

# Interest Rate Risk in the Belgian Banking Sector

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## 1. Introduction

*Interest rate risk* refers to the exposure of a bank's net interest income and the market value of its equity to unexpected changes in interest rates<sup>(1)</sup>. The exposure results from differences in the price sensitivities of assets and liabilities to unexpected interest rate changes, caused by maturity, duration, and repricing mismatches and the presence of embedded options in the balance sheet<sup>(2)</sup>.

There are three factors motivating the supervisory authorities' current interest in measuring and assessing the interest rate risk in the banking sector. First and foremost, supervisors want to ascertain whether or not banks have sufficient capital in place to cover the interest rate risk incurred in their trading activity and asset and liability management. In this respect, it needs to be stressed that while the Basel I and II Accords represent milestones in supervisory policy by introducing minimum capital requirements for different categories of risk, they do not automatically impose an explicit capital charge tied to the interest rate risk in a bank's banking book. Instead, within the framework of Pillar II of Basel II, supervisors are asked to identify and monitor banks that run excessive banking book interest rate risk (so-called "outliers"). Supervisors can then impose a hedge on these banks or ask them to hold additional capital.

A second motivating factor follows from the continuing importance of interest rate risk in banks' balance sheets, despite the current low level and volatility of European interest rates and the trend towards disintermediation. Indeed, although fee income has become increasingly important, net interest income still accounts for more

than half of total bank income. Moreover, given that Belgian banks finance a considerable proportion of their assets with sight and savings deposits, the effect of changes in market rates on the spread between deposit and market rates and on deposits withdrawals will potentially have a large impact on the ultimate interest rate risk exposure. Also, the risk of even small upward changes in long-term interest rates on the holding returns of bonds in the securities portfolio of banks must be acknowledged. Bond prices are potentially very sensitive to small policy changes that affect the short end of the yield curve. Campbell (1995) describes how initially modest Fed policy moves in 1994 triggered sharp increases in long bond yields that eventually culminated in a global bond market crisis.

Third, in the autumn of 2004 the European Commission is expected to endorse International Financial Reporting Standard 39 *Financial Instruments: Recognition and Measurement*. The standard aims at increasing transparency about a bank's risk-taking by imposing a stricter and more complete recording of its assets and liabilities. For example, the standard does not allow underperforming bonds to be shifted from the trading book (where they are marked-to-market) to the banking book (where they are booked at historical cost) to

(1) Within the scope of this paper, interest rate changes are assumed to originate from the risk-free non-callable zero coupon bond yield curve and not from changes in credit risk. The reader is referred to the paper "The Determinants of Credit Spreads" in this Financial Stability Review for evidence about the link between changes in risk-free interest rates and credit spreads.

(2) The embedded options materialize mainly in the form of sight and savings deposits withdrawals on the liability side and early loan repayments at the asset side of the balance sheet, conditional on a specific interest rate scenario. This paper will focus attention to the former. The reader is referred to Uyemura and van Deventer (1994) for US empirical evidence and references on the latter.

avoid a drop in bank net income. As such, the standard is expected to lead to increased volatility of Belgian bank income and capital.<sup>(3)</sup>

The paper is organised as follows. Section 2 focuses on the economic rationale behind the existence of intermediaries that expose themselves to interest rate risk by financing long-term assets with short-term liabilities and deposits. A bank that assumes a *maturity* mismatch does not necessarily assume a *repricing* mismatch. So, ultimately, we should explain why banks do not transform long (fixed) interest rates into short (variable) rates at small cost using interest rate swaps, since this would effectively eliminate the risk exposure that follows from the maturity mismatch. Section 3 quantifies and discusses popular measures of aggregate interest rate risk exposure in the Belgian banking system, reflecting a going concern as well as a market or liquidation view of the banking system. The two views are actually complementary in constructing a complete, true and fair view of interest rate risk exposure. We use repricing tables and gap reports to gain further insight into the total interest rate risk exposure of the Belgian banking system. Given that the treatment of deposits accounts turns out to be of paramount importance in a true and fair assessment of the interest rate risk exposure of Belgian banks, we also review the literature on deposit account modeling. Section 4 briefly describes the supervisory framework of the Basel II Accord for measuring, monitoring, and controlling the interest rate risk of banks. Section 5 concludes and summarises the main messages.

## 2. The economics behind interest rate risk exposures

### 2.1 Why maturity-mismatching banks exist

Individuals are typically risk averse and this characteristic is reflected in their preferences. Those with an excess of funds typically have a preference to lend short, while those with a shortage of funds have a preference to borrow long. Still, in the presence of perfect financial markets (Arrow and Debreu (1954)), there would be no need for maturity-mismatching intermediating banks, since savers and borrowers would execute their transactions directly in financial markets with sufficiently rewarded and willing counterparties (see also Modigliani and Miller (1958)). So, the true *raison d'être* of banks are market imperfections such as information asymmetries, transaction costs, tax distortions and market incompleteness.<sup>(4)</sup>

Given the existence of market imperfections, there is a role for banks in bringing risk-averse savers and borrowers together. However, banks create a mismatch between the maturity of their assets and liabilities by issuing demandable and other short-term debt and granting long-term loans. Among many others Diamond (1984) and Gorton and Pennacchi (1990) try to understand the exact circumstances under which each of these two separate activities might require the existence of an intermediary, as opposed to being implemented directly through arm's-length financial markets. Although this literature yields many insights, only a few papers address the more fundamental question of why it would make economic sense for a single institution to carry out both functions under the same roof. Real synergies have to exist between the two activities, since if there exist none, there would be no *rationale* for the existence of loan making and deposit taking banks.

Kashyap et al. (2002) show that, indeed, so long as markets are imperfect, synergies exist between deposit-taking and loan-making activities. They argue that banks offer credit lines or loan commitments to their borrowers, such that the latter hold the option to draw down the loan on demand over a specified period of time. Once the decision to extend a credit has been made, the borrower can show up at any time and withdraw funds, just as with a demand deposit. In that sense, banks provide their customers with liquidity on both the liability and asset side to accommodate their unpredictable needs, extending the original Diamond and Dybvig (1983) argument<sup>(5)</sup>. Now, given that financial markets are imperfect, a bank cannot accommodate liquidity shocks instantaneously by raising new external finance, so that a buffer stock of liquid assets needs to be held. Holding this buffer is costly for several reasons: opportunity costs, tax distortions, increased agency costs, etc. So, if demand withdrawals and loan draw downs are not perfectly correlated, a real synergy arises and a bank would be able to hold a smaller total liquid asset stock than two separate institutions would have to hold jointly.

(3) The recent amendments to IAS 39 (IASB (2004)) seem to leave scope to reduce income volatility by applying the restricted fair value option. While hedge accounting imposes stringent documentation demands and is therefore unlikely to be used by Belgian banks, the restricted fair value option can be used as a short-cut alternative to hedge accounting to reduce income volatility. See the article "*Impact of IAS 39 on asset and liability management and banks' capital ratios*" in this Financial Stability Review. The interested reader is referred to ECB (2004) for a general discussion and impact study of more fair valuation of financial instruments.

(4) An important "market imperfection" in the Belgian legal environment is the favourable tax treatment of savings deposits ("*gereguleerde spaardeposito's/dépôts d'épargne réglementés*"). The interest proceeds from savings deposits are currently tax-exempt insofar they do not exceed 3,040 euro per household, leading to their importance in the financing portfolio of a bank (see also Section 3.2).

(5) The classic motivation (Diamond and Dybvig, 1983) for banks to offer deposits derives from the existence of random liquidity shocks faced by depositors and the need for depositors to be insured against these liquidity shocks. The law of large numbers implies that aggregating over these idiosyncratic liquidity shocks leads to exploitable diversification benefits.

Other arguments have also been raised. Dermine (2003) lists several synergies between loan making and deposit taking that lead to real cost reductions. For example, there could be joint operating expenses in delivering deposits and loans, or the terms of mortgage loans could simply require the opening of deposit accounts. Diamond and Rajan (2001) argue instead that banks commit themselves to bearing withdrawal risk by issuing demandable deposits. Hence, the bank will be committed to do the utmost to collect from borrowers to repay depositors. If not, a run might be precipitated and the bank would fail. Similarly, Calomiris and Kahn (1991) argue that deposits may discipline bankers and hence, by submitting themselves to demandable deposits, bankers may attain a lower cost of capital. Finally, Mester et al. (2001) argue that deposits may help banks in monitoring borrowers, thereby becoming superior lenders.

## 2.2 Why repricing-mismatching banks exist

The previous section argues that risk aversion, market imperfections, and real synergies in banks' balance sheets may justify the existence of maturity-mismatching banks. However, banks can run maturity or duration mismatches yet still match the *repricing* characteristics of their assets and liabilities, and *vice versa*. For example, when a bank makes price-sensitive (fixed rate) long-term loans and finances them by less price-sensitive (variable rate) liabilities, it can always opt to swap the long-term fixed interest rates on the loans into short-term variable interest rates at small cost. So, we need to go one step further and understand why banks expose themselves to a repricing mismatch.

