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Abstract

This paper studies the determinants of net interest margin and of the exposure to the interest rate risk of a sample of 125 local Italian banks during the period 2006-2018. Relative to prior literature, to take advantage of the unprecedented interest rate environment determined by European Central Bank (ECB)'s unconventional monetary policy measures, we consider two sub-periods: 2006-2011 and 2012-2018.

Banks' net interest margin increases with the intensity of maturity transformation, with a larger effect in the years 2012-2018, and with their exposure to interest rate risk. At this specific regard, we shed more light than previous studies by distinguishing among three sources of this risk, namely the one referred to the loans issuing and deposits collecting activity, the one stemming from the securities portfolio, and the one associated with derivatives positions.

Maturity transformation is associated with an increase in interest rate risk exposure, again with an impact that is stronger over the years 2012-2018. Funding from the ECB is associated with a higher interest rate risk exposure in the years 2006-2011, while it results in a reduction in the second part of the analysed period. We argue that ECB's (targeted) long-term refinancing operations lead to higher funding stability and strengthen banks' capacity to withstand potential upward shocks in interest rates. The opposite occurs for the deposits held by our sample bank at the ECB.

Keywords: Net interest margin; Interest rate risk; Maturity transformation; Unconventional monetary policy.

JEL Classification: G21; G32; E43; E52.

1. Introduction

Banks' exposure to interest rate risk is at the centre of the current debate on the financial stability of the euro area, due to the potential negative effects of the normalization of the European Central Bank's (ECB) monetary policy, which has raised the three benchmark rates by 450 basis points from the levels of July 2022.[1] The crisis of US Savings and Loan Associations in the 1980s has shown for the first time ever the systemic nature of the interest rate risk (Curry and Shibut, 2000). The collapse of the Silicon Valley Bank and the failure of Signature Bank, in early March 2023, again in the US, have recently reminded us of the adverse effects stemming from the combined impact of interest rate and liquidity risks when banks do not properly manage the maturity mismatch between their assets and liabilities in a context of rising rates.[2]

Understanding banks' actual exposure to interest rate risk is not only relevant from a financial supervision perspective but is also useful for predicting the potential effect of changes in monetary policy rates on the real economy (Van den Heuvel, 2012). The empirical evidence supporting the existence of the risk-taking channel of monetary policy focuses on credit risk (Altunbas *et al*., 2014; Jiménez *et al*., 2014; Paligorova and Santos, 2017). However, within the supervisory review and evaluation process (SREP), the assessment of interest rate risk exposure by supervisory authorities may lead to the so called additional Pillar 2 requirements (P2Rs), which, all else being equal, reduce banks' lending capacity.

To account for the changes in financial markets conditions of the years after the 2007-2008 global financial turmoil and the 2010-2011 euro area sovereign debt crisis, which were mainly induced by the monetary policy responses to those events, the Basel Committee on Banking Supervision (BCBS) updated in 2016 the standardized method introduced in 2004 to estimate banks' exposure to interest rate risk of the banking book[3] (BCBS, 2016).

Among the other things, the Committee proposed the adoption of six different interest rate shock scenarios to measure the impact of the interest rate risk. In 2017 the ECB conducted a stress test exercise to verify the sensitivity of a bank's banking book assets and liabilities and net interest margin to the six BCBS (2016)'s shock scenarios. In July 2018, the European Banking Authority (EBA) updated its guidelines on interest rate risk management, by also incorporating the same six shock scenarios. On October 20, 2022, the EBA also published new guidelines, replacing and updating those of 2018, and two technical regulatory standards, effectively introducing BCBS' provisions into the European Union.

The strong commitment by banking supervisory authorities and the new monetary policy stance have boosted further studies on interest rate risk-related issues (Molyneux *et al*., 2022; Hoffmann *et al*., 2019; Altavilla *et al*., 2018; Chaudron, 2018; Bednar and

[1] At the time of writing, the decision regarding the last rate hike dates back to September 14, 2023, when the Governing Council decided to raise the interest rate on the main refinancing operations and the interest rates on the marginal lending facility and the deposit facility to 4.50%, 4.75% and 4.00% respectively, with effect from 20 September 2023. For details about the sequence of ECB's rates rises, please refer to the following link: https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.it.html.

[2] https://www.fdic.gov/news/speeches/2023/spmar2723.html#_ftn4

[3] In the rest of the paper by "interest rate risk (exposure)" we mean the sensitivity to changes in interest rates of the only the banking book and not also of the trading book.

Elamin, 2014). In this perspective, we have a twofold objective and provide a contribution to the two empirical research areas dealing with bank profitability and riskiness, respectively. First, we investigate the determinants of banks' profitability by specifically focusing on the impact of their maturity transformation and the associated exposure to interest rate risk on the net interest margin. Second, we study the factors that can explain banks' sensitivity to interest rates. We contribute to previous studies in these areas since, to the best of our knowledge, no paper has examined whether and how the adoption of unconventional monetary policies, and the consequent extraordinary financial markets conditions, have influenced how maturity transformation and interest rate risk exposure affect bank profitability, on the one hand, and the determinants of interest rate risk exposure, on the other. Furthermore, we focus on local banks, which have never been specifically investigated by prior studies.

To fill this gap, we examine 125 Italian banks during the period 2006-2018, of which 106 are limited liability cooperative banks, (90 "*banche di credito cooperativo*" and 16 "*banche popolari*"), with the remaining 19 having a joint-stock company legal form ("*società per azioni*"), and split our sample period in two sub-periods: first, the years from 2006 to 2011; second, those from 2012 to 2018, during which banks have been running their business under a scenario never experienced before, which was shaped by ECB's ultra expansionary monetary policy. In December 2011 and January 2012, the ECB launched the long-term refinancing operations (LTROs), followed in 2014 and 2016 by the first two series of targeted long-term refinancing operations (TLTROs). Furthermore, in June 2014, for the first time ever, the ECB decided to cut its deposit facility rate below 0%, to -0.1%, thus starting the so-called negative interest rate policy (NIRP).

These measures changed banks' liability structure (ECB, 2021), with impacts in terms of performance and stability, the analysis of which has in our view relevant implications for both industry and supervisors. We focus on Italian banks since the huge presence of intermediaries typically active in collecting financial resources through short-term (sight and savings) deposits and in issuing medium- and long-term loans, usually held until maturity, makes the Italian banking system an ideal context to tackle the issues mentioned above.

As far as the period of our investigation is concerned, a 12-year time horizon allows us to run our analyses under different financial markets conditions. We specifically refer to the different configurations of the yield curve over those years, especially with regard to the changes in its slope. Since, due to their traditional intermediation activity, our sample banks use to ride the yield curve, changes in the slope of this latter have a tremendous impact on their profitability and stability.[4]

Following the pioneer work of Flannery and James (1984), empirical studies typically measure interest rate risk exposure by estimating the sensitivity of bank equity returns to changes in interest rates. From a methodology perspective, we contribute to prior studies by adopting a duration gap approach, which is in line with the prudential regulation set by the Basel Committee on Banking Supervision (BCBS, 2004, 2006, 2016), and, at Italian national level, by the Bank of Italy's Circular 285/2013. We are motivated in doing so because of the importance to appropriately consider the impact on bank economic value of changes in interest rates in the case of banks running a traditional intermediation business, like those included in our sample.

The relevance of such risk measure has been recently stressed by Andrea Enria, Chair of the ECB Supervisory Board, in a speech at the Deutsche Bundesbank symposium "Bankenaufsicht im Dialog" on November 8, 2022. According to Mr. Enria, banks tend to assess their exposure to interest rate risk from a short-term income perspective.

