Yield Curve of Bangladesh and Burning Economic Issues

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Abstract

Background: Yield curve is the combination of interest rates against different maturity of bills and bonds. Weighted average interest rate of accepted bids is used to derive the yield curve. 91-day government treasury bill rate is the reference rate of the economy. Yield curve may be concave, convex or relatively flat depending on the short term and long term interest rates and amount. Interpolation and extrapolation method is used to derive the yield of a particular maturity due to lack of secondary market in Bangladesh.

Methods: Summation of all individual auction rates provides shape of the yield curve. Mathematical convention is demonstrated to formulate the price and interest rate of bill and bond. Macroeconomic development is considered to derive the yield curve rates. Amount of liquidity and need of the government and central bank specifically establish the yield rate.

Results: It will help to determine the interest rate of the economy impacting the exchange rate, CPI inflation rate and GDP growth.

Application: Yield curve rate is used for calculating deposit and lending rates of banks bearing in mind the liquidity position of the economy. It will also help to evaluate the held to maturity (HTM) and held for trade (HFT) securities of the banking and trading book of the banks.

Key words: Budget systems, debt management and monetary policy.
JEL classification: H61, H63 and E52.

1. Introduction

Bangladesh Bank (BB) bill, different maturity of government treasury bills and bonds are the element of yield curve **(Chart-1)**. Weighted average rate of the accepted bid in a particular auction is used to draw the yield curve. Cut-off rate of the bills and coupon rate of the bonds are not applied in deriving yield curve of Bangladesh. Auction of government treasury bills and BB bill is held discount basis. In this case auction winner deposit the discount amount (say Tk. 98) and receive full amount (Tk. 100) at maturity. Here government or BB receives discounted amount. Individual bidder will receive interest according to their individual submitted rate. Lower price of the bid provides higher rate. But the treasury bond winner need to deposit premium amount (over than Tk.100) if the submitted rate is below the coupon rate. In case of devolve if the devolve rate is higher than coupon rate then the price of the bond will be lower. In such case the bidder need to pay the discounted amount (lower than Tk. 100) in order to receive the same coupon rate. Thus government will receive the full amount, which has been notified earlier. Higher devolve rate comparing coupon provide the interest rate benefit. In secondary trading corresponding lower rate will provide the interest rate differential gain to the devolve holder. In government treasury bills the cut-off rate is the devolved rate. The devolved rate of bond is different. 10 basis point need to add with the previous auction bond coupon rate to arrive the devolved rate of the current auction. Considering the added 10 basis point immediate past auction all lower rates are considered to make simple mathematical average in arriving devolved rate of a particular auction. The devolved rate of the bonds can be lower or higher comparing the coupon rate. The bid winner in the auction does not further devolved. The unsubscribed amount of the auction is distributed to the Primary Dealers (PD) and non-PD and Bangladesh Bank if necessary.

Banks can utilize the government treasury bills and bonds as collateral to get the assured liquidity support facility (LSF) if the bills and bonds are purchased within 2 months and 15 days back. All other case for instance to get the repo facility the bills and bonds will be treated as outright purchase. The bills and bonds used for yield curve are short and long term to match the asset and liability of banks. The 91-day, 182-day and 364-day Bangladesh government treasury bill are short term instrument. 2-year, 5-year, 10-year, 15-year and 20-year bonds are treated as long term. Government bills and bonds are the debt management tools. Apart from that 30-day BB bill is the short term bill and used as BBs own instrument for open market operation (OMO).

