Measuring the interest rate risk of Belgian regulated savings deposits

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Introduction

Deposits are at the core of banks' financial intermediation function. By issuing deposits, banks reconcile the wishes of small savers for high liquidity and low risk with the needs of investors, who require stable funding for risky, large, and long term projects. By transforming liquid deposits into long term assets, banks expose themselves to interest rate, credit, and liquidity risks, for which they are remunerated by a typically positive interest rate margin.

There exists a wide range of deposit accounts. *Sight deposits* can be withdrawn at any time and may be used as means of payments, but barely offer positive nominal returns. *Term deposits* offer substantially higher market-consistent returns, but cannot be withdrawn until their defined contractual term expires. *Savings deposits* are special, in the sense that they preserve a high degree of liquidity, while offering a relatively attractive rate of return.(1)

In Belgium, savings deposits are also special because they are the subject of important regulation affecting their pricing, remuneration structure, and fiscal treatment.(2) The favourable fiscal treatment aims to promote savings, whereas the price and remuneration structure regulation aims more at promoting economic objectives, such as the stimulation of fixed interest loan contracts by decreasing the variability of banks' volume and cost of funds.

Yet, savings deposit accounts raise important financial stability issues. Not only do they represent a significant proportion of banks' liabilities, but the large volume of funds is used as a major maturity transformation instrument, since aggregate savings deposit volumes tend to be fairly stable. However, depositors possess the right or option to withdraw all or a part of their deposited funds at any time. The existence of this "embedded" option, together with the bank's option to change the savings deposit rate in response to market rate changes, complicates banks' risk management and supervisors' prudential assessment. Nonmaturity accounts are complex financial instruments to price, value, and manage.

The difficulty of measuring the interest rate risk of savings deposits is mainly due to the presence of the two embedded options mentioned above, which are clearly not independent of each other. For example, if banks were to raise deposit rates only partially in response to an increase in market rates, depositors might withdraw their balances, or part of them, in order to invest their funds at the higher market rates. However, if banks fully adjust savings deposit rates to increases in market rates, the bank incurs a substantial cost as the increased deposit rate applies to all existing deposit balances, including the portion that would not have been withdrawn in the absence of a full adjustment. Such considerations and interactions show that repricing and volume risks should be studied jointly within an interest rate risk framework.

(1) In general, deposit accounts with uncertain effective maturity, i.e. sight and savings deposits, are often referred to as *nonmaturity* deposit accounts. Nonmaturity refers to the fact that the behavioural or effective maturity is perceived to be quite different from the contractual maturity, which is zero or close to zero. The return wedge between nonmaturity and defined maturity deposit accounts can be interpreted as an extra illiquidity risk premium that term depositors implicitly require. Alternatively, nonmaturity depositors can be thought to pay an insurance premium against illiquidity by accepting a lower return.

(2) The price and remuneration structure regulation is first specified in the Royal Decree of December 29 1983 and updated in the Royal Decree of August 27 1993 (KB/WIB 1992), while fiscal regulation of savings deposits already goes back to 1962. See Box 3 in the Overview of this FSR for further details. Belgium is not unique in regulating savings deposits. France, for example, also has a similar regulation in place for its saving passbooks, while Finland also had tax exempt deposits until mid 2000.

We analyse the interaction of bank and depositor behaviour from a conceptual point of view and discuss the different modelling approaches that can be used to model and measure it. While we focus on the special case of savings deposit accounts in this article, our analysis has a wider relevance, as similar modelling techniques can be applied to other financial instruments with effective maturities that differ from contractual ones, such as sight deposits or mortgage loans with embedded prepayment options.

The article is structured as follows. Section 1 analyses the stylized facts of Belgian regulated savings deposits, i.e. importance in the Belgian economy, recent evolution, and description of deposit volume and rate dynamics. Section 2 then focuses attention on the different approaches to measure savings deposits' interest rate risk. Finally, Section 3 concludes.

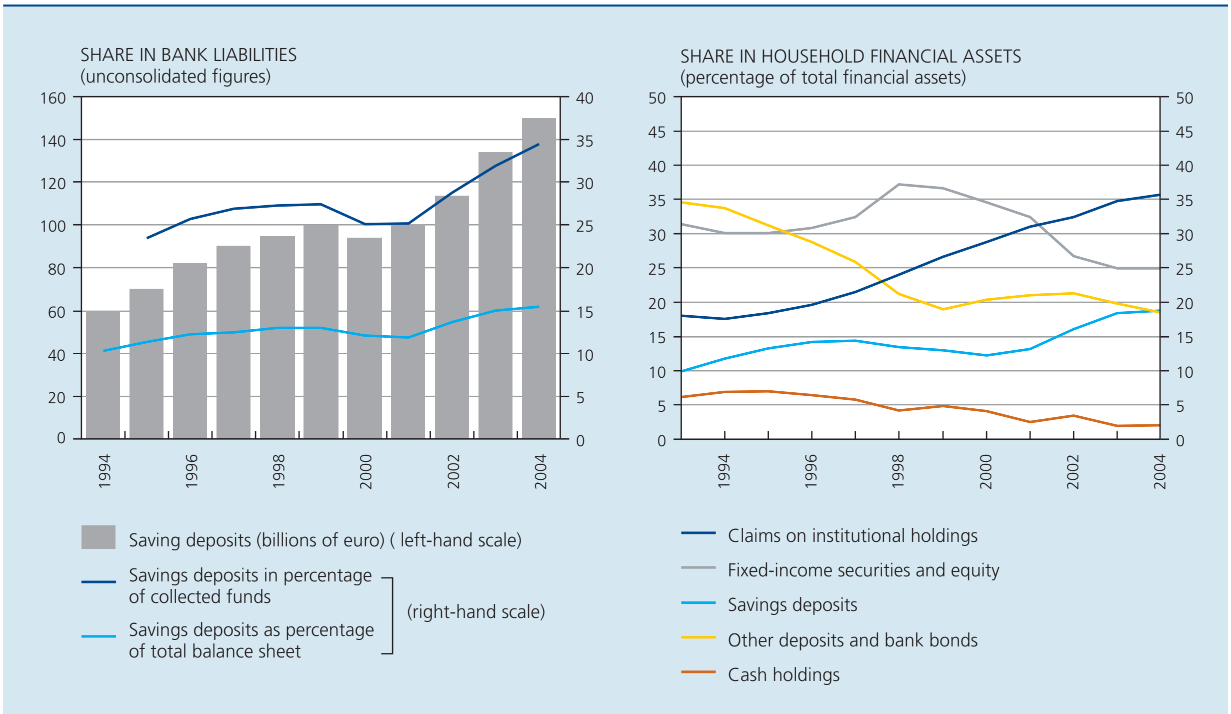
1. Importance and dynamics of Belgian regulated savings deposits

1.1 Importance

Savings deposits play an important role in the funding of Belgian banks. The left-hand side panel of Chart 1 shows that they increased from 60 billions of euro in December 1994 to 150 billions in December 2004, i.e. somewhat more than 50 p.c. of Belgian 2004 GDP. Savings deposits also gained importance in relative terms. The share of regulated savings deposits in bank liabilities increased from 10.3 p.c. to 15.5 p.c. in the last decade, while, expressed as a percentage of funds collected from customers (i.e. bank bonds and total deposits), their share increased from 23.5 p.c. to 34.4 p.c.

