3 Composition of interest rates

3.1 Learning outcomes

After studying this text the learner should / should be able to:

1. Describe the yield curve.
2. Be familiar with the literature on the composition of interest rates.
3. Describe the components of interest rates.
4. Elucidate the risk-free rate.

3.2 Introduction

We have discussed the relationships of short-term nominal interest rates and hinted at the relationship between short- and long-term rates. We now take this further.

A number of economics and finance scholars have decomposed the nominal rate of interest. We offer a refinement to the analyses, which has as its starting point the 1-day real risk-free rate (rfr). It is equal to the 1-day nominal rfr less inflation. Before we begin the analysis we need to elucidate the yield curve, which we only touched upon briefly earlier. The following are the sections:

- The yield curve.
- Literature on the composition of interest rates.
- Composition of interest rates: an alternative analysis.
- Literature on the risk-free rate.
- The risk-free rate: an alternative view.
- Relationship of interest rates revisited.

3.3 The yield curve

3.3.1 Introduction

A yield curve (YC) depicts the rates on bonds of various remaining terms to maturity at a point in time. In other words it is a snapshot of the relationship between bond rates and terms to maturity. It is also called the *term structure of interest rates*. We present a *positively-sloped* (a.k.a. *normal*) YC in Figure 3.1.

In order to elucidate, let us assume that this is a YC for government securities (i.e. TB and bond rates[18]) at 4 p.m. on 20 June. The YC is telling us that the rates shown in Table 3.1 were recorded at 4pm on that day. Note: they are read from the YC.

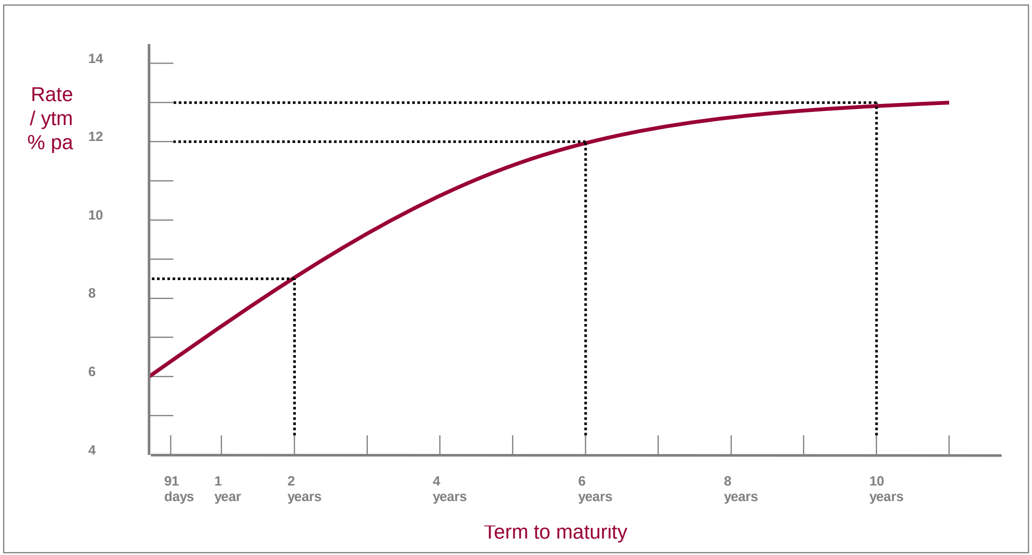


Figure 3.1: Normal yield curve

Maturity of security	Rate
1-day (TB)	6.0%
91-days (TB)	6.5%
1 year (government bond)	7.5%
2 years (government bond)	8.5%
3 years (government bond)	9.65%
4 years (government bond)	10.60%
5 years (government bond)	11.42%
6 years (government bond)	12.00%
7 years (government bond)	12.32%
8 years (government bond)	12.50%
9 years (government bond)	12.81%
10 years (government bond)	13.00%
11 years (government bond)	13.11%

Table 3.1: Government security rates recorded on 20 june

Where did this YC come from? It was constructed from the rates that prevailed on government securities of various maturities at 4 p.m. on 20 June. Figure 3.2 depicts this.

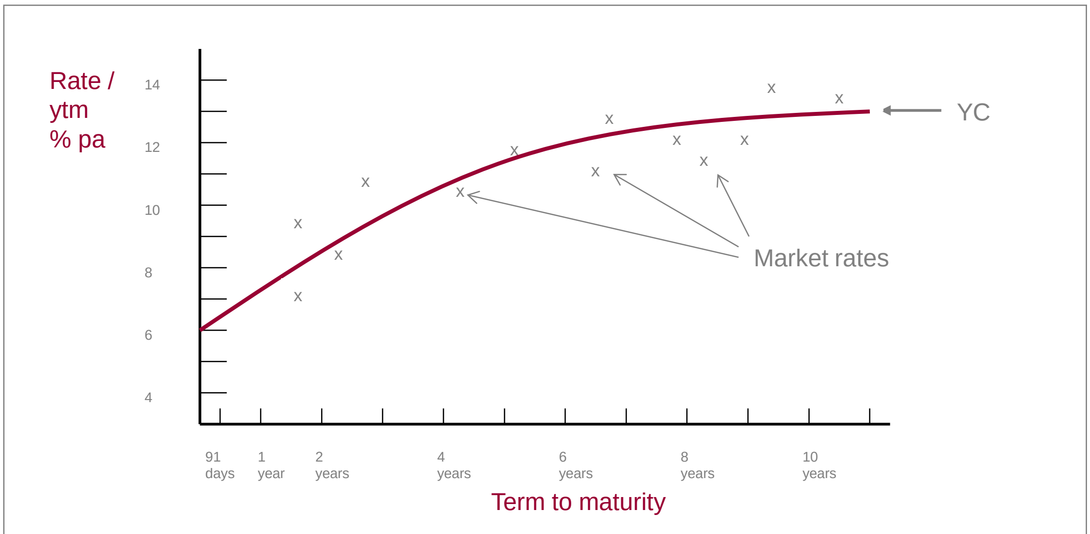


Figure 3.2: Market rates and constructed yield curve (YC) (normal YC)

