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Interest Rate Risk in Banking: a Theoretical and Empirical Investigation through a Systemic Approach (Asset & Liability Management)

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ABSTRACT

The paper provides a theoretical analysis of the interest rate risk in banking through a systemic approach that is known in literature as "asset & liability management" approach.
The paper provides also an empirical investigation on the exposure of banks to interest rate risk, using three different scenarios: parallel shift, slope shift, and bump shift of interest rate curves.

Keywords: Interest Rate Risk, Asset & Liability Management, Banking, Risk Management.

1. INTRODUCTION

Interest rate risk management in banking has assumed such importance during the last decades in relation to the higher interest rate volatility. It has become increasingly important to measure, manage, and assess the impact of this volatility on the economics of banking.
Interest rate risk has been defined as the exposure of a bank's economic and financial conditions to unfavorable changes in interest rates curves. An interest rate fluctuation may have a negative impact on the economic and financial statement through assets, liabilities, and off-balance sheets positions related to interest rates.
In banking, the amount of interests on deposits will decrease and the market value of the liability portfolio will rise if interest rates decline; on the contrary, the amount of interests on loans and financial instruments will decrease and the market value of the assets portfolio will increase if interest rates decline. Such relative movements in the amount of interest and the value of portfolios could shrink the bank's interest margin and economic equity. Interest rate fluctuations impact on bank's income, bank's market value, and amount of financial intermediation. Interest rate risk relies on deposits, loans, and off-balance sheets financial operations. Interest rate risk in

banking is originated by a mismatching of assets and liabilities maturities, and interest rate repricing (on assets and liabilities). Interest rate risk in banking is affected by the amount, structure, maturity, rate sensitivity, and quality, of a bank's assets and liabilities. Briefly, the drivers of interest rate risk are: maturity structure of assets and liabilities, conditions of interest rate changes, and interest rate spread (interest receivable and interest payable).
The paper is organized as follows. The second section starts with a discussion of maturity and duration models in measuring interest rate risk in banking. The third section discusses the management of interest rate risk and the strategies that can be implemented in the asset & liability management perspective. The forth section provides an empirical analysis on the exposure of banks to interest rate risk. The final section concludes.

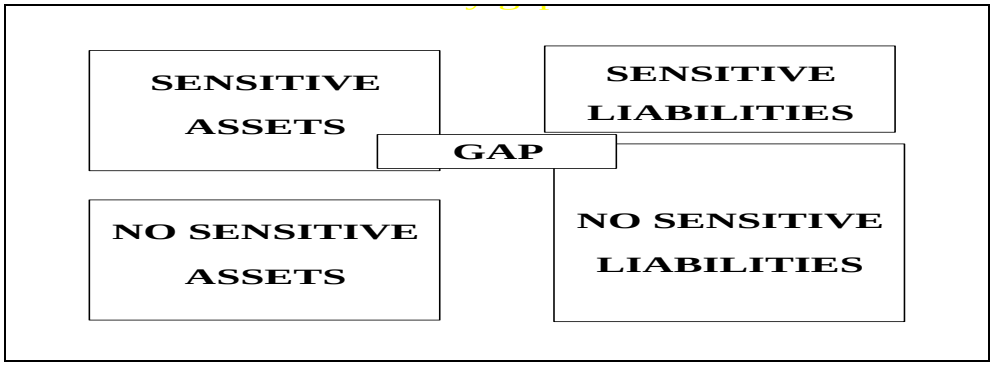
2. MATURITY AND DURATION MODELS TO MEASURE INTEREST RATE RISK IN BANKING

In order to measure the impact of interest rate risk in banking the financial literature and practice have developed two different approaches: the current earnings approach and the economic value approach (Bessis, 2009; Drago, 1998, 2001; Fabrizi, 1990, 1991, 1995; Gualandri, 1990a, 1990b; Lusignani, 1990, 1996, 2004; Onado, 2004; Resti & Sironi, 2007).
The first approach is based on maturity gap models. This approach needs historical-costs accounting. The objective is the bank income. This is the traditional approach to interest rate risk assessment taken by many banks. Through the splitting of assets and liabilities into sensitive and no-sensitive assets and liabilities, it is possible to estimate the impact of the interest rates fluctuations on net interest margin:

$$\Delta \text{ Interest margin} = \text{Sensitive assets} * \Delta i - \text{Sensitive liabilities} * \Delta i = GAP * \Delta i$$

The interest rate risk derives from the mismatch between the sensibility of assets to interest rates fluctuations, and the sensibility of liabilities to interest rates fluctuations (Figure 1).

Figure 1 – Maturity gap models: the basic concept.



In order to improve the evaluation, the annual gap may be divided into shorter periods. The time horizon is splitted into shorter time-buckets. The new marginal or incremental gap models can estimate the impact of interest rates fluctuations on interest margin using periodic gaps that are consistent with the characteristics of banking firms. To calculate the periodic gaps is necessary to compare assets and liabilities of every time-bucket. The sum of gaps of every temporal bucket is the cumulative gap. It is a useful solution to overcome the problems of the maturity gaps based

on a long time horizon. The calculation of different gaps for different time periods or buckets improves the estimation of the impact of the interest rates fluctuations on bank's net interest margin.

Nevertheless, the simple compensation of the individual positions of gaps (cumulative gap) does not take into account differences in the time of revision of interest rates. To overcome such limitation, each periodic gap must be weighted by the average time left until the end of the gapping period (time that goes from the leverage maturity of the gap to the end of the evaluation period). The sum of the individual weighted periodic gaps gives the weighted cumulative gap, which is a more accurate measure of cumulative gap obtained from a simple clearing of the periodic gaps. Using weighted periodic gaps and weighted cumulative gaps a bank can better forecast the impact of infra-annual interest rate fluctuations.

The estimated exposure to interest rate risk has been obtained assuming that the interest rates of all sensitive assets and liabilities change the same value. This hypothesis is consistent with the assumption of perfectly competitive banking markets, and the absence of information asymmetries. In reality, there is an imperfect correlation between market interest rates and bank interest rates (on assets and liabilities). In order to overcome such limitations it is necessary to find suitable parameters that allow to quantify (on average) the difference in dynamics of bank interest rates with market interest rates. Beta coefficient reflects the variability differences between market interest rates and banking interest rates. The beta coefficient is determined in relation to a market interest rate chosen as a benchmark (eg. treasury bonds, interbank deposits, etc.). A beta coefficient >1 implies that the leverage variation is more proportional to market interest rates changes. A beta coefficient <1 implies that the leverage variation is less proportional to market interest rates fluctuations. In doing so, it is possible to determine periodic standardized GAPs and cumulative standardized GAPs.