Based on June 2022 data, supervised banks confirmed that their net interest income would react positively to a 200-basis point shock in the yield curve. Nevertheless, on average, the same shock would have a negative impact on banks' economic value, with the 20 most affected intermediaries experiencing reductions in their common equity tier 1 (CET1) ranging from 100 to 400 basis points. The impact would be larger for retail banks, due to a business model which rests on a longer duration gap.[5]

Our main results show that the intensity of maturity transformation contributes positively to banks' net interest margin and determines an increase in interest rate risk exposure of the banking book. As expected, this latter is also associated with a raise in banks' profitability, measured in terms of net interest margin. Banks' net interest margin increases with the slope of the yield curve, while it is positively affected by the rates level in the years 2006-2011 and negatively during the period 2012-2018, thus entailing in this second case significant frictions in asset and liability re-pricing, based on which interest rate increases compress banks' net interest margin in the short term.

The ECB funding is associated with higher interest rate risk exposure in the years 2006-2011, while it results in a reduction of the negative impact on banks' economic value in the second part of the period under analysis. Therefore, in the second period it seems that the contribution of ECBs' LTROs and TLTROs in terms of our sample banks' funding stability translates into a superior capacity to withstand potential upward shocks in interest rates. The opposite occurs for the deposits held by our sample banks at the ECB: they reduce interest rate risk over the years 2006-2011, whereas are positively associated with banks' risk exposure during the years ranging from 2012 to 2018.

The remainder of the paper is organized as follows: section 2 contains an analysis of the main studies on the determinants of banks' net interest margin and interest rate risk exposure; section 3 presents the empirical investigation, examining the methodology and discussing the variables used in the analysis and developing four hypotheses to test; section 4 describes data and discusses our main findings; in section 5 we provide some additional analysis and robustness checks; section 6 concludes.

[4] If measured as the difference between the 10-year and 3-month swap rates, as done by Esposito *et al.* (2015), over the 2006-2018 period, the slope of the yield curve first gradually decreased up to the summer of 2008. Then, after Lehman Brothers' failure and the subsequent reduction in monetary policy rates by the ECB, with, for example, the rate on main refinancing operations going down from 3.75% of October 15, 2008, to 1% of December 14, 2011, it recorded a significant increase. Finally, following the European sovereign debt crisis, a new slope reduction was observed.

[5] For further details, visit the following ECB webpage:
https://www.bankingsupervision.europa.eu/press/speeches/date/2022/html/ssm.sp221108~ee0264b638.en.html

2. Literature review

This article contributes to two strands of banking research: first, the studies analyzing the determinants of profitability, particularly those measuring it in terms of net interest margin; second, the research examining the factors affecting interest rate risk exposure. Sections 2.1 and 2.2 review this literature.

2.1 The determinants of bank profitability

The first empirical studies about the determinants on banks' profitability date back to the 1980s. A first group of works has developed and extended the seminal paper by Ho and Saunders (1981). Then, a bunch of papers specifically has investigated the impact of interest rates on bank profits, even by making a distinction between short-term and long-term interest rates, and accounting for the characteristics of the yield curve, particularly in terms of its slope. More recently, literature has been dealing with the effects of banks' interest rate risk exposure and maturity transformation activity, on the one hand, and of unconventional monetary policies, on the other. Empirical results of these two latter streams of studies are mixed and call for further analysis.

Ho and Saunders (1981) describe the bank as a risk-averse intermediary providing liquidity through maturity transformation. If the volumes of loans and deposits, which in their model have the same 1-year maturity, do not match, the bank turns to the money market and becomes exposed to refinancing (reinvestment) risk if loans are larger (smaller) than deposits. They show that major US banks' NIM depends on management's risk aversion, average transactions size, market structure, and interest rate volatility.

The Ho and Saunders (1981) model has been subsequently extended. McShane and Sharpe (1985) identify market interest rate fluctuations as the main source of risk, rather than the uncertainty in loan returns and deposit costs. Angbazo (1997) includes a measure of interest rate risk exposure in the model and considers its interaction with credit risk. Allen (1988) hypothesizes different maturities for loans and deposits and accounts for two types of loans, with interdependent demand functions. Entrop *et al*. (2015) remove the assumption of equal maturities for loans and deposits to explore the extent to which interest risk exposure is priced into bank margins, and conclude that German banks generally price individual interest rate risk via the asset side into the NIM, whereas only small, local banks price interest rate risk via the liability side. Maudos and Fernández de Guevara (2004) explicitly take operating costs into account and use the Lerner index to measure the degree of competition. Carbó Valverde and Rodríguez-Fernàndez (2007) introduce non-traditional activities into the theoretical framework, proposing a multi-output model to analyse the relationship between bank margins and operational specialization. Finally, Maudos and Solís (2009) simultaneously consider operating costs, diversification, and activity specialization, finding a positive relationship between banks' margin and the Lerner index, operating costs, and interest rate volatility, and a negative correlation with management quality and non-interest income.

Interest rates are among the main determinants of bank profitability. Generally, studies report a positive correlation between rates and NIM, interpreting it as a natural consequence of maturity transformation (Flannery, 1981; Hancock, 1985; Bourke, 1989; Saunders and Schumacher, 2000). Some works distinguish between short and long-term rates. According to Albertazzi and Gambacorta (2009), the net interest margin is positively correlated with economic trends and long-term rates, while it is unaffected by short-term rates. Bolt *et al*. (2012) confirm the positive correlation of banks' net interest margin with long-term rates, with an intensity that depends on the economic cycle phase and decreases as the yield curve slope increases; however, short-term rates negatively impact the net interest margin, with an effect that increases with the weight of wholesale funding.

More recently, scholars have focused on the impact of interest rate risk exposure, maturity transformation, and monetary policy on bank profitability. As for the effects of interest rate risk exposure and maturity transformation, Entrop *et al*. (2015) show that interest rate risk exposure and expected returns from maturity transformation contribute to determining German banks' NIM. Bologna (2017) documents that a more intense maturity transformation is associated with higher NIMs for Italian banks, particularly as the yield curve slope increases. Nevertheless, if excessive, maturity transformation might lead to a larger risk exposure without any benefit in terms of NIM.

Regarding the relationship between monetary policy and bank profitability, Alessandri and Nelson (2015) develop a model providing a broad picture of the consequences of a monetary policy shock. By raising short-term rates and flattening the yield curve, a policy tightening typically reduces banks' income. Unconventional monetary policies based on asset purchases are expected to lower income margins to the extent that they succeed in lowering long-term yields. Their empirical analysis is referred to a panel data set containing information on the UK activities of the United Kingdom and foreign banking groups.

Borio *et al*. (2017) prove that short-term interest rates and the slope of the yield curve positively influence the return on assets of an international sample of banks, and document that extremely low interest rates and a flat yield curve erode bank profitability. Conversely, evidence from Altavilla *et al*. (2018) does not indicate any effect on euro area banks' profitability in the years 2000-2016 following a decrease in short-term interest rates and/or a flattening of the yield curve. Claessens *et al*. (2018) observe that a 1 percentage point decrease in interest rates implies an 8 basis point reduction in the NIM of an international sample of banks coming from 47 countries. Furthermore, low rates enhance this effect and, for each additional year, of a "low for long" scenario, NIM and return on assets decrease by an additional 9 and 6 basis points, respectively.

Coulier *et al*. (2023) document that the sensitivity euro area banks' net interest income to changes in interest rates and in the slope of the yield curve depends on the extent of their maturity mismatch: according to their estimates, the NIM raises by 4.8 bps if the 3-month overnight index swap rate experiences a 1% increase, and by 5.8 bps if there is a 1% rise in the yield curve slope. The positive effect of a yield curve steepening on NIMs is larger for banks more engaged in the maturity transformation function. Nevertheless, the authors warn that this might dissipate in the future, especially for banking systems characterized by the prevalence of variable-rate lending.