The above aggregate ratios conceal the fact that there is actually a substantial amount of variation across banks, according to their specialization and size. For example, whereas savings deposits account for 11 p.c. of liabilities on average for the 4 largest Belgian banks in 2004, this average proportion reaches 43 p.c. for the medium-size banks specialised in the distribution of this product.

CHART 1 IMPORTANCE OF REGULATED SAVINGS DEPOSITS FOR BELGIAN BANKS AND HOUSEHOLDS



Source : CBFA, NBB.

The right-hand side panel of Chart 1 shows that savings deposits also account for a significant and increasing proportion of Belgian household assets : their share increased from 9.9 p.c. in December 1993 to 18.8 p.c. in September 2004. As a result, savings deposits have recently outstripped the combined total of bank bonds and all other deposits held by households.

The importance of savings deposits in the interest rate risk management of Belgian banks is illustrated in Chart 2. The chart groups Belgian banks' assets, liabilities and net off-balance-sheet (OBS) positions according to their remaining time to repricing, from up to 8 days to more than 10 years. The difference between the long and the short positions across the repricing buckets is synthesised in the line indicating the overall net position. This latter is positive at the long end of the maturity spectrum and negative at the short end, which confirms the typical maturity transformation function of Belgian banks.

Besides the nine repricing buckets with specific time to repricing intervals, there exists a considerable amount of assets and liabilities with *indeterminate* time to repricing. For example, savings deposits are classified in this category and represent about 50 p.c. of all liabilities with indeterminate time to repricing.[1] However, to the extent that savings deposits effectively have a high degree of stability and relatively sticky interest rates, they should be allocated to longer maturity buckets for risk management purposes, thereby helping to dampen the overall interest rate risk.

1.2 Deposit rate dynamics

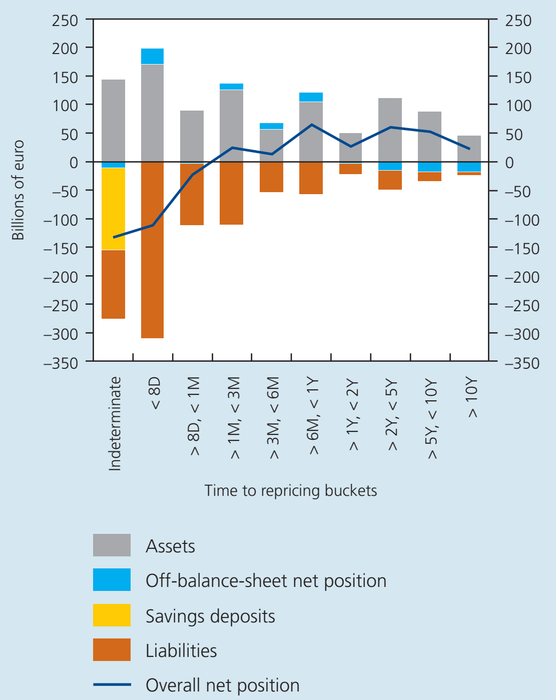
Chart 3 represents a quarter century of monthly Belgian market and savings deposit rates. More specifically, the savings deposit rate -proxied here by the base rate plus the loyalty premium offered by a major player in the market, hence representative of the rates applied by the large Belgian banks- is plotted against the 3m Treasury Certificate rate and the 10 year government bond rate. Focussing on the market rates, we observe a positively sloped yield curve in most of the past 25 years, with some exceptions in the early 1980s and 1990s. Comparing market with deposit rates, we see that savings deposit rates on average lie substantially below market rates.

(1) Own funds and fixed assets such as own buildings are also classified in the indeterminate time to repricing bucket, whereas mortgage loans are classified according to their contractual time to repricing, despite the presence of an early repayment option.

(2) Ausubel (1990) and Neumark and Sharpe (1992) show that the market structure indeed affects the deposit rate setting behaviour of banks. For example, both the equilibrium level and the speed of adjustment of deposit rates are found to depend on market concentration. It turns out that deposit rates are on average higher in less concentrated markets, in line with what we expect.

CHART 2 ASSETS AND LIABILITIES OF THE BELGIAN BANKING SECTOR ACCORDING TO RESIDUAL TIME TO REPRICING

(September 2004, unconsolidated figures, billion of euro)



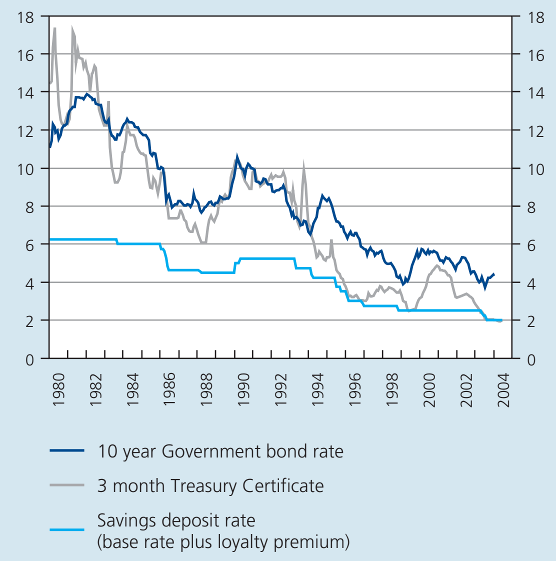
Source : CBFA, NBB.

The spreads between long rates and savings deposit rates have been relatively stable, decreasing only slightly over time. Spreads between short market rates and savings deposit rates are much less stable and have dropped significantly in the last decade.