The estimated exposure to interest rate risk has been obtained assuming a uniform impact of interest rates fluctuations on assets and liabilities. In reality there may be time-lags between bank interest rates changes and market interest rates changes. We should take into account the actual timing of adjustment of bank interest rates. The real repricing of balance sheet items is different to contractual repricing. Delayed adjustments of the rates of assets and liabilities "on demand" are different in the case of increase or decrease of interest rates. The solution is the repositioning of assets and liabilities "on demand" in order to take into account the time of revision of interest rates.

The evolution of models (basic, incremental, standardized and repositioning) makes it possible to achieve greater accuracy in estimating the effects of changes in market interest rates on net interest income (or interest margin).

Notwithstanding, the first approach based on maturity gap models assumes that intermediated funds do not change throughout the period of assessment (static perspective of evaluation). The focus is on the impact of net interest income (income risk): the effects of interest rates fluctuations on assets/liabilities are neglected. In addition, implicit and explicit options embedded in banking products are another source of interest rate risk in banking (for example: bonds with call or put provisions, cap or floor on interest rates, loans which give borrowers the right to prepay balances, deposits which give depositors the right to withdraw funds at any time). The behavior of bank's customers effects uncertainty related to the exercise of embedded options in credit/debit contracts. A possible solution could be the use of simulation and behavior models in which multiple scenarios are combined.

The above analysis confirms that the sources of interest rate risk in banking are:

- timing differences in the maturity (for fixed-rate) and repricing (for floating-rate) of bank assets, liabilities, and off-balance sheet positions (repricing risk);
- changes in the slope and shape of the yield curve (yield curve risk);
- imperfect correlation in the adjustment of the rates earned and paid on different instruments with otherwise similar repricing characteristics (basic risk);
- options embedded in many bank assets, liabilities, and off-balance sheet portfolios (option risk).

Maturity gap management can help minimize the impact of market interest rates fluctuations on net interest income, but this does not prevent the bank may suffer losses related to impairment of the balance sheet. A change in market interest rates can lead to a reduction in the value of balance sheet assets greater than liabilities, with the effect of reducing the economic value of the bank's equity and the return to shareholders (Bessis, 2009; Hull, 2012).

Greater attention to interest rate risk (balance sheet view) requires the application of financial tools (duration), already developed in portfolio management of fixed-income securities. The duration is not only an indicator of average length of time (it measures the average return of cash flows), but it is also an indicator of risk (it measures the price sensitivity of an asset or liability to interest rates fluctuations). The use of duration to all assets and liabilities in bank balance sheet allows the quantification of the effects of market interest rates changes on bank equity.

Using the tool of duration, the second approach of interest rate risk management develops duration gap models whose objective is the economic value of equity (Bierwag & Kaufman, 1985; Drago, 1998, 2001; Fabrizi, 1990, 1991, 1995; Gup & Brooks, 1993; Lusignani, 1996; Wetmore & Brick, 1990).

The duration analysis studies the impact that changes in interest rates may have on the market value of bank equity. The market value of equity is the difference between the market value of assets and the market value of liabilities (net present value of cash flows from all assets and liabilities on balance sheet and off-balance sheet). Through the evaluation of the duration of all assets and liabilities, the weighted average duration of assets and liabilities, and the duration gap (or duration mismatch), it is possible to estimate the impact of interest rate changes on the value of equity.

The drivers of the bank's exposure to interest rate risks are: difference between asset duration and liability duration; total assets and liabilities (corporate size), and interest rates fluctuations.

The economic value approach considers the impact of interest rates fluctuations on the present value of all future cash flows (assets, liabilities, and off-balance sheet positions). It offers a more comprehensive view of the potential long-term effects of fluctuations in interest rates.

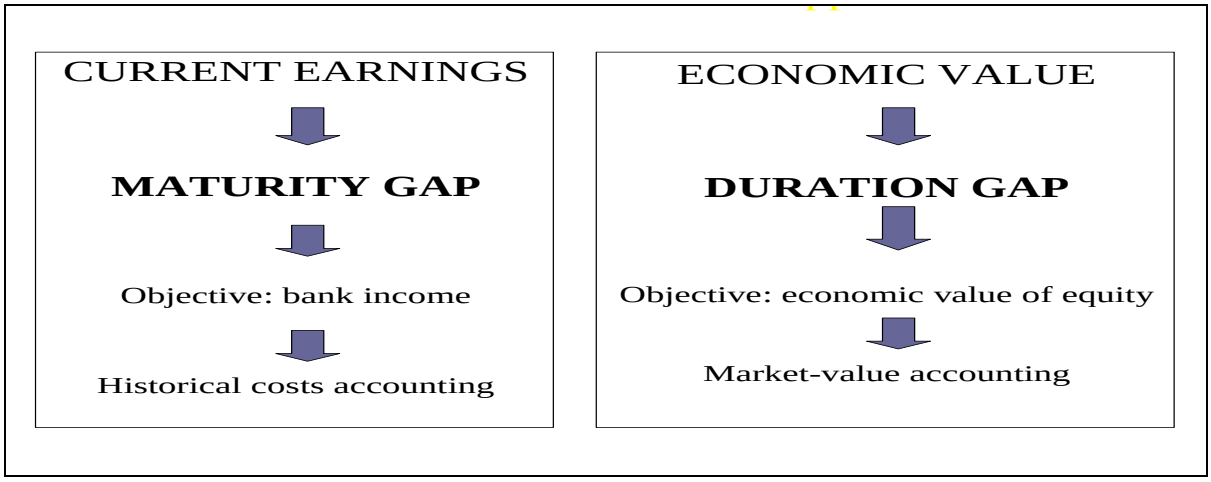
Briefly, the duration mismatch results in a rate sensitivity of the equity. In words, the formula says:

$$\text{Interest sensitivity of equity} = \text{Duration GAP} * \text{leverage} * \Delta i / 1 + i$$

Duration gap models are also affected by simplifying assumptions. Mainly, a bank operates in various markets with rates of return and fundraising rates equal to each other; asset interest rate sensitivity is equal to liability interest rate sensitivity. To overcome these simplifying assumptions we should measure the beta duration gap. In addition, basic duration models assume a linear function that links the market value of the financial instrument to its yield to maturity, and a parallel shift of the yield curve. To overcome the first limitation it is necessary to measure

the convexity of the function. The convexity measures the curvature of the relationship between the economic value and the yield of a financial instrument. To overcome the second limitation, partial duration measures are useful tool to extend duration measures to non-parallel shifts of the yield curve (Bessis, 2009; Hull, 2012).
Briefly, beta duration management gives an estimation of bank's interest rate risk exposure. It can become a target-indicator for portfolio choices of bank balance sheets. Many difficulties are related to the effective implementation of duration gap models in banking. They require a market-value accounting.
The two different approaches (current earnings approach and economic value approach) are complementary approaches to interest rate risk in banking. The first quantifies the exposure to interest rate risk in terms of interest margin fluctuations. It focuses on the risk management of the net interest margin. The second approach quantifies the exposure to interest rate risk in terms of fluctuations of economic value of equity. Figure 2 compares the two different approaches.