Literature survey on debt management and OMO is conducted to gain wide-ranging knowledge in the multidimensional perspective. Adepoju and et al.[1] has reviewed the roles of debt management practices on sustainable economic growth and development with particular emphasis on Nigeria. Information was generated extensively from literature, the Nigeria Central Bank and National Bureau of Statistic reports. The analyses of the data collected with descriptive statistics indicate that, availability of access to external finance strongly influences the economic development process of any nation. Debt is an important fund needed to support sustainable economic growth. But a huge external debt without servicing in case of Nigeria before year 2000 constituted a major impediment to the revitalization of her shattered economy as well as the alleviation of debilitating poverty. The much needed inflow of foreign resources for investment stimulation, growth and employment were hampered. Without credit cover, Nigerian importers were required to provide 100 percent cash covers for all orders and this therefore placed a competitive disadvantage compared to their counterparts elsewhere. Failure of any owing country to service her debt obligation results in repudiation risk preventing such to obtain new loans since little or no confidence will be placed on the ability to repay. It will also undermine the effort to obtain substantive debt relief over the medium term with a tremendous increase in interest, arrears and other penalties. This will subsequently depress the economy both in the long and short runs. Best arrangement in debt payment must be put in place from time to time in response to changes in the economy and the polity. Debt can only be productive if it is well managed and if the rate of return is higher than the cost of debt servicing.

Hai-Chin Yu (Taiwan), Ken H. Johnson (USA), Der-Tzon Hsieh [2] using an effective sample of 3,453 observations selected from the Taiwanese stock exchange attempts to reconcile divergent outcomes from the extant literature on debt structure (public, bank, and non-bank private debt). Sampled firms from this emerging market generally acquire debt from both public and private sources, with a strong preference for bank debt, suggesting, among other things, that bank debt and public debt complement each other rather than acting as substitutes. Pradhan [3] Caballero [4], Akhtar [5], Varadaranjan [6] and Mike [7] have worked on debt management and OMO specially for developing countries and linked to yield curve.

Battellino and Macfarlane [8] wrote more countries moving away from direct controls toward market-oriented methods implementing monetary policy, interest has increased in the operating procedures for open market operations. Most what has been written on the subject comes from the United States, but is instructive to look at practices in a range of countries. The paper outline procedures used to implement open market operation in Australia, Canada, Germany, New Zealand, the United Kingdom, and the United States! It draws out similarities and differences and notes the inter-relationships between operating procedures and the institutional structure of the financial system in each country.

2. Methods

Quantitative and qualitative analysis has been performed in this paper. Insight of government treasury bills and bonds and BB bill has been discussed lucidly. Operational procedure and financial interactions of the related variable is the essence of this paper.

3. Economic elements of yield curve

3.1 Particular and complementary solution of the bills and bonds: Marginal interest rate volatility may create vulnerability in the balance sheet of banks following capital adequacy in Tier 1 and Tier 2 of Basel II. At the same time particular and complementary solution is important to understand the underlying fact of principal and interest rate calculation. Particular solution is related to the principal amount of bills and bonds. While the complementary solution deals with interest rate part depending on the economic fundamentals. The complementary solution is the compound interest of the principal at time t, which starts counting from t=0. The particular solution is the value of a bill or bond at time t, this starts counting from t=1. In economics we find particular solution (Yp) and complementary solutions (Yc)[1] in arriving total solution of bills and bonds: $Y(t) = y_p + y_c$. In case of particular solution the right hand side is constant, that is $dy/dt + ay = b \rightarrow 0 + ay = b$ therefore $y_p = b/a$. The complementary solution can be $y_c = A.e^{-t^2}$. Therefore the total solution can be written as $Y = b/a + A.e^{-t^2}$. The bidders of a bond at the beginning deposit the

[1] Complementary solution (y_c) can be elaborated as; $y_c = Ae^{-bt}$. Thus, $dy/dt+2ty=0$ [A=2]$\rightarrow dy/dt = -2ty \rightarrow dy/y = -2tdt \rightarrow \int 1/y.dy = -2\int tdt \rightarrow \ln y = 2.(t^2/2)+c \rightarrow \ln y = t^2+c \rightarrow e^{\ln y} = e^{-t^2+c} \rightarrow y = e^{-t^2}.e^c$ therefore $y_c = A.e^{-t^2}$.

principal amount. Finally the bidder gets back the principal (y_p) amount and interest (y_c). The principal amount is compounded with the e base interest rate. The bidders of the auction calculate the interest rate (coupon or discounted rate) depending on the economic rudiments. Price and interest rate are the two components of bill and bond. In the life time of bill and bond the price changes due to change in market yield. But the coupon based on interest rate will remain same. The price and coupon are related to the essence of mathematical particular and complementary solution respectively. The numerical calculation procedures of bills and bonds are described next.