This paper is close to the works about the impact of interest rate risk and maturity transformation on bank profits and is also linked to the monetary policy related research. Relative to this literature, we contribute first by using a measure of interest rate risk that is

compliant with the prudential supervision and that we are able to decompose to account for the exposure stemming from the positions deposits collecting & loans issuing activity, that associated with securities portfolio and the one referred to the derivatives use. Second, to assess the maturity transformation, we use the inverse of the net stable funding ratio, which is something never done before, to the best of our knowledge. Finally, we consider the 2010-2018 period, which allows to examine these relationships under different financial market conditions and to assess the potential impact of unconventional monetary policies.

2.2 The determinants of interest rate risk exposure

It is approximately 40 years that banking scholars devote efforts to study the determinants of banks' vulnerability to interest rates movements. In the '80s of the last century, first papers focused on the analysis of the impact of the maturity mismatch between assets and liabilities and adopted a market-based approach to measure banks' riskiness, which was particularly assessed through the sensitivity of stock returns to changes in interest rates. Successive works have progressively extended the list of potential factors affecting interest rate risk exposure, by accounting for a number of bank-specific characteristics, mainly related to the composition of the asset and liability sides of the balance sheet, such as equity endowment and loan and deposit volumes, and to the peculiarities of the profit and loss account, considering for example the share of non-interest income over total revenues and loan loss provisions set aside to cover credit risk. Finally, the protracted scenario of extremely low, and even negative, interest rates caused by the ultra-expansionary monetary policies adopted in response to the global financial crisis, earlier, and to the euro area sovereign debt crisis, later, has incentivised researchers to investigate the impact of both these extra-ordinary conditions and the consequences of the normalization process started in July 2022.

In 1984, Flannery and James show that the mismatch of asset and liability maturities could explain the different sensitivity of banks to interest rates fluctuations. Subsequent works by Yourougou (1990), Kwan (1991), and Akella and Greenbaum (1992) support this thesis and several empirical studies extended the analysis by incorporating the effect of derivative usage on banks' interest rate risk (Hirtle, 1997; Schrand, 1997; Zhao and Moser, 2006). Some authors focus on the correlation of banks' interest rate risk exposure with a range of specific bank characteristics. Drakos (2001) shows that working capital is the main source of Greek banks' sensitivity to interest rate changes, a significant portion of which also depends on market value, equity, and debt. Fraser *et al*. (2002) prove that US banks' interest rate risk exposure is negatively (positively) correlated with the amount of equity, sight deposits, and loans. The correlation is positive with the share of non-interest revenues, probably because an increase in the incidence of such revenues is associated with a greater involvement in securities-related activities, such as underwriting and advisory. Saporoschenko (2002) finds that Japanese banks' interest rate risk exposure is positively correlated with bank size and deposit volume, while the maturity gap does not seem to have a significant impact.

Reichert and Shyu (2003) show that the use of options tends to increase interest rate risk exposure of US, European and Japanese large international banks, whereas both interest rate and currency swaps generally reduce it. Equity endowment, commercial loans, liquidity level, and loan loss provisions have a significant impact on interest rate risk exposure, although not entirely consistent among the three geographical areas. Based on the analysis of Asia-Pacific banks, Au Yong *et al*. (2007) suggest that the level of derivatives activity is positively associated with long-term interest rate exposure but negatively with short-term interest rate exposure.

Unlike the studies discussed above, Esposito *et al*. (2015) measure the exposure to the interest rate risk using the BCBS' duration gap approach. They show that Italian banks have limited interest rate risk exposure and manage it using changes in balance sheet exposure and interest rate derivatives as substitutes, with a substantial heterogeneity in risk management practices. Smaller banks and those with a greater commitment to traditional banking follow an integrated approach to managing interest rate and credit risk. Most of their sample banks tend to value gains from interest rate increases even in the face of widening funding gaps.

By analysing the interest rate risk exposure of Eurozone listed banks under the ECB's supervision Foos *et al*. (2017) assess the sensitivity of bank stock prices to changes in level, slope, and curvature of the yield curve. This sensitivity depends on bank-specific characteristics: larger intermediaries, with higher capital coefficients, and larger (smaller) customer loans (deposits) shares, are particularly sensitive to interest rate changes. Chaudron (2018) studies changes in interest rate risk exposure over time and how asset returns and interest margins depend on income from maturity transformation for a sample of Dutch banks, under a scenario of falling rates and flattening yield curve. Interest rate risk exposure is negatively correlated with financial leverage, shows a U-shaped relationship with solvency, does not systematically vary with bank size, and is higher for banks that received public assistance during the global financial crisis.

Hoffmann *et al*. (2019) analyse a sample of banks directly supervised by the ECB and find that for half of these intermediaries an increase in interest rates leads to higher net worth and income. Variation in risk exposure seems to be greater across countries than across bank business models. Particularly, by examining two groups of countries, i.e., those where fixed rates prevail and those where rates are mostly variable, they find that banks with a larger share of retail loans drive the observed variation. Molyneaux *et al*. (2020) identify specific bank characteristics that may amplify or weaken the impact of an interest rate hike on 81 Eurozone banks. Banks with a higher share of variable interest rate loans and a diversified loan portfolio, both by sector and geographical area, are less exposed to rising interest rates.

We add to this literature by specifically investigating whether and how deposits at and, especially, funds borrowed from the ECB contribute to determine banks' exposure to interest rate risk. In this perspective, we again take advantage of the sample period we are interested in. In the years 2010-2018 banks had to face unprecedented financial market conditions, which were shaped by the ECB's ultra-expansionary monetary policy measures, namely the NIRP, which was introduced in June 2014, and the LTROs and TLROs, through which the euro area monetary authority aimed to ensure banks' support to the real economy by providing them with stable and extremely competitive funding sources.

Thus, we not only detect the contribution of factors never considered by prior studies, but we also can test some of the relationships traditionally investigated by previous works under conditions never experienced before.

3. Empirical analysis

3.1 Methodology

The study of the impact of maturity transformation, interest rate risk exposure and the other micro and macro determinants on banks' net interest margin is conducted through the following linear regression model in equation (1):

$$NIM_{it} = c + \sum_{j=1}^{J} \beta_j X_{it}^j + \sum_{m=1}^{M} \beta_m X_t^m + \varepsilon_{it} \qquad \varepsilon_{it} = v_i + u_{it} \qquad (1)$$

where:

- NIM_{it} is the measure of bank profitability, i.e., the ratio of the net interest margin over total assets of the *i-th* bank at time *t*, with *i = 1, ..., N* and *t = 1, ..., T* years;
- c is a constant;
- X_{it}^j are bank-specific variables, among which the two main variables, respectively measuring the interest rate risk exposure and the intensity of maturity transformation, plus some other control variables;
- X_t^m are macroeconomic control variables;
- ε_{it} is the error term, with a bank-specific component v_i and an idiosyncratic factor u_{it}.