Figure 2 - Interest rate risk: assessment approaches.



3. INTEREST RATE RISK AND THE ASSET & LIABILITY MANAGEMENT PERSPECTIVE IN BANKING

Interest rate risk is a kind of financial risk that affects all financial institutions. Interest rate risk is a normal part of banking. As highlighted by the Basel Committee on Banking Supervision (2004, p. 5) excessive interest rate risk can pose a significant threat to a bank's earnings and capital base. Changes in interest rates affect a bank's earnings by changing its net interest income and the level of other interest sensitive income and operating expenses. Changes in interest rates also affect the underlying value of the bank's assets, liabilities, and off-balance-sheet instruments because the present value of future cash flows change when interest rates change.
To measure, monitor, and control the exposure to interest rate risk most banks have adopted an asset & liability management (ALM) perspective. The asset & liability management perspective has theoretical, empirical, and regulatory implications (Drago, 1998, 2001; Fabozzi, Konishi, 1998; Fabrizi, 1990, 1991, 1995; Saita, 2000; Sironi, 1996). From the theoretical point of view, it plays an important role in evaluating correlations between assets and liabilities positions, and the complexity of structures and nature of assets, liabilities, and off-balance sheet positions, with respect to interest rate risk exposure. From the empirical point of view, it refers to the

implementation of interest rate risk management processes and structures, as well as systems of internal controls.

The asset & liability management may be defined (Gup & Brooks, 1993) as the simultaneous planning of all asset and liability positions on the bank's balance sheet under consideration of the different bank management objectives and legal, managerial and market constraints, for the purpose of enhancing the value of the bank, proving liquidity, and mitigating interest rate risk. In other words, asset-liability management is a planning procedure that accounts for all assets and liabilities of a bank by maturity, amount, and interest rate, in order to measure and control interest rate risk (Zenois & Ziemba, 2006).

To set and implement asset & liability management policies, structures, and operations in banking, most banks have established asset & liability management committees (ALCO). In sum, they carry on their functions and activity at 3 level of analysis: management report, business planning, and hedging policy.

The asset & liability management is a valid perspective to measure, control, and regulate interest rate risk in banking (Abi, 1991, 1995; Gualandri, 1990; Onado, 2004; Scannella, 2005a, 2005b, 2006). It is confirmed by the prudential regulation. Also the new regulation (known as Basel III) gives much importance to the measurement and management of interest rate risk through asset & liability management models and instruments. The recent financial crisis has also increased the importance of the asset & liability management perspective in risk management (Scannella, 2010, 2012).

The principles for the management and supervision of interest rate risk issued by the Basel Committee on Banking Supervision (2004) recognize that it is essential that banks have a comprehensive risk management process in place that effectively identifies, measures, monitors and controls interest rate risk exposures, and that is subject to appropriate board and senior management oversight. Sound risk management practices are essential to the prudent operation of banks and to stability in the financial system.

A sound process may be divided into four steps. The first one is the identification and understanding of interest rate risk. It implies also the preliminary evaluation of the impact on income and economic value of banks' balance sheet. The second step is the analysis and the identification of the drivers and principal components of the interest rate risk in banking. The next step is the measuring of the interest rate risk, using different models and approaches that are available for different kinds of banks. A bank has to balance between the cost of using a model and the benefits in terms of quality and reliability of risk measures. The final step is the management of interest rate risk, in order to reduce or eliminate the impact of the interest rate risk on income and economic value of banks' balance sheet.

The asset & liability management perspective recognises the complementarity of the current earnings approach and the economic value approach in measuring and managing interest rate risk in banking. Net interest income and economic value of equity are the two objects of asset & liability management in banking.

In the asset & liability management perspective, banks may implement three types of strategies:

- *tier matching*: search for a perfect balance of assets and liabilities in term of maturity (maturity gap) or duration (duration gap);
- *term-structure intermediation*: manage the risk exposure (to manage the gap in relation to interest rates structure);
- *hedging*: transfer risk to others in order to reduce or remove the risk exposure.

With the first and second strategy, a bank modifies the composition of assets and liabilities on balance sheet, in terms of gap value, maturity structure, structure of interest rates (fixed and floating). The drivers are:

- sensitivity of bank interest rates to market interest rates fluctuation;
- elasticity of deposits and loans to interest rate fluctuation;
- customer relationship and banking market structure;
- securities and interbank market.

The first and second strategy allows banks to internally manage the interest rate risk. It means that banks manage their assets and liabilities to reduce the mismatch on repricing or the mismatch on duration. Risk management requires a change in the duration gap and thus the maturity of assets and liabilities (feasibility of gap variations). Let us take an example to illustrate this point. If a bank has a negative maturity gap (Gap <0) it is exposed to interest rates increases. The two strategies suggest banks to reduce the gap size (modifying assets and liabilities). By matching the maturity of assets to the maturity of liabilities, a bank can immunize the interest margin from the effects of changing interest rates. In addition, if a bank has a positive duration gap (gap >0) it is exposed to interest rates increases. The two strategies suggest banks to lengthen the duration of liabilities and/or shorten the duration of assets. By matching the duration of the portfolio of assets to the duration of the portfolio of liabilities, a bank can immunize its equity from the effects of changing interest rates. Effectively, the strategies "maturity matching" and "duration matching" do not immunize the portfolio by non-parallel shifts of interest rate curve. By matching the duration of assets and liabilities a bank is hedged against small parallel shifts in the yield curve. Furthermore, the duration can be extended to consider non-parallel yield curve shifts (partial duration approach).