The decreased spreads between market and deposit rates may reflect a combination of structural changes in the market. Among these factors we could mention (i) the smaller cross-subsidisation by savings deposits of other banking products, (ii) lower servicing costs of savings deposits thanks to advances in technology, and (iii) changes in the competitive conditions. The latter refer to increased competition between savings deposits and other banking products, as well as increased competition between different banks within the market for savings deposits. Indeed, interest margin competition seems to have increased over time.[2] While the share of total liabilities of the four largest banks in the sector increased strongly during the last decade due to a wave of mergers and acquisitions, an inverse trend can be observed for the savings deposits in the same time span, where the share of the four largest banks actually decreased

CHART 3 BELGIAN MARKET AND SAVING DEPOSIT RATES

(Percentages)



Source : NBB.

from 75 to 69 p.c.. A further Herfindahl-Hirschman index (HHI) analysis[1] signals that the competitive pressure is coming from a couple of medium-sized players, since the HHI for savings deposits still increased between December 1994 and December 2004 (from 1,130 to 1,800). However, the growth in the HHI for total liabilities was much stronger (from 760 to 2,580), so that the ratio of the former to the latter gradually dropped from 140 p.c. in 1994, to only 85 p.c. in 2004.

Despite these spread-tightening factors, Chart 3 indicates that savings deposit rates have been and still are rather sticky compared to market rates. When banks change the savings deposit rate, they seem to do so in a partial and sluggish way, i.e. in the same direction as lagged market rates and typically in multiples of 1/8th percentage points. The savings deposit rate level is capped by law, but binding deposit rate ceilings do not appear to have been the dominant factor in explaining deposit rate stability.[2] Indeed, deposit rates were also stable in the period prior to 1983, when there was no legal cap, and in recent years, when the cap was no longer binding. An obvious explanation for the upside deposit rate stickiness is that a repricing of savings deposits is not limited to newly issued deposits, as is the case with term deposits, but involves all outstanding balances. Hence, increasing the savings deposit rate is relatively costly for a bank with a large volume of savings deposits.

Box 1 presents further econometric evidence of partial, and asymmetric, adjustments of Belgian savings deposit rates.

1.3 Deposit balance dynamics

Deseasonalised savings deposit balances have grown fairly steadily over time.[3] During the last quarter century, they increased by 4.1 p.c. annually on average in real terms (7.1 p.c. in nominal terms). These averages conceal the fact that growth has been relatively strong in the last 5 years (6.2 p.c. real, 8.2 p.c. nominal), and was more moderate in the 80s and 90s (3.5 p.c. real, 6.9 p.c. nominal).

Chart 4 shows year-on-year growth rates of deseasonalised savings deposits. Despite the typically positive growth rates, aggregate deposit balances have sometimes decreased in the past, as illustrated by the negative growth rates in the periods 1990-1994 and 2000-2002. Deposit balances dropped by about 12 billions of euro (peak to trough in 1990-1994), i.e. approximately 20 p.c. of February 1990 balances, and by about 8 billions of euro (peak to trough in 2000-2002), i.e. approximately 8 p.c. of January 2000 balances.

Either general market conditions or idiosyncratic events may cause depositors to withdraw all or part of their balances.[4] Given that idiosyncratic events (e.g. death, divorce, relocation, house-ownership, etc.) are to a large extent diversifiable across depositors, aggregate deposit balance dynamics are driven by general market conditions.

More specifically, as is clearly illustrated in Chart 4, savings deposit balance growth rates are affected by depositors' opportunity cost, i.e. the maximum return that the deposited funds could earn if the funds were not deposited in a savings account. We approximate the opportunity cost as the difference between the 3m Treasury Certificate rate, net of withholding taxes, and the deposit rate.

(1) The Herfindahl-Hirschman statistic is defined as the sum of squared market shares (in percentage points) of individual banks. The statistic decreases both as the number of banks in the market increases and as the disparity in size between the banks decreases. It approaches zero when the banking sector consists of a very large number of banks of relatively equal size.

(2) The Royal Decree of August 27 1993 (KB/WIB 1992) specifies that the remuneration of savings deposits must consist exclusively of a base rate and a growth or loyalty premium. See also Box 3 in the Overview of this FSR for further details about the remuneration structure. Since April 1990, the legal ceiling has remained unchanged at 6 p.c., i.e. a base rate ceiling of 4 p.c. and a premium ceiling of 2 p.c. Between December 1983 and April 1990, the ceiling has been changed on various occasions.

(3) Savings deposit balances data show clear end-of-calendar-year effects, due to the pay-out of interest to the deposit holder at the end of each calendar year. Therefore, deseasonalised balances are analysed.

(4) Note that the Royal Decree of August 27 1993 (KB/WIB 1992) stipulates that banks must be able to require a 5 days' notice for withdrawals exceeding 1,250 euro and to impose a limit on withdrawals of 2,500 euro in any two-week period. In practice, these options are hardly used.

Box 1 – Belgian savings deposit rate dynamics

Deposit rate dynamics may be further analysed following O'Brien (2000), who has estimated a partial adjustment model for U.S. retail deposit rates. In the model, deposit rate changes depend on whether deposit rates are above or below a possibly time-varying long-run equilibrium or target deposit rate, which in turn is assumed to be a function of market rates. The model allows for an asymmetry in the reaction speed at which the deposit rate is expected to mean-revert to its long-run equilibrium level, since the upward change parameter may differ from the downward change parameter. O'Brien finds that deposit rates are particularly sluggishly when deposit rates are below their long-run equilibrium level, but adjust more swiftly when they are above this level. This asymmetry is considered to be a stylized fact of deposit rate dynamics in many countries. We estimate a similar non-linear partial adjustment model for Belgian implicit deposit rate changes[1]:

$$\Delta R_t = \big(\lambda^+ I_t + \lambda^-(1-I_t)\big)(br_t - g - R_{t-1}) + e_t$$
$$I_t = 1 \quad \text{if} \quad br_t - g - R_{t-1} > 0$$
$$\mathrm{I}_t = 0 \text{ otherwise}$$

where λ^+, λ^-, b, and g are the parameters to be estimated. The variable R_t stands for the deposit rate and $br_t - g$ is defined as the unobserved time-varying equilibrium deposit rate, itself a function of the market rate r_t (3m Euribor in our application). O'Brien argues that the long-run equilibrium deposit rate should be at a break even level. Hence, b can be considered to be a proxy for 1 minus the marginal reserve requirement if such a requirement applies, and g reflects the servicing cost and hence should be positive. I_t is an indicator variable that signals whether actual deposit rates are above or below the long run equilibrium deposit rate level. The estimates of the parameters λ^+ and λ^- will then teach us whether deposit rates adjust at different speeds when they are above or below the equilibrium level, respectively.