The existence of a positive average yield spread, being the difference between yields on long and short bonds, is *not* a sufficient reason for banks to lend at a long rate and borrow at a short rate, i.e. expose themselves to a repricing mismatch. Indeed, the short-term yield cannot simply be compared with the long-term yield to infer something about their relative returns (i.e. the *ex post* excess return). The short-term yield is an expected return over a short horizon or holding period, while the long-term yield is the expected return over a long horizon or holding period. If the two need to be compared, either the long-term yield has to be compared with the average yield of rolling over short-term bond yields over the life of the long bond, or the short yield has to be compared with the uncertain short-term holding return of the long bond. Both fair comparisons imply that *expectations about interest rate dynamics* and rewards for being exposed to interest rate risk – *expected excess returns or risk premia* – need to be taken into account. Given that both components are unobserved, we need a model to separate yields into expectations about interest rate dynamics and risk premia.<sup>(6)</sup>

### 2.2.1 Expectations about interest rate dynamics

The most simple no-arbitrage theory<sup>(7)</sup> is the *pure expectations theory*, where the assumption is made that bonds of different maturities are perfect substitutes. Hence short and long-term bonds are expected to earn the *same* return over the *same* holding period. Rolling over subsequent short-term bonds should earn the same return as buying and holding a long-term bond, which implies that the long-term yield is an average of current and future expected short-term yields over the life of the long-term bond. So if a positive yield spread is observed, this does not imply that long bond returns are expected to be higher than returns on short bonds (over any horizon). Instead, the theory predicts in that case that over the long horizon, short-term bond yields are expected to increase so that both short-term and long-term bonds are expected to earn the same amount over the horizon of the long bond. Alternatively, the theory predicts that over the short horizon the long rate tends to rise<sup>(8)</sup>, such that the generated capital losses fully offset the initial yield advantage and expected returns are again identical.

If the pure expectations theory holds true, a yield spread will not lead to an increase in the market value of a bank's equity, irrespective of the size of the yield spread and the duration mismatch between assets and liabilities. This is explained by the fact that the short yield on the liability is expected to increase over the life of the long asset so that the present value of net interest income exactly equals zero. If interest rates increase by less than what is expected by market participants as reflected in current forward rates, then this is actually positive for the asset sensitive bank and the market value of its equity will increase. Duration is only (approximately) a correct measure for price sensitivity of equity when the implicit assumption that the yield curve is flat holds true.<sup>(9)</sup> Conversely, if the yield curve cannot reasonably be assumed to be flat, then the forward rate curve is the relevant benchmark for assessing the impact of an increase in the yield curve on the market value of equity (see Box 1 for a simple numerical illustration).

(6) Alternatively, we need models to separate forward rates into future yields and risk premia. Given the one-to-one relationship between zero coupon bond yields and forward rates, we choose not to discuss the latter in this paper.

(7) A thorough review of the class of affine no-arbitrage term structure models is outside the scope of this article (see Dai and Singleton (2000) and Maes (2004)).

(8) Notice the somewhat counterintuitive implication of the pure expectations theory, namely that if the yield spread is unusually large, long yields are expected to increase and not decrease over the short run (and *vice versa*). The paradox is solved once one acknowledges that short rates are also expected to increase, at a faster pace than long rates according to the theory. So, yield spreads will still tend to become smaller, when they are unusually large.

(9) Notice that in that theoretical case, the forward rate curve is identical to the yield curve and, hence, the market does not expect interest rates to increase or decrease in the future. As a result, any change in interest is by definition unexpected.

## Box 1 – The forward rate curve as the benchmark for assuming a repricing mismatch

This Box aims to illustrate that a positive yield spread always involves risk. Assume that the zero coupon bond (ZCB) yield curve today looks as in Table 1.

**TABLE 1** ASSUMED ZERO COUPON BOND YIELD CURVE AND IMPLIED 1-YEAR FORWARD RATES

(Percentages per annum)

Time to maturity / Time	ZCB yields	Implied 1-year forward rates <sup>(1)</sup>
1 .....	2.00	2.00
2 .....	3.00	4.01
3 .....	4.00	6.03
4 .....	5.00	8.06
5 .....	6.00	10.10

(1) Implied 1-year forward rates can be derived from the ZCB yields. E.g., the forward rate that one can lock in today between 3 and 4 years in the future can be derived as 6.03 p.c. =  $((1.04)^3 / (1.03)^2) - 1$ .

Imagine that a bank considers financing a 5-year government coupon bond (face value 100, priced at par, ZCB yield curve as in Table 1, hence with yield and coupon rate equal to 5.768 p.c.) with a 1-year revolving time deposit (2 p.c.). The two yields 5.77 p.c. and 2 p.c. cannot be compared as such, given that the 5-year coupon bond yield is the average annual return over a holding period of 5 years, while the 1-year yield is the annual return over a holding period of 1 year. A comparison needs to be made on the same footing (i.e. holding period). Either we compare the 2 p.c. yield on the 1-year time deposit with the unknown 1-year holding return of the 5-year bond (given that its price might change), or we compare the 5.77 p.c. 5-year yield with the return of rolling over consecutive 1-year time deposits, where we need to acknowledge that the 1-year yields (returns) are uncertain between years 2 and 5.

However, uncertainty about future interest rates can always be eliminated by locking in future 1-year financing costs today, using the implied 1-year forward rates derived from the ZCB yields. If future 1-year interest rates are locked in or future interest rates are exactly equal to the implied forward rates, which is referred to as *scenario 1* in Table 2, then the initial 3.77 p.c. margin will turn negative in later years since locked-in financing costs can be seen to increase from 2.0 p.c. to 10.1 p.c.. The net present value of net interest income over the next five years is exactly equal to zero, so the market value of equity is *not* affected.

Interest rate changes that are in line with current forward rates do *not* affect the market value of a bank's equity, irrespective of any maturity mismatch. Only unexpected changes in interest rates will affect the market value of a bank's equity. If future financing costs are not locked in and if actual future interest rates are above what is implied by the forward rates, for example *scenario 2*, we find that market value of equity suffers from this unexpected increase in interest rates. However, if future interest rates increase but to a lesser extent than predicted by the forward rates, for example *scenario 3*, the market value of equity actually *increases*, despite the increasing short-term interest rates.



TABLE 2 SCENARIOS FOR FUTURE 1-YEAR INTEREST RATES AND THEIR IMPACT ON NET INTEREST INCOME

Year	Financing cost dynamics			Net interest income (NII) <sup>(1)</sup>		
	Scenario 1 Future short rates locked in or as expected	Scenario 2 Future short rates unexpectedly higher	Scenario 3 Future short rates unexpectedly lower	Scenario 1 Future short rates locked in or as expected	Scenario 2 Future short rates unexpectedly higher	Scenario 3 Future short rates unexpectedly lower
1	2.00 p.c.	2.00 p.c.	2.00 p.c.	3.77	3.77	3.77
2	4.01 p.c.	5.01 p.c. (+1 p.c.)	3.01 p.c. (-1 p.c.)	1.76	0.76	2.76
3	6.03 p.c.	7.03 p.c. (+1 p.c.)	5.03 p.c. (-1 p.c.)	-0.26	-1.26	0.74
4	8.06 p.c.	9.06 p.c. (+1 p.c.)	7.06 p.c. (-1 p.c.)	-2.29	-3.29	-1.29
5	10.10 p.c.	11.10 p.c. (+1 p.c.)	9.10 p.c. (-1 p.c.)	-4.33	-5.33	-3.33
<b>Effect on market value of equity (NPV of sum of NII)</b>				<b>nihil</b>	<b>-3.40</b>	<b>3.40</b>

(1) *NII*<sub>t</sub> is computed as follows: (5.77 p.c.-1yr interest rate at t) \* 100.

(2) The effect on market value of equity is computed as the sum of net present values of net interest income over the next 5 years (discounting by the zero coupon bond yields in Chart 1). For example, the effect on market value of equity for scenario 1 is computed as:  $3.77 / (1.02)^1 + 1.76 / (1.03)^2 + (-0.26) / (1.04)^3 + (-2.29) / (1.05)^4 + (-4.33) / (1.06)^5 = 0$ .

### 2.2.2 Risk premia

It has been argued above that expectations that deviate from the market's interest rate expectations may motivate a bank to assume a repricing mismatch. However, in reality, no bank is able to *systematically* outguess market expectations. Hence, taking positions based on interest rate expectations will not lead to systematic increases (or decreases) in market value of equity and an alternative explanation is needed for the existence of repricing mismatching banks.

The existence of a *risk premium* or *expected excess return* turns out to be the main driver for assuming a repricing mismatch. The return that a long bond holder expects to receive over a short bond return (i.e. the risk premium) makes it potentially worthwhile to assume a mismatch. When risk premia are zero, a bank will be indifferent with regard to holding short or long assets and liabilities.

The *liquidity premium theory* builds on the pure expectations theory, but relaxes the assumption that bonds of different maturities are perfect substitutes. Indeed, risk-averse investors might very well prefer to hold short-term bonds because of their higher liquidity, driving up their price and driving down the yields at the short end. Put differently, investors may require a non-zero risk premium to hold the less liquid long-term bonds. In sum, while the pure expectations theory assumes risk premia to be zero, the liquidity premium theory relaxes this assumption and allows them to be maturity-dependent (but constant over time).