The third strategy implies a transfer of risk to others in the financial market through derivative instruments. The *hedging* strategy with derivatives can be implemented at two levels: micro-hedging level (a bank takes positions in derivatives markets to reduce risk originated from a single asset or liability) and macro-hedging level (a bank takes positions in derivatives markets to reduce risk originated from all assets and liabilities). The third strategy allows banks to externally manage the interest rate risk. Banks use financial derivatives to hedge the exposure to interest rate risk.

4. AN EMPIRICAL INVESTIGATION: PARALLEL, SLOPE, AND BUMP SHIFTS OF INTEREST RATE CURVE IN BANKING.

In this section we conduct an empirical investigation on the exposure of interest rate risk in banking. Preliminarily we illustrate the methodology.
The sample includes 4 banks that characterize four different banking markets:

- ICBC, Industrial and Commercial Bank of China limited, for the international banking market;
- UniCredit S.p.A., for the European banking market;
- Banca Popolare di Vicenza, Società Cooperativa per Azioni, for the Italian cooperative banking market;

- Banca Don Rizzo Credito Cooperativo della Sicilia Occidentale Società Cooperativa, for the Sicilian cooperative banking market.

The data source is the financial report published by the four banks in the year 2011. More specifically, the principal data sources are the repricing/maturity tables of asset and liability portfolios[ii]. The time horizon is splitted in 5 buckets (ICBC) and 8 buckets (UniCredit, Banca Popolare di Vicenza, and Banca Don Rizzo).
From the above mentioned repricing tables we calculate the interest rate mismatch as follows:

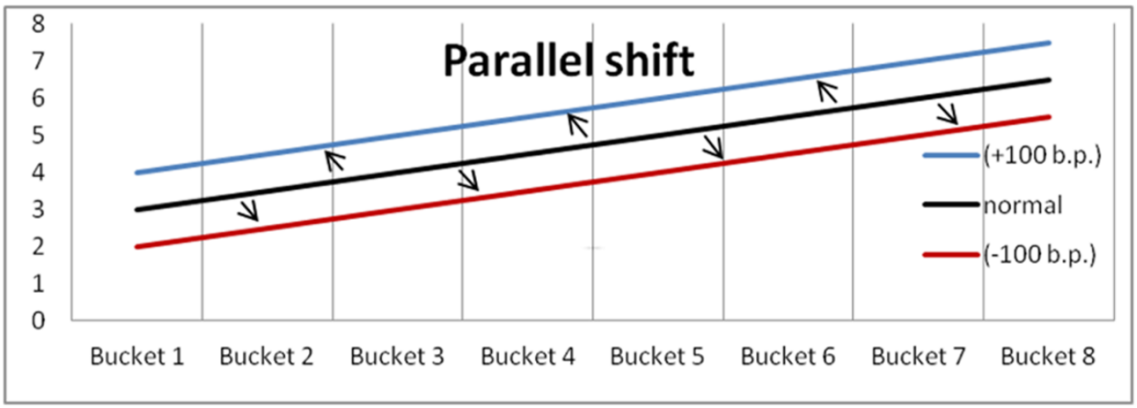
Interest rate mismatch = assets – liabilities + financial derivatives[iii].

Once we have calculated the interest rate mismatch for each bank, we estimate the variation of net interest income in case of interest rate increase (+100 basis points) and interest rate decrease (-100 basis points), as suggested by the asset & liability management approach. We identify three different scenarios: parallel shift, slope shift, and bump shift of interest rate curves.

4.1 Parallel shift of interest rate curve

The aim of this analysis is to measure the exposure of each bank to interest rate risk, in a parallel shift of interest rate curve scenario, as suggest by financial literature (Figure 3).

Figure 3 - Parallel shift of interest rate curve.



CASE 1: ICBC

Table 1. ICBC maturity table and net-interest income sensitivity.

Type/ residual maturity	Less than three months	Three months to one year	One to five years	More than five years	Non- interest-bearing
Assets	7.973.587	3.771.753	1.721.963	1.349.400	660.165
Liabilities	9.860.628	2.795.563	1.137.818	159.441	565.595
Interest rate mismatch	**−1.887.041**	**976.190**	**584.145**	**1.189.959**	**N/A**
ΔNII +100 b.p.	**−18.870,41**	**9.761,9**	**5.841,45**	**11.899,59**	
ΔNII −100 b.p.	**18.870,41**	**−9.761,9**	**−5.841,45**	**−11.899,59**	

Source: ICBC (2011), Financial Report.

The results on the above table show a considerable exposure to interest rate risk in the first bucket (less than three months). It is a normal situation for banking because banks raise funds at short run with a lower interest rate than those on long run. This is the usual structure of the interest rate curve of banks. The gaps for intermediate periods are positive (period between 3 months and 5 years). The gap, however, increase consistently for the last bucket (more than 5 years). This situation could be usual in banking because banks invest in the long run with higher interest rates than short run investments.
The variation of net interest income, for the entire horizon, is +8.632,53 for a parallel shift of +100 bps and -8.632,53 for a parallel shift of -100 bps. But, for the annual period the variation of net interest income is -9.108,51 for a parallel shift of +100 bps and +9.108,51 for a parallel shift of -100 bps.

CASE 2: UniCredit

Table 2. UniCredit maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	143.347.142	232.925.988	44.110.317	51.154.879	131.150.128	59.026.438	46.979.029	6.411.078
Liabilities	256.450.148	237.170.046	34.604.035	30.526.379	84.821.975	30.293.841	17.713.447	2.634.699
Financial derivatives	36.307	−2.811.079	− 613.791	−108.160	3.533.366	− 245.920	279.050	_
Interest rate mismatch	**−113.066.699**	**−7.055.137**	**8.892.491**	**20.520.340**	**49.861.519**	**28.486.677**	**29.544.632**	**3.776.379**
ΔNII +100 b.p.	**−1.130.666,99**	**−70.551,37**	**88.924,91**	**205.203,4**	**498.615,19**	**284.866,77**	**295.446,32**	**37.763,79**
ΔNII −100 b.p.	**1.130.666,99**	**70.551,37**	**−88.924,91**	**−205.203,4**	**−498.615,19**	**−284.866,77**	**−295.446,32**	**−37.763,79**

Source: UniCredit (2011), Consolidated Reports.