TABLE 1 ESTIMATES FOR THE PARTIAL ADJUSTMENT MODEL FOR BELGIAN IMPLICIT DEPOSIT RATES

(Data from June 1996 to September 2004)

Parameter	Range of parameter estimates for the four largest Belgian banks
λ^+	0.000 to 0.002
λ^-	0.072 to 0.267
b	0.826 to 0.990
g	0.000 to 0.005

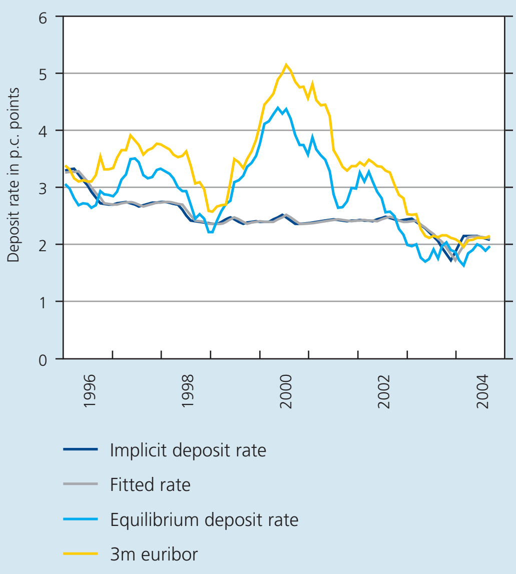
Table 1 presents the range of constrained nonlinear regression coefficient estimates that we obtain for the four largest Belgian banks, using a sample of 1996:06-2004:09 implicit deposit rates and the 3m Euribor rate for the market rate. The estimates are qualitatively similar to O'Brien's (2000), since we also find asymmetry in the adjustment of deposit rates towards the long run equilibrium level : λ^+ is estimated to be substantially smaller than λ^-, which implies that deposit rates react rather sluggish towards a higher long run equilibrium deposit rate, but respond more swiftly to a lower long run equilibrium deposit rate[2].

(1) Implicit deposit rates are defined as the ratio of the interest that is paid out by the bank over a certain period divided by the average outstanding balances over the same period. Compared to advertised rates, defined as the sum of base and premium rates, implicit deposit rates may better reflect the true cost to the bank, given the sometimes intricate day count rules that apply to the premium rates. Moreover, implicit rates make it easier to integrate pre- and post-merger deposit rate data.

(2) We have formally tested the asymmetry in deposit rate dynamics by computing a test statistic based on the sum of squared errors for both the unrestricted asymmetric and restricted symmetric model. The asymmetry is found to be statistically significant for most banks at conventional confidence levels.

CHART 1 MARKET AND DEPOSIT RATE DYNAMICS FOR A REPRESENTATIVE BELGIAN BANK IN A PARTIAL ADJUSTMENT MODEL

(Percentages, quarterly data)



Source : NBB.

The June 1996 to September 2004 partial adjustment dynamics for a representative Belgian bank are plotted in Chart 1, results being qualitatively similar for other banks. It can be seen that the model fits actual deposit rate levels and changes well. Actual deposit rates seem to decrease most when actual rates are above their long-run equilibrium level, whereas they remain relatively sticky when actual rates are below the long-run equilibrium level.

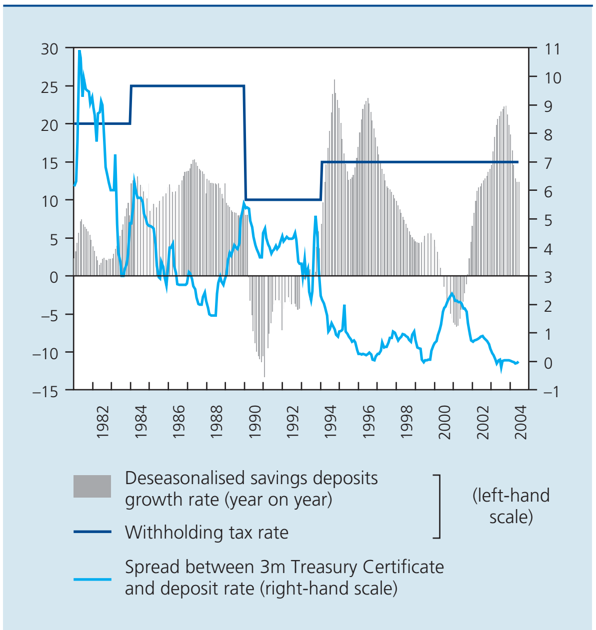
Defined as such, the opportunity cost is affected by two components : (i) the interest rate spread between the 3m Treasury Certificate rate and deposit rates and (ii) the withholding tax level. We expect a priori that an increased opportunity cost, i.e. a higher spread or a lower withholding tax level, leads to lower or negative deposit balance growth rates, and vice versa.

Both components appear to be important in understanding depositors' withdrawal behaviour. Indeed, the level of the withholding tax rate provides a partial explanation for deposit balance dynamics, as a substantial amount of earned interest on regulated savings deposits is exempt from this tax. The drop in aggregate deposit balances in 1990 coincides with the drop in the withholding tax from 25 p.c. to 10 p.c. in 1990. When the withholding tax was raised again in 1994 to 15 p.c., deposit balances returned to positive growth rates.

However, withholding tax regime changes are unable to explain the drop in aggregate balances in 2000-2002, since the withholding tax regime has remained unchanged since 1994. The second component of the opportunity cost, the increased spread between market and deposit rates, may have played a role here. Table 1 reports estimates from regressing the deseasonalised monthly changes in log deposit balances on a constant and the spread between 3m Treasury Certificates and the deposit rate. In line with what we expect, we find an inverse relation between the spread and savings deposit balances growth rates. More specifically, for each percentage point increase in the spread, the monthly deposit balance growth rate is

CHART 4 MAJOR DETERMINANTS OF MONTHLY YEAR-ON-YEAR CHANGES IN AGGREGATE SAVINGS DEPOSITS

(Unconsolidated figures, percentages)



Source : NBB.

TABLE 1 SENSITIVITY OF DEPOSIT BALANCE GROWTH RATES TO CHANGES IN INTEREST SPREADS

(Sample period : January 1981 to December 2003)

	Full sample	Pre 1994	Post 1994
Constant	0.934	0.837	1.271
Spread (monthly p.c.)	–0.116	–0.092	–0.535
p.m. Spread (annual p.c.) . .	*–1.4*	*–1.1*	*–6.6*

Table entries are ordinary least squares coefficient estimates. Corresponding *t*-statistics, corrected for heteroskedasticity and autocorrelation, are not reported, but imply statistical significance at conventional confidence levels. The spread is the difference between the 3m Treasury Certificate and the deposit rate (base rate plus loyalty premium). Monthly changes in deseasonalised log balances are used as dependent variable.
Source : NBB.

expected to be 0.116 p.c. lower, which corresponds to a 1.4 p.c. lower annual growth rate.