In the case of non-zero risk premia, yield spreads contain predictions of both (short- and long-term) yield changes and risk premia, and we need to disentangle yield spreads into both unobserved components. If either of the above two term structure theories holds in reality, that is if risk premia are zero or constant over time, then yield spreads are optimal predictors of future movements in yields. More specifically, both theories have implications for short-term changes in long yields and long-term changes in short yields. These predictions can be tested using simple regression analysis. In post-war US data (Fama (1984), Fama and Bliss (1987), Campbell and Shiller (1991), Campbell, et al. (1997)), short yields tend to increase when yield spreads are high – in line with the theoretical predictions –, but long yields tend to fall when yield spreads are high -counter to the theoretical predictions. So, to the extent that the yield spread forecasts short-term changes in the long rate, it does so in the *wrong* direction, amplifying the return differential between short and long bonds, instead of bridging it. Similar evidence for Belgian long-term interest rate dynamics is presented in Box 2.<sup>(10)</sup>

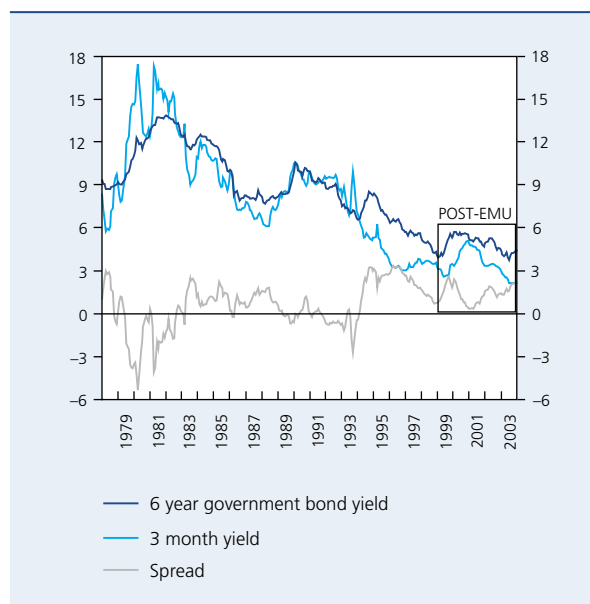
In sum, the regression evidence in the literature and in Box 2 suggests that neither the pure expectations nor the liquidity premium theory, although intuitively appealing, describes actual yield curve dynamics. With respect

(10) No evidence is presented for the alternative test of long-term changes in Belgian short-term yields. Results for this alternative test are in line with the theoretical predictions (with respect to the sign of the coefficient) and are available on request.

## Box 2 – Do the pure expectations and liquidity premium theories of the term structure hold in Belgium ?

Chart 1 plots the short and long end of the Belgian nominal yield curve between January 1978 and December 2003. The following observations can be made. First, the yield spread or yield curve slope is positive on average, but has fluctuated between  $-5.35$  p.c. and  $+3.35$  p.c. The last inversion of the yield curve dates from July 1993 and lasted until February 1994. Second, short-term interest rates are more volatile than long-term interest rates, which implies that non-parallel shifts of the yield curve are not exceptional. Third, the correlation between both interest rates is extremely high (94 p.c. in the full sample). Fourth, interest rates are heteroskedastic, i.e. their volatility is level-dependent.<sup>(1)</sup>

**CHART 1** BELGIAN SHORT AND LONG TERM NOMINAL YIELDS  
(Percentages; monthly data)



Source : NBB.

At the very least, any candidate theory needs to explain two stylised facts about yield curves, namely that yields on short and long bonds move together, and that, on average, the yield curve is upward sloping. The pure expectations theory is able to explain the former but not the latter, while the liquidity premium is potentially able to explain both facts. So we focus attention on the test of the liquidity premium theory (i.e. including the maturity-dependent constant risk premium).

The liquidity premium hypothesis is the joint hypothesis that markets are rational and that risk premia are time-invariant. We can test the hypothesis by regressing changes in long yields on the (scaled) yield spread (formal derivation in Campbell et al. (1997)):

$$y_{n-1,t+1} - y_{nt} = \alpha_n + \beta_n \frac{(y_{nt} - y_{1t})}{n-1} + \varepsilon_{n,t+1}$$

(1) The conditional volatility is not observed without making a modeling assumption. We have used the RiskMetrics model to derive the conditional volatility of the 3 month interest rate. Results are available on request.



where  $y_{nt}$  is the yield at time  $t$  of a bond with remaining time to maturity  $n$ , and where  $\varepsilon_{n,t+1}$  can be interpreted as a one-period-ahead prediction error. Hence, the error term should exhibit no autocorrelation, although it may be heteroskedastic. We use White (1980) standard errors to correct for the latter.

The liquidity premium theory can be rejected when the  $\beta_n$  slope coefficient differs from unity in a statistically significant way. In Table 1 below, we observe that the estimate for  $\beta_n$  is not only statistically significantly different from unity, but that it is even negative, implying that a larger than average spread tends to accompany a decrease in long interest rates, an apparent violation of the hypothesis. The results imply that a naive investor, who judges bonds by their yields to maturity and buys long bonds when their yields are relatively high (and not when their expected relative return is high, so disregarding the possible riskiness of the strategy), has tended to earn superior returns over the period 1978:01-2003:12 in Belgium.

**TABLE 1** RESULTS FOR BELGIUM OF REGRESSING LONG YIELD CHANGES ON THE SCALED YIELD CURVE SLOPE (1978:01-2003:12)

	$\alpha_n$	$\beta_n$
Coefficient estimate . . . . .	-0.004	-1.215
Standard error <sup>(1)</sup> . . . . .	0.019	0.784

Source: NBB.  
 (1) White (1980) standard errors are used. These standard errors correct for the possible impact of heteroskedasticity.

to these results, it is important to highlight the fact that these regression tests are always *joint* hypothesis tests, testing that market expectations are rational and that risk premia are constant. Given that the hypothesis is convincingly rejected, the result reflects *either* a failure of investor rationality *or* the presence of time-varying risk premia. Recently, Dai and Singleton (2002) and Maes (2003) have presented statistical evidence<sup>(11)</sup> that the existence of time-varying risk premia and not the irrationality of market expectations lies at the root of the expectations and liquidity premium theory rejections. Both studies conclude that market expectations are rational, but that the reward for being exposed to interest rate risk is complex and time-varying, and not zero, constant, or simply proportional to the level of the interest rate (as in Cox, et al. (1985)). Other candidate explanations have been proposed, stressing econometric problems, but Bekaert and Hodrick (2001) conclude that the latter cannot convincingly explain the widespread rejection of the expectations and liquidity premium theory.<sup>(12)</sup>

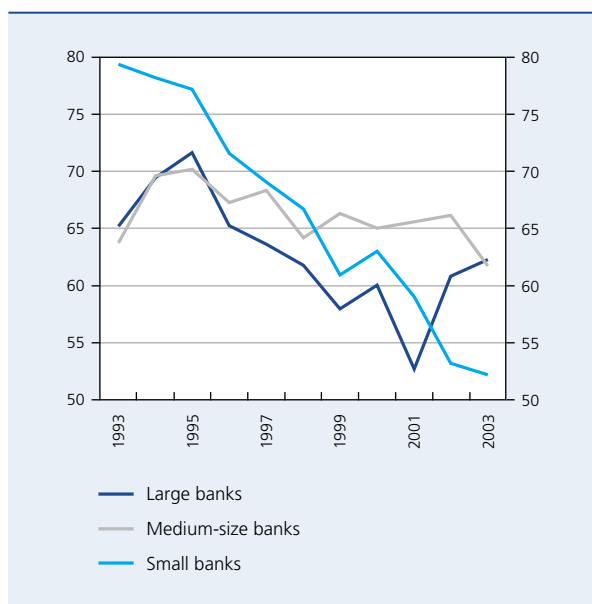
### 3. Measuring the interest rate risk exposure in the Belgian banking sector

A bank's net worth can be looked upon from two complementary perspectives: a going concern perspective and a market or liquidation perspective. Correspondingly, there are two main concepts used to assess interest rate risk: *net interest income at risk*, measuring how interest rate shocks affect net interest income, and *market value of equity at risk*, measuring how interest rate shocks affect the market value of equity.<sup>(13)</sup> In addition, interest rate changes may also trigger early loan repayments and deposit withdrawals, which cause a bank's cash flows to behave differently from expected. So, a cash flow risk also results from the embedded options in a bank's assets and liabilities.

(11) Their evidence is based on the panel estimation of the multi-factor affine class of term structure models.  
 (12) These explanations include small sample biases and the existence of Peso effects. Small sample biases may arise because of the persistence of yield spreads, whereas Peso problems arise if investors anticipate and price an event or regime change that does not materialise in-sample.  
 (13) Uyemura and van Deventer (1994) show that it is generally impossible to hedge both target accounts simultaneously against interest rate risk.

**CHART 1** NET INTEREST INCOME AS PERCENTAGE OF TOTAL INCOME FOR LARGE, MEDIUM-SIZE AND SMALL BANKS <sup>(1)</sup>

(Data on an unconsolidated basis)



Source : NBB.

(1) Small banks are defined as having less than 500 million euro of total assets, large banks as having more than 10 billion euro of total assets.

### 3.1 Net interest income at risk

Chart 1 shows that *net interest income* is an important component of total income for Belgian banks.<sup>(14)</sup> The average ratio of net interest income to total income for 1993-2003 is somewhat above 60 p.c. for large banks and somewhat above 65 p.c. for medium-size and small banks.<sup>(15)</sup> These averages mask quite different dynamics and trends, however. While the ratio decreases almost monotonically for small banks from 80 p.c. to somewhat above 50 p.c., it is relatively stable for medium-size banks hovering between 60 p.c. and 70 p.c. The ratio for large banks starts and ends at the medium-size bank level but fluctuates more to the downside in the middle six years bottoming out slightly above 50 p.c. in 2001 but recovering again towards 2003. In general, the average ratio of net interest income to total income seems to have declined slowly over the last ten years reflecting a disintermediation trend.

(14) "Bank product" is used for total income, being the sum of net interest income and other income. Bank product is used to cover costs, value corrections with respect to the normal banking activity and taxes. The residual is the result of the income statement.

(15) Small banks are defined as having less than 500 million euro of total assets, large banks as having more than 10 billion euro of total assets.

The pronounced and continuous decline in small bank's net interest income as a percentage of total net income can be explained by the big banks' absorption of a large number of small banks, characterised by classic intermediating activities, where the remaining small banks are mainly the ones more specialised in non-interest income generating activities. The different dynamics of medium-size and large banks' net interest income ratios in the period 2000-2002 may have resulted from a stronger dependence on stock market performance of larger banks, for example through their commissions earned on UCITs specialised in equities.