The market rates on government securities of different maturities are represented by the x's and the YC is drawn with the use of a statistical technique. Thus, it will be apparent that the YC is a *graphical representation of the relationship between rate and term to maturity of bonds at a specific point in time.*

An YC is a useful tool:

- Rates (ytms) for year intervals can be derived for analysis purposes. For example, rates can be derived from the curve for 1 year, 2 years, 3 years, and so on. Thus, over a period a *time series* of rates for various terms is available. Recording the rate on a *specific* 10-year bond on month-ends of little use because each month the bond has one month less to maturity.
- Securities can be valued using the YC. The holder of a poorly traded bond is able to value the bond because the curve gives the "average" rate for all terms.
- The YC serves as a benchmark for both buyers of bonds and new issues of bonds.
- A government bond YC is a benchmark for the rates on non-government bonds.

It will be evident that in a sophisticated market the points (the x's) will not be as scattered as in the above example; they will be closer to the YC that is constructed from them.

It is to be noted that the above discussion was concerned with the *ytm YC*. It is the most familiar YC and is a representation of the relationship between yield to maturity and term to maturity of a group of homogenous securities (usually government).

3.3.2 Disadvantage of the ytm yield curve

However, there is a "problem" with the ytm YC. In the definition of ytm is the implicit assumption that coupon payments are reinvested at the ytm; this is rarely achieved (which can be called *reinvestment risk*). The only bond devoid of reinvestment risk is the zero coupon bond that has one payment at the end of its life.[19] For these reasons other YC types have been devised, such as:

- Par YC.
- Coupon YC.
- YC of "on-the-run treasury issues".
- Zero-coupon (a.k.a. spot) YC.

The ideal or "pure" YC is the *zero-coupon YC* (a.k.a. *spot YC*), i.e. a curve constructed from the rates on a series of central government zero coupon bonds and TBs. We do not have the space to take this issue further.

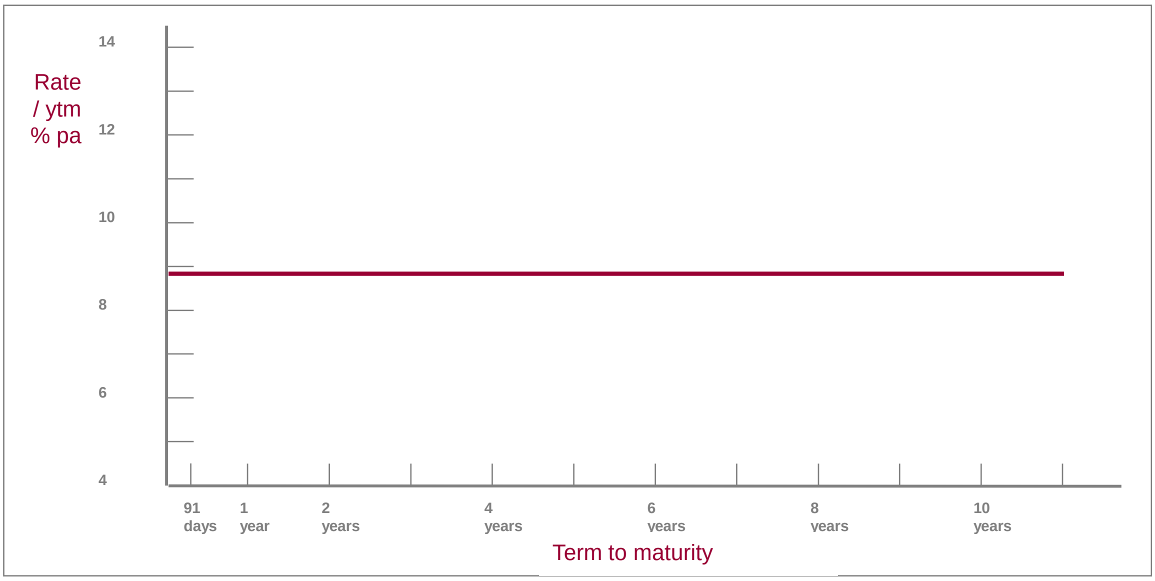


Figure 3.3: Flat YC

3.3.3 Shape of yield curve

Yield curves take on different shapes at different times. The normal YC is the one presented Figures 3.1–3.2, i.e. it is *positively sloped*, and it implies that the longer the bond the higher the return. Investors are rewarded for holding bonds of longer maturity. The other two basic shapes are the *flat YC* and the *inverted or negatively sloped YC*. The flat curve is portrayed in Figure 3.3.

The flat YC implies that there is no reward for the risk of a longer-term investment. Irrespective of term to maturity, all investors in government bonds earn the same rate (ytm). This curve usually represents the stage between normal and inverse.