To detect the determinants of our sample banks' interest rate risk exposure, we employ the linear regression model of the following equation (2):

$$IRRBB_{it} = c + \sum_{j=1}^{J} \beta_j \Phi_{it}^j + \sum_{m=1}^{M} \beta_m \Phi_t^m + \varepsilon_{it} \qquad \varepsilon_{it} = v_i + u_{it} \qquad (2)$$

where:

- $IRRBB_{it}$ is the measure of the exposure to interest rate risk in the banking book of the *i-th* bank at time *t*, with *i = 1, ..., N* and *t = 1, ..., T* years;
- c is a constant;
- Φ_{it}^j are bank-specific variables, among which three main variables, respectively measuring the intensity of maturity transformation, loans from the ECB and deposits at the ECB, plus some other control variables;
- Φ_t^m are macroeconomic control variables;
- ε_{it} is the error term, with a bank-specific component v_i and an idiosyncratic factor u_{it}.

All the variables, both main and control variables are described in the following section 3.2 and presented in Table 1. Following Bologna (2017) for the NIM determinants, and Entrop *et al*. (2015) for the IRRBB analysis, models in equations (1) and (2) are estimated using the Generalized Method of Moments (GMM) proposed by Blundell and Bond (1998), widely used in the literature to estimate a dynamic panel equation with a relatively small time dimension and a larger number of units, i.e., with small T and large N. The approach accounts for endogeneity, controls for unobserved heterogeneity, and handles biases and inconsistencies typical of OLS estimates, provided there is no second-order serial correlation and the instruments used are valid. Consistent with Bologna (2017), bank size is considered a predetermined variable, all other bank-specific variables are treated as endogenous, and macroeconomic variables are treated as exogenous. We instrument for all the bank-specific regressors but bank size; we apply the instruments to the level equation and, to limit their proliferation, we cap to two the number of lags of the endogenous variables used as instruments.

To assess the impact of unconventional monetary policy measures on the relationships between bank profitability and interest rate risk exposure with their respective determinants, each model is estimated for two sets of years of the entire investigation period. The first includes the years ranging from 2006 to 2011, when the ECB still had to introduce such measures; the second goes from 2012 to 2018, when the long-term refinancing operations, the targeted targeted long-term refinancing operations and the negative interest rate policy were all at work.

3.2 Variables

3.2.1 Variables of interest and hypotheses development

The ratio of net interest margin to total assets (NIM) is our measure of bank profitability and is the dependent variable of the model in equation (1), where banks' exposure to the interest rate risk (IRRBB) and the proxy for their maturity transformation (MT) are the main independent variables. As for the IRRBB variable, our banks' exposure to interest rate risk has been calculated using the economic value approach adopted by the prudential supervision and considering a +200 bp parallel shock in interest rates. Assets and liabilities have been allotted into the time bands of the regulatory maturity ladder based on their residual maturity or repricing date. For each time band, the difference between assets and liabilities, i.e., the so-called net position, is calculated and then weighted by the product of an average modified duration coefficient and the interest rate shock. Summing up the weighted net positions of all the time bands and dividing this sum by a measure of regulatory capital yields a risk indicator, a positive (negative) value of which signals a decrease (increase) in the overall bank economic value. A positive value of the risk indicator means a reduction in the bank economic value as a percentage of its regulatory capital.

Data required for the IRRBB estimation has been hand collected from our sample banks' balance sheet. From this perspective, this study is close to Chaudron (2018) and Esposito *et al*. (2015), who respectively use Dutch and Italian national supervisory data. Compared with previous studies, this allows us a much greater detail about banks' exposure, of which we take advantage in the analysis

of profitability determinants. Our data collection and analysis allow to break the overall risk indicator down into three components, whose incidence on banks' NIM has never been investigated before.

Particularly, these three components are defined as follows: first, the "banking exposure" (IRRBB_B), given by the part of the total IRRBB exposure stemming from traditional and direct borrowing and lending activities, mainly consisting in deposits and loans; second, the "securities exposure" (IRRBB_S), which is the contribution of our banks' securities portfolio to the overall exposure, and third the "derivatives exposure" (IRRBB_D), which is related to banks' positions on derivative financial products. Again, as for the overall risk indicator, positive values of the risk indexes referred to these components mean a raise in the bank exposure to interest rate risk.

In line with prior literature (Angbazo, 1997; Saunders and Schumacher, 2000; Maudos and Fernández de Guevara, 2004; Entrop *et al*., 2015), the exposure to the interest rate risk is expected to be positively associated with the net interest margin, thus implying a positive expected sign for the coefficient of the variable IRRBB. Our first research hypothesis, concerning the impact of banks' exposure to interest rate risk and their profitability, can be therefore stated as follows:

H1: Banks' exposure to interest rate risk in the banking book positively affects net interest margin.

Data constraints do not allow to consider the contractual maturity of our banks' assets and liabilities to measure the proxy for the maturity transformation activity, as done by Bologna (2017) and Esposito *et al*. (2015), who respectively estimate maturity transformation as the duration of assets and liabilities and as a function of the contractual remaining time to maturity. Following Casu *et al*. (2018), the intensity of maturity transformation is first measured by the inverse of the net stable funding ratio introduced by the Basel III reform of the international prudential supervision after the 2007-2008 global financial crisis. So, put in terms of liquidity regulation, the first proxy for the maturity transformation, labelled MT1, is the ratio of required stable funding to available stable funding. Consistent with previous studies (e.g., Bologna, 2017), within the robustness checks section, we replace MT1 with the ratio of the loans granted to over the deposits collected from retail customers (MT2). In line with prior literature (Bologna, 2017; Foos *et al*., 2017), both MT1 and MT2 are expected to have a positive impact on net interest margin, on the one hand, and on interest rate risk, on the other, thus implying positive regression coefficients in both equations (1) and (2). Our second hypothesis, referred to the relationship between maturity transformation and profitability can be stated as follows:

H2: Banks' maturity transformation positively affects net interest margin.

The IRRBB variable becomes the dependent variable of equation (2), where we analyse the determinants of banks' exposure to the interest rate risk in the banking book. Relative to prior literature, the impact of the monetary policy measures implemented by the ECB in the second part of the sample period is assessed through the exam of the relationships between IRRBB, on the one hand, and loans from and deposits at the ECB, on the other hand. Specifically, two items of sample banks' balance sheets are considered: "Cash and cash equivalents" on the asset side, which includes deposits at the ECB and "Liabilities to banks" on the liability side, which contains the funds that banks receive from the ECB. The ratios of these two items to total assets are labelled LAB and DFB.

As far as the expected signs of their regression coefficients, we argue that, since the use of funding from the ECB through (targeted) long-term refinancing operations has allowed banks to stabilize their liabilities, as in the intentions of the ECB itself,[6] their presence in intermediaries' funding mix should reduce these latter exposure to upward interest rate fluctuations, which entails that the expected sign of the DFB regression coefficient is negative. In this sense, even if they use a different measure for the exposure to the interest rate risk, our expectation is in line with Molyneux *et al*. (2022), who highlights the positive effects of TLTROs in terms of reduced and diversified funding costs. As for the variable LAB, an increase of which contributes to make more liquid the overall assets side of a bank involved in the traditional intermediation activity, with a large share of long-term loans on the asset side, we expect a negative sign for the LAB regression coefficient. The final two hypotheses tested in the empirical analysis, about the relationship between LAB and DFB, on the one hand, and IRRBB, on the other, can be stated as follows:

H3: Banks' funds from the ECB reduce the exposure to the interest rate risk.

H4: Banks' deposits at the ECB reduce the exposure to the interest rate risk.

3.2.2 Control variables

In our analysis of the determinants of net interest margin and interest rate risk exposure we use two groups of control variables: a first set consists of bank-specific indices, respectively measuring bank size, credit risk exposure and overall risk aversion. The second set of regressors includes macroeconomic variables, namely the level of interest rates, the slope of the yield curve, and the state of the Italian economy.