The results on the above table show a large exposure of interest rate risk in the first bucket (assets and liabilities at sight), but this is a normal situation for banks that raise funds at short run with an interest rate lower than those on long run. The gaps for intermediate periods are positive and moderate (for periods higher than 3 months). Gaps increase consistently up the bucket 1 to 5 years. Then gaps decrease. The variation of net interest income for the entire time horizon is +209.602,02 for a parallel shift of +100 bps and -209.602,02 for a parallel shift of 100 bps. But, for the annual period, the variation of net interest income is -907.090,05 for a parallel shift of +100 bps and +907.090,05 for a parallel shift of -100 bps.

CASE 3: Banca Popolare di Vicenza

Table 3. Banca Popolare di Vicenza maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	11.800.740	15.033.957	3.057.975	474.146	2.136.029	1.267.589	2.503.977	_
Liabilities	12.025.128	14.028.371	1.986.189	1.789.485	5.810.172	2.935	659.688	_
Financial derivatives	12.252	23.025	−607.665	−503.958	2.533.178	−1.143.648	−308.462	_

Interest rate mismatch	**−212.136**	**1.028.611**	**464.121**	**−1.819.297**	**−1.140.965**	**121.006**	**1.535.827**	_
ΔNII +100 b.p.	**−2.121,36**	**10.286,11**	**4.641,21**	**−18.192,97**	**−11.409,65**	**1.210,06**	**15.358,27**	_
ΔNII −100 b.p.	**2.121,36**	**−10.286,11**	**−4.641,21**	**18.192,97**	**11.409,65**	**−1.210,06**	**−15.358,27**	_

Source: Banca Popolare di Vicenza (2011). Annual Report.

The results on the above table show an exposure of interest rate risk in the first bucket (assets and liabilities at sight). The gaps for next buckets are positive and considerable for a period from 3 months to 6 months. The gaps in the intermediate buckets (from 6 months to 5 years) are negative and large. The gaps increase in the bucket from 5 to 10 years, and considerably in the buckets over 10 years. The variation of net interest income for the entire horizon is -228,33 for a parallel shift of +100 bps and +228,33 for a parallel shift of -100 bps. But, for the annual period the variation of net interest income is -5.387,01 for a parallel shift of +100 bps and +5.387,01 for a parallel shift of -100 bps.

CASE 4: Banca Don Rizzo

Table 4. Banca Don Rizzo maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	79.746	159.841	29.417	12.281	47.795	25.560	23.903	_
Liabilities	261.882	11.276	17.468	7.011	51.910	807	_	_
Financial derivatives	_	316	85	27	198	91	33	_
Interest rate mismatch	**−182.136**	**148.881**	**12.034**	**5.297**	**− 3.917**	**24.844**	**23.936**	_
ΔNII+100 b.p.	**−1.821,36**	**1.488,81**	**120,34**	**52,97**	**−39,17**	**248,44**	**239,36**	_
ΔNII −100 b.p.	**1.821,36**	**−1.488,81**	**− 120,34**	**−52,97**	**39,17**	**−248,44**	**−239,36**	_

Source: Banca Don Rizzo (2011), Relazioni e Bilancio.

The results on the above table show an exposure of interest rate risk in the first bucket (assets and liabilities at sight). The gaps for intermediate periods are positive and moderate. The gap in the second bucket (up to 3 months) is large. The gaps in the bucket from 5 years to 10 years are higher than the bucket over 10 years.
The variation of net interest income for the entire horizon is +289,39 for a parallel shift of +100 bps and -289,39 for a parallel shift of -100 bps. But, for the annual period the variation of net interest income is -159,24 for a parallel shift of +100 bps and +159,24 for a parallel shift of -100 bps.

4.2 Slope shift of interest rate curve

The aim of this analysis is to measure the exposure of each bank to interest rate risk, in a short and long run shift of interest rate curve scenario, as suggest by financial literature (Figure 4, 5).

Figure 4. Short run shift of interest rate curve.

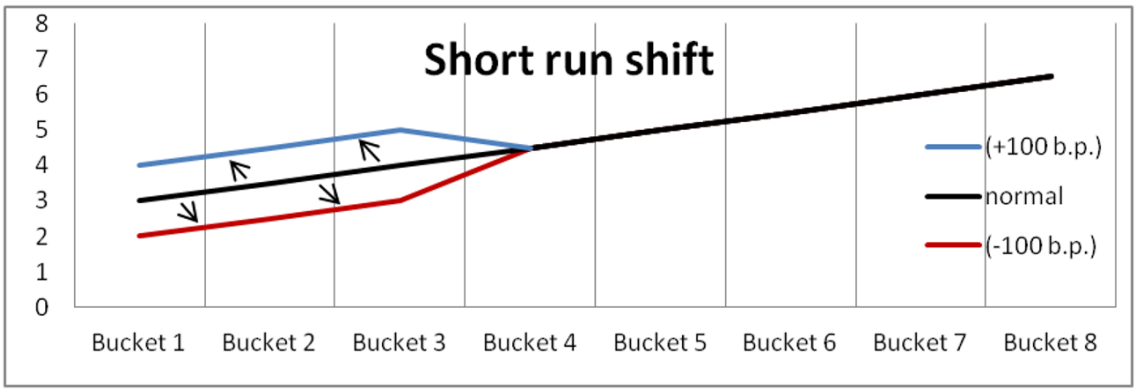
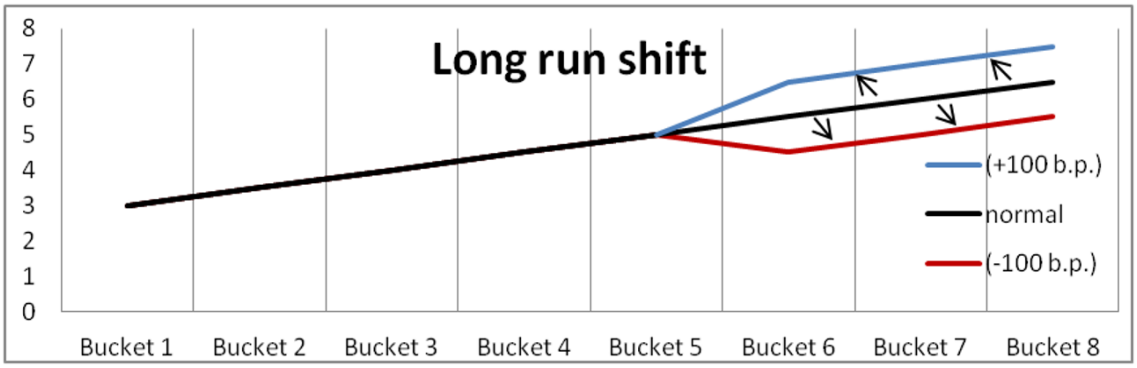


Figure 5 – Long run shift of interest rate curve



CASE 1: ICBC

Short run shift

Table 5. ICBC maturity table and net-interest income sensitivity.