The sensitivity of annual growth rates is estimated to be only 1.1 p.c. when we focus on the pre-1994 subsample and as high as 6.6 p.c. in the post-1994 subsample, which may signal increased mobility and sophistication of small investors in the last decade.(1) The post-1994 increased sensitivity of deposit balance growth rates to changes in spreads between market and deposit rates can also be observed in Chart 4.

Notwithstanding this evidence on sensitivity of savings balances to rates, it is clear that depositors on aggregate do not withdraw their entire balances when rates on alternative investments are higher, i.e. it is not only deposit rates but also deposit balances that tend to behave in a sluggish way. This is also found to be the case in other countries. The term "core deposits" is sometimes used to reflect the fact that a substantial part of savings deposit balances is held by retail depositors who are not highly rate sensitive and are not expected to withdraw their balances over a short period of time. Key factors that may explain such behaviour are switching costs, mainly in relation to the services provided to the customer or the information cost incurred by looking for alternatives.

2. Measuring the interest rate risk of savings deposits

As illustrated in Section 1, deposit rate and balance dynamics of savings accounts are clearly intertwined. In practice and to limit the repricing impact of deposit rate changes, banks only sluggishly adjust savings deposit rates. However, if savings deposits are not fully and immediately repriced with market rates, this may entail an outflow of deposits, which banks will have to replace at a higher cost. In the end, the volume and repricing effects have to be taken into account simultaneously in the interest rate risk management of banks.

To measure the interest rate risk of savings deposits, two approaches can be adopted. The first one centres on banks' profitability and net interest income at risk. If the sensitivity of deposit rates and balances to market interest rate increases is underestimated, bank profitability will decline unexpectedly, as deposit rates are repriced more quickly and deposit balances are withdrawn more quickly than anticipated. If the sensitivity to market rate increases is overestimated, the bank may as a result invest in relatively short-term assets to hedge the interest rate risk and thus forego more profitable long-term investments.

Alternatively, the assessment can be based on the impact on banks' solvency or market value of equity at risk. In case of a move in market interest rates, it is important to measure the market value sensitivity of savings deposits, since savings deposits value changes may partially offset

(1) A formal Chow breakpoint test statistic confirms the statistical significance of the difference in sensitivity between the two subsamples. The p-value of the test statistic is 1.2 p.c.

the value change in the other direction on the asset side, thereby acting as a hedge for the market value of equity.(1) In this article, we focus upon the latter solvency approach and analyse the *duration*, i.e. market value sensitivity to interest rate changes, of savings deposits.

Section 2.1 illustrates the impact that different savings deposits duration hypotheses can have on the assessment of the interest rate risk of Belgian banks. Section 2.2 discusses the various models that are available to estimate the duration of savings deposits. Finally, Section 2.3 critically discusses these models from a statistical and especially prudential point of view.

2.1 Duration of nonmaturity accounts : should we care ?

The contractual duration of savings deposits is close to zero. However, in normal times, the behavioural or *effective* duration of savings deposits is much larger and will depend on the sensitivity of deposit rates and balances to market rates. Extreme sensitivity to changes in market rates gives rise to a zero duration, whereas extreme insensitivity or sluggishness of deposit rates and balances gives rise to a much longer duration, close to the duration of a consol.

(1) We define equity as net assets, i.e. what remains after deducting liabilities from assets.

(2) Banks typically measure the duration of savings deposits in their internal models by allocating savings deposits to various categories, such as core, volatile and remaining deposits, where each of these categories receives a specific duration. The exercise here in fact assumes that the weighted average total duration across these categories is equal to 0 to 5 years.

(3) The risk weights are computed as proposed by the Basel Committee on Banking Supervision, i.e. as the approximate modified duration times the assumed interest rate shock (see BIS (2004)). The approximate modified duration calculation is based upon the midpoints of each time bucket, e.g. a time to maturity of 3.5 years is used to proxy for the modified duration of exposures in the 2 to 5 year time to repricing bucket.

(4) It is important to realise that these losses of market value of equity will not be immediately and fully reflected in banks' profit and loss through a lower net interest income. The change in market value of equity, i.e. the discounted sum of future net interest income, simply measures the difference in price when liquidating the bank's assets and liabilities before and after the yield curve shock (liquidation viewpoint and not going concern viewpoint).

In fact, the effective durations differ widely across time and banks, possibly reflecting bank-specific deposit rate setting behaviour, client-specific withdrawal behaviour, the general interest rate environment, and differences in the modelling approaches used by banks to estimate duration.

The importance of variation in duration estimates is reflected in Table 2, which illustrates the impact of unexpected yield curve shocks on the market value of equity of the Belgian banking sector for different savings deposits duration assumptions, all else remaining equal.(2) The table reports the results of interest rate stress tests for the overall Belgian banking sector for six different durations of savings deposits (from 0 to 5 years). The shock tested is a 2 p.c. upward shift of the entire yield curve. The data used for this test are (i) the various net exposures per time to repricing bucket as illustrated in Chart 2 and (ii) risk weights per time to repricing bucket that proxy for the impact of the simulated yield curve shock on the market value of equity in the different time buckets.(3) The risk weights are then multiplied by the net exposures and the sum of these products gives an estimate of the change in the market value of equity following specific yield curve shocks.

The stress tests also require to introduce hypotheses concerning the duration of sight deposits. As they can be withdrawn at any time, sight deposits are incorporated, in the supervisory reporting scheme, in the repricing bucket 'up to 8 days'. However, these deposits are mostly held for transaction purposes instead of investment purposes which makes them quite insensitive to interest rate changes. To take this specificity into account, an ad-hoc treatment has been introduced through two hypotheses. In a first scenario, 50 p.c. of sight deposits are kept in the 'up to 8 days bucket' while the other 50 p.c. are shifted to offset the longest positive net exposures. In the second scenario, 100 p.c. of sight deposits are used to offset the exposures with the longest duration.

TABLE 2 IMPACT OF A 2 P.C. UPWARD PARALLEL YIELD CURVE SHOCK ON THE BELGIAN BANKING SECTOR'S MARKET VALUE OF EQUITY (1)

(Expressed in percentage of regulatory own funds, unconsolidated December 2004 figures)

Hypotheses for sight deposits	Duration of savings deposits in years					
	0	1	2	3	4	5
50 p.c. offset of longest positive exposures	–14.0	–8.5	–3.3	1.8	6.6	11.2
100 p.c. offset of longest positive exposures . . .	–7.0	–1.5	3.7	8.7	13.6	18.2

Source : NBB.
(1) Calculated under the hypothesis of an initial flat 4 p.c. interest rate with all currencies converted to euro.