We know the rise or fall of interest rate affects the price of the bills and bonds. Simple exponential function is $y=f(t)=b^t$. Here (b>1). Let, b=2. Thus, $y = 2^t$. In the generalized exponential solution $y= 9^t \rightarrow Y=(3^2)^t$. Therefore, $Y=3^{2t}$ and here base is 3 instead of 9. Thus base amount can be narrowed down in the stipulated amount (Tk.100). The continuous compounding interest rate function e^t possesses the remarkable property of being its own derivatives. That is, $d/dt(e^t)= e^t$. Here, we observing the fact or reducing the task of differentiating. More complicated natural exponential function can also be dealt such as,$y=Ae^{rt}$. Firstly, let, w = rt. Therefore, $Y= A^{ew}$ (A and r are constant). $dy/dt=(dw/dt \cdot dy/dt)=Ae^w.r = r.A.e^{rt}$ .That is $d/dt(Ae^{rt}) = r.Ae^{rt}$. The mathematical procedure of the base e should thus be amply clear to analyze the time path. Elaborately let, $\phi(x)=e^x$. Maclaurin series of e^x. is, $e^x = \phi(x)= \phi'(x)+x^2/2! \phi''(0)+x^3/3!.\phi'''(0)+$ … … … $=1+x/1! +x^2/2!+x^3/3!+$… … … as, $\phi'(x)= \phi''(x)= \phi'''(x)= \phi^{iv}(x)=e^x= \phi(x)$. We can write $\phi'(0)= \phi''(0)= \phi'''(0)= \phi^{iv}(0)=e^0=1$. Applying special case, x=1 we get $e^1 = 1+1+1^2/2! + 1^3/3!+ 1^4/4!+ 1^5/5!=2.7182819$.
Economic interpretation of e: Let capital = Tk.1, interest rate is 100% per annum (Tk,1 per year). Then after 1 year
$V(1)$ = initial principal (1+interest rate) $= 1(1+100\%)=1(1+1/1)^1$=Tk.2.
$V(2) =(1+50\%)(1+50\%) =(1+50\%)^2 = (1+1/2)^2$
$V(3) =(1+1/3)^3$, $V(4) =(1+1/4)^4$,
$V(m) = (1+1/m)^m$
$\lim_{m\rightarrow\infty} V(m) = \lim_{m\rightarrow\infty} (1+1/m)^m=e$

3.2 Calculation procedure of Treasury Bill :

1. Implicit yield (**2.02%**) = [(100- 99.5000 (offer price)) ×365 × 100] / (99.5000(offer price) × 91) (duration of the bill).
2. Offer price (**99.50**) =(365×100×100)/((91×2.02)+(365×100))
3. Offer value (**99.50**) = (99.50 (Offer price)× 100) (Face value) /100
4. Weighted price (**99.50**) = (199.0 (Cumulative offer value)) × 100/ 200 (Cumulative face value).
5. Corresponding Yield (**2.02%**) = [(100-99.50 (Weighted Average Price)] × 365×100/ (99.50 × 91-day).

3.3 Bond Pricing (yield based multiple price auction)

In order to get bond price we can use the insert function of Microsoft Excel menu selecting Price option (settlement, maturity, rate, yield, redemption, frequency, basis). Incorporating relevant data in the particular field we obtain the **Price** (**15-Feb-12,15-Feb-17,10%,10%,100,2,1).** As the rate (10%) and yield is same the price of the bond will be Tk.100. Deviation of yield from rate will generate different price, which may be lower or higher than Tk.100.