To find out how net interest income of Belgian banks relates to yield spread and market interest rate changes, we regress quarterly net interest income on its lag, the yield spread, and changes in short and long-term interest rates. Results are presented in Table 1 for large, medium-size and small banks for the period 1993:Q1 to 2003:Q4. The following findings can be derived from the table. First, the large, positive, and significant coefficient on lagged net interest income for all banks suggests that the effects of changes in the slope of the yield curve and market interest rates, if any, are only felt gradually. Second, changes in short and long rates do not affect net interest income of banks in a statistically significant way. Third, net interest income of small and medium-size banks is affected in a statistically significant way by the yield spread over the period considered. The yield spread enters with a positive sign, suggesting that a steeper (flatter) than usual yield curve is associated with higher (lower) net interest income. If the yield spread were to increase by 100 basis points, *ceteris paribus*, quarterly net interest income of medium-size (small) banks would increase by 0.56 (0.06) million euro, i.e. 6.3 (9.0) p.c. of their average net interest income. For the large banks in our sample, we do not find statistically significant yield spread coefficients.

English (2002) reports results of a similar regression for a sample of countries based on annual data from 1979-2001. Overall, his conclusions are not clear-cut. He finds a significant positive spread effect for the US (in line with our results for medium-size and small banks), insignificant spread effects for 5 out of 10 countries and statistically significant negative spread effects for 4 out of 10 countries. He finds similar results to ours with respect to the weight of lagged net interest income and the insignificance of the changes in short and long rates (with a few exceptions). From these mixed results, he concludes that, in addition to changes in the slope of the yield curve, many other factors might also play a role in the dynamics of net interest income, including changes in technology and more subtle influences such as banks' hedging activities.



**TABLE 1** RELATIONSHIP BETWEEN NET INTEREST INCOME, YIELD SPREADS AND MARKET INTEREST RATE CHANGES

(Data on an unconsolidated basis, 1993:Q1-2003:Q4)

	Own lag	Yield spread	Change in short-term interest rate	Change in long-term interest rate
<b>Large banks<sup>(1)</sup></b>				
Coefficient . . . . .	0.92 <sup>(2)</sup>	5.80	3.150	-0.94
Standard error . . . . .	0.10	5.60	12.70	27.90
<b>Medium-size banks<sup>(1)</sup></b>				
Coefficient . . . . .	0.83 <sup>(2)</sup>	0.56 <sup>(3)</sup>	0.33	-1.40
Standard error . . . . .	0.09	0.32	0.59	1.30
<b>Small banks<sup>(1)</sup></b>				
Coefficient . . . . .	0.74 <sup>(2)</sup>	0.06 <sup>(2)</sup>	0.02	-0.03
Standard error . . . . .	0.11	0.03	0.06	0.12

Source: NBB.

(1) Small banks are defined as having less than 500 million euro of total assets, large banks as having more than 10 billion euro of total assets.

(2) Denotes statistical significance at the 95 p.c. confidence level.

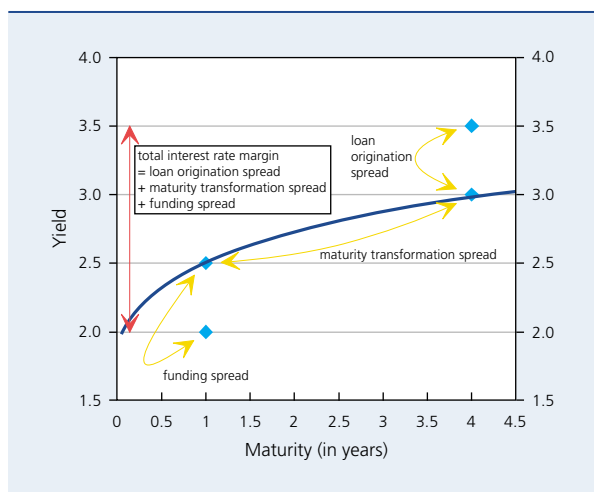
(3) Denotes statistical significance at the 90 p.c. confidence level.

In general, the concept “net interest income” covers more than the income generated by the maturity transformation role of banks. Typically, the bank’s loan business unit is able to grant loans at a contractual rate that lies above the Euribor yield curve, and its deposit-gathering business unit is able to attract funds at a lower rate than it needs to pay in the interbank market. A matched maturity technique is often used to split the total interest rate margin (net interest income) into different components, attributable to loan origination, maturity transformation, and deposit financing. This decomposition is illustrated in

Chart 2. From the Chart it is clear that the total spread that drives reported net interest income also remunerates the bank for the liquidity and credit risks that it assumes, apart from the mismatch risk. The loan origination and deposit financing spread will partially reflect the imperfect contestability of the market, regulatory barriers to entry, and the market power of the institution. If competition amongst banks is fierce, the latter spread components may even temporarily become negative.

It is important that management understands what portion of their net interest margin is attributable to each of the components in order to assess the interest rate risk exposure of their activities. The truly risky component in the net interest rate margin is the maturity transformation spread. The bank will need to trade off the expected net interest income against the following risks.

**CHART 2** TOTAL INTEREST RATE MARGIN (NET INTEREST INCOME) DECOMPOSITION  
(Stylised illustration)



– *Parallel yield curve risk*. This source of interest rate risk stems from timing differences in the repricing of assets, liabilities and off-balance-sheet instruments. Even if we assume that the entire curve shifts up and that the total spread and its components remain the same, total net income is still at risk. Indeed, bank liabilities typically reprice earlier than assets (see Section 3.3), implying that interest expenses increase in the short run without an offsetting increase in interest revenues. For these reasons, parallel yield curve risk is also often referred to as repricing risk.

- *Non-parallel yield curve risk*. A second source of risk originates from the yield curve changing shape, i.e. inverting, flattening, steepening, etc. Short-term interest rates are more volatile than long-term interest rates, which implies that non-parallel shifts of the yield curve are not exceptional. Part of the mismatch spread component may disappear or the spread may even become negative. *Ceteris paribus*, a flattening of the yield curve is worse for net interest income than a parallel upward shift.
- *Basis risk*. A third source of interest rate risk originates from imperfect correlation between paid and received interest rate changes on different instruments with otherwise similar repricing or maturity characteristics. Basically, this source of risk originates from the fact that the loan spread and funding spread in Chart 2 are not perfectly correlated with changes in their corresponding market (Euribor) interest rates.
- *Embedded option risk*. Finally, assets, liabilities, and off-balance-sheet positions often incorporate implicit or explicit options that can lead to behavioural maturities that significantly differ from their contractual ones. The embedded options are generally exercised to the advantage of the holder, i.e. to the detriment of the bank. Instruments with embedded options include bonds with call or put provisions, mortgage loans that allow borrowers to repay the balance early for refinancing reasons, and sight and savings deposits that allow depositors to withdraw funds at any time.

### 3.2 Market value of equity at risk

Although the focus on net interest income is important, it is incomplete. The market value of *all* fixed rate instruments is immediately affected when interest rates change. Whether or not these changes manifest themselves immediately in earnings depends on accounting rules. While unrealised losses can temporarily be buried in historical cost accounting, they will eventually surface, usually in the form of earnings that underperform the market. The market or liquidation value perspective evaluates the interest rate risk to a bank's net worth from all interest rate sensitive portfolios across the full maturity spectrum of the bank. Regulators find the market perspective very useful, since decreases in the market value of equity can be a leading indicator of future earnings and solvency problems. It can also help in identifying risk exposures that are not evident in an analysis of short-term earnings. See OCC (1989) for a stylised example of the latter.

However, the market value approach also raises a number of relevance and reliability problems. For example, swings in the market value of an instrument that is truly intended to be held to maturity are irrelevant and could potentially generate misleading intermediary reported income changes, given that the price will be pulled back to par at maturity. Moreover, obtaining a reliable measurement is sometimes difficult when markets are illiquid, thin, or non-existent, or where complex embedded options are included. In those cases, discretionary modelling assumptions need to be made, possibly with an important valuation impact. Finally, the market approach by definition does not allow us to identify the timing of the accounting recognition of the decline in earnings.<sup>(16)</sup>

(16) These various issues are currently raised in the debate on fair value accounting (see ECB, 2004). The article "Impact of IAS 39 on asset and liability management and banks' capital ratios" in this Financial Stability Review tries to look ahead by assessing the likely implications of the new financial reporting standards on a stylised balance sheet.

**TABLE 2** AGGREGATE BALANCE SHEET STRUCTURE OF THE BELGIAN BANKING SECTOR

(Data on an unconsolidated basis, December 2003, percentages of total assets, i.e. 880 billion euro, 1993-2003 annual average growth rates in percentage between brackets)

ASSETS		
Interbank loan portfolio	26	(+2.6)
Client loan portfolio	36	(+5.3)
Mortgage loans	8	
Other loans	28	
Securities portfolio	28	(+4.1)
Banking book	22	
Trading book	6	
Other	10	(+13.4)
<b>Total</b>	<b>100</b>	<b>(+4.7)</b>
LIABILITIES		
Interbank borrowing	32	(+2.3)
Deposits	47	(+4.2)
Sight deposits	10	(+10.5)
Savings deposits	15	(+10.7)
Term deposits	14	(+2.6)
Other deposits <sup>(1)</sup>	8	(-3.3)
Own equity and subordinated debt	6	(+9.6)
Other	15	(+15.0)
<b>Total</b>	<b>100</b>	<b>(+4.7)</b>

Source : NBB.

(1) Other deposits consist out of bank bonds (kasbons, bons de caisse) and certificates of deposit.

