

UNIVERSITY OF NIŠ The scientific journal FACTA UNIVERSITATIS Series: Economics and Organization, Vol.1, No 5, 1997 pp. 31 - 40 Editor of Series: Dragiša Grozdanović Address: Univerzitetski trg 2, 18000 Niš, YU Tel: +381 18 547-095, Fax: +381 18-547-950

YIELD CURVE AND INTEREST RATE RISK

UDC: 336.764.2; 339.164.4

Borko Krstić, Srđan Marinković

Faculty of Economics, University of Niš, Trg VJ 11, 18000 Niš, Yugoslavia

Abstract. Yield curve present graphical interpretation of term structure of interest rates, as a functional relationship between maturates of debt instruments differing only in length of time to maturity and it's yield to maturity. This is an instrument, which enable us to focus on factors relevant for portfolio interest rate risk. For correct assessment of portfolio interest rate risk, total term structure of interest rates (that is, yield curve) must be taken into account, not only single interest rate. The yield curve represents a highly useful analytical apparatus for it gives useful information about market expectation of future interest rates and their components. It is also a necessary prerequisite for correct debt instrument valuation. Under current circumstances in our country, however, usefulness of yield curve is substantially blurred due to inefficiency and strong influence of non-market criteria on financial markets.

1. THE CHANGES IN FINANCIAL ENVIRONMENT AND INTEREST RATES DYNAMICS

Interest rate risk is defined as vulnerability of net interest income, or of portfolio present values, to changes in interest rates (5, p.16). There are many factors affecting interest rate changes on the market. Sometimes, crucial factor is regulation; e.g. sudden shift in monetary policy, fiscal policy and exchange rate policy or in degree of financial market regulation. Analysts agreed that interest rates instability during 80's and 90's was caused, in first place, by systematic changes in degree of national financial markets regulation that took place in last few decades on a global level, especially by interest rate deregulation in USA (1986). Those changes were preceded by an important shift in Federal Reserve's monetary policy. In order to set the long-term strategy of inflation lowering, on October 1979. Federal Reserve System announced the shift in intermediary target; that is, it's future intention to control monetary aggregates rather than to deal with interest rate stabilization. Consequences of those changes were both deposit and loan rates growth and instability on a global level.

Received, November 15, 1998

Fig. 1 shows the growth of instability during the last decades, along with interest rates volatility and mismatching of long-term and short-term interest rate changes, a phenomenon of great importance for successful implementation of numerous hedging strategies against interest rates risk.



Fig. 1. History of the term structure, USA, January 1955 - December 1979. Source: P. Lau, An Empirical Examination of Alternative Interest Rate Immunization Strategies, unpublished Ph. D. disertation, Madison: University of Wisconsin, 1983. (9, p. 340)

2. THEORETICAL BACKGROUND OF INTEREST RATE RISK — YIELD TO MATURITY CONCEPT

Financial market is not homogenous, but " … represents a highly fragmented set of (partial) markets … Prices of all instruments are influenced by concrete market factors with every single instrument having specific yield rate. But, what gives the market character of unique market is the interest rates hierarchy, which corresponds with risk characteristics of investment in different financial instruments and is maintained by supply and demand forces." (18, p.131). Therefore, fragmentation of financial market is characterized by interest rates fragmentation, while interest rates hierarchy characterizes coherence of financial market. Since, for purpose of the analysis, we need to break down the interest rate, it is convenient to identify the factors (e.g. maturity, different credit quality, different structure and amount of interest payments) that makes interest rates on various debt instruments to be different (15, p.103). However, because of yield to maturity concept, different debt instruments become comparable. Briefly, investor will realize the yield to maturity at the time of purchase only if the bond is held to maturity and the coupon payments can be reinvested at the yield to maturity. The main quality of this concept is capability to:

- calculate effective required yield for investment in debt instrument (bonds, commercial paper, mortgage backed securities etc.).
- calculate effective costs of debt capital,
- compare and integrate of different financial market segments.