Type/ residual maturity	Less than three months	Three months to one year	One to five years	More than five years	Non- interest-bearing
Assets	7.973.587	3.771.753	1.721.963	1.349.400	660.165
Liabilities	9.860.628	2.795.563	1.137.818	159.441	565.595
Interest rate mismatch	**−1.887.041**	**976.190**	**584.145**	**1.189.959**	**N/A**
ΔNII +100 b.p.	**−18.870,41**	**9.761,9**	_	_	_
ΔNII −100 b.p.	**18.870,41**	**−9.761,9**	_	_	_

Source: ICBC (2011), Financial Report.

ICBC would suffer, in terms of net-interest income, a greater flatness of interest rate curve, in case of a +100 bps increase of interest rate (-9.108,51), as it is showed in the red circle. However, a greater slope of interest rate curve, for a -100 bps decrease of interest rate, would be beneficial in terms of net-interest income (+9.108,51).

Long run shift

Table 6. ICBC maturity table and net-interest income sensitivity.

Type/ residual maturity	Less than three months	Three months to one year	One to five years	More than five years	Non- interest-bearing
Assets	7.973.587	3.771.753	1.721.963	1.349.400	660.165
Liabilities	9.860.628	2.795.563	1.137.818	159.441	565.595
Interest rate mismatch	**−1.887.041**	**976.190**	**584.145**	**1.189.959**	**N/A**
ΔNII +100 b.p.	_	_	**5.841,45**	**11.899,59**	
ΔNII −100 b.p.	_	_	**−5.841,45**	**−11.899,59**	

Source: ICBC (2011), Financial Report.

ICBC would benefit, in terms of net-interest income, a greater steepness of interest rate curve, in case of a +100 bps increase of interest rate (+17.741,04). However, a greater flatness of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-17.741,04).

CASE 2: Unicredit

Short run shift

Table 7 – UniCredit maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	143.347.142	232.925.988	44.110.317	51.154.879	131.150.128	59.026.438	46.979.029	6.411.078
Liabilities	256.450.148	237.170.046	34.604.035	30.526.379	84.821.975	30.293.841	17.713.447	2.634.699
Financial derivatives	36.307	−2.811.079	− 613.791	−108.160	3.533.366	− 245.920	279.050	_
Interest rate mismatch	**−113.066.699**	**−7.055.137**	**8.892.491**	**20.520.340**	**49.861.519**	**28.486.677**	**29.544.632**	**3.776.379**
ΔNII +100 b.p.	**−1.130.666,99**	**−70.551,37**	**88.924,91**	_	_	_	_	_
ΔNII −100 b.p.	**1.130.666,99**	**70.551,37**	**−88.924,91**	_	_	_	_	_

Source: UniCredit (2011), Consolidated Reports.

UniCredit would suffer, in terms of net-interest income, a greater flatness of interest rate curve, for a +100 bps increase of interest rate, equal to a -1.112.293,45. However, a greater slope of interest rate curve, for a -100 bps decrease of interest rate, would be beneficial in terms of net-interest income (+1.112.293,45).

Long run shift

Table 8. UniCredit maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	143.347.142	232.925.988	44.110.317	51.154.879	131.150.128	59.026.438	46.979.029	6.411.078
Liabilities	256.450.148	237.170.046	34.604.035	30.526.379	84.821.975	30.293.841	17.713.447	2.634.699
Financial derivatives	36.307	−2.811.079	− 613.791	−108.160	3.533.366	− 245.920	279.050	_
Interest rate mismatch	**−113.066.699**	**−7.055.137**	**8.892.491**	**20.520.340**	**49.861.519**	**28.486.677**	**29.544.632**	**3.776.379**
ΔNII +100 b.p.	_	_	_	_	**498.615,19**	**284.866,77**	**295.446,32**	_
ΔNII −100 b.p.	_	_	_	_	**−498.615,19**	**−284.866,77**	**−295.446,32**	_

Source: UniCredit (2011), Consolidated Reports.

UniCredit would benefit, in terms of net-interest income, a greater steepness of interest rate curve, for a +100 bps increase of interest rate (+1.078.928,28). However, a greater flatness of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-1.078.928,28).

CASE 3: Banca Popolare di Vicenza

Short run shift

Table 9. Banca Popolare di Vicenza maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	11.800.740	15.033.957	3.057.975	474.146	2.136.029	1.267.589	2.503.977	_
Liabilities	12.025.128	14.028.371	1.986.189	1.789.485	5.810.172	2.935	659.688	_
Financial derivatives	12.252	23.025	−607.665	−503.958	2.533.178	−1.143.648	−308.462	_
Interest rate mismatch	**−212.136**	**1.028.611**	**464.121**	**−1.819.297**	**−1.140.965**	**121.006**	**1.535.927**	**_**
ΔNII +100 b.p.	**−2.121,36**	**10.286,11**	**4.641,21**	_	_	_	_	_
ΔNII −100 b.p.	**2.121,36**	**−10.286,11**	**−4.641,21**	_	_	_	_	_

Source: Banca Popolare di Vicenza (2011), Annual Report.

Banca Popolare di Vicenza would benefit, in terms of net-interest income, a greater flatness of interest rate curve, for a +100 bps increase of interest rate (+12.805,96). However, a greater slope of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-12.805,96).

Long run shift

Table 10. Banca Popolare di Vicenza maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	11.800.740	15.033.957	3.057.975	474.146	2.136.029	1.267.589	2.503.977	_
Liabilities	12.025.128	14.028.371	1.986.189	1.789.485	5.810.172	2.935	659.688	_
Financial derivatives	12.252	23.025	−607.665	−503.958	2.533.178	−1.143.648	−308.462	_
Interest rate mismatch	**−212.136**	**1.028.611**	**464.121**	**−1.819.297**	**−1.140.965**	**121.006**	**1.535.827**	_
ΔNII +100 b.p.	_	_	_	_	**−11.409,65**	**1.210,06**	**15.358,27**	_
ΔNII −100 b.p.	_	_	_	_	**11.409,65**	**−1.210,06**	**−15.359,27**	_

Source: Banca Popolare di Vicenza (2011), Annual Report.

Banca Popolare di Vicenza would benefit, in terms of net-interest income, a greater steepness of interest rate curve, for a +100 bps increase of interest rate (+5.158,68). However, a greater flatness of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-5.158,68).