As can be expected for a banking sector largely engaged in maturity transformation activities, the market value of Belgian banks' equity would be significantly affected by large unexpected upward yield curve shifts[4]. More importantly, Table 2 indicates that, for any given yield curve shock, the specific duration estimate of savings deposits has a large impact on the ultimate change in market value of equity. There is a clear monotonic relation between the impact of parallel yield curve shocks and the duration, with smaller duration resulting in a larger negative impact.

Under the hypothesis that only 50 p.c. of sight deposits are shifted to the long end of the repricing spectrum, a 2 p.c. parallel shock is projected to reduce the banking sector's market value of equity by an amount equal to 14 p.c. of regulatory own funds when the average savings deposits duration is assumed to be 0. This negative impact is reduced to 8.5 p.c. when the duration is assumed to be 1 year. If all sight deposits are allocated to the repricing bucket with the longest duration, those losses are reduced respectively to 7 and 1.5 p.c. of regulatory own funds.

It is also interesting to observe that the banking sector becomes liability sensitive when savings deposits are assumed to have relatively long durations. In this case the market value of equity would start to increase after a parallel increase in interest rates in this case[1].

Internal model estimates of duration differ substantially across individual banks. In the next section, we will discuss the most common models that are being used by banks to estimate the duration of their nonmaturity accounts.

2.2 Modelling and estimating the duration of nonmaturity accounts

To estimate the duration of their nonmaturity accounts, most large Belgian banks rely on a particular variant of the static replicating portfolio model described below. However, some Belgian banks actually use or have been experimenting with more sophisticated modelling approaches, such as dynamic replicating portfolio models and net present value Monte Carlo simulation models. This section briefly discusses the general idea behind the different modelling approaches.[2] Some supervisory concerns about these techniques are identified in Section 2.3.

STATIC REPLICATING PORTFOLIO MODELS

The idea is to calculate the return from investing the available volume of deposits in a portfolio of fixed-income assets with various maturities such that a specific objective criterion is optimised and subject to the constraint that the portfolio exactly replicates the dynamics of outstanding deposit balances over some historic sample period. For example, a possible criterion could be to select the portfolio of assets that yields the *most stable margin* over the deposit rate over the sample period, i.e. the portfolio that minimises the standard deviation of the margin, while replicating the deposit balance dynamics. Alternatively, another criterion may aim to *maximise the risk-adjusted margin*, measured by the margin's Sharpe ratio, i.e. the ratio of the average margin to the standard deviation of the margin, while replicating the deposit balance dynamics. The duration of saving deposits is then estimated as the duration of the replicating portfolio, combining fixed-income assets of various maturities, that optimizes the criterion.[3]

A concrete application of the replicating portfolio model to a Belgian bank is illustrated in Box 2.

(1) The above results need to be interpreted with care, given that many caveats apply: (i) the exercise is done on unconsolidated figures only, (ii) options and other nonlinear products are treated in a relatively rudimentary way at their delta value and, for example, do not reflect caps and floors, (iii) exposures of opposite sign in different currencies are assumed to offset and each other.

(2) There are few descriptions of the replicating portfolio approach in the public domain. The description below is based on Wilson (1994), as well as on discussions we had with several ALM practitioners and CBFA analysts (see also Box 2). Ellis and Jordan (2001) and OTS (2001) are good introductory reviews of the Monte Carlo net present value approach. We will not discuss the very different statistical individual account approach, where the idea is to track and store data on individual deposit accounts for several years and to measure their sensitivity to changes in deposit and market rates. Anderson and McCarthy (1986) describe such a statistical approach and report deposit premiums between 6 and 8 p.c. The results of Sheehan (2004) also indicate that deposits have substantial value to financial institutions. He finds that the value of core deposits varies substantially by institution, depending on the institution's supply of deposits and ability to retain deposits.

(3) An additional important decision variable can be inferred from these simple models, since the estimated optimal portfolio return can be interpreted as the correct transfer price of the deposited funds. Indeed, the transfer price of savings deposits can be defined as the return that the bank could have gained if it had invested the deposited funds in the replicating portfolio, since the latter minimizes the interest margin risk and reflects the withdrawal risk. All business lines subsequently may be required to use the transfer price as their hurdle rate, i.e. their benchmark cost of funds. In universal banks or financial conglomerates, the determination of a fair transfer price for funds allocated to the different business lines is an important issue.

Box 2 – Replicating portfolio models: application to a Belgian bank

The replicating portfolio approach basically boils down to an optimisation problem: we need to pick a vector of portfolio weights of assets such that the value of the objective function is optimised and subject to the restrictions that, at all instances, the volume of the replicating portfolio should match that of the replicated deposits. All weights need to sum up to unity and short selling is often not allowed. Given that only liquid, standard assets are held to maturity, the investment strategy will only require small trading costs, which are subsequently neglected in the empirical analysis.

Typically, the replicated deposits are only a portion of total deposits, since banks, in practice, classify total deposits into interest-rate insensitive core deposits, volatile deposits, and remaining balances. Only the latter will get replicated, whereas core deposits are assumed to be invested at a discretionary long horizon and volatile deposits at the interest rate risk free short horizon.

For the optimisation criterion of minimising the standard deviation of the margin, i.e. the spread between the portfolio return and the deposit rate, the problem can be stated as follows:

$$Min \quad std(r_p - R)$$

subject to the constraints that (i) $\sum^{n} w_i r_i = r_p$, where $\sum^{n} w_i = 1$, (ii) no short sales are allowed, i.e. $w_i \geq 0, \forall i$, and (iii) the volume of deposits is perfectly replicated by the portfolio investment at all sample dates. In the above, r_p denotes the return of the replicating portfolio, R the deposit rate, and $\{w_1, \ldots, w_n\}$ the vector of weights corresponding to the set of n available standard assets, each with return r_i. Since market rates are higher than deposit rates on average (recall Chart 3), the resulting replicating portfolio return will typically exceed the deposit rate, and average margins will be positive. Investments are held to maturity and need to be rolled-over when they mature.