Yield to maturity concept is consistent with actual standing in financial theory that value of any financial assets can be determined by discounting of expected cash flow. A debt instrument's yield to maturity is just a special form of discount rate. Basic determinants affecting discount factor are, at the same time, the elements of yield rate. There is a consensus in the theory with respect to factors affecting nominal yield rate to maturity, which are (3, p. 103-108):

– the real risk-free rate of interest. It is the rate that would exist on a rissoles security if zero inflation were expected over the life of the security;

-inflation premium. It is equal to the average expected inflation rate over the life of the security;

– default risk premium. This premium reflects the possibility that the issuer will not pay interest or principal on a debt instruments in the stated amount and at the stated time. In the case of default free issuers this premium is zero;

-liquidity premium. It reflects possibility of securities conversion to cash on short notice at a reasonable or fair market price. This premium mainly depends on characteristics of the market in which they are traded, other words, on market structure;

– interest rate risk premium. This premium is also referred as maturity risk premium or Hicksian liquidity premium. As we will explain later, longer-term bonds are exposed to a significant risk of price declines, and interest rate risk premium is compensated by lenders to reflect this risk. This premium is extremely difficult to measure, but it seems to vary over time, rising when interest rates are more volatile and uncertain, then falling when interest rates are more stable.

Risk premium and maturity are in direct relationship only for discount instruments, while the premium for coupon instruments is related to so-called "duration", a measure of interest rate risk. Generally, existence of stable interest rates or absolute certainty of interest rate formation process either erode or completely offset the premium.

Any interest rate, i.e. an instrument's yield to maturity, consists of two elements: real risk-free rate and inflation premium. Difference between yield rates is influenced by another three elements, which can vary through time, but in essence does not represent a part of interest rate risk. Hence, essential factors influencing changes in nominal yield rates, i.e. existence of interest rate risk, are changes in real risk-free rates and inflation premiums. However, for correct assessment of interest rate risk we need another point to be taken into account. Empirically determined imperfect correlation and different yield variance for instruments with different maturity shows that the two elements have different values depending on the instrument's maturity. This is especially important for the institutions with portfolio consisting of debt instruments of different maturates, both on assets and liability side.

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3. YIELD CURVE AND TERM STRUCTURE OF INTEREST RATES

Apparatus allowing abstraction of irrelevant factors and focus on factors relevant for portfolios' interest rate risk is so-called term structure of interest rates or yield curve. Yield curve present graphical approximation of term structure of interest rates, as a functional relationship between maturates if debt instruments differing only in length of time to maturity and it's yield to maturity.

The shape of the term structure might change dramatically as time goes by. These changes will cause great interest rate risk. On the three-dimensional diagram (see Fig. 1), we can see changes of yield curve shape for a long period. In this diagram, yield to maturity is plotted vertically; time is plotted horizontally going from right to the left, and term to maturity increases toward the rear of the diagram. The lower-right portion of the diagram presents term structure for January 1955. The upper-left portion of the diagram presents term structure for December 1979. The first term structure is upward sloping, with long-term yields above short-term yields. The second is downward sloping, and is maintained by inverted relationship between short-term yields and long-term yields. The upward-sloping term structures are more common than downward-sloping term structures, as it is obvious from the figure. As we shall see later, this may reflect either the presence of interest rate risk premium or so-called Hicksian liquidity premiums, or it may simply reflect the fact that the market, to some extent, anticipated the upward trend in the general level of interest rates that occurred over the period.

However, at any given point in time, there are three possible factors influencing the shape of the term structure:

- 1. The market's expectations regarding the future direction of interest rates,
- 2. The presence of liquidity premiums in debt instruments' expected returns,
- 3. Market inefficiency or possible impediments to the flow of funds from the longterm side of the market to the short-term side and vice versa.

Theoretical analysis confirms that in efficient markets ambience yield curve will solely depend on market response to collective beliefs about future interest rate movements, i.e. that interest rates derived form current interest rates term structure are correct forecast of future interest rates; otherwise, the current term structure forecasts the future term structure so interest rates formation is not characterized by uncertainty, the key element of interest rate risk.

View that short-term and long-term instruments are perfect substitutes, so that investing in a long-term instrument must provide the same yield as investing in a shortterm instrument with successive reinvestment to maturity, is supported with arbitrage program's argument on efficient market. Simultaneous purchase and sale of bond of different maturates can assure the yield determined by market consensus about future interest rate movements for any of the instruments. Therefore, term structure of the yield will be solely determined by expectations about future interest rate movements. According to expectations hypothesis, flat yield curve imply that market is expecting a drop in future interest rates. Having such expectations, investors are ready to realize lower yield by purchasing long-term bonds for they can not expect continuous reinvestment in short-term bonds to be better alternative (because of expected yield lowering). On the other hand, upward sloping yield curve implies expected rise of interest rates. Investors will invest in long-term instruments as long as their yield is bigger than the yield on short-term instruments; otherwise, they would prefer successive reinvestment in short-term instrument.