CASE 4: Banca Don Rizzo

Short run shift

Table 11. Banca Don Rizzo maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	79.746	159.841	29.417	12.281	47.795	25.560	23.903	_
Liabilities	261.882	11.276	17.468	7.011	51.910	807	_	_
Financial derivatives	_	316	85	27	198	91	33	_
Interest rate mismatch	**−182.136**	**148.881**	**12.034**	**5.297**	**− 3.917**	**24.844**	**23.936**	_
ΔNII +100 b.p.	**−1.821,36**	**1.488,81**	**−120,34**	_	_	_	_	_
ΔNII −100 b.p.	**1.821,36**	**−1.488,81**	**120,34**	_	_	_	_	_

Source: Banca Don Rizzo (2011), Relazioni e Bilancio.

Banca Don Rizzo would suffer, in terms of net-interest income, a greater flatness of interest rate curve, for a +100 bps increase of interest rate (-212,21), as it is showed in the red circle. However, a greater slope of interest rate curve, for a -100 bps decrease of interest rate, would be beneficial in terms of net-interest income (+212,21).

Long run shift

Table 12. Banca Don Rizzo maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration

Assets	79.746	159.841	29.417	12.281	47.795	25.560	23.903	_
Liabilities	261.882	11.276	17.468	7.011	51.910	807	_	_
Financial derivatives	_	316	85	27	198	91	33	_
Interest rate mismatch	**−182.136**	**148.881**	**12.034**	**5.297**	**− 3.917**	**24.844**	**23.936**	_

ΔNII +100 b.p.	_	_	_	_	**−39,17**	**248,44**	**239,36**	_
ΔNII −100 b.p.	_	_	_	_	**39,17**	**−248,44**	**−239,36**	_

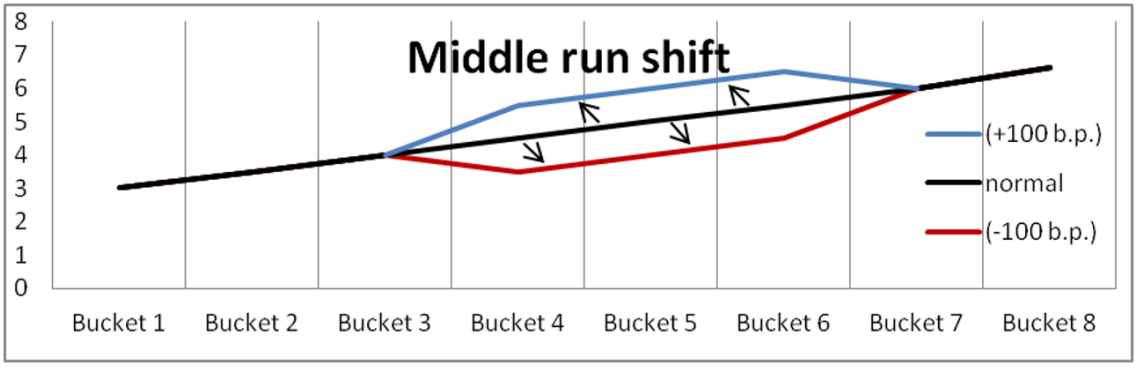
Source: Banca Don Rizzo (2011), Relazioni e Bilancio.

Banca Don Rizzo would benefit, in terms of net-interest income, a greater steepness of interest rate curve, for a +100 bps increase of interest rate (+448,63). However, a greater flatness of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-448,63).

4.3 Bump shift of interest rate curve.

The aim of this analysis is to measure the exposure of each bank to interest rate risk, in a middle run or "bump" shift of interest rate curve scenario, as suggest by financial literature (Figure 6).

Figure 6. Bump shift of interest rate curve.



CASE 1: ICBC

Table 13. ICBC maturity table and net-interest income sensitivity.

Type/ residual maturity	Less than three months	Three months to one year	One to five years	More than five years	Non- interest-bearing
Assets	7.973.587	3.771.753	1.721.963	1.349.400	660.165
Liabilities	9.860.628	2.795.563	1.137.818	159.441	565.595
Interest rate mismatch	**−1.887.041**	**976.190**	**584.145**	**1.189.959**	**N/A**

ΔNII +100 b.p.	_	**9.761,9**	**5.841,45**	_
ΔNII −100 b.p.	_	**−9.761,9**	**−5.841,45**	_

Source: ICBC (2011), Financial Report.

ICBC would benefit, in terms of net-interest income, an upward bump of interest rate curve, for a +100 bps increase of interest rate (+15.603,35). However, a downward bump of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental, in terms of net-interest income (-15.603,35).

CASE 2: UniCredit

Table 14. UniCredit maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	143.347.142	232.925.988	44.110.317	51.154.879	131.150.128	59.026.438	46.979.029	6.411.078
Liabilities	256.450.148	237.170.046	34.604.035	30.526.379	84.821.975	30.293.841	17.713.447	2.634.699
Financial derivatives	36.307	−2.811.079	− 613.791	−108.160	3.533.366	− 245.920	279.050	_
Interest rate mismatch	**−113.066.699**	**−7.055.137**	**8.892.491**	**20.520.340**	**49.861.519**	**28.486.677**	**29.544.632**	**3.776.379**
ΔNII +100 b.p.	_	_	**88.924,91**	**205.203,4**	**498.615,19**	_	_	_
ΔNII −100 b.p.	_	_	**−88.924,91**	**−205.203,4**	**−498.615,19**	_	_	_

Source: UniCredit (2011), Consolidated Reports.

UniCredit would benefit, in terms of net-interest income, an upward bump of interest rate curve, for a +100 bps increase of interest rate (+792.743,5). However, a downward bump of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-792.743,5).

CASE 3: Banca Popolare di Vicenza

Table 15. Banca Popolare di Vicenza maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	11.800.740	15.033.957	3.057.975	474.146	2.136.029	1.267.589	2.503.977	_
Liabilities	12.025.128	14.028.371	1.986.189	1.789.485	5.810.172	2.935	659.688	_
Financial derivatives	12.252	23.025	−607.665	−503.958	2.533.178	−1.143.648	−308.462	_
Interest rate mismatch	**−212.136**	**1.028.611**	**464.121**	**−1.819.297**	**−1.140.965**	**121.006**	**1.535.927**	_
ΔNII +100 b.p.	–	_	**4.641,21**	**−18.192,97**	**−11.409,65**	_	_	_
ΔNII −100 b.p.	–	_	**−4.641,21**	**18.192,97**	**11.409,65**	_	_	_

Source: Banca Popolare di Vicenza (2011), Annual Report.