We estimate such a model on data for a large Belgian bank for the period June 1996-November 2004, where Bibor/Euribor and zero coupon bond yields are used as market rates and implicit deposit rates. The baseline specification of our model assumes (i) a 100 month window size (total length of our sample), (ii) six assets with 3m, 6m, 12m, 3yr, 5yr and 10yr maturities, (iii) minimisation of the standard deviation of the margin as objective

TABLE 1 IMPACT OF CHANGES IN REPLICATING PORTFOLIO MODEL PARAMETERS AND STRESS EVENTS ON THE DURATION ESTIMATE OF REGULATED SAVINGS DEPOSITS

	Model specifications			
	0 = baseline	1	2	3
Optimisation criterion	Std. dev.	Sharpe ratio	Std. dev.	Std. dev.
Core deposits (p.c.)	25	25	10	10
Volatile deposits (p.c.)	10	10	25	25
Stress event	no	no	no	yes
Average margin (p.c.)	3.21	3.41	3.21	1.76
Standard deviation margin (p.c.)	0.11	0.15	0.11	0.31
Duration (years)	4.0	4.3	4.0	1.9
Total duration (years)	3.5	3.7	2.9	1.6

Source: NBB.

function, and (iv) 25 p.c. core deposit balances, invested at a 7 year horizon, and 10 p.c. volatile balances, invested at a monthly horizon. The remaining 65 p.c. of original balances is replicated by the model.

Besides the baseline specification, we will also analyse the sensitivity of duration estimates to alternative model specifications, in particular the impact of (i) an alternative objective criterion, (ii) alternative assumptions about proportions of core and volatile deposits, and (iii) stress circumstances(1). More specifically, in specification 1 we repeat the optimisation in the baseline case, except for the optimisation criterion, which is now to maximise the Sharpe ratio of the margin. Indeed, a bank may want to accept a slightly higher standard deviation of the margin, if it can increase the average margin substantially by doing so. Specification 2 lowers the proportion of core deposits from 25 p.c. to 10 p.c. and increases the proportion of volatile deposits from 10 p.c. to 25 p.c., compared to baseline. Specification 3 introduces a stress scenario by adding six monthly observation points to the available sample of deposit rates, savings deposit balances, and market rates, after which the estimation is conducted over the 106 available time points. The stylized stress circumstances imply that (i) all market rates increase with 0.5 p.c. every month for the next 6 months, (ii) savings deposit rates increase by 0.33 p.c. every month, (iii) balances are assumed to remain constant, and (iv) core deposits drop to 10 p.c. and volatile deposits increase to 25 p.c. of total deposits.

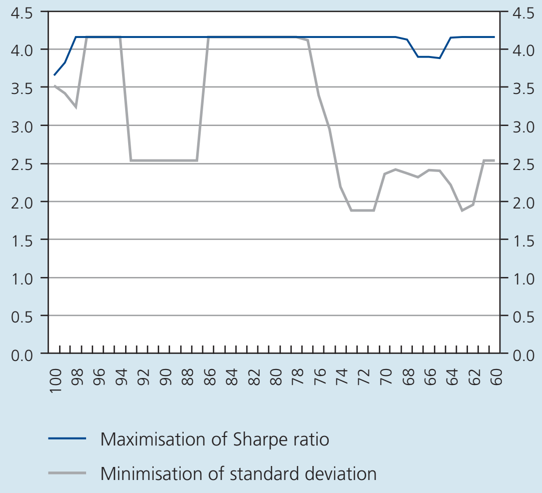
The last two rows of Table 1 report the duration estimates that result from our optimisation exercise. We distinguish between the duration estimate that follows from our replicating portfolio application to non-volatile, non-core deposits and the total duration estimate that also incorporates the effect of the assumptions about volatile and core deposits. The baseline model specification results in a total duration estimate of 3.5 years. As expected, we can see that the Sharpe ratio criterion in specification 1 implies a slightly higher margin standard deviation, but at the benefit of a substantially higher average margin. The total duration is estimated to increase only slightly. Specification 2 reveals the sensitivity of the total duration estimate to the assumptions made with regard to core and volatile deposits. The total duration may decrease by more than 6 months if core deposits are shifted to volatile deposits. Finally, the stress circumstances in specification 3 lead to a substantial deterioration of both the average margin and the standard deviation of the margin, compared to the baseline case. Most importantly, the total duration falls to 1.6 years.

In Chart 1 we plot the full sample (i.e. 100 month) total duration estimate against increasingly smaller window size duration estimates (up to the 60 month window) for both the standard deviation and Sharpe ratio criterions. The chart reveals that the choice of the estimation window may not be innocuous, since the duration estimate varies between 1.8 and 4.2 years in the standard deviation optimisation, depending on how far back in time one is willing to go. We also observe that the standard deviation and Sharpe ratio criterions need not always give similar results. The former may lead to substantially lower estimates in our case. This is intuitive, since, in periods where interest rate volatility becomes relatively more important, the standard deviation criterion duration will immediately reflect this, while the Sharpe ratio criterion will trade off the increased volatility against a smaller margin.

(1) We have also analysed the robustness of duration estimates with respect to the inclusion and exclusion of zero coupon bonds and the use of advertised instead of implicit deposit rates, but found that duration estimates were reasonably close to our baseline estimates along these dimensions.

CHART 1 DURATION ESTIMATES FOR DIFFERENT WINDOW SIZES

(In years, total duration)



DYNAMIC REPLICATING PORTFOLIO MODELS

Whereas, in the static replicating portfolio models, maturing funds are always renewed at the same maturity and the replicating portfolio vector is assumed to be constant, dynamic replicating portfolio models allow the bank to react more quickly by adapting the portfolio to changes in client behaviour and the market environment.[1] In particular, the models are able to incorporate uncertainty in interest rate and balance dynamics by generating scenarios of their possible future outcomes, whereas care is taken to capture the observed correlations between interest rates and volumes. Since the scenarios are based on current market circumstances, the resulting replicating portfolios are adjusted dynamically over time to the current situation.

NET PRESENT VALUE MONTE CARLO SIMULATION MODELS

The net present value Monte Carlo simulation models are related to the dynamic replicating portfolio models, in the sense that they also try to capture the impact of uncertainty about rates and balances and their interaction. However, they differ through a focus on the valuation of deposit accounts, defining the value of the deposit liability as the discounted future cash flows that correspond to servicing outstanding balances. The idea can be summarized in five steps:

1. The dynamics of deposit rates and deposit balances are estimated as a function of market rates, lagged variables, and other, potentially relevant variables.

2. A large number of market rate paths, say 1000, are then simulated for the next, say, 30 years, from which 1000 simulated deposit rate and balances paths are then derived. The time t economic rent[2] is defined as outstanding balances at time t times the difference between market rates and the cost to the bank of issuing the deposits, i.e. the sum of the deposit rate that is paid plus the servicing cost as a percentage of outstanding balances at t. Hence, the dynamics of economic rents depends on the dynamics of the spread between market and deposit rates, deposit balances, and servicing costs.