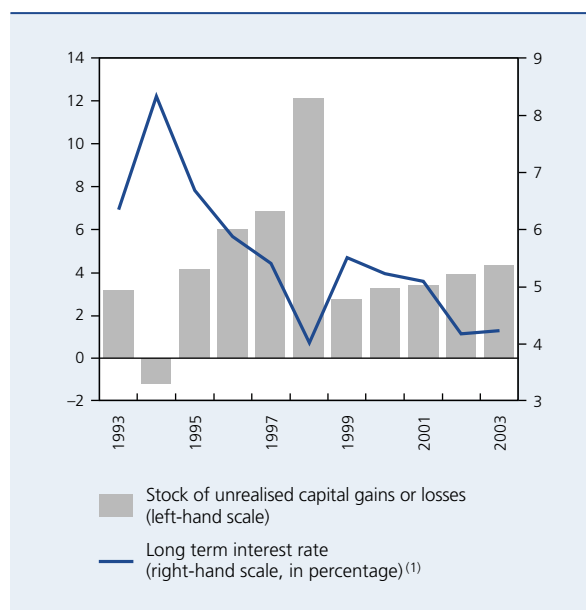
Table 2 reflects the aggregate balance sheet of the Belgian banking sector on December 2003, where the entries between brackets represent estimates of average annual growth rates in the respective balance sheet accounts over the last ten years. At the end of 2003, total assets in the Belgian banking system equated 880 billion euro or about 330 p.c. of nominal Belgian GDP. The corresponding ratio for the Netherlands is similar (345 p.c.), it is somewhat lower for France and Germany (266 p.c. and 240 p.c. respectively), but it is dramatically lower for the UK and the US (140 p.c. and 71 p.c. respectively). This suggests that the latter two economies are more market based and less bank based systems than typical European continental banks. Total assets have been growing at a rather stable pace throughout the last 10 years, attaining an average annual growth rate of 4.7 p.c.

On the more detailed level, own equity and subordinated debt and savings and sight deposits have grown relatively fast on the liability side, compared to total deposits and total liabilities. Deposits and interbank borrowing represent 80 p.c. of liabilities. On the asset side, the differences are less pronounced. We see that the loan book<sup>(17)</sup> and securities book together make up 90 p.c. of total assets.

Below, we measure the approximate impact that interest rate changes have had on the market value of some Belgian banks' assets during the last ten years. This exercise will be limited to the securities portfolio of the Belgian banking sector, since this portfolio is the only one for which marked-to-market prices are readily available. The securities portfolio represented 28 p.c. of the balance sheet total at the end of 2003.<sup>(18)</sup> About 80 p.c. of the securities portfolio corresponds to the banking book for which changes in market value are only recorded when instruments are actually realized. As this accounting method only records a fraction of the total, i.e. realised and unrealised change in market value, we used additional information available through the Belgian prudential reporting scheme to extract the difference between the book and market value of securities in the banking book portfolio. This yields a measure of the hidden cumulative gains or losses in the banking book portfolio. By adding the yearly variations in the total unrealised capital gains to the yearly realised capital gains on the banking book, we obtain a measure of the total yearly changes in the market value of the banking book portfolio (See Chart 3). If we map the cumulative gains or losses against the long interest rate, we obtain a strong negative correlation. This is confirmed by a regression of total (i.e. realised and unrealised) capital gains in the banking book on the long interest rate (using quarterly data from 1993:Q1 to 2003:Q4). The R-squared is 43 p.c. and the coefficient on the long interest rate is statistically and economically

**CHART 3** CUMULATIVE UNREALISED CAPITAL GAINS OR LOSSES IN THE BANKING BOOK

(Data on an unconsolidated basis, billions of euro unless stated otherwise)



Source : NBB.

(1) Average actual yield for loans with 6 years remaining to maturity.

significant. Every 100 basis points increase in the interest rate leads to a decrease of 1.5 billion euro in the cumulative capital gain, with a 95 p.c. confidence interval of [-2.1 billion, -0.98 billion].

If we want to measure the market value change of the *total* securities portfolio, we have to add the value of changes in the trading book. Chart 4 compares the three components of securities portfolio income, i.e. realised income in the banking book, unrealised income in the banking book, and trading book income. From the chart, the following observations can be made. First, total securities portfolio income is very volatile. The average value is 1.4 billion euro with a standard deviation of 4.7 billion euro. Second, the unrealised income in the banking book is by far the most volatile component, both in levels and proportionally (unrealised banking book income varies between 10 p.c. and 84 p.c. of total securities portfolio income<sup>(19)</sup>). Third, the average realised income in the banking book is 1.1 billion, whereas it amounts to 150 million for

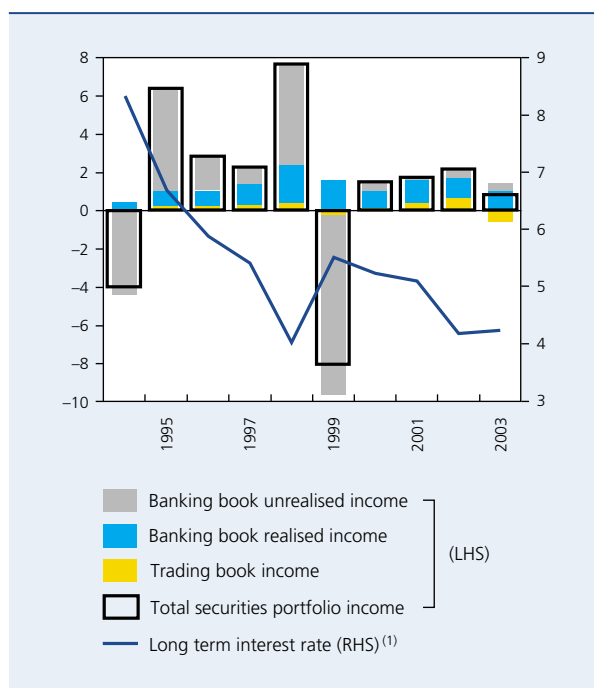
(17) On average about 65 p.c. of the loan book is fixed-rate versus 35 p.c. variable-rate. Differences across individual banks can be substantial to the extent that variable-rate loans dominate in the loan books of some banks.

(18) This proportion is much higher than in most other EU countries, illustrating the important role played by Belgian banks in the financing of the federal government.

(19) We have disregarded the three years with negative components.

**CHART 4** DIFFERENT SOURCES OF SECURITIES PORTFOLIO INCOME

(Data on an unconsolidated basis, billions of euro)



Source : NBB.

(1) Average actual yield for loans with 6 years remaining to maturity.

the trading book and to only 115 million for unrealised banking book income. While the unrealised banking book income has been positive for 8 out of the last 10 years, it was negative in 1994 and 1999. The unrealised losses in the banking book can be seen to make up the bulk of the securities portfolio loss in those years. The long-term interest rate dynamics are superimposed and can be seen to have played an important role. Note also that, despite the fact that the interest rate increase was smaller in 1999 than in 1994, we observe a larger unrealised banking book loss in 1999. Two potential explanations can be given for this outcome. First, given the convex relationship between prices and yields, the price sensitivity (duration) of a given portfolio increases for lower levels of interest rates. Interest rates were indeed lower in 1999 than in 1994. Second, there is a volume effect in the sense that the volume of net assets that reprice in one year or later was substantially higher in 1999 than in 1994.

(20) Again, we make reference to the article in this Financial Stability Review "Impact of IAS 39 on asset and liability management and banks' capital ratios" which assesses the total balance sheet effects of financial reporting according to IAS 39 rules.

Of course, the discussion above only concerns the securities portfolio. Total market value effects on the asset side may be bigger, although there may also be some limited compensation on the liabilities side of the balance sheet.<sup>(20)</sup> In the next section, we assess the interest rate risk exposure in the Belgian banking system more generally.

### 3.3 Aggregate gap report for the Belgian banking sector

*Repricing tables* allocate assets, liabilities, and off-balance-sheet instruments into time bands according to the time remaining to repricing. They allow us to form a more refined image of interest rate risk exposure and can also be used to study the two measures of interest rate risk mentioned above, net interest income at risk and market value of equity at risk.

By measuring the net assets (liabilities) that remain after subtraction of liabilities per time band, gap reports are constructed from repricing tables. *Gap reports* are used to measure net interest income at risk and to indicate the timing of the risk. Since a bank earns a return on its assets and has to pay interest on its liabilities, net interest income is expected to change by the mismatch times the expected interest rate change. Importantly, gap reports can also be used to evaluate the effects of changing interest rates on the market value of equity. *Duration gap reports* analyse the impact of a change in interest rates on the market value of a bank's equity. To this end, the mismatches are accorded risk weights that reflect the sensitivity of the net positions in each time-band to a given unexpected change in interest rates. Finally, the weighted mismatches are added together and this aggregated number is typically compared to a measure of capital. In practice, a proxy of modified duration is used to compute the risk weights. It is clear that if interest rates increase unexpectedly, the value of both assets and liabilities will drop, so that the interest rate sensitivity of the assets and liabilities will determine whether or not equity will increase, decrease, or stay the same.

The weaknesses of repricing tables and gap reports are well-documented:

- There are potential mismatches *within* each time band, hence significant risks may remain hidden when the time-to-repricing time bands are large.
- The time value of money and the payment of taxes and coupons is ignored.
- In reality, the yield curve often shifts in non-parallel ways and is regularly upward sloping, while a parallel shift and a flat yield curve is implicitly assumed in assessing the impact on market value of equity (see Box 1).

- The risks from embedded options (early loan repayments and deposit withdrawals) are typically not captured.
- Basis risk is not taken into account.
- The underlying assumption is that no new business is generated and that all maturing assets and liabilities are reinvested in the same time-band.