Banca Popolare di Vicenza would benefit, in terms of net-interest income, a downward bump of interest rate curve, for a -100 bps decrease of interest rate (+24.961,41). However, an upward

bump of interest rate curve, for a +100 bps increase of interest rate, would be detrimental in terms of net-interest income (-24.961,41).

CASE 4: Banca Don Rizzo

Table 16. Banca Don Rizzo maturity table and net-interest income sensitivity.

Type/ residual maturity	Sight	Up to 3 months	3 to 6 months	6 to 12 months	1 to 5 years	5 to 10 years	Over 10 years	Unspecified duration
Assets	79.746	159.841	29.417	12.281	47.795	25.560	23.903	_
Liabilities	261.882	11.276	17.468	7.011	51.910	807	_	_
Financial derivatives	_	316	85	27	198	91	33	_
Interest rate mismatch	**−182.136**	**148.881**	**12.034**	**5.297**	**− 3.917**	**24.844**	**23.936**	_
ΔNII +100 b.p.	_	_	**120,34**	**52,97**	**−39,17**	_	_	_
ΔNII −100 b.p.	_	_	**− 120,34**	**−52,97**	**39,17**	_	_	_

Source: Banca Don Rizzo (2011), Relazioni e Bilancio.

Banca Don Rizzo would benefit, in terms of net-interest income, an upward bump of interest rate curve, for a +100 bps increase of interest rate (+134,14). However, a downward bump of interest rate curve, for a -100 bps decrease of interest rate, would be detrimental in terms of net-interest income (-134,14).

4.4 Final remarks

The four banks of our sample have an asset & liability management (ALM) organization in which the board of directors is the starting point of the interest rate risk management process. The four banks give a definition of interest rate risk and identify its sources. The instruments and strategies to manage interest rate risk are distinguished between trading book and banking book. ICBC gives less information on this aspect of analysis. The time-buckets are also affected by regulation. ICBC adopts a smaller subdivision than other banks.

All the four banks measure the sensitivity of net-interest income for +/- 100 bps interest rate curve fluctuation. UniCredit, Banca Popolare di Vicenza, and Banca Don Rizzo adopt also a sensitivity analysis on economic value. Each bank then adopt other risk management tools, such as: simulation models, stress tests, operative limits, duration gap analyses, gaps on fixed rate items, static and dynamic gaps, internal behavior models for at sight financial posititions. In particular, behavior models are adopted principally by UniCredit and Banca Popolare di Vicenza. On the contrary, ICBC denies totally these methods. Banca Don Rizzo adopts only a little part of the above methods, for regulatory reasons.

Most banks have used derivatives to hedge financial positions. Only Banca Don Rizzo has not used derivates, both for trading and banking book. ICBC uses principally IRS (interest rate swaps) contracts and much less currency swap contracts, both for cash flows hedge and for fair value hedge. UniCredit uses principally IRS contracts, but also cross currency swaps, forward contracts, options, equity swaps, and other derivates. Banca Popolare di Vicenza uses only IRS contracts and options contracts. For positive gaps banks sell forward contracts (as forward rate agreements-FRA), sell interest rate swap contracts (receiving a fixed interest rate and paying a

floating interest rate), or take a long position on futures market. Banks also buy call options on bonds and floor options on interest rates. For negative gaps banks buy forward rate agreements (FRA), buy interest rate swap contracts (receiving a floating interest rate and paying a fixed interest rate), or take a short position on futures market. Banks also buy put options on bonds and cap options on interest rates.

The four banks publish different repricing or maturity contract tables. ICBC and UniCredit publish them for all banking portfolio. UniCredit decomposes its portfolio into different currencies. Banca Popolare di Vicenza and Banca Don Rizzo do not publish the entire portfolio, but decompose the tables for each currency (Banca Popolare di Vicenza distinguishes among euro, American dollar, British pounds, Swiss franc, Japanese yen and other currencies; Banca Don Rizzo distinguishes among euro, American dollar, Canadian dollar and Swiss franc currencies).

The above results of the empirical analysis allow us to give some final remarks. The four banks show a negative interest rate mismatch in the first bucket. The gaps in the last buckets for all banks are always positive. It may imply that banks invest in long run in which interest rate are higher than short run.

There are some differences in intermediate periods. In details, ICBC and UniCredit show a positive and increasing gaps. In some intermediate buckets the gaps are also higher than longer periods. Banca Don Rizzo shows a different situation. It has a positive mismatch in the second bucket (the largest gap), then the value of the gaps swing. In addition, Banca Popolare di Vicenza has a negative gap in the first bucket, a positive gap in the next two buckets, and a negative gap in the third and fourth bucket.

5. CONCLUSION

Interest rate risk is one of the most important market risk in the economics of banking. The paper has compared the maturity and duration models to measure, manage, and control interest rate risk in banking. The maturity models are based on the current earnings approach. It is the traditional approach to interest rate risk assessment taken by many banks. The duration models are based on the economic value approach. They are complementary approaches to interest rate risk in banking.

The paper has also highlighted some theoretical, empirical, and regulatory implications of the asset & liability management perspective that most banks have adopted to measure, monitor, and control the exposure to interest rate risk.

In the second part of the paper we conduced an empirical investigation on the exposure of banks to the interest rate risk, using three different scenarios: parallel shift, slope shift, and bump shift of interest rate curves. The above results of the empirical analysis allowed us to identify the strategies that banks may adopt to manage interest rate risk in the asset & liabilitity management perspective: tier matching, term-structure, and hedging strategies.

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Endnotes

[i] Abstract, and sections n.1, 2, 3, 5 have been written by Enzo Scannella. Section n.4 has been written by Enzo Scannella and Dario Bennardo.

[ii] For ICBC and UniCredit the analysis is carried out for the overall banking portfolio. On the contrary, for Banca Popolare di Vicenza and Banca Don Rizzo, the analysis is carried out only for the Euro portfolio. All data are expressed in euro for the European banks. For ICBC data are expressed in renminbi (Rmb).

[iii] ICBC incorporate financial derivatives both in asset and liability side. UniCredit and Banco Popolare di Vicenza compensates long position with short positions in financial derivatives (long position - short positions). Banca Don Rizzo aggregates long position with short positions in financial derivatives (long position + short positions).