In the context of expectation hypothesis, efficient market hypothesis implies that all relevant information's are included in future interest rates expectation. A new information may appear, but it soon will be reflected through market's changed expectations. Logically, since expectations are subjected to adjustment according to new information's, prices and yields of instruments with different maturates will randomly fluctuate around their real, inherent values (15, p. 111). Hence, in case of absolute certainty on a market investors would demand the same yields regardless the instrument's maturity. Away from absolute certainty, expected yield on a long debt instruments must exceed that on a short instruments by a premium which compensates the investors for the greater risks of principal loss, so-called risk premium. Hicks suggest following arguments for existence of risk premium: "...to hedge their future supplies of loan capital ... borrowers will have a strong propensity to borrow long, because of the desire to keep one's hands free to meet uncertainty most institutions would prefer to land short. Finally, "speculators" will offset this "constitutional weakness" in the supply of long funds by borrowing short and lending long; however, they must receive a premium return as , compensation for the risk they are incurring" (6, p.784). Mentioned preferences, in conformity with liquidity preference theory imply that under normal conditions a positive liquidity premium exists which increases with years to maturity, causing the yield curve to be upward sloping.

Basic contribution of the theory is an acceptable explanation for domination of upward sloping yield curve. Expectation theory, however, failed to explain why yield curve is upward sloping in most cases. Remember that according to efficient market hypothesis possibilities for interest rates rise or drop are equal in the long-term, so there is no reason to believe that domination of upward sloping yield curve is caused by domination of expectation of rise in future interest rates.

A group of theories, known as theories of segmented market, are concerned with the impact of impediments to free capital flow from one term segment to another. According to the theories, the impediments are, generally, the same preferred maturity of different institutions. For example, commercial banks because it's liabilities' nature in the form of short-term deposits and traditional emphasis on liquidity preferred short-term investments, while, on the other hand, institutional investors, because of long-term liabilities preferred long-term bonds. Hence, contrary to liquidity-preference theory, all investors would not have uniform short-term horizons. "In terms of its implications, the Liquidity-Preference Model can be considered as a special case of the Preferred Habitat Theory (modern version of theory of segmented markets — *objection of translator*), namely that case in which all investors have a habitat equal to the shortest holding period." (6, p.784).

Accordingly, the slope of the yield curve depends on supply/demand conditions in the long-term and short-term markets, while change in term structure depends on capital fluctuations from actors having a preference to actors having different preference. If money happens to flow to the inhabitants of the long-term segment, they will buy long-term bonds, bidding their prices up and their yields down. Modern and significantly moderate version of theory of segmented markets was first set forth in Modigliani and Sutch (1966). On the other hand, Preferred Habitat Theory is, in essence, an adaptation of the expectation theory. However, although it's objective advantages, these theory is

not completely empirically affirmed (13, p. 575).

Existence of positive, but variable Hicksian premium is identified by many empirical analysis, confirming that current term structure do not depend solely on market expectations of future interest rates, so both the condition of market efficiency and analytical value of yield curve were put in question (papers 8, 12 i 16). Impact of different impediments, e.g. impact of term preferences on funds flow between term segments of credit market, is also confirmed, once again putting into question the efficiency market hypothesis. Since required market efficiency is not confirmed, we can conclude that interest rate is unpredictable variable, that is, certain interest rate risk exists.

We have seen that yield curve changes, i.e. changes in interest rates term structure represents approximation of interest rates dynamics. However, in order to estimate impact of yield curve changes (that is, total structure of yield rates from different term segments) on current value or market price of portfolio consisting of debt instruments we need to know how prices and yield of a debt instrument, say a bond, are adjusting (7, p. 20):

$$P = \sum_{t=1}^{n} \frac{C}{(1+r)^{t}} + \frac{M}{(1+r)^{n}},$$
(1)

where: P = bond price,

C = coupon payment value,

M = maturity payment value (principal),

n = maturity period of debt instrument,

r = yield to maturity,

Expression (1) shows that bond price is inversely related to expected yield. Yield increase will cause fall in bond price (i.e. capital loss) and vice versa. However, to identify interest rate risk it must be noticed that the price of a bond will change for one or more of the following three reasons (7, p. 27):

- 1. There is a change in the required yield owing to changes in the credit quality of the issuer.
- 2. There is a change in the price of the bond selling at a premium or a discount, without any change in the required yield, simply because the bond is moving toward maturity.
- 3. There is a change in the required yield owing to a change in the yield on comparable bonds (that is, a change in the yield required by the market).

Only the last factor is of relevance to the research; it represents the essence of interest rate risk, affecting, more or less, whole financial market. It is caused by macroeconomic developments, e.g. underemployment of national capacities, changes in national competition environment, monetary and fiscal policy (both domestic and foreign), and other developments.

Expression (1) is well-known discount model for bond price evaluation. "In principle, risk management and valuation present different aspects of the same problem. Both require characterizing the sources of risk, that affect bond prices, including the number, nature, and behavior as regards bond prices. However, risk management is often simpler than valuation, it involves examining how small changes in risk factors affect bond prices" (14, p. 298). As we shall see, the basic model for interest rate risk management is

derived from bond price model. There are many theoretically well-grounded models for interest rate exposure estimation. The most advanced method is based on financial assets' interest rate sensibility, that is, on so-called duration concept; it is highly sophisticated but very complicated to use (for detailed analysis see 11).

Duration is a concept first introduced by Frederick Macaulay. The author's main object was to provide more complete summary information about the time structure of a bond than term to maturity. Maturity provides information only about the date of final payment. However, coupon bonds generate regularly scheduled payments before maturity. Thus, maturity provides and incomplete description of the time pattern of all the payments of a bond. The longer the term to maturity, the higher the coupon rate, or the higher the market yield, the more important are the coupon payments relative to the maturity payments (10, p.750).

Apart from original Macaulay's model, a number of other models are being developed, bringing some changes to the original model. Fisher–Weil's (1971) method, which is to be described, brings discount rate level into relation with yield curve. Other words, any cash flow will be discounted by the yield rate that can be obtained on discount instrument with same maturity. For example, given the cash flow with two years maturity, its current value will be computed when its maturity value is discounted by yield rate, which can be obtained on discount securities with two years maturity. Yield rate is taken from zero coupon yield curve (1, p. 38).

The unique role of duration in relating changes in bond price to changes in interest yields may be derived by computing the differential of bond price with respect to interest rate. The price of a bond is equal to the sum of the present values of the stream of coupon payments and of the final payment at maturity. Taking the differential with respect to r and divide with P:

$$\frac{dp}{P} = -\frac{\sum_{t=1}^{n} \frac{(C_t)t}{(1+r_t)^t} + \frac{M}{(1+r_n)^n}}{P} \left[\frac{dr}{(1+r)}\right]$$
(2)

If all coupon payments are discounted by the yield to maturity, the numerator in equation (2) is equivalent to the numerator in the definition of duration specified in equation (4). The denominator of equation (4) is equivalent to the definition of bond price specified in equation (1), in this way we have (10, p. 751):

$$\frac{dp}{P} = -D\left[\frac{dr}{(1+r)}\right] \tag{3}$$

Equation (3) confirm the general theorem that for a given change in interest rates, percentage changes in bond prices vary proportionately with duration. The maximum change in price occurs when the duration is at a maximum and vice versa. Interest rate elasticity of debt instruments prices in equation (3) response to duration defined by equation (4).

$$D = \frac{\sum_{t=1}^{n} \frac{(C_t)t}{(1+r_t)^t} + \frac{M}{(1+r_n)^n}}{\sum_{t=1}^{n} \frac{C_t}{(1+r_t)^t} + \frac{M}{(1+r_n)^n}}$$
(4)

where: D = duration of debt instrument,

t = period in which payment is made, $r_t =$ yield applicable for period t.

This formulation (4) is seen to be a weighted average of the time period in which payments are to be made. Each period is weighted by the present value of the corresponding payment of price of the maturing serial bond. That is, duration identifies the length of time from the present at which the bond generates the average present value. This period may be considered the average life of the bond. It is equal to the maturity of a single payment zero coupon bond selling at the same market price as the coupon bond, generating the same yield, and having a par value equal to the sum of the total payments generated by the bond when all coupons are reinvested to maturity.

Basic purpose of duration is, hence, to hedge against interest rate risk. By means of portfolio redistribution, in sense of assets and liabilities duration matching, we can eliminate vulnerability to changes in interest rates term structure. Therefore, if duration is genuine measure of vulnerability to interest rate changes, than the changes in term structure will have the same impact on current value of assets and liabilities. However, for this strategy to be effective, two elements must be evaluated: the form that unexpected yield curve shifts may assume and the impact of such shifts on the asset's value. The quality of an immunization strategy depends on how well these elements have been anticipated.

Traditional immunization strategies are based on the assumption that yield curve shifts are parallel. If yield curve shifts do not follow this pattern, the percentage change in the value of a single asset may not be equal to the percentage change in the value of a portfolio of assets of different maturity, even if their sensitivities to interest rates changes are equal. Empirical evidence shows that term structure shifts are generally non-parallel. Interest rates over short maturates display a higher volatility than interest rates over long maturates, and interest rate changes are not perfectly correlated across different maturates. In particular, if we consider changes over a short time horizon, we see that the correlation between short-term and long-term rate changes becomes fairly low.

Starting from these considerations, traditional immunization strategies can improve performance that controls for the unequal volatility and imperfect correlation of interest rates of different maturity. In paper (4, p. 127-141) concrete propositions are given for successful quantitative portfolio immunization.

4. ANALYSIS OF INTEREST RATES TERM STRUCTURE IN DOMESTIC ECONOMY

Data on interest rates in domestic financial system can be obtained from National Bank of Yugoslavia's (NBY) publication that is based on commercial banks' monthly reports on interest rates (2). However, this data pertains entirely to the banks' loan and deposit rates and are given in form of weighted loan and deposit interest rates by type and terms of loans and deposits. These are the only relevant data for estimation of interest rate term structure in domestic economy.

Information's on arrangements interest rates and terms, which can be obtained from brokers/dealers on money market, are not indicative because of very short average term of transactions, which rarely exceed 30 days. Given a small depth of the market, even for this term segment, information's are unreliable and do not allow correct interpolation of

term structure.

Analysis of loan interest rates' term structure is fraught with following problems:

- insufficient efficiency and freedom of financial market as a whole (high degree of formal regulation, interest rates constraints, high implicit taxation via required reserves policy, mandatory subscription of treasury bills, etc.);

-high degree of informal regulation caused by financial dependence of financial intermediaries (domination of perpendicular credit flows);

-rudimentary segment for long-term credits, insufficient volume of transactions (especially transactions outside rationalized credit flows), so the transactions does not reflect real state of supply and demand;

-data on interest rates on public debt instruments are not relevant because of influence of NBY regulation concerning mandatory subscription. Moreover, market for treasury instruments is illiquid.

Generally, domestic banks' loan interest rates are characterized by inverse term structure. Weighted long-term loan interest rate was 1.52 (as of July 1997) to 23.18 (as of May 1998) times higher than weighted short-term interest rate during period January 1997. — July 1998. Some authors attribute this phenomenon to insufficient domestic accumulation (17, p.40). According to the expectation theory, lower weighted long-term interest rate should imply expectations of interest rates lowering, which would represent credibility affirmation of anti-inflation economic policy. In that case, inflation premium lowering would overrun the effect of long-term interest rates increasing by Hicksian risk premium. Although we could partly agree with the expectations, other explanation of the term structure mentioned above is more convenient. We consider that, because of the impediments mentioned above, domestic loan market is highly segmented. The impediments between short-term and long-term segment, in our case, are caused by impact of various market and non-market developments on supply and demand, even on relevant interest rate. While short-term loans sector is significantly protected against regulation, particularly in area of interbank liquidity loans and money market borrowing, financial flows on market for long-term loans are substantially rationed. Lack of long-term fund sources in banks' balance sheets, together with large demand for loans were the grounds for extensive interventions of government and quasi-government institutions. In view of low volume of transactions and strong influence of non-market criteria, the segment might be considered quasi-market, while interest rate might be considered non-market. Particularly indicative items, in that sense, are loans for housing/public utilities construction and funds placed through Federation Fund, whose interest rates, during the period mentioned above, were several times lower than the weighted interest rate on long-term loans. We can conclude that, in domestic environment, indicative power of interest rates term structure is considerably reduced due to interventions through subsidized credit policy and other reasons, generally, due to inefficiency and strong influence of non-market criteria on financial markets.

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KRIVA PRINOSA I KAMATNI RIZIK

Borko Krstić, Srdjan Marinković

Kriva prinosa predstavlja grafičku interpretaciju ročne strukture kamatnih stopa kao funkcionalnog odnosa između dospeća kreditnih instrumenata, različitih jedino po dospeću i njihove stope prinosa po dospeću. To je instrument koji nam omogućava da se usmerimo na faktore relevantne na kamatni rizik složenih portfolia. Za korektno merenje kamatnog rizika portfolia mora se sagledati ukupna ročna struktura kamatnih stopa, odnosno, kriva prinosa, a ne samo pojedinačna kamatna stopa. Kriva prinosa predstavlja izuzetno koristan analitički instrumentarijum, koji nam pruža upotrebljive informacije o budućim kamatnih stopama i komponentama budućih kamatnih stopa, koje tržište očekuje. Ona je takođe, neophodan preduslov za korektnu evaluaciju kreditnih instrumenata. Zbog aktuelnog stanja u domaćoj ekonomiji, pre svega, usled neefikasnosti i jakog uticaja netržišnih kriterijuma na domaća finansijska tržišta, indikativnost krive prinosa je značajno smanjena.

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