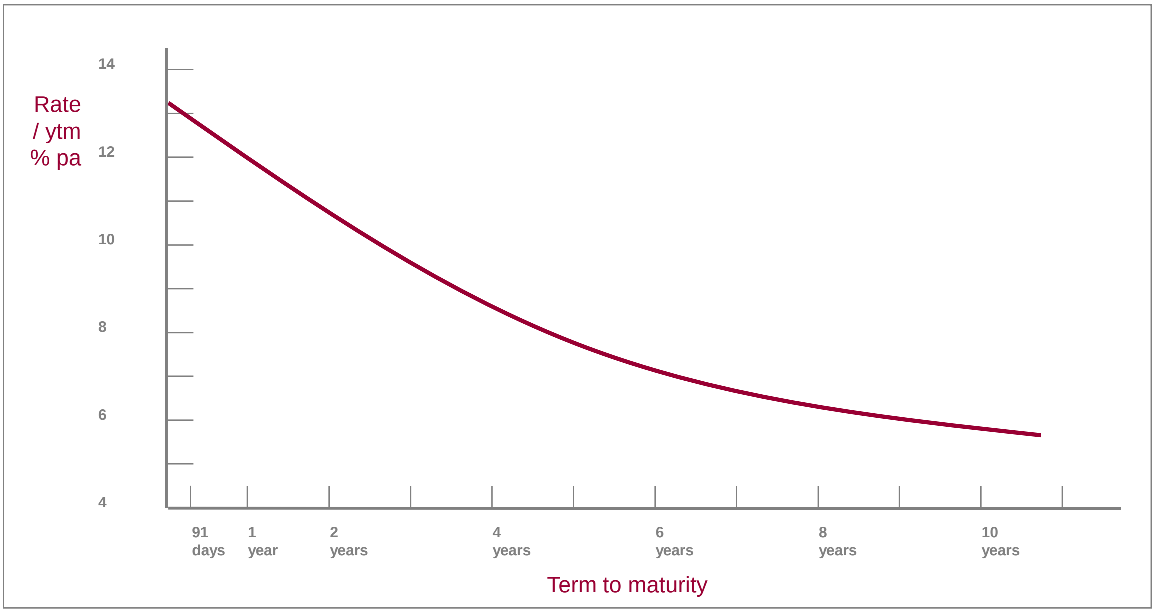


Figure 3.4: Inverse YC

The inverted or negatively sloped YC is illustrated in Figure 3.4. This curve tells us that investors are negatively compensated for holding long-term securities; they are "prejudiced" in relation to the holders of short-term securities – or so it appears. In reality, this YC normally comes about in periods of high rates when the monetary authorities are conducting a stringent monetary policy, driving up short-term rates. The long-term investors are content to accept short rates being higher than long rates because they *harbour strong expectations* that the shape of the YC is about to change to a normal shape and that the entire YC will shift downwards.

This means that the inverse YC is indicating that longer term investors are willing to accept lower rates now in exchange for large expected capital gains in the near future, i.e. the *income sacrificed will be more than compensated for by the capital gain*.

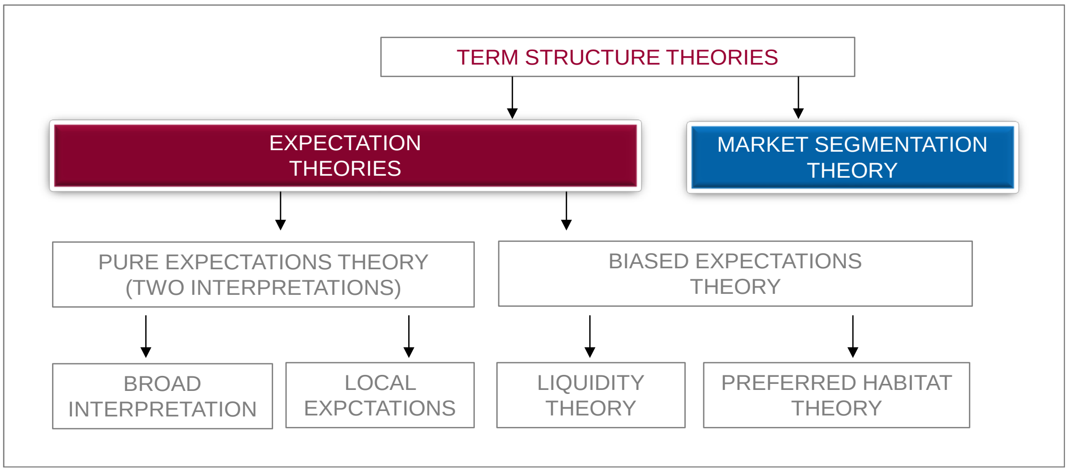
3.3.4 Theories of the term structure of interest rates

Two main theories have evolved to explain the YC, i.e. the expectations theory and the market segmentation theory. The former is categorised[20] into the pure expectations theory (of which there are two interpretations) and the biased expectations theory. There are two interpretations of the latter. Box 3.1 presents the term structure theories.

All these theories share a hypothesis about the behaviour of short-term forward rates and assume that the forward rates implied in current long-term bond rates are closely related to market participants' *expectations* about the future short-term rates.

The *pure expectations theory* postulates that the YC at any point in time reflects the market's expectations of future short-term rates. Thus, an investor with a 10-year investment horizon has a choice of buying a 10-year bond (and earn the current yield on his bond) or of buying 10 successive 1-year bonds. The return on the two investments will be the same, i.e. long-term rates are geometric averages of current and expected future short-term rates.

In terms of this theory, a positively shaped YC indicates that short-term rates will rise over the investment term, and a flat curve indicates that short rates are to be stable over the investment horizon.



Box 3.1: Term structure theories

As noted, there are basically *two broad interpretations* of this theory. The main criticism of this theory is that it does *not consider the risks* associated with investing in bonds.

The *liquidity theory* suggests that investors will hold longer term securities only if they are offered a long-term rate that is higher than the average of expected future rates by a risk premium that is *positively related* to the term to maturity (i.e. rises uniformly with maturity). Put another way: *the expected return from holding a series of short bonds is lower than the expected return from holding a long-bond over the same time period*. Thus, forward rates are not an unbiased estimate of the market's expectations of future rates, because they embody a liquidity premium.

The *preferred habitat theory* buys the theory that the term structure of interest rates reflects the expectation of the future path of interest rates and the risk premium. However, it rejects the notion that the risk premium must rise uniformly with maturity. Thus, the risk premium can be positive or negative and can induce investors to move out of their preferred habitat, i.e. their preferred part of the curve. It will be evident that in terms of this theory the YC can be positively sloping, inverse or flat.

The *market segmentation theory* holds that investors have preferred maturities of bonds dictated by their liabilities. Thus, banks will hold short-term securities and retirement funds / insurers will hold long-term securities. They will not shift from one sector to another to take advantage of opportunities. The YC reflects supply and demand conditions in the various maturity sectors of the YC.

3.4 Literature on the composition of interest rates

In the below analysis we assume a normal YC (i.e. a positively-sloped YC).

Prof Irving Fisher in his *Theory of interest* in 1930 was one of the first scholars to "split" the rate: the nominal interest rate. He postulated that the nominal interest rate (*nr*), i.e. the observed rate, is equal to, and is therefore comprised of, the real rate (*rr*) and the expected inflation rate ($e\pi$). At low levels of interest rates and low and stable inflation this may be expressed as:

$$nr = rr + e\pi$$

Essentially, Prof Fisher hypothesised that lenders demand a premium over the real rate of interest to compensate for the inflation-induced attrition of their monies lent. He asserted that nominal interest rates adjust in line with expected changes in the rate of inflation. Fisher did not state the term of asset he was referring to or its status in terms of risk.

Since then a number of economics and finance scholars have presented the elements that make up the nominal rate of interest. One example (Blake, 2000:86), which is largely representative, is presented in Figure 3.5. The starting point is the *real rate of interest* (*rr*), which is the rate of interest expected / demanded in a risk-free and inflation-free economic milieu. The *expected rate of inflation* (*eπ*) is added to the *rr* arrive at the nominal rate of interest (*nr*).

According to Blake the third component is the *liquidity premium* (*lp*), which increases with term to maturity. This is so because lenders prefer to lend short, since short-term securities are more liquid than long-term securities, and the latter are more subject to losses in capital value. Borrowers, on the other hand, prefer to borrow long, because of *rollover risk*, that is, the risk of rolling over borrowings on unfavourable terms. Hence, borrowers are prepared to pay a liquidity premium to lenders. The preferences of lenders and borrowers in combination bring about the upward sloping YC (Yield Curve 1).

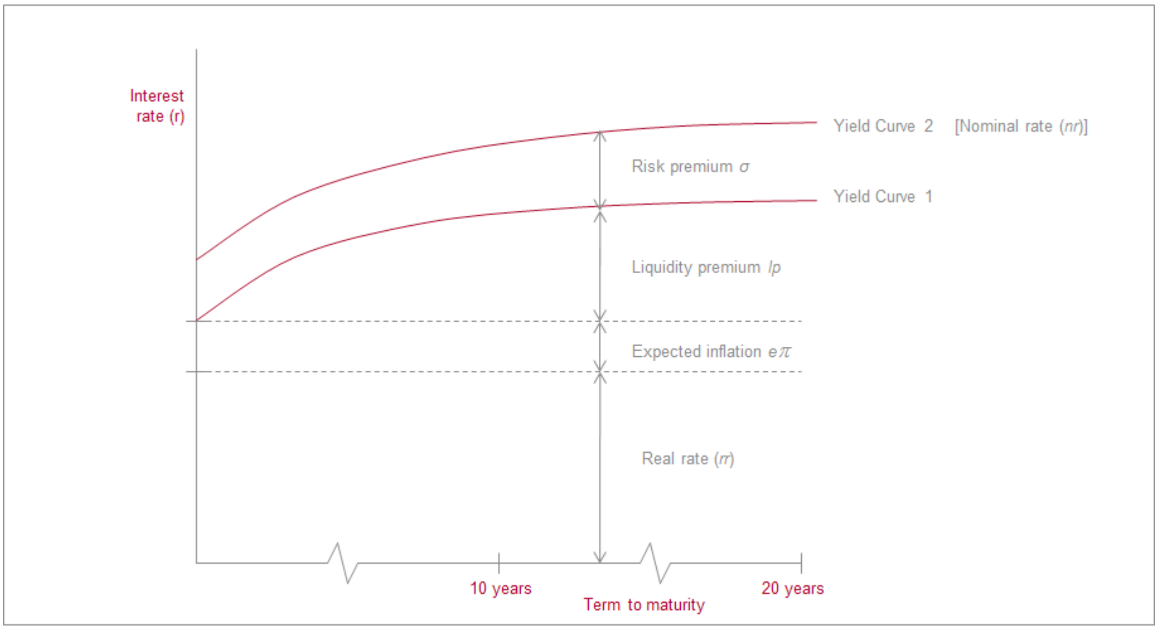


Figure 3.5: Composition of nominal rates

The fourth component, according to Blake, is the *risk premium* (σ), made up of *specific risk* (a.k.a. *unsystematic risk* and *diversifiable risk*) and *market risk*. Specific risk has four dimensions: management risk, business / operating risk, financial risk and collateral risk. Market risk (also known as *systematic risk* and *undiversifiable risk*) is the risk of default of the issuer, the risk of changes in capital value (which increases with term to maturity), and reinvestment risk (the risk of reinvesting coupon payments at lower than expected rates). Thus, every point on Yield Curve 2 has components as follows:

$$nr = rr + e\pi + lp + \sigma.$$

3.5 Composition of interest rates: an alternative analysis

The above analysis is useful indeed. However, it makes no reference to the *risk-free rates* and *non-risk-free* (or *risky*) rates. In this section we offer a refinement to the analysis, which has as its starting point the *1-day real risk-free rate* (*rrfr*) (see Figure 3.6). By *risk-free* is meant *credit-risk-free*. This is the rate on a 1-day unexpired maturity TB or government bond in an inflation-free environment.[21]

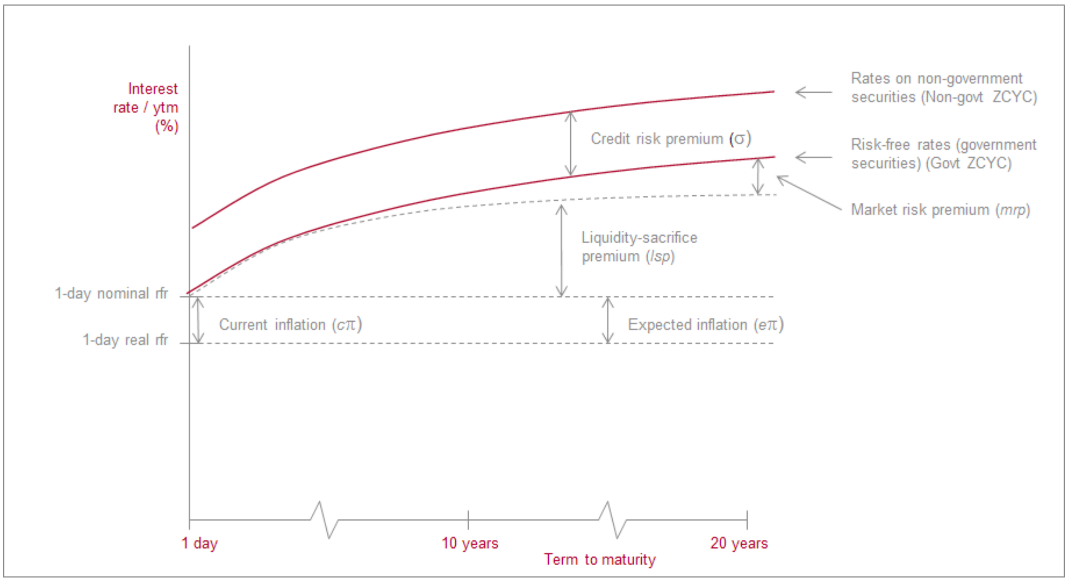


Figure 3.6: Composition of nominal rates (alternative)

The *1-day rrfr* is the lowest rate in the debt market in an inflation-free environment. However, such an environment rarely exists, and the *current rate of inflation* ($c\pi$) is taken into account in arriving at the *1-day nominal rfr* (*nrfr*):

$$\textit{1-day nrfr} = \textit{1-day rrfr} + c\pi.$$

The *current* inflation rate in a low and stable inflation environment is relevant to the analysis. Market participants tend to use in their pricing behaviour the last published inflation rate, which at worse is six weeks old and at best two weeks old[22]. Also, in a low and stable inflation environment, it is unlikely that the next published inflation rate will differ much from the last one (it may differ by a few decimal points, for example, change from 2.2% to 2.4%).This is small enough to disregard.

The *1-day nrfr* is the lowest rate in the debt market. It contains no *liquidity-sacrifice premium* (*lsp*) (note the change from the previously used terminology: *liquidity premium*) because it has one day to maturity, that is, the investor has an investment with the shortest possible term to maturity. The *lsp* applies from the 2-day term to maturity and it rises as term to maturity increases, for the reasons described earlier: lenders prefer to lend short and borrowers prefer to borrow long. We need to question whether an *lsp* exists where the government bond market is liquid. The answer is that one is never 100% certain that a market will remain liquid.

As the term to maturity increases the component current inflation ($c\pi$) gives way to *expected inflation* ($e\pi$), because there is no certainty that the current low and stable inflation environment will prevail. The fourth component is the *market risk premium* (*mrp*). Market risk here is regarded as having two components: (1) the risk of *changes in capital value*, which increases with term to maturity, and (2) *reinvestment risk*, that is, the risk of reinvesting coupon payments at lower than expected rates.

Thus, after the 1-day term to maturity, which we give as:

$$\textit{1-day nrfr} = \textit{1-day rrfr} + c\pi,$$

we are in the domain of the *government security YC,* which we call the government zero-coupon YC (Govt ZCYC[23]) in Figure 3.6. Thus, the components of all government security interest rates beyond 1-day are:

$$nrfr = \textit{1-day rrfr} + e\pi + lsp + mrp.$$

The rates of interest on government securities are the lowest in the debt markets because they are credit-risk-free. In the financial markets, the rates of interest on the debt instruments of non-government issuers are benchmarked against the equivalent-term rates on government securities. For example, the 10-year bonds of prime-rated ABC Company may trade at 200 basis points (bp) over the 10-year government bond rate. This is the *credit risk premium* (σ) demanded by the lenders.

The credit risk premium (by which is meant the risk of default), and the YC for corporate securities, depicted as "Non-govt ZCYC", are included in Figure 3.6. It is assumed that the YC is also a ZCYC and that the rates apply to AAA-rated borrowers (that is, homogenous corporate bonds in terms of risk).

The non-government ZCYC is depicted as running parallel to the government bond ZCYC, indicating that the credit risk premium is the same for all terms to maturity. This may not be the case: the premium may increase with maturity if corporate bonds are not as easily marketable as government bonds, which is usually the case.

With the addition of the credit risk premium (σ) to the equation, we are now "explaining" the nominal rates of AAA-rated companies (*nrc*). Each point on the corporate ZCYC is composed as follows:

$$nrc \quad = 1\text{-}day\ rrfr + e\pi + lsp + mrp + \sigma.$$

It should be clear that the above was not an attempt to explain the slope of the YC (the theories do that). It is merely an attempt to "build" interest rates from the logical starting point (the *1-day rrfr*) to the longer-term rates.

3.6 Literature on the risk-free rate

The *nrfr* (from here on referred to as the *rfr*) has a celebrated role in finance. It is the lowest debt interest rate in the monetary system; it is a benchmark rate; it is a significant input in models such as the Black-Scholes options pricing model, arbitrage pricing theory, capital market theory, the valuation of equities, the valuation of futures (cost of carry model), and many others. Despite its significance, there still exists some confusion as to its identity and even to its very existence.

Every author on the financial markets, economics of finance and finance makes reference to the *rfr,* and has a view on its somewhat blurred identity or nonentity status. We mention a few.

Reilly and Norton (2003:275) state that:

> "…the nominal risk-free rate [is the rate on] risk-free securities such as government T-bills."

Similarly, Gitman (1997:389) states:

> "The risk-free rate…is the rate of return…on a virtually riskless investment such as a US Treasury bill."

Adams et al. (2003:342) state that:

> "The risk-free rate of interest is the yield on a notional default-free bond…"

Cecchetti (2006:97) states that:

> "…a risk-free security is an asset whose future value is known with certainty and whose return is the risk-free rate" and that "no truly risk-free asset exists, so the risk-free rate is not directly observable."

Rose and Marquis (2006:116) maintain that:

> "…the pure or risk-free rate of interest exists only in theory" and that "the closest real-world approximation to this pure [risk-free] rate of return is the market interest rate on government bonds."

Bodie, et al. (1999:181) state that:

> "…it is common practice to view Treasury bills as 'the' risk-free asset. Their short-term nature makes their values insensitive to interest rate fluctuations."

Pilbeam (1998:92), under a discussion on bonds, asserts that:

> "Government bonds have the advantage of being risk-free in the sense that the purchaser…can be sure that the government will pay the coupon payments and the maturity value. Ultimately the government could just print money if it had to."

Mayo (2003:365) states that:

> "…no exact measure of the real risk-free rate exists."

In a similar vein, Bailey (2005:88) mentions:

> "A risk-free asset, if one exists…"

3.7 The risk-free rate: an alternative view

We present the view that there are as many *rfrs* as is the length of the government bond ZCYC, and that the relevant *rfr* is the one that corresponds to the application. For example, if a 180-day futures contract requires valuation, the applicable *rfr* is the 180-day point on the government bond ZCYC. The same applies to options. In the case of the valuation of shares as offered by the capital asset pricing model (CAPM), the applicable *rfr* should a longer term *rfr*, such as the 5-year *rfr*, and not the TB rate as proposed by some authors.

An important issue here is that the bottom end of the government security YC is closely related to and influenced by the PIR. This is discussed more fully in the next section.

3.8 Relationship of interest rates revisited

Figure 3.7 is the same as Figure 3.6, except that the rrfr has been removed, and the other short-term nominal rates have been superimposed, to show further relationships. This has been discussed, but we would like to add a few points:

- The rates on short-term prime debt (CP, BA's and PNs) will run along the YC for prime non-government securities (up to one year, because this is the maximum maturity).
- PR (which can be regarded as a 1-day rate – as discussed earlier) will be higher than the rate on prime CP, BA's and PNs because it is non-marketable debt.
- The rate on bank credit (overdrafts) to non-prime customers is shown at the point PR+2%.
- The NCD YC (a.k.a. the money market YC) is shown, with its starting point being similar to the rate paid on call deposits.

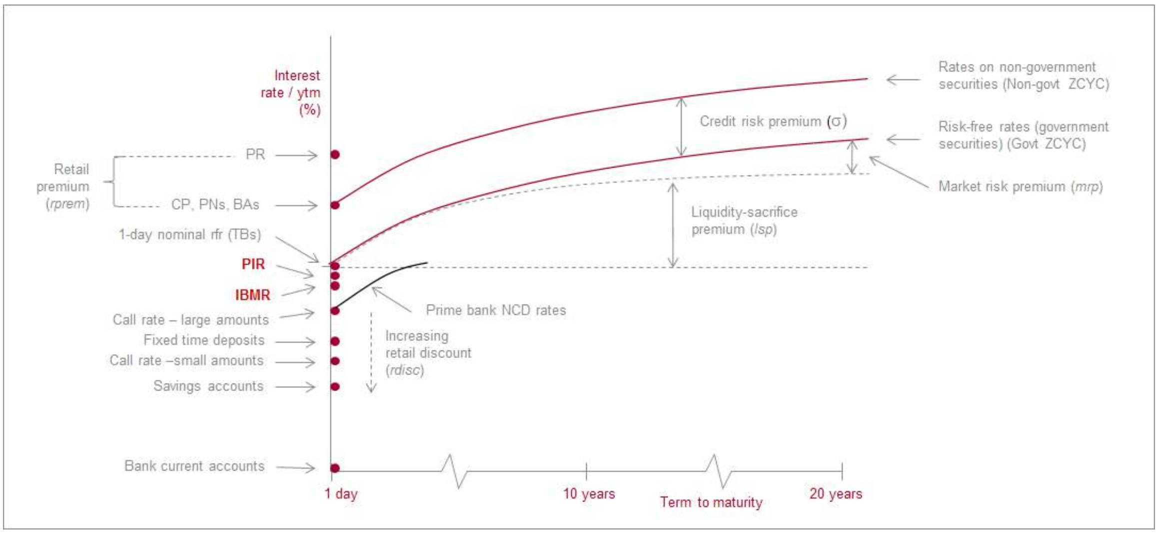


Figure 3.7: PIR, YC & money market rates

The most significant point to make here relates to the genesis of interest rates: the starting point of the *nrfr* YC is the PIR, that is, the lending rate of the central bank for borrowed reserves. As we have seen, in most countries (in normal times) the central bank, through open market operations, ensures that the banks are indebted to it at all times. This takes place in the central bank-to-bank interbank market (cb2b IBM).

The central bank levies the PIR on the borrowed reserves. Consequently, the PIR becomes the ceiling rate in the interbank market and for wholesale call money (one-day) deposits. In their endeavours to avoid borrowing from the central bank, the rate in the market-driven bank-to-bank interbank market (b2b IBM) is driven up to close to the PIR, as is the call deposit rate. This is borne out in practice, as we have seen, and show again in Figure 3.8. It shows the PIR (the ceiling rate) with the wholesale call money rate and the b2b IBM rate for a particular country[24] for a period of eleven years (monthly data). Recall that the R^2 of PIR and wholesale call money rate = 0.98, and the R^2 of PIR and IBMR = 0.97.

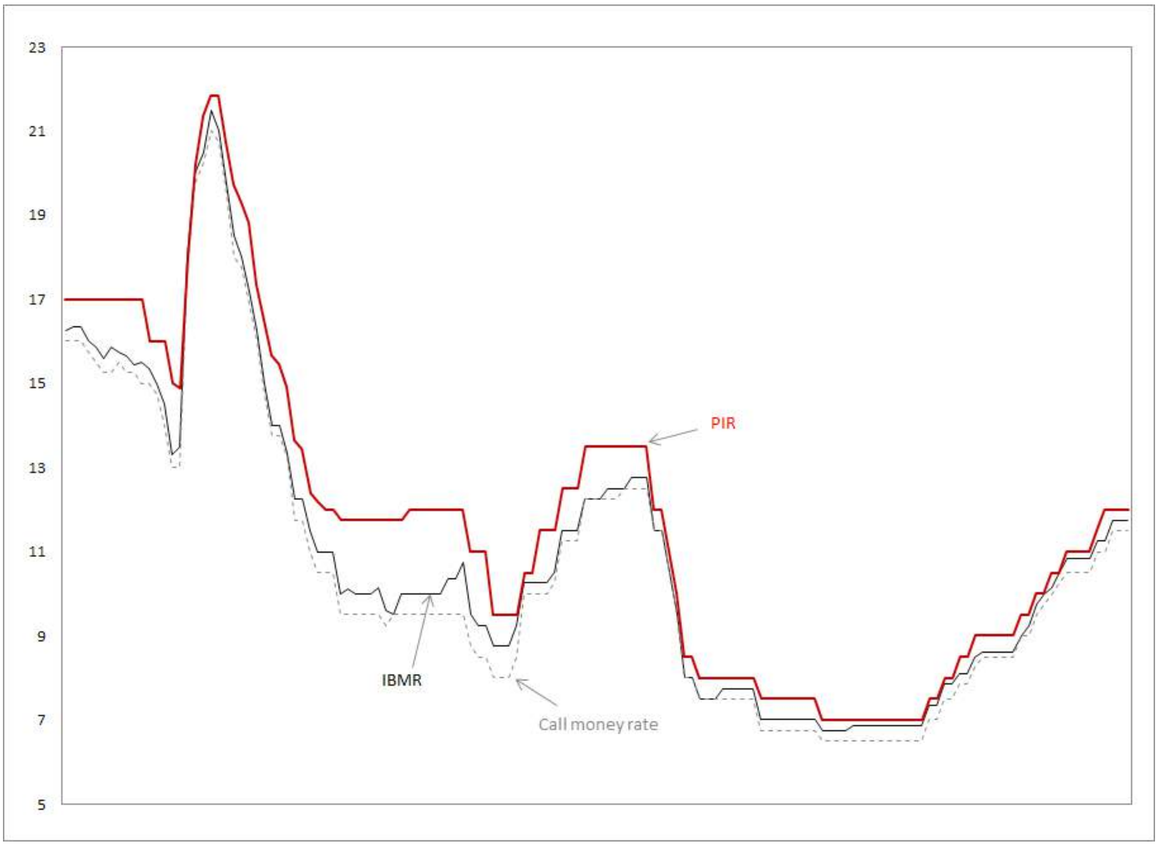


Figure 3.8: PIR, call money rate & IBMR

The ultimate objective of monetary policy is to "set" the PR (the benchmark lending rate) of the banks, and thus influence the demand for bank credit (the main determinant of money stock growth). This is achieved via the jealously-guarded bank margin. By "setting" the rates on banks' liabilities via the PIR, the central bank "sets" the prime rate of the banks. Figure 3.9, showing the relationship between PIR and PR, is repeated for the same country for a period of over 50 years (monthly data). Recall that R^2 = 0.98.

A final word: the reader will have noted the differences in the levels of debt instrument interest rates, deposit interest rates, and IBM rates in Figure 3.7. We point these out clearly in Figure 3.10. It is evident that the IBM rates are key in terms of influencing the bank deposit rates and, via the "sticky" bank margin, the lending rates.

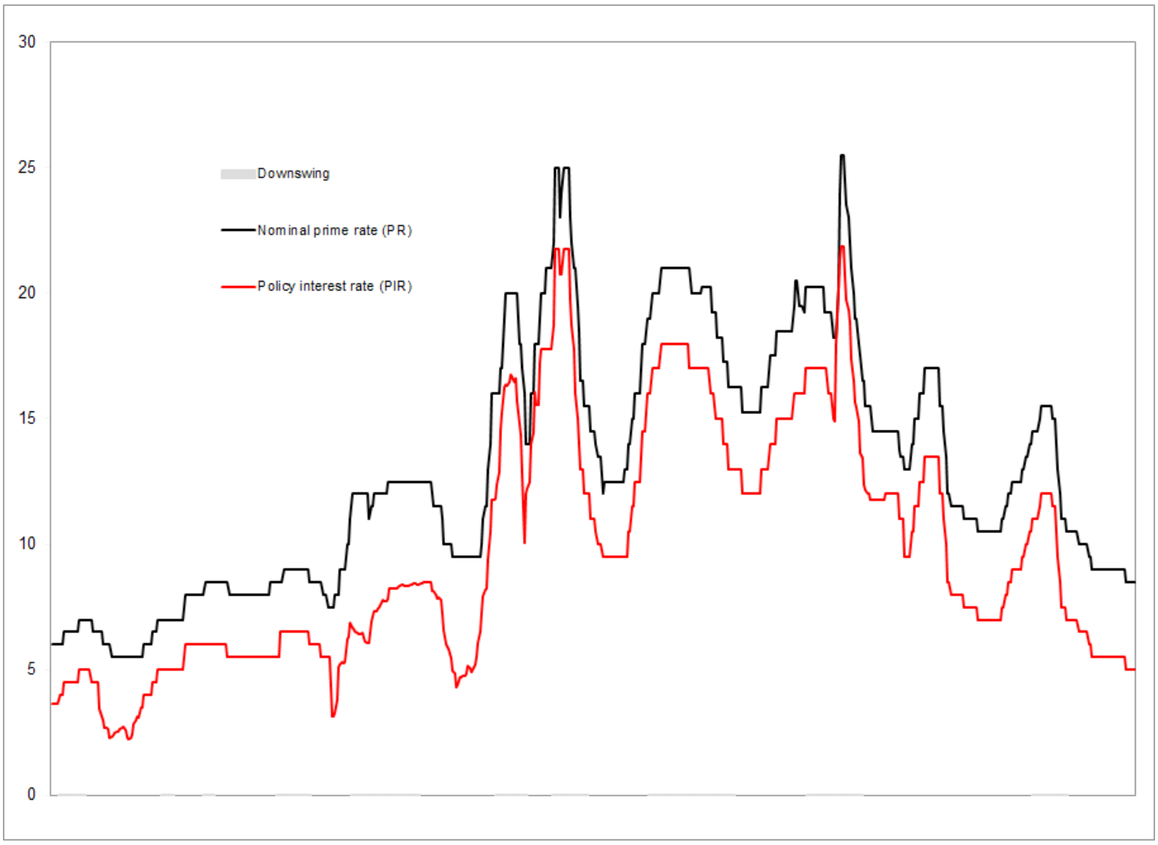


Figure 3.9: PIR & PR

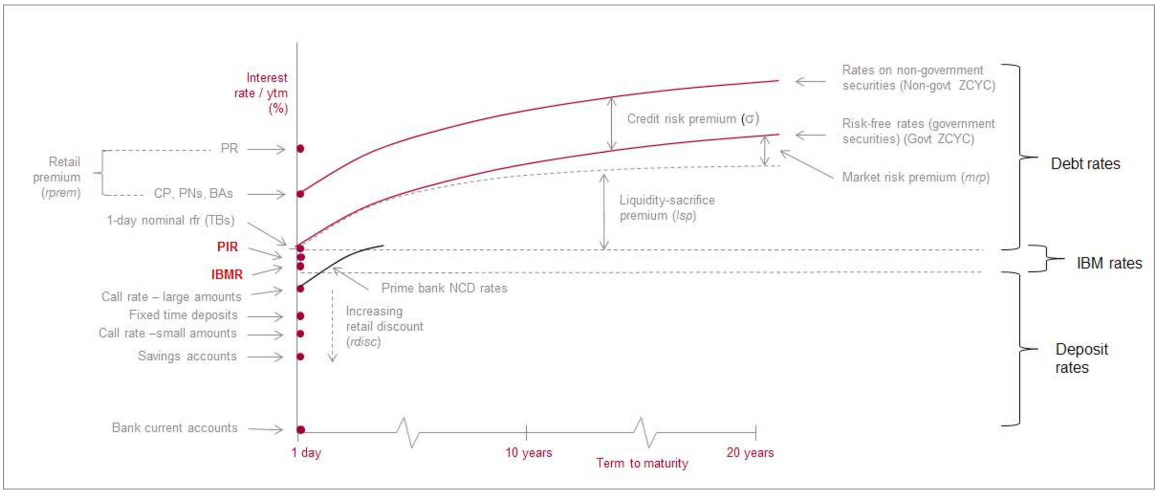


Figure 3.10: PIR, YC & money market rates

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