Clearly, each of the above points potentially biases the interest rate risk measurement. Despite these weaknesses, however, gap reports remain a consistent and simple means by which banks and supervisors can assess possible mismatches within banks’ balance sheets. Moreover, it is possible to accommodate some of the above weaknesses, for example by constructing different gap reports each corresponding to a specific interest rate dynamics scenario. Associated assumptions can then be made about the repricing characteristics of assets, liabilities, and off-balance-sheet instruments and about early loan repayments and deposit withdrawals.<sup>(21)</sup>

Chart 5 reflects the aggregate repricing table for the entire Belgian banking system at the end of December 2003.<sup>(22)</sup> Ten time-to-repricing time bands (hereafter, time bands) can be distinguished from top to bottom. At the long end (top of Chart 5) the “over 10 years” time band records all

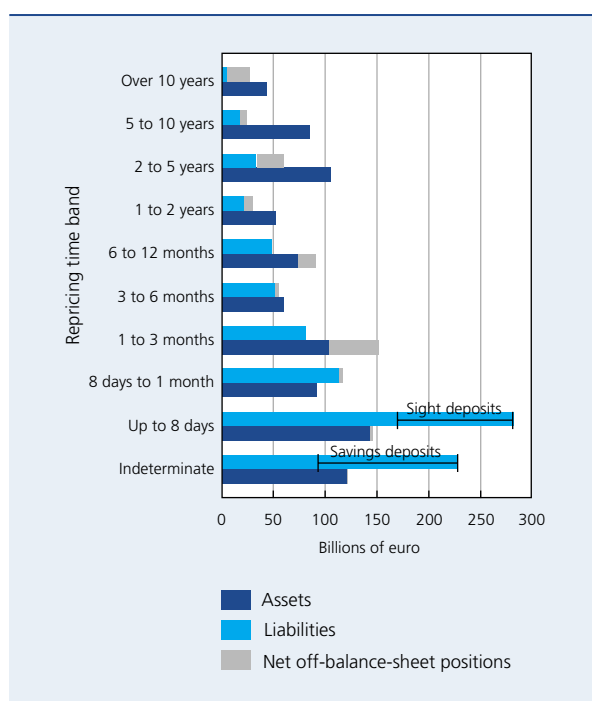
assets, liabilities, and off-balance-sheet instruments that reprice more than 10 years in the future. At the short end there is the “up to 8 days” time band recording all assets, liabilities, and off-balance-sheet instruments that reprice within 8 days. Sight deposits are by default classified in the shortest time band liabilities (91 billion euro in total, i.e. 32 p.c. of “up to 8 days” liabilities).

Apart from these nine specific time bands, there is an important “indeterminate” time band (bottom of Chart 5), containing all assets and liabilities that cannot readily be classified in any of the nine specific time bands. The bulk of the indeterminate liabilities is made up of savings deposits (134 billion euro, i.e. about 60 p.c. of total indeterminate liabilities), accrued charges and deferred income (23 p.c.), and own capital (14 p.c.), while deferred charges and accrued income (52 billion euro, i.e. 43 p.c. of total indeterminate assets), advances in overdrafts (15 p.c.), and fixed assets (25 p.c.) account for the bulk of the indeterminate assets. The size of the indeterminate time band is certainly not negligible, being the second largest on the liabilities side (after the “up to 8 days” time band), the third largest on the asset size, and the second largest in terms of gap (after the “up to 8 days” time band).

The structure of liabilities and assets across the time band spectrum suggests that Belgian banks fund a net amount of long assets with a net amount of short and “indeterminate” liabilities. Although off-balance-sheet instruments (interest rate swaps, forward rate agreements, interest options) have grown by an annual average rate of 16.5 p.c. over the last ten years, Chart 5 makes clear that their net positions do not fundamentally change the asymmetry in the balance sheet. While a part of the interest rate risk exposure can be seen to be hedged by means of net off-balance-sheet instruments, there remains a substantial mismatch between the repricing characteristics of banks’ assets and liabilities. Net off-balance-sheet positions are used to decrease (hedge) the existing on-balance mismatches for time bands “one to two years” and longer, while their use typically increases the existing on-balance mismatches below one year (notably the “6 to 12 months” and “1 to 3 months” time bands).

**CHART 5** AGGREGATE REPRICING TABLE OF THE BELGIAN BANKING SECTOR (DECEMBER 2003)

(Data at the end of december 2003 on an unconsolidated basis, billions of euro)



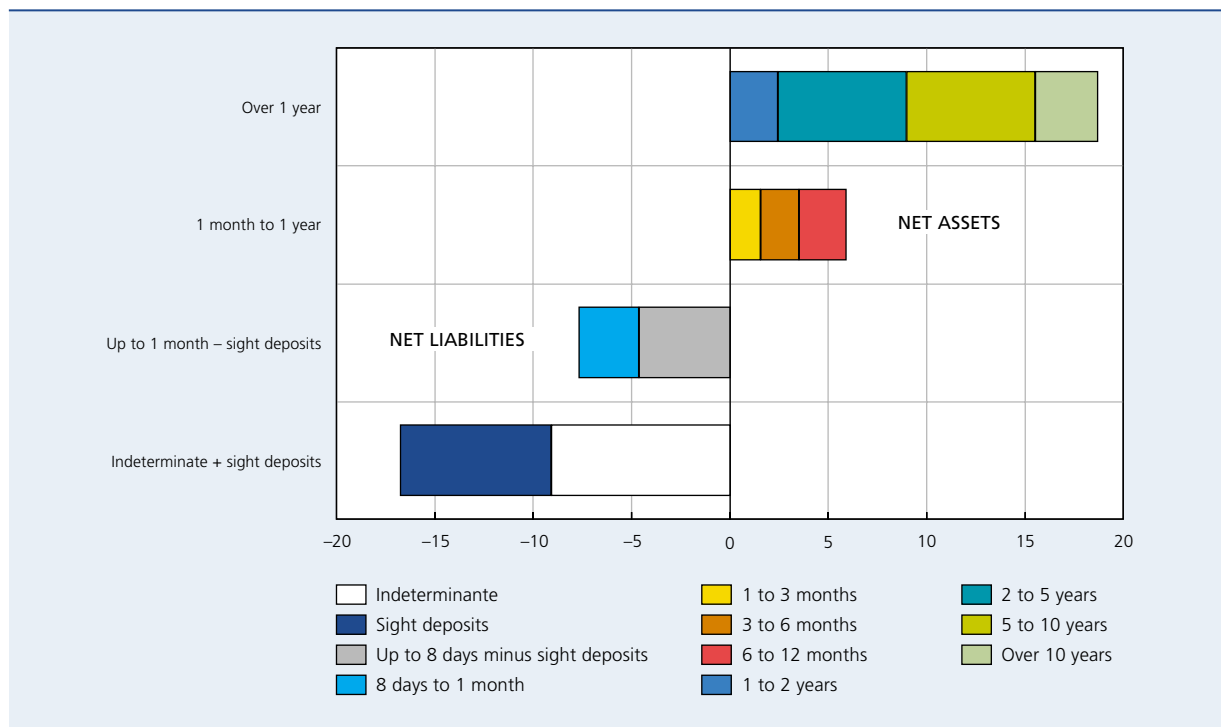
Source : NBB.

(21) For example, a capped adjustable rate mortgage with annual repricing could be considered to be fixed rate in a strongly rising interest rate environment and a one-year repricing asset in a declining rate environment.

(22) Downloaded from the Belgian prudential reporting scheme. The following data limitations should be mentioned. First, these data are not gathered at the consolidated bank account level, but only on a solo basis. Second, the data cannot distinguish between trading, banking and loan books. Given that trading book positions and mismatches can be rather quickly reversed (unwound), the observed mismatch will be sensitive to overestimation bias. However, in Table 2 we documented the fact that the size of the trading book positions is relatively small compared to the balance sheet total, hence the bias is likely to be small as well.

**CHART 6 SIMPLIFIED AGGREGATED GAP REPORT FOR THE BELGIAN BANKING SECTOR**

(Average aggregated gap report, from the first quarter 1993 to the last quarter 2003, percentages of total assets)



Source : NBB.

A rearrangement of the time bands sheds more light on the repricing transformation activity of Belgian banks. Chart 6 presents the simplified gap report, aggregating on- and off-balance-sheet positions and grouping selected time band, to provide a clearer view of the repricing transformation role of banks (average gap report 1993:Q1-2003:Q4). Given that the two middle time bands approximately offset each other, the chart suggests that Belgian banks mainly finance net long assets such as mortgages and Belgian government bonds with sight deposits and net indeterminate liabilities (which roughly equal total savings deposits in size). Of course, the two middle bands do not offset each other exactly and some of the net liabilities up to one month may finance net long assets over one year. Also, the net indeterminate liabilities do not necessarily equal savings deposits. But if one is willing to make these assumptions for simplicity, two separate areas in the repricing schedule emerge.

The two inner time bands in Chart 6 reflect the activity of banks in money markets and with large corporates (time advances, time deposits) and suggest that the interest rate risk exposure for the positions until one year is rather limited. The two outer time bands in Chart 6 reflect

the core business bank activity of attracting deposits to finance long-term assets. While the two outer time bands appear to suggest a large mismatch, the key to assessing the exposure to interest rate risk requires computing the *effective* or *behavioural* duration of sight and savings deposits. Despite a contractual maturity of basically zero for sight and savings deposits (being withdrawable on demand), both these types of deposits are referred to in the literature as non-defined-maturity deposits, since their effective maturity is not unambiguously defined, and is likely to substantially exceed the contractual maturity in normal market circumstances.

How should the effective duration of deposits be treated? Should deposits be tranching out over a number of months, quarters, or years or should the stable base be assigned to the long-term time band and the residual to the overnight time band? The answers to these important questions will depend on the view one holds, and they have led to controversy between standard setters, the industry, and supervisors in the recent IAS 39 debate. Indeed, in their risk management practices, bankers assume this behavioural duration to be relatively long (typically several years), reflecting a going concern view of the bank that net long assets are financed with a stable

base of core interest rate insensitive deposits<sup>(23)</sup>. Instead, some standard setters argue that the behavioural duration is substantially smaller in certain interest rate scenarios and that it lies closer to the contractual duration of sight and savings deposits. In the extreme, standard setters consider all balances to be overnight and very rate sensitive, reflecting a liquidation view of the bank. Prudential supervisors fall mostly in between these two extreme viewpoints. For example, they argue that in today's low interest rate environments deposits partially reflect funds sheltered from a less buoyant stock market. As interest rates increase, these funds will move to more productive investments, either in or outside of the bank. This suggests that the assumptions about the stable portion of deposits should be carefully reviewed and attention should be paid so that the risk sensitivity of deposits is not understated.