Bank-specific variables

The variable used to account for the size of the bank (SIZE) is given by the natural logarithm of total assets. Empirical investigations show conflicting results regarding its impact on net interest margin: Albertazzi and Gambacorta (2009) and Ho and Saunders (1981) observe that NIM increases with bank size, while Fungáčová and Poghosyan (2011) and Maudos and Fernández de Guevara (2004) find a negative relationship between the two variables. Therefore, we do expect either a positive or a negative sign for the regression coefficient of the SIZE variable in equation (1). Its impact on the exposure to interest rate risk is expected to be positive, with a positive regression coefficient in equation (2). Consistent with a moral hazard interpretation of the relationship between

[6] https://www.ecb.europa.eu/ecb-and-you/explainers/tell-me/html/tltro.en.html

size and risk variables, we expect a reduction in risk aversion as bank size increases, due to the increased probability that banks are perceived as "too big to fail".

Credit risk exposure (CR) is measured by the ratio of non-performing loans to total assets. According to most of previous studies, an increase in credit risk should result in a corresponding increase in net interest margin due to the higher risk premium required by banks (Angbazo, 1997; Maudos and Fernández de Guevara, 2004). However, since some works highlight a negative relationship (e.g., Williams, 2007), we do not take any a priori position on the expected sign of the regression coefficient for this variable in equation (1). In the analysis of the determinants of interest rate risk exposure in equation (2), on the other hand, a negative relationship is expected in line with prior literature (e.g., Foos *et al*., 2017).

Risk aversion (RA) is often assessed through indicators of capital adequacy typical of prudential supervisory practices or through traditional leverage ratios. Consistent with Bologna (2017), risk aversion is here measured by the capital in excess to the required minimum to total risk-weighted assets, i.e., the difference between the total capital ratio and the minimum threshold of 8%. The literature presents conflicting results on the relationship between bank net interest margin and the degree of risk aversion, even if most of studies highlight a positive relationship (Angbazo, 1997; Fernández de Guevara, 2004; Maudos and Solís, 2009; Bologna, 2017), justified by the demand from intermediaries for higher margins to compensate for the opportunity cost arising from the greater allocation of own funds withdrawn from the income-generating circuit of productive investments. Entrop *et al*. (2015) use the ratio of excess capital over regulatory minimums to total assets to estimate bank risk aversion and confirm the positive correlation between this measure and net interest margin. By reducing banks' riskiness, greater capital endowment could lead to a reduction in the cost of funding, resulting in an increase in net interest margin. Nevertheless, prudent management could lead not only to higher capitalization but also to extremely conservative lending policies, which, because of the lower interest income, would justify a negative relationship between capitalization and NIM. In line with the majority of previous studies, we expect a positive regression coefficient for the RA variable in equation (1).

The ex-ante analysis of the impact of our measure of risk aversion on the IRRBB variable in equation (2) is not straightforward as well, and previous literature does not help because banks' exposure to interest rate risk is mainly given by market-based sensitivity measures. Since higher solvency, expressed by a wider endowment of own funds compared to the minimum required threshold, allows the bank to assume more risk, the expected sign of the relationship between the RA and IRRBB might be positive. On the other hand, a higher capital endowment reduces the leverage and make the liability side more stable, thus reducing IRRBB coeteris paribus. In the light of that, the expected sign of the regression coefficient of the RA variable in equation (2) might be either positive or negative.

Macroeconomic variables

As far as macroeconomic control variables are concerned, previous studies have included interest rate volatility, the level and slope of the yield curve. Consistent with Esposito *et al*. (2015), in the first specification of the profitability model described in equation (1), temporal dummies are used (see columns 1 in both panels of Table 4). These dummies not only capture the effect of macroeconomic conditions, which are invariant for banks but vary over time, but also help to mitigate endogeneity issues due to the presence of variables whose behaviour may be driven by common macroeconomic factors. In two subsequent specifications (see columns 2 and 3 in both panels of Table 4), macroeconomic control variables are used, such as the growth rate of gross domestic product (GDPGR), the level of short-term interest rate, given by the three-month Euribor (EUR3M), and the slope of the yield curve (SLOPE), calculated as the difference between the 10-year IRS swap rate and the three-month Euribor. Consistently with previous research, all these variables are expected to have a positive relationship with bank net interest margin in equation (1).

Following Grove (1974) and Prisman and Tian (1993), we assume that it is the yield spread rather than the level of interest rates that impacts interest rate risk exposure: therefore, the regression coefficient of the EUR3M variable is expected to be non-significant in equation (2). The spread between long-term and short-term rates (SLOPE) is an indicator of future changes in long-term rates (Campbell and Shiller, 1991) and can be interpreted as a measure of banks' ability to "exploit" the yield curve by employing a borrow short and lend long strategy.

An increase in the slope of the yield curve should correspond to an increase in interest rate risk exposure, thus suggesting a positive regression coefficient for the SLOPE variable in equation (2). We do not have any a priori about the relationship of the state of the economy, as measured by the GDP growth rate, and banks' exposure to interest rate risk, since previous literature does not typically use this control.

Table 1: Variables

	Variable	***Symbol***	***Description***	***Source***
Bank specific variables				
Net interest margin (dependent variable in eq. 1)	$\frac{\text{Net interest margin}}{\text{Total assets}}$	NIM_{it}	Ratio of net interest margin to total assets	BF
Interest rate risk in the banking book (dependent variable in eq. 2)	IRRBB	$IRRBB_{it}$	BCBS risk indicator based on a +200 bp shock.	BS
Interest rate risk from banking activity	IRRBB_B	$IRRBB\_B_{it}$	Share of IRRBB exposure stemming from deposit collection and loans issuing activity	BS
Interest rate risk from securities portfolio	IRRBB_S	$IRRBB\_S_{it}$	Share of IRRBB exposure stemming from securities portfolio	BS

Interest rate risk from derivatives	IRRBB_D	$IRRBB\_D_{it}$	Share of IRRBB exposure stemming from derivative positions	BS
Credit risk	$\frac{\text{Non} - \text{performing loans}}{\text{Total assets}}$	CR_{it}	Ratio of non performing loans to total assets	BF
Maturity transformation	$\frac{1}{\text{Net Stable Funding Ratio}}$	$MT1_{it}$	Inverse of Net Stable Funding Ratio	BF
	$\frac{\text{Customer loans}}{\text{Customer deposits}}$	$MT2_{it}$	Ratio of customer loans to customer deposits	BF
Risk aversion	$\text{Total Capital Ratio} - 8\%$	RA_{it}	Difference between total capital ratio and 8%	BF
Bank size	Ln(Total assets)	$SIZE_{it}$	Natura logarithm of total assets (in € thousands)	BF
Deposits at the ECB	$\frac{\text{Deposits at the ECB}}{\text{Total assets}}$	LAB_{it}	Ratio of deposits at the ECB to total assets	BF+BS
Funding from the ECB	$\frac{\text{Debt towards ECB}}{\text{Total assets}}$	DFB_{it}	Ratio of debt towards ECB to total assets	BF+BS
Macroeconomic variables				
GDP annual growth rate	$\frac{GDP_t - GDP_{t-1}}{GDP_{t-1}}$	$GDPGR_t$	Annual GDP growth rate (in percentage)	EU
Short-term interest rate level	3-month Euribor	$EUR3M_t$	Average annual 3-month Euribor (in percentage)	REF
Yield curve slope	Spread between long-term interest rate and short-term interest rate	$SLOPE_t$	Difference between 10-year IRS rate and 3-month Euribor (in percentage)	REF

Note: BF = Moody's Analytics Bank-Focus; BS: Bank balance sheets; EU = Eurostat; REF = Refinitiv Datastream

4. Data and results

4.1 Data

We examine a sample of 125 unlisted Italian banks, active at a provincial or regional level, over the period ranging from 2006 to 2018 with annual observations. The sample includes 106 limited liability cooperative banks, of which, according to the Italian banking law, 90 are "*banche di credito cooperativo*" and 16 are "*banche popolari*", with the remaining 19 having a joint-stock company legal form ("*società per azioni*"). We refer to the "*banche di credito cooperativo*" and "*banche popolari*" generally as "*cooperative banks*", and to the joint-stock banks as "*joint-stock banks*".