(1) See Frauendorfer and Schürle (2003) and Zenios and Ziemba (1992) for examples of multistage stochastic programming models.

(2) The banking literature suggests that economic rents exist (Selvaggio (1996), O'Brien (2000), Anderson and McCarthy (1986), etc.). Potential sources of economic rents include: regulatory barriers to entry leading to market concentration (Jarrow and van Deventer (1998), Hannan and Berger (1991)); clients accepting low deposit rates because they benefit from other services, for example more advantageous mortgage financing (Jarrow and van Deventer (1998)); costs to consumers of switching banks (Ausubel (1992), Sharpe (1997)); and limited memory of depositors (Kahn, Pennacchi, and Sopranzetti (1999)).

3. The value of the saving deposit account, often referred to as the deposit liability value, is then defined and computed as the net present value of all future economic rents, averaged over all simulation paths. The difference between current nominal outstanding balances in euro and the deposit liability value is defined as the deposit premium.

4. Steps two and three are repeated, but now based on the simulated market rate paths shocked by, typically, 100 basis points. As a result, we get different numbers for deposit liability value and deposit premium.

5. In line with the traditional definition, the duration of the saving deposit account is then set equal to the change in the deposit liability value divided by the change in the market interest rate[(1)].

There are two related modelling approaches to calculate the net present value of future economic rents, and both are common in option pricing and term structure modelling[(2)] The first is the Option Adjusted Spread (OAS) approach, where the idea is to discount expected future cash flows with a discount rate that reflects the riskiness of the cash flows. The discount rate includes an extra risk premium, the OAS, to account for the embedded option riskiness of the cash flows. The second approach is the contingent claim or no-arbitrage approach. Here, the idea is to manipulate the true cash flows so that the manipulated cash flows can be discounted at the risk free rate. The manipulation of the cash flows is done by subtracting a risk premium that reflects the embedded option risk, resulting in certainty-equivalent cash flows.

2.3 Prudential concerns and assessment

The replicating portfolio and net present value Monte Carlo simulation models each raise a number of statistical and conceptual concerns. Because the concerns are not easy to address, supervisors may have been discouraged from relying on any single specific modelling approach to estimate duration of savings deposits. The concerns can be grouped into two broad categories: specification of behavioural relationships and sensitivity to discretionary model assumptions.

(1) O'Brien (2000) reports typical mean retail deposit premia between 10 and 20 p.c. of outstanding deposits, i.e. the deposit liability value lies 10 to 20 p.c. below its nominal value (hence issuing deposit accounts typically increases the market value of equity of banks).

(2) Examples of the former are Selvaggio (1996) and Office of Thrift Supervision (2001), examples of the latter are Hutchison and Pennacchi (1996), Jarrow and van Deventer (1998), O'Brien (2000), Janosi, Jarrow and Zullo (1999), and Kalkbrener and Willing (2004).

A reliable and robust measurement of the relationship between deposit balances and deposit rate dynamics is very difficult to obtain, since the relationship may in fact change from bank to bank and even, within the same bank, over time. For example, new financial products can make more attractive alternatives available to depositors, which will increase their sensitivity to the opportunity cost.

Moreover, the use of backward looking approaches to tackle this issue, i.e. looking at the last x years of data to estimate behavioural relationships, may not reveal relevant information when the future is likely to be very different from the past. A related problem is that the use of a longer time series, which is in principle advisable for more reliable statistical inference, may increase the risk of failing to detect changes in market or behavioural structure.

The static replicating portfolio models suffer particularly from these drawbacks, whereas the net present value Monte Carlo simulation and dynamic replicating portfolio models are more forward-looking through simulating and averaging over a range of possible future scenarios. However, the latter still remain sensitive to the specification of behavioural relationships.

Besides the above problems relating to the specification of behavioural relationships, the model results are also quite sensitive to discretionary model parameter choices. For example, replicating portfolio models require assumptions about the optimisation criterion, the proportion of "core" and "volatile" deposits, and the relevant window size for estimation, while net present value Monte Carlo models also require a selection of explanatory variables that enter the behavioural relationships and assumptions about the size of the servicing cost parameter.

The application of the replicating portfolio model to a large Belgian bank in Box 2 illustrates that the impact of alternative assumptions about model parameters may not be innocuous in terms of the estimated duration of savings deposits. While replicating portfolio (and alternative models) may be useful as risk management tools, the relatively large range of duration estimates that can be derived from these models may make supervisors reluctant to use a single model to make inferences about the interest rate risk of savings deposits. From the supervisory viewpoint, the value added of a consistent modelling approach across banks lies in the fact that uniform parameter assumptions are applied across different banks, which should enhance the comparability of the estimates between institutions and through time.

In general, a problem with the observed range of banks' reported duration estimates is that it is unclear whether those variations are due to different bank behaviour, client behaviour, modelling approach, parameter assumptions, general interest rate market environment, or a combination of all these factors. Moreover, it is unclear to what extent the duration estimated in normal times reflects savings deposits' characteristics in stressful circumstances.

Conclusions

The favourable tax treatment and the liquidity services that regulated savings deposits provide to the deposit holder, as well as the stable source of finance they represent for banks, account for the popularity of saving deposits in Belgium.

Given their importance, savings deposits potentially have major financial stability implications for the Belgian financial system. Compared to defined maturity accounts and traditional fixed-income products, regulated savings deposits are challenging to analyse from a prudential and risk management perspective. Those complexities arise from the presence of two embedded options, the withdrawal option and the deposit rate setting option, which are clearly not independent of each other. The exercise of one of those options will certainly influence the timing of the exercise of the other.

In this article, we identified stylised facts regarding the dynamics of Belgian saving deposit balances and rates and discussed the models that are being proposed and used by banks to account for their interest rate risk. We discussed potential model weaknesses, which are in fact not specific to the Belgian context, from a prudential point of view. We find that simple static replicating portfolio models may fail to reflect the impact of stress events and are particularly vulnerable to model risk. Net present value Monte Carlo and dynamic replicating portfolio models seem conceptually stronger and are able to capture uncertainty about future events, but still rely heavily on discretionary model assumptions and the stability of the behavioural relations. Hence, they may also yield a relatively large range of duration estimates.

In the end, interest rate risk management of nonmaturity accounts remains an art as well as a science, being inherently exposed to model risk. Therefore, it is perhaps understandable that the IASB is reluctant to enter the debate of fair valuation of nonmaturity accounts at anything below the nominal value, and that bank regulators want to make conservative assumptions regarding the duration of savings deposits in their off-site identification of interest rate risk outliers.

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