Here,
Settlement= Security's settlement date: **15-Feb-12** (on which the security is bought or sold:1day added for leap year).
Maturity=Maturity date: **15-Feb-17**(the date when security expires).
Rate= Security's annual coupon rate: **10%** (cut off yield rate of particular auction).
Yield= Security's annual yield: **10%** (quoted by the bidder in a particular auction).
Redemption= **100**(face value).
Frequency= **2** (for semi-annual coupon rate).
Basis=**1**(actual/actual).

3.4 Extrapolation of bond yield rate: Due to lack of secondary market the yield for 2.5 year of a 5 year bond using yield curve (**Chart-1**) rate of related tenure can be premeditated as: 5year yield(9.660%) – ((10 year yield(10.9200%)-5 year yield(9.6600%))/10-5)×2.5 (period passed:2+0.5) (26weeks/52weeks).9.6600–(((10.9200-9.6600)/5) ×2.5) = 9.0300%

3.5 Interpolation of bond yield rate: Yield for 18 year of a 20 year bond with 2 year remaining maturity. We need to calculate 3 year (5(class interval of 5,10,15,20 year bond)-2) bond yield and add with 15 year bond to dig up the 18

year bond yield (18=15+3).15year yield(11.4200%) + ((20 year yield(11.9645%)-15 year yield(11.4200%))/20-15)×period remaining(3 year). 11.4200+(((11.9645-11.4200)/5) ×3) = 11.7467%. Yield curve is shown in (**Chart-1**).

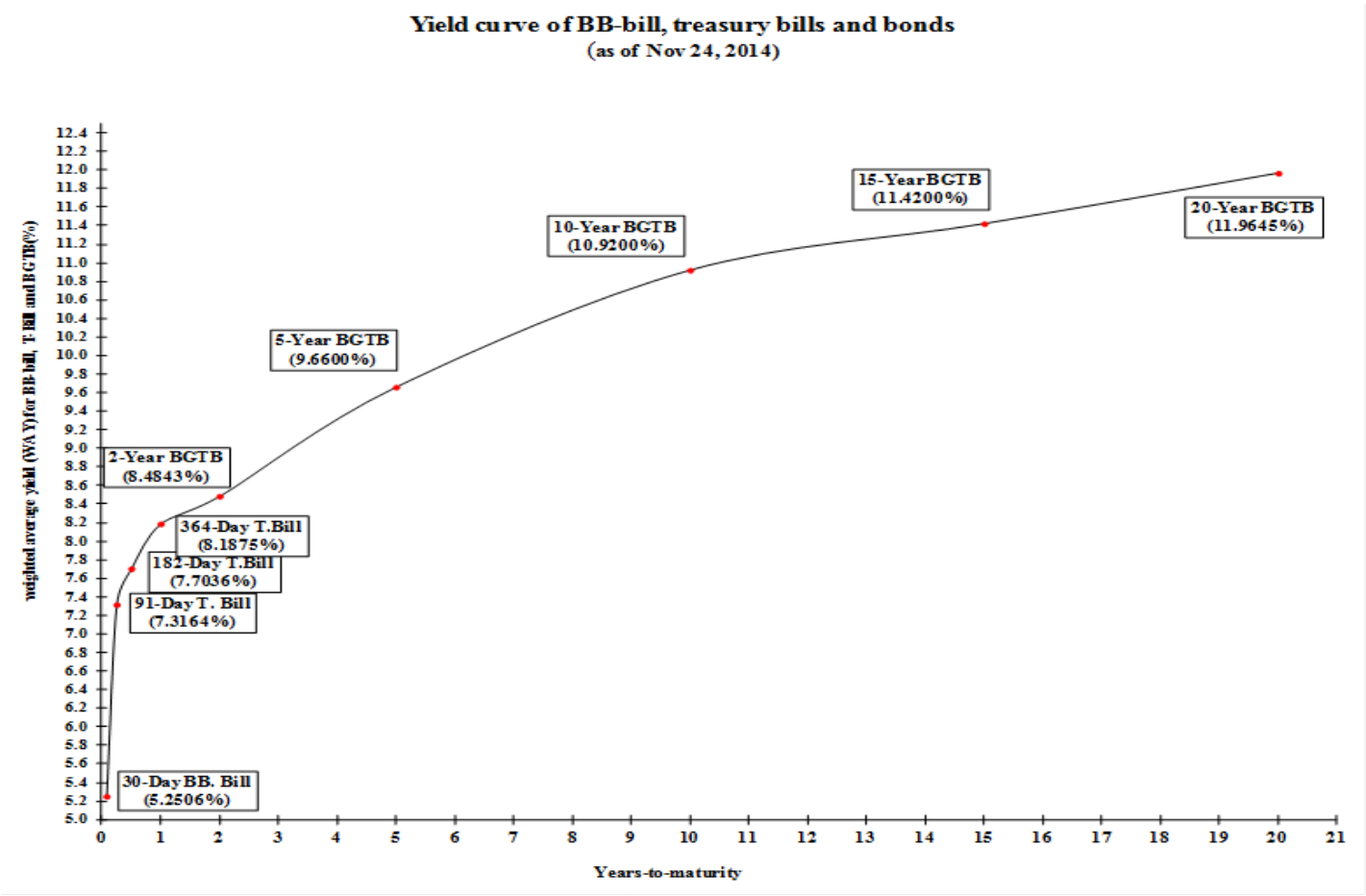

Chart-1

3.6 Dirty price and clean price of bond: On the basis of coupon rate 10% and 9.50% current yield with certain time holdings the dirty price of bond is Tk. 101.95. After 60 days of holdings if the bond is sold the buyer of the bond need to pay 60 days accrued interest of Tk. 1.64 and the clean price of the bond will be Tk.100.31. A corporate bond has a coupon rate of 7.2% and pays 4 times a year, on the 15th of January, April, July, and October. It uses the 30/360 US day count convention. A trade for 1,000 par value of the bond settles on January 25. The prior coupon date was January 15. The accrued interest reflects ten days' interest, or Tk.2.00 (7.2% of 1,000 * (10 days/360 days)).

The full value of the bond is set by the market at Tk.985.50. The following calculation illustrates the values of related terms. The market convention for bond price assigns a dirty price of Tk.98.55 to the trade, not 0.9855. This is sometimes referred to as the price for 100 par value.

3.7 Bond Pricing Example :

The following table illustrates the effective interest rate method of amortizing Tk.4100 (premium) on a bond payable. After gradual amortizing of Tk.4100 during 6-month time interval the bond reached its face value at Tk.100,000 (**Table-1**).

Term	Value
Full Market Value	Tk 1,000
Dirty Price	Tk.985.50
Accrued interest	98.55
Flat market value	Tk.983.50
Clean price	98.35

Table 1. Amortization of Bond

A	B	C	D	E	F	G
Date	Interest Payment Stated 4.5% x Face	Interest Expense Mkt 4% x Previous BV in G	Amortization Of Bond Premium C minus B	Balance In Bond Premium Account	Balance In Bonds Payable Account	Book Value of the Bonds F plus E
	Credit Cash	Debit Interest Expense	Debit Bond Premium			
Jan 1, 2010				4,100	100,000	104,100
Jun 30, 2010	4,500	4,164	(336)	3,764	100,000	103,764
Dec 31, 2010	4,500	4,151	(349)	3,415	100,000	103,415
Jun 30, 2011	4,500	4,137	(363)	3,052	100,000	103,052
Dec 31, 2011	4,500	4,122	(378)	2,674	100,000	102,674
Jun 30, 2012	4,500	4,107	(393)	2,281	100,000	102,281
Dec 31, 2012	4,500	4,091	(409)	1,872	100,000	101,872
Jun 30, 2013	4,500	4,075	(425)	1,447	100,000	101,447
Dec 31, 2013	4,500	4,058	(442)	1,005	100,000	101,005
Jun 30, 2014	4,500	4,040	(460)	545	100,000	100,545
Dec 31, 2014	4,500	3,955	(545)	0	100,000	Tk.100,000
Total	45,000	40,900	(4,100)			

For mark to market and amortized cost system company can use extrapolation and interpolation method to get bond yield. Certain amount of government outstanding blocked debt taken through overdraft from BB can also be amortized following 10 years schedule improving the balance sheet of BB.

4. Basel II capital adequacy requirement of government bonds

According to Basel II risk weighted asset of Tk. 100 value 5-year government treasury bond with 2-month remaining maturity for instance is Tk. 2 (100×0.20%×10) using standardized approach. To arrive this number 0.20% risk factor for 2-month remaining maturity is multiplied by conversion factor 10 (capital asset ratio) with base amount. Bank is needed to keep 10% of risk weighted asset i,e. Tk 0.20 in Tier 1 for minimum capital requirement. DMBs HFT securities need to calculate in the trading book and HTM need to report in banking book. Calculation of HFT treasury bills and bonds is needed to incorporate in the trading book rather banking book to address general market risk. The specific risk of treasury bills and bonds is zero. Pillar 1 of Basel II deals with minimum capital asset requirement of risk weighted asset of Tier 1 and Tier 2. Pillar 2 deals with supervisory issues addressing related risk for adequate capital asset requirement. Pillar 3 of Basel II reflects disclosure issues of banks and financial institutions.

4.1 Stress testing of government securities: Rise in interest rate at 1% level will decrease the price of bills and bonds used as base. Fall in risk weighted asset of bills and bonds due to lower base surfacing from market will lead to maintain lower capital in the DMBs balance sheet. Lower capital in the balance sheet will condense the capital asset ratio (CAR). Further rise in interest rate at 2% or 3% level eventually may lower the CAR below 10. All these depend on market rate of HFT government securities. It may be mentioned that CAR below 10 according to Basel II will expose the bank as vulnerable.

4.2 Duration of bond: Government bond with a yield to maturity of 8.00%, a par value of Tk.100, a coupon rate of 10%, and a cash-flow frequency of 2 time(s) per year will have a duration of 4.10 years. Duration measures how long, in years, it takes for the price of a bond to be repaid by its internal cash flows. DMBs need to consider it cautiously, as bonds with higher durations reflect more risk and have higher price volatility than bonds with lower durations.

Duration GAP (DGAP) impact the market value of equity and overall position of the bank. DGAP crop up combining weighted average duration of assets and liabilities of which investment of government securities are integrated. Formulation of DGAP:

DGAP=DA-(MVL/MVA)×DL [DA=Duration of asset; DL= Duration of liability; MVL= Market value of liability and MVA= Market value of asset].

DGAP = 3.07-(10000 /11000)×1.62 =1.60. Longer DGAP causes larger change in the market value of DMBs equity. 1% rise in interest rate will reduce the market value of equity equivalent to Tk. 161.47 crore impacting balance sheet of banks as follows:

$\Delta MVE \cong (-DGAP) \times (\Delta i/(1+y)) \times TA$

$= -1.60 \times (0.01/(1+0.09)) \times 11000 = -161.47$ crore

5. Conclusion

Bangladesh Bank meticulously determines the cut-off rate of bills and bonds considering the excess reserves of the banks and liquidity need of the government. Effective yield curve rate specially the 91-day government treasury bill rate contributes in arriving call money, deposit and lending rates of the banks. The book values of the banks are affected with the yield of the bills and bonds following Basel II norms. Due to lack of secondary market Interpolation and extrapolation of yield curve provide the rate for valuation of bills and bonds. The HFT and HTM securities are also evaluated depending on the yield curve. Appreciation of Taka rate lowers the exchange rate. Higher interest rate also contribute to lower the inflation rate considering monetization and pass through. Solidity of the yield curve rates impact in determining the GDP growth of the country.

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