Data regarding banking variables is taken from the Moody's Analytics Bank-Focus database, except for interest rate risk exposure, which is calculated based on data collected from our sample banks' balance sheets. To avoid double counting, our data is drawn from the consolidated balance sheets, if available, or from the unconsolidated financial statements, otherwise. Data related to the level of the three-month Euribor and the slope of the yield curve is obtained from the Refinitiv Datastream database, while the annual growth rate of the Italian gross domestic product is computed based on data from Eurostat.

Table 2A shows the main descriptive statistics of the variables for the whole sample, whereas Table 2B reports those referred to the cooperative banks (Panel A) and commercial banks (Panel B) sub-samples, as well as the results of the tests run for the statistical significance of the differences between the means (Panel C). Overall, our sample banks are heavily engaged in traditional credit intermediation activities: the average values of the ratio of loans to customers to total assets and the ratio of customer deposits to total assets are 69.09% and 51.72%, respectively (data not shown here). The ratio of loans to customers to total assets is 69.14% for the sub-sample of cooperative banks and 68.30% for joint-stock banks; customer deposits are 51.33% of cooperative banks' total assets and 58.40% of joint-stock banks' total assets.

Table 2A shows that the average value of the net interest margin to total assets ratio (NIM) is 2.2%, and the ratio of non-performing loans to total assets (CR) is 7.7%. As for the overall interest rate risk exposure (IRRBB), in the case of a parallel shift upward of the yield curve by 200 basis points, our sample banks experience a reduction in their economic value averaging 1.7% of the regulatory capital during the years 2006-2018. On average, a 200-basis point increase in the yield curve leads to a raise in our banks' economic value, if we focus on the component of the interest rate risk exposure stemming from the traditional loans-deposits intermediation activity (IRRBB_B is -8.2%), and to a reduction of their economic value, if we look at the interest rate risk exposure stemming from banks' positions in securities (IRRBB_S is 6.9%) and derivatives (IRRBB_D equals 2.1%).

Our sample banks comply with the requirement imposed by the prudential supervisory framework in terms of the NSFR: MT1, which is its inverse, has an average value of 0.909. In terms of risk aversion (RA), banks in the sample have an average regulatory capital surplus to the minimum capital requirement of 8%, amounting to approximately 7.8%, implying an average total capital ratio over the period of about 15.8%. Regarding the variables measuring the transitions with the ECB, the average values of the ratio of deposits at the ECB to total assets (LAB) and the ratio of funding from the euro area monetary authority to total assets (DFB) are 6% and 9.4%, respectively. The evolution over the years 2006-2018 of these two variables is depicted in Figure 1, which reports a significant increase in DFB due to the launch of the first LTROs in December 2011 and January 2012, followed by two series of TLTROs of 2014 and 2016.

Table 2A: Descriptive statistics: whole sample for the years 2006-2018

	Mean	Std. Dev.	Median
NIM	0.022	0.007	0.021
IRRBB	0.017	0.119	0.000
IRRBB_B	-0.082	0.104	-0.087
IRRBB_S	0.069	0.123	0.022
IRRBB_D	0.021	0.051	0.004
CR	0.077	0.049	0.067
MT1	0.909	0.141	0.882
RA	7.789	5.208	6.742
SIZE	13.724	1.123	0.078
DFB	0.094	0.088	0.049
LAB	0.060	0.043	13.606
GDPGR	-0.080	2.101	0.774
EUR3M	1.266	1.667	0.573
SLOPE	1.654	0.912	1.302

Note: For the definition of the variables, please refer to the previous Table 1

Figure 1A: Deposits at (LAB) and funding from (DFB) the ECB: whole sample for the years 2006-2018

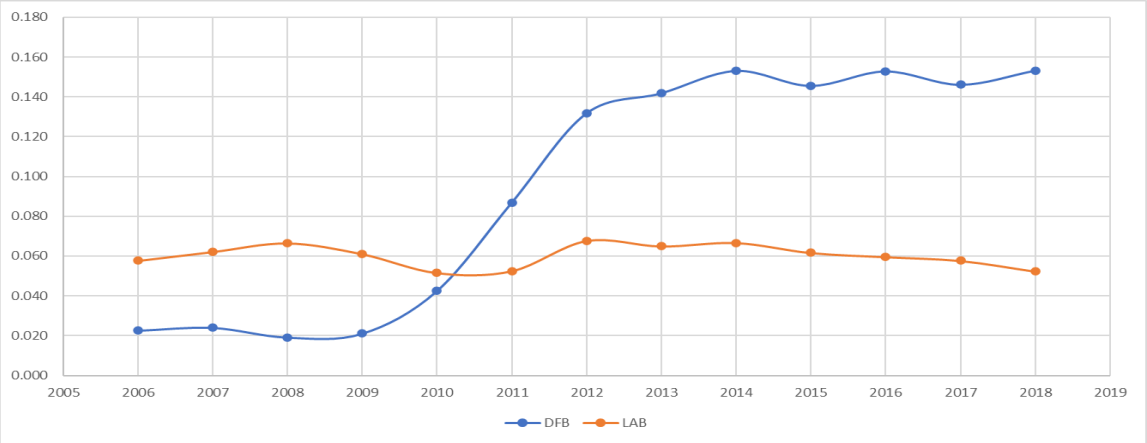


Table 2B reports that cooperative and joint-stock banks have approximately an equal ratio of net interest margin to total assets (2.2% for cooperative banks and 2.1% for joint-stock intermediaries), even if the very small difference appears statistically significant at the 1% confidence level. Cooperative banks seem to be more risk adverse than joint-stock institutions (the mean value of the variable RA is 8.001% for the former and 4.043% for the latter, with a difference statistically significant at the 1% confidence level). Joint-stock banks are on average larger than cooperative ones (the mean of the natural logarithm of their total assets is 14.950 vs. 13.651 for cooperative intermediaries), again with a difference which is statistically significant at the 1% confidence level. Cooperative banks seem to be slightly less involved in maturity transformation activity, being characterized by a 0.908 value for the MT1 variable, smaller than the 0.921 value of the joint-stock institutions.

While cooperative banks are exposed to a 200-bp raise in interest rates (IRRBB is 1.9%), joint-stock institutions would experience a decline in their economic value following a decrease in interest rates (IRRBB equals -2.2%), with a difference statistically significant at the 1% confidence level. No statistically significant difference is found for the exposure stemming from loans-deposits intermediation activity: IRRBB_B stands at 8.2% for cooperative banks and at 7.9% for joint-stock ones. As concerns both the securities portfolio and derivatives positions, cooperative banks are more exposed to a raise in interest rates than joint-stocks intermediaries: IRRBB_S and IRRBB_D are 7.1% and 2.2%, respectively, for the former, and 4.3% and 0.5%, respectively, for the latter, with mean differences statistically significant at the 1% confidence level for both securities and derivatives positions.

