	-9.955	5.125	2.459	4.053	5.458	5.547
12M					-6.527	-7.250	-9.362	6.817	3.848	5.536	7.088	6.916
2Y						-7.462	-9.619	-3.257	-6.044	-5.667	-5.327	-5.324
3Y							-2.009	1.131	-5.050	-4.523	-4.817	-4.369
4Y								-0.376	0.672	-5.249	-6.108	-3.328
5Y									-6.972	-7.474	-5.835	-6.953
7Y										-8.830	-10.081	-7.455
10Y											-8.691	-8.100
20Y												-4.440
25Y												

∫∂ Noet E. Ravalo Ph.D.

Findings & Recommendations

- Unbundle the 5-7 yr and 7-10 yr time bands.
- Consider upward adjustment in following durations:

☞ 1-2 yrs	FROM	1.40	TO	1.55
☞ 6-7 yrs		4.65		5.00
☞ 9-10 yrs		5.80		6.80

- Consider the volatilities implied by beta PDF/CDF
- Use the latest market benchmarks on the volatilities
- Results show basis risk of not less than 70%

$\int \partial$ Noet E. Ravalo Ph.D.

Findings & Recommendations

- **Unbundle the 5-7 yr and 7-10 yr time bands.**
- **Consider upward adjustment in following durations:**
  - ☞ **1-2 yrs FROM 1.40 TO 1.55**
  - ☞ **6-7 yrs 4.65 5.00**
  - ☞ **9-10 yrs 5.80 6.80**
- **Consider the volatilities implied by beta PDF/CDF**
- **Use the latest market benchmarks on the volatilities**
- **Results show basis risk of not less than 70%**

∫∂ Noet E. Ravalo Ph.D.

Simulated Disallowance Results

TABLE 9
CALCULATED z-SCORES BASED ON SIMULATED DISALLOWANCE

	1M	3M	6M	12M	2Y	3Y	4Y	5Y	7Y	10Y	20Y	25Y
1M		5.026	3.131	3.239	3.107	6.176	5.567	5.053	4.718	1.595	4.298	4.847
3M			4.282	5.017	2.970	4.037	1.343	4.261	-0.916	1.519	2.935	1.991
6M				9.438	6.517	6.048	4.895	5.125	2.459	4.053	5.458	5.547
12M					8.323	7.600	5.488	6.817	3.848	5.536	7.088	6.916
2Y						4.488	2.331	11.593	8.806	9.184	9.523	9.526
3Y							9.941	15.981	9.800	10.327	10.033	10.482
4Y								14.475	15.523	9.601	8.743	11.522
5Y									4.978	4.476	6.115	4.997
7Y										3.120	1.869	4.495
10Y											3.259	3.850
20Y												7.510
25Y												

$\int \partial$ Noet E. Ravalo Ph.D.

Validation of the BIS Market Risk Model for Debt Instruments: The Philippine Case

This slide show was prepared as part of the Technical Assistance provided by EMERGE to the Bangko Sentral ng Pilipinas (BSP, the Philippine Central Bank).

The Economic Modernization through Efficient Reforms and Governance Enhancement (EMERGE) Activity is under contract with the CARANA Corporation, Nathan Associates Inc. and The Peoples Group (TRG) to the United States Agency for International Development, Manila, Philippines (USAID/Philippines)
Contract No. AFP-I-00-00-03-00020 Delivery Order 800