In the end, the allocation of instruments with an undetermined time to maturity to a specific time band remains an art as well as a science.

### 3.4 Deposit accounts and their embedded options

Deposit accounts constitute an important portion of the funding sources of a bank (see Table 2 above). Hence, both their *volume* and *pricing* potentially has a large impact on the interest rate risk exposure of a bank. While a deposit account looks like a fairly simple financial instrument, embedded options are attached that render their modelling and valuation complex.<sup>(24)</sup>

First, the depositor holds the option to withdraw all or part of the balance in the account at par. This withdrawal option poses a significant risk for any bank, given that it is generally exercised to the advantage of the holder, i.e. to the detriment of the bank. For example, when interest rate increases make depositors withdraw some of their funds to invest them at higher returns (and in the case where these withdrawals exceed reserves), a bank may need to sell off some of the long assets at a considerable loss or replace the cheap deposit financing with more costly alternatives. Of course, when a bank expects higher savings deposits withdrawals in the future due to higher interest rates, it can defend itself by buying put options or caps on the banking book portfolio securities. While the annual growth rate of savings deposits over the last ten years has been a sound 10.7 p.c. on average (exceeding the 4.7 p.c. annual average growth rate of total Belgian liabilities by far), the total amount of savings deposits between December 1999 and December 2000 did decrease by 5.9 billion euro, i.e. -5.9 p.c. of total savings deposits at that time.

Second, banks hold the option to set the interest rate that they pay to savings deposits holders, i.e. the *deposit rate*. They change this deposit rate at their own discretion, its movements being largely driven by competition and internal cost factors.<sup>(25)</sup> Stylised facts about deposit rates include the following (Van den Spiegel (1993) and O'Brien (2000)):

- Below-market rates are typically paid even after accounting for non-interest costs net of fees.
- Deposit rates exhibit substantial stickiness.
- Deposit rate adjustments tend to be asymmetric, displaying rigidity when market rates are increasing (so that rate spreads become larger), and flexibility when market rates are decreasing (so that rate spreads become smaller).

Deposited funds below a certain threshold are risk-free, given the existing Belgian deposit insurance scheme.<sup>(26)</sup> Yet, they pay rates that are typically lower than the corresponding risk-free rates. The market value of a financial instrument that pays less than the rate on a comparable-risk investment will reflect this arbitrage opportunity. Normally, such arbitrage opportunities are quickly eliminated by competition as other banks enter this lucrative market and start to bid up the price. However, the market for deposit accounts is not an active one like that for other liabilities such as bonds or equity, and substantial market power exists in retail deposit markets (Hutchison and Pennacchi (1996), Ausubel (1991) and Van den Spiegel (1993)). There are also regulatory barriers to entry, since one cannot simply start issuing deposits to arbitrage away the profit (Jarrow and van Deventer (1998)). The spread between what a bank might receive from investing the deposited funds at the risk-free rate and what a bank has to pay to the deposit holders (the deposit rate and the servicing cost) is called an economic rent in the literature (see Jarrow and van Deventer (1998)). As a result of the existence of economic rents, the market value of deposit account balances typically lies below par (Selvaggio (1996)). In other words, each

(23) The banks argue that the dispersion of savers reduces the likelihood of a sudden withdrawal in the absence of a systemic crisis, and argue that deposit insurance and emergency liquidity assistance allow to avoid such a systemic crisis. This article does not deal with the liquidity risk exposure of banks, but focuses only on the interest rate risk exposure.

(24) Moreover, deposit accounts also offer important payment services to their holder which are equally difficult to price.

(25) Note that the maximum retail deposit rate in Belgium has been regulated and legally capped at 4 p.c. from 1986 onwards. This cap concerns the base rate only, and not the growth premium (that is paid on every new amount left on an account during a well-defined period) nor the loyalty or fidelity premium (that is paid to each deposit left on an account during a specified period). These premia are also capped at 2 p.c. Note that the deposit rate on sight deposits balances is currently very low, 0.5 p.c., and typically remains unchanged, irrespective of market rate dynamics.

(26) In Belgium, deposit balances enjoy a state guarantee up to a specific coverage limit per customer of 20,000 euro, which is applied to the sum of a depositor's accounts at a failed bank (but no longer to each account separately). For a historical review of deposit insurance in Belgium and in Europe, see Garcia and Prast (2004).

euro of generated deposits creates shareholder value for the bank.<sup>(27)</sup>

## 4. Supervision of interest rate risk and the Basel II Accord

To assess the behavior and cash flows of financial instruments with embedded options in different interest rate environments, relatively more complicated approaches need to be applied to a more detailed breakdown of financial instruments. Box 3 provides a brief literature review. Embedded options complicate considerably the assessment of the interest rate risk exposure of the deposit-taking institution as a whole.<sup>(28)</sup> They also raise significant challenges for those needing to supervise the risk in banks' balance sheets. In fact, the complexity of measuring the impact of embedded options in deposit accounts was one factor in the decision not to adopt formal capital requirements for bank's non-trading positions (Fed (1995)). The general supervisory approach to the measurement of interest rate risk is discussed in Section 4, to which we now turn.

Ultimately, it is up to the capital owners of the bank to decide how much interest rate risk exposure they would like to assume. The responsibility of the supervisory authorities is to protect depositors and debt holders against excessive risk-taking by the bank. This section describes the general *supervisory framework* for measuring and monitoring interest rate risk exposures of banks.

(27) The present value of all future economic rents is non-zero. Indeed, banks typically pay premia when acquiring core deposits from other banks. A US study in *Bank Mergers & Acquisitions* (March 1995 issue) shows evidence of 49 core deposit transactions completed between February 4 and March 3 1995, and reports that the average premium paid was 10.17 p.c. of deposit balances (ranging from a low of 0.3 p.c. to a high of 27.1 p.c.).

(28) Within the framework of this article, we have chosen not to discuss other important balance sheet items with embedded options, such as bonds with call or put provisions and mortgage loans that allow borrowers to repay the balance early, with or without penalty. Mortgage early repayments occur for both economic and demographic reasons. Economic reasons may include interest rates decreasing sufficiently for refinancing to become profitable and demographic reasons may include home-owners moving to another region, divorcing, trading-up to a bigger house, or dying. In the US, the rate of demographic early repayments hovers around a constant percentage (about 6 p.c. per year), while the rate of economic early repayments can be substantially larger, up to 50 p.c. per annum when interest rates drop by 500 basis points or more (Uyemura and van Deventer, 1994).

### Box 3 – Deposit account modeling

In this Box, we briefly review the literature on deposit account modeling. With respect to the setting of deposit rates, two modeling approaches are used. It is either assumed that the bank is able to reset the deposit rate each period to maximise the present value of the balances (as in Hutchinson and Pennacchi (1996)), or that it resets the deposit rate periodically to obtain a target margin (as in Selvaggio (1996)). Van den Spiegel (1993) presents anecdotal evidence that deposit rate setting was used by Belgian banks to stabilise the global interest rate margin of the bank, so as to safeguard their important economic role as maturity transformers. Competition amongst banks shifted to providing services to the customers, which in turn led to the phenomenon of overbanking.

With respect to the modeling of deposit balance dynamics and their sensitivity to interest rate changes, there are roughly two methodologies available in the public domain. In the *option-adjusted spread* approach (Selvaggio (1996), OTS (2001) and Goosse et al. (1999)) expected cash flows are discounted using a discount rate that reflects their riskiness, due to the option risk. The main concern is to estimate the appropriate spread, referred to as the option-adjusted spread (OAS), which is added to the riskfree rate such that the present value of expected cash flows calculated over many different interest rate paths equals the observed market value. The market value of the deposit account is its face value minus the discounted present value of its economic rents. Typically the discount rate is assumed to be LIBOR plus the option-adjusted spread.

The idea in the *contingent claim* or *arbitrage-free valuation* approach (see Hutchison and Pennacchi (1996), Jarrow and van Deventer (1998), Janosi et al. (1999), O'Brien (2000), and Dermine (2003)) is to discount at the risk-free rate, but after adjusting the expected cash flows by subtracting a risk premium. Put differently, certainty-equivalent cash flows are discounted at the risk-free rate. The embedded options are modeled explicitly using option-pricing techniques. Future deposit account balances are a function of the path of future interest rates. The present value is calculated for a stream of cash flows over different interest rate paths, taking into account how the cash flows will vary as interest rates change. This is usually accomplished using a Monte Carlo simulation.





Both approaches always make assumptions about the specific arbitrage-free term structure models that is used for the simulation of market interest rate uncertainty (Vasicek (1977), Heath et al. (1992), Cox et al. (1985), etc.) and about how the deposit rate (symmetric or asymmetric) and deposit balances react with respect to changes in market interest rates. The deposit rate and deposit balance equations are typically estimated by means of a parsimonious autoregression. Ellis and Jordan (2001) give an elaborate review of the literature and summarize the findings with respect to duration and premia estimates. The Table below, which is a reflection of their work, shows that premia and duration estimates differ widely over the different studies and over the different kinds of deposit accounts.

**TABLE 1** ESTIMATED DEPOSIT ACCOUNT DURATION AND DEPOSIT ACCOUNT PREMIA

	Sample used	Sample period	Transactions account		Money market deposit account (MMDA)	
			Premia	Duration	Premia	Duration
Hutchison and Pennacchi (1996) . . .	200 banks	1986-1990	6.6	6.7	7.0	0.4
O'Brien (2000) . . . . .	100 banks	1983-1994	15.3	1.1	10.9	0.5
Janosi et al. (1999) . . . . .	Aggregate FED data	1988-1995	2.7	2.4	n.a.	n.a.
OTS (2001) . . . . .	Thriffs	1988-2001	7.0	2.8	2.0	1.3

Source: Ellis and Jordan (2001).

(1) Table entries are medians from the listed studies. The premia are expressed as percentage of the face value.

Most large Belgian banks seem to use a *replicating portfolio* approach to model the dynamics and price sensitivity of their deposits accounts.<sup>(1)</sup> The idea here is to choose the optimal portfolio of securities, financed by savings deposits, so that an optimal trade off is achieved between the resulting average margin, the volatility of the margin, and the prediction error made with respect to the *ex post* margin. The optimal trade off is chosen by the Asset and Liability Committee of the bank. Van den Spiegel (1993) suggests to shorten the duration of the replicating portfolio when interest rates are becoming abnormally low and high, i.e. when spread and volume risks are increasing, respectively. The duration of the replicating portfolio can be lengthened when interest rates have mean-reverted to normal levels.

(1) Goosse et al. (1999) point to some difficulties in the replicating portfolio approach and conclude that the market value of deposits accounts displays convexity, and that this convexity cannot be replicated by a portfolio of government zero coupon bonds.

Under current Basel I regulation, a bank is required to set aside capital to cover its credit and market risks, where the latter includes the interest rate risk in the trading book (but not in the banking book) (BIS, 1996). With respect to the trading book, a bank needs to hold sufficient capital to cover the sensitivity of market value of equity to a specific and unexpected change in interest rates. The unexpected change is defined as a shock of 100 bp at the shortest time band, gradually declining to a 60 bp shock at the longest time band. The Basel II Accord (BIS, 2003a) consists of a three Pillar approach<sup>(29)</sup>. Next to a more sophisticated and risk-sensitive treatment of credit risk and a status quo for the treatment of market risk,

Pillar I also considers operational risk. Pillar I is basically a refined and extended version of the Basel I regulation and like Basel I also imposes a formal capital requirement on the interest rate risk that originates from the trading book. Pillar II of Basel II invites bank regulators to control the level of interest rate risk in the banking book (next to other sources of risk). It urges supervisors to look for the banks that are *outliers* with respect to their interest rate risk exposure in the banking book. An outlier is defined as a bank that would lose more than 20 p.c. of its Tier 1 and

(29) Pillar III is about market discipline and reporting requirements and is outside the scope of this article.

Tier 2 capital due to a specific stress scenario (200 basis point shift of the flat yield curve or an equivalent scenario). Basel II does not impose specific rules about the behavioural assumptions that underlie the above test. Specifically, it does not impose detailed rules on how to treat deposit accounts. National supervisors will have the discretion to require additional capital or a reduction in the risk profile by imposing a hedge (for example, impose the purchase of a cap) on outlier banks that run excessive banking book interest rate risk.

The Belgian supervisory authority, i.e. the Banking, Finance, and Insurance Commission (BFIC), employs a threefold approach to the supervision of interest rate risk in the banking book. *First*, the BFIC computes interest rate risk ratios on a quarterly frequency and based on gap reports of individual banks on a solo basis, where the ratios compare the sum of weighted net mismatches over all time band against measures of capital and earnings. The weights applied to the gaps or mismatches are proxies for the modified duration of the different net asset and liability portfolios. Banks with ratios that exceed certain thresholds are defined as outliers. The resulting ratios are used as detection devices only and not as thresholds that automatically trigger extra capital requirements. The supervisor is well aware of the possible drawbacks and of the potential risks that might remain concealed when using repricing tables and gap reports. However, gap reports remain simple tools that may be used to assess possible mismatches within banks' balance sheets. The main advantage of the existing approach is its consistent comparison across banks. *Second*, outliers trigger on-site inspections to check more accurately with the bank's own data whether or not the bank is exposed to excessive interest rate risk in the banking or trading book. Possibly further prudential measures can be and have

been taken, following constructive dialogue between the BFIC and the bank under consideration. The BFIC asks the concerned banks to compute the duration of their assets and liabilities using detailed product information about cash flows and time of maturity. In addition, they provide the banks with specific assumptions and parameters, amongst others with respect to the assumed interest rate change and the duration of savings deposits<sup>(30)</sup>. For those banks where a specific duration gap threshold is exceeded between assets and liabilities, a specific extra capital charge is required by the BFIC. *Third*, the BFIC also regularly assesses the adequacy and effectiveness of a bank's interest rate risk management and the quality of risk measurement, monitoring and control functions, based on general principles issued by the Basel Committee of Banking Supervision (BIS, 2003b), of which a selection is reproduced in Box 4.

## 5. Concluding remarks

Banks finance their assets by means of liabilities with different maturity, duration, and repricing characteristics. This transformation activity of banks meets an important need in any economy, but potentially leads to the exposure of a bank's net interest income and market value of equity to unexpected changes in interest rates. Ultimately, banks do so because they expect to earn an extra return or risk premium from lending at a long rate and borrowing at a short rate (yield spreads are incomplete measures of excess returns and neglect the riskiness behind mismatching strategies). Moreover, because no bank is able

(30) The BFIC asks banks to assign the savings deposits to the "6 to 12 month" time band. For its own interest rate risk assessment, the BFIC in fact considers several assumptions about the risk weights, the distribution of savings deposits across the repricing schedule, and the assumed interest rate shock, where it takes care to remain consistent over all institutions in each scenario.

### Box 4 – Principles to be used by supervisors in evaluating the interest rate risk management of banks

The principles below represent a selection of the 15 principles that have been issued by the Basel Committee on Banking supervision (BCBS, 2003b) in order to help supervisors in their assessment of the adequacy and the effectiveness of a bank's interest rate risk management, in assessing the banking book interest rate risk exposure, and in developing an adequate supervisory response to that risk.

#### Risk measurement, monitoring and control functions

- It is essential that banks have interest rate risk measurement systems that capture all material sources of interest rate risk and that assess the effect of interest rate changes in ways that are consistent with the scope of their activities. The assumptions underlying the system should be clearly understood by risk managers and bank management.
- Banks must establish and enforce operating limits and other practices that maintain exposures within levels consistent with their internal policies.



- Banks should measure their vulnerability to loss under stressful market conditions – including the breakdown of key assumptions – and consider those results when establishing and reviewing their policies and limits for interest rate risk.
- Banks must have adequate information systems for measuring, monitoring, controlling and reporting interest rate exposures. Reports must be provided on a timely basis to the bank's board of directors, senior management and where appropriate, individual business line managers.

#### Information for supervisory authorities

- Supervisory authorities should obtain from banks sufficient and timely information with which to evaluate their level of interest rate risk. This information should take appropriate account of the range of maturities and currencies in each bank's portfolio, including off-balance-sheet items, as well as other relevant factors, such as the distinction between trading and non-trading activities.

#### Capital adequacy

- Banks must hold capital commensurate with the level of interest rate risk they undertake.

#### Supervisory treatment of interest rate risk in the banking book

- Supervisory authorities must assess whether the internal measurement systems of banks adequately capture the interest rate risk in their banking book. If a bank's internal measurement system does not, banks must bring the system to the required standard. To facilitate supervisors' monitoring of interest rate risk exposures across institutions, banks must provide the results of their internal measurement systems, expressed in terms of the threat to economic value, using a standardised interest rate shock.
- If supervisors determine that a bank is not holding capital commensurate with the level of interest rate risk in the banking book, they should consider remedial action, requiring the bank either to reduce its risk, to hold a specific additional amount of capital, or a combination of both.

to systematically outguess market expectations, it is risk premia and not interest rate expectations that should drive the maturity and repricing mismatches of banks. However risk premia are not stable through time, but fluctuate widely in ways that cannot easily be linked to variables such as the level of current interest rates and economy-wide variables. While the statistical properties of risk premia can be captured by modern state-of-the-art term structure models, an economic explanation is still lacking and stands as a challenge for finance researchers.

This paper has presented estimates for the interest rate risk exposure of the aggregate Belgian banking sector, both from a liquidation perspective and going concern perspective. The average ratio of net interest income to total income seems to have declined slowly over the last ten years reflecting disintermediation, although important differences between large, medium-size, and small banks can be distinguished in the dynamics and level of this ratio. In line with results for other countries, this paper finds that the statistical evidence about the interest rate determinants of changes in Belgian net interest income is not clear-cut, possibly reflecting the fact that net interest income captures a lot more than what is generated by the maturity transformation role of banks. The impact of

current accounting practices that allow banks to smooth their income through shifting securities from the trading book to the banking book at their discretion might also be important. In this respect, one of the objectives pursued by IAS 39 is to increase the transparency of banks' risk-taking.

The repricing gap report of the aggregate banking sector allows us to identify the main interest rate risk exposure of Belgian banks. The inner time bands reflect the activity of banks in the money market and with large corporations and suggest a rather limited interest rate risk exposure, notwithstanding the fact that off-balance-sheet instruments typically increase the existing mismatch in this part of the repricing schedule. The outer time bands of the gap report reflect the core activity of Belgian banks of taking sight and savings deposits to finance long term assets. The interest rate risk exposure is sizeable, despite the fact that off-balance-sheet instruments typically reduce the level of the individual on-balance-sheet mismatch in this range of the repricing schedule. To the extent that deposit balances have a behavioural duration that significantly exceeds their contractual duration, interest rate risk exposure may still be limited. However, in today's low interest rate environment, deposits at

least partially reflect funds sheltered from a less buoyant stock market. As interest rates increase, these funds may move to more productive investments either in or outside of the bank, leaving the bank exposed to higher financing costs. In this respect, assumptions about the stable portion of deposits deserve careful review, so as not to understate the risk sensitivity of savings deposits in specific interest rate scenarios.

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