Figure 1B separately shows for cooperative and joint-stock banks the trend in the deposits at the ECB (Panel A) and the funding coming from the euro area monetary authority (Panel B) over the years 2006-2018. Joint-stock banks show a marked decline in the deposits they have at the ECB: the variable LAB goes from 11.82% in 2006 to 5.85% in 2016, whereas the trend for the cooperative

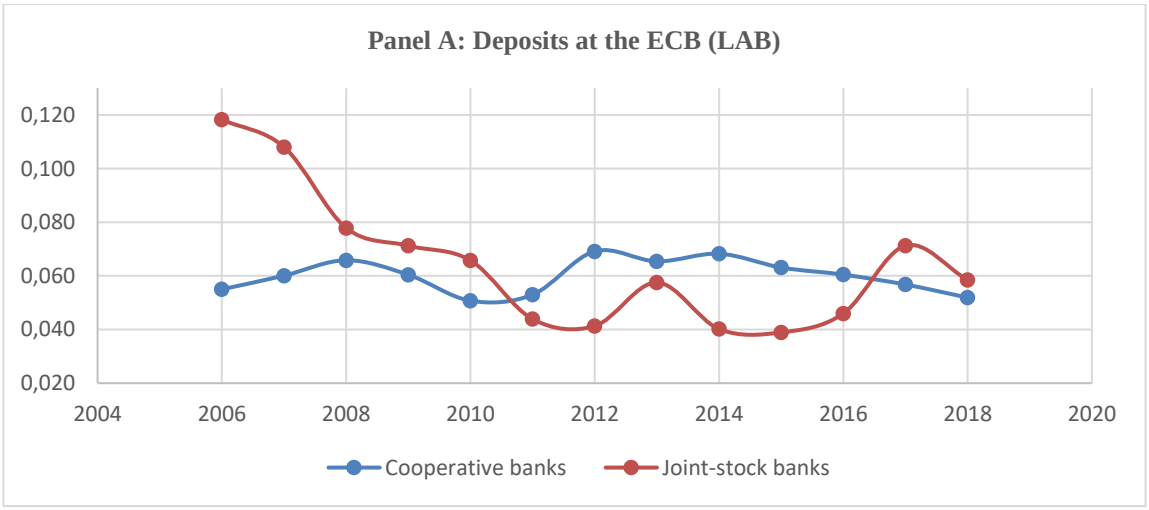
banks seems to be quite flat. Both groups of banks experience a steep increase in the share of deposits from the ECB to total assets (DFB), which starts from a value of 2.91% and 2.22% for joint-stock and for cooperative banks in 2006 and gets to 18.43% and 15.11%, respectively, in 2018.

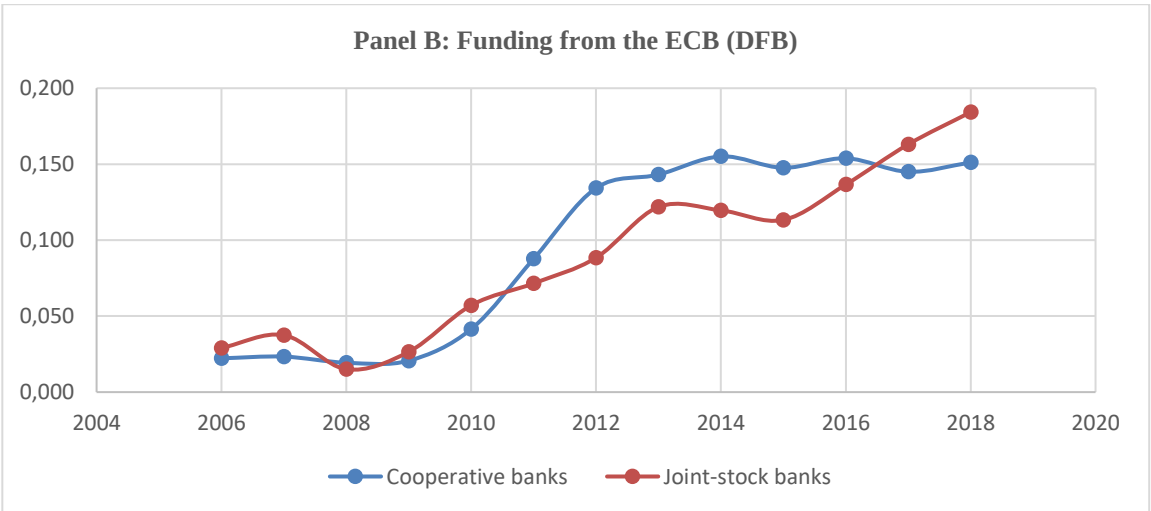
Table 2B: Descriptive statistics: cooperative banks vs. joint-stock banks for the years 2006-2018

	Panel A: Cooperative banks			Panel B: Joint-stock banks			Panel C: Difference in means (cooperative banks vs. joint-stock banks)
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	
NIM	0.022	0.007	0.021	0.019	0.006	0.018	0.004***
IRRBB	0.019	0.118	0.000	-0.022	0.131	-0.016	0.041***
IRRBB_B	-0.082	0.104	-0.087	-0.079	0.109	-0.070	0.002
IRRBB_S	0.071	0.123	0.023	0.043	0.121	0.007	0.028**
IRRBB_D	0.022	0.050	0.005	0.005	0.061	0.000	0.017**
CR	0.077	0.048	0.068	0.071	0.070	0.047	0.006
MT1	0.908	0.140	0.882	0.921	0.166	0.890	-0.013
RA	8.001	5.251	6.970	4.043	2.067	4.110	3.957***
SIZE	13.651	1.058	13.564	14.950	1.455	14.655	-1.299***
DFB	0.094	0.087	0.080	0.091	0.104	0.061	0.003
LAB	0.060	0.042	0.050	0.062	0.057	0.044	-0.002

Notes: For the definition of the variables, please refer to the previous Table 1. **, *** indicate statistically significant correlation coefficients at the 5% and 1% levels.

Figure 2B: Deposits at the ECB (LAB) (Panel A) and funding from the ECB (DFB) (Panel B): cooperative banks vs. joint-stock banks for the years 2006-2018





Note: For the definition of the variables, please refer to the previous Table 1.

Table 3A shows the pairwise correlation coefficients among the variables under investigation in our empirical analysis for the whole sample over the years 2006-2018, whereas Panel A and Panel B of Table 3B do the same for the sample of cooperative and joint-stock banks, respectively.

Table 3A shows that NIM and IRRBB are inversely correlated with each other and respectively exhibit negative and positive correlations with the measures of credit risk exposure (CR), the intensity of maturity transformation activity (MIT1), and funding from the ECB (DFB).

The level of interest rates (EUR3M) and the slope of the yield curve (SLOPE) are positively correlated with the ratio of net interest margin to total assets and negatively correlated with interest rate risk exposure.

For both NIM and IRRBB, the correlation coefficient with the proxy measuring banks' risk aversion (RA) is positive. Table 3B confirms these results for the two groups of banks we have in our sample, with the only exception of the correlation coefficients of RA with NIM and IRRBB for the joint-stock banks, which are negative and positive, respectively, even if only marginally significant at the 10% confidence level.

Table 3A: Pairwise correlation coefficients: whole sample for the years 2006-2018

	NIM	IRRBB	CR	MT1	RA	SIZE	DFB	LAB	GDPGR	EUR3M	SLOPE
NIM	1										
IRRBB	-0.12***	1									
CR	-0.45***	0.19***	1								
MT1	-0.31***	0.33***	0.46*	1							
RA	0.10***	0.21***	-0.09***	-0.14***	1						
SIZE	-0.32***	-0.03	0.09***	0.26***	-0.28***	1					
DFB	-0.41***	0.39***	0.38***	0.72***	0.13***	0.16***	1				
LAB	0.04*	0.00	-0.07***	-0.26***	0.17***	-0.27***	0.07**	1			
GDPGR	-0.09***	0.03	0.08***	0.14***	0.05**	0.01	0.08***	-0.06**	1		
EUR3M	0.55***	-0.32***	-0.54***	-0.48***	-0.10***	-0.17***	-0.54***	0.03	0.03	1	
SLOPE	0.27***	-0.16***	-0.15***	-0.07***	-0.06	-0.01	-0.19***	-0.03	-0.56***	-0.12***	1

Notes: For the definition of the variables, please refer to the previous Table 1. *, **, *** indicate statistically significant correlation coefficients at the 10%, 5% and 1% levels.

Table 3B: Pairwise correlation coefficients: cooperative banks vs. joint-stock banks for the years 2006-2018

Panel A: Cooperative banks

	NIM	IRRBB	CR	MT1	RA	SIZE	DFB	LAB	GDPGR	EUR3M	SLOPE
NIM	1										
IRRBB	-0.20***	1									
CR	-0.43***	0.18***	1								
MT1	-0.48***	0.31***	0.45***	1							
RA	0.11***	0.20***	-0.10***	-0.15***	1						
SIZE	-0.42***	-0.02	0.09***	0.28***	-0.26***	1					
DFB	-0.56***	0.37***	0.39***	0.71***	0.13***	0.20***	1				
LAB	0.10***	0.02	-0.06**	-0.26***	0.19***	-0.27***	0.07***	1			
GDPGR	-0.05*	0.02	0.08***	0.14***	0.05*	0.01	0.07***	-0.07***	1		
EUR3M	0.76***	-0.32***	-0.56***	-0.48***	-0.11***	-0.18***	-0.56***	0.01	0.03	1	
SLOPE	0.02	-0.15***	-0.15***	-0.06**	-0.05*	-0.01	-0.19***	-0.03	-0.56***	-0.12***	1

Panel B: Joint-stock banks

	NIM	IRRBB	CR	MT1	RA	SIZE	DFB	LAB	GDPGR	EUR3M	SLOPE
NIM	1										
IRRBB	-0.36***	1									
CR	-0.33***	0.28**	1								
MT1	-0.40***	0.66***	0.59***	1							
RA	-0.20*	0.22*	-0.05	0.08	1						
SIZE	0.06	0.10	0.27**	0.06	-0.15	1					
DFB	-0.46***	0.68***	0.32***	0.86***	0.23**	-0.17	1				
LAB	0.00	-0.20*	-0.21*	-0.28**	-0.01	-0.43***	0.02	1			
GDPGR	-0.13	0.07	0.11	0.10	0.20*	0.03	0.15	0.06	1		
EUR3M	0.64***	-0.31***	-0.41***	-0.50***	-0.43***	0.04	-0.41***	0.28***	-0.02	1	
SLOPE	0.13	-0.34***	-0.20*	-0.16	-0.30***	-0.11	-0.19*	-0.07	-0.54***	-0.04	1

Note: For the definition of the variables, please refer to the previous Table 1. *, **, *** indicate statistically significant correlation coefficients at the 10%, 5% and 1% levels.

4.2 Results

4.2.1 The determinants of the net interest margin

Table 4 shows the results of the model in equation (1) applied to the whole sample of banks. Panel A refers to the years ranging from 2006 to 2011, whereas Panel B contains the estimates obtained for the period 2012-2018. For each panel, specifications (1) and (2) both include the overall measure of banks' exposure to interest rate risk (IRRBB); specification (2) also accounts for macroeconomic and financial variables, namely the Italian GDP growth rate (GDPGR), interest rate level (EUR3M), and yield curve slope (SLOPE). In specification (3), we replace the overall interest rate risk indicator with its three components, respectively measuring the exposure stemming from traditional activity of deposits collecting and loans issuing (IRRBB_B), the risk from securities held in their portfolio (IRRBB_S), and that from their positions in financial derivatives (IRRBB_D).

At the bottom of the table, we report the statistics and the corresponding p-values of the Arellano Bond test for autocorrelation and of the Sargan test of overidentifying restrictions (Arellano and Bond, 1991). The AR(2) tests confirm that the model is not subject to serial correlation issues. Specifically, the AR tests reject the hypothesis of second-order serial correlation, which is satisfactory as both the first and second lags of endogenous variables are utilized as instruments for their current values. The results of the Sargan test support the validity of the instruments used in the estimation.

The autoregressive component of the net interest margin to total assets ratio ($NIM_{i,t-1}$) is significant in explaining the level of the same variable in time *t*, both statistically and economically, except for specification (1) for the period 2006-2011, where, though significant at the 1% confidence level, the coefficient is approximately four times smaller than those of the other specifications. Overall, bank size (SIZE), credit risk exposure (CR) and risk aversion (RA) are significantly associated with the NIM. *Ceteris paribus*, banks' net interest margin appears to be larger for smaller banks, for intermediaries less exposed to credit risk and less risk adverse.

The evidence regarding the relationship between credit risk and net interest margin contradicts the prevailing literature but is in line with the hypothesis that banks might be willing to grant loans to lower credit-quality borrowers to increase their market share. The negative coefficient of the size variable is in line with previous studies and suggests that the larger is the bank, the lower is the net interest margin, which might be consistent with their objective to develop a broader and broader client base. Banks' risk aversion seems to exert a limited impact on their net interest margin, given the size of the regression coefficients of the RA variable.

The GDP growth rate and yield curve slope are positively correlated with net interest margin, as expected. However, the level of interest rates, proxied by the three-month Euribor rate, exhibits a change in the sign of the coefficient between the two sub-periods: net interest margin increases with rising interest rates in the years 2006-2011, while it experiences a decrease over the 2012-2018 period. To further investigate this aspect, the model was adjusted by adding independent variables representing changes in interest rates (D.EUR3M) and yield curve slope (D.SLOPE), which can be interpreted as short-term effects of interest rate changes.

The negative coefficients of these additional variables suggest significant frictions in the repricing of assets and liabilities, particularly in the second period, where unexpected increases in interest rates may compress bank net interest margin in the short-term. These frictions seem to persist even in the long term, with higher interest rates and a steeper yield curve potentially leading to a reduction in net interest margin.

Minor differences between the two periods are also observed in terms of interest rate risk exposure (IRRBB), although the coefficient remains positive in both groups of years, thus providing an overall support to our H1 hypothesis. By comparing the regression coefficients of the variable IRRBB in specifications (1) and (2) of both sub-periods, we observe that banks' profitability benefits slightly more from a raise in their interest rate risk exposure over the years 2012-2018.

This might suggest that during the years characterized by extremely low interest rates and a flat yield curve, there might be incentives for banks to take more interest rate risk in their banking book to raise their profitability. Specification (3) reveals a decrease in the contribution to net interest margin from pure loans-deposits intermediation (IRRBB_B) and securities portfolio (IRRBB_S) in the years 2012-2018. Again, a lower and flatter yield curve might clearly be the cause of these results during these years, if compared

with the years 2006-2011. On the contrary, the impact of the positions in financial derivatives (IRRBB_D) on NIM seems to be larger than that observed in the years 2006-2011, suggesting that the decrease in banks' NIM associated with the other two components of the overall interest rate risk indicator is balanced out by the positive effect of the derivatives positions.

Overall, the positive and statistically significant regression coefficients of the variable MT1 across all the specifications for both groups of years are consistent with our hypothesis H2 about the benefits of maturity transformation on banks' NIM. It is worth noting that these benefits are more pronounced in the years 2012-2018, relative to the 2006-2011 period. This is in line with the evidence of a positive impact of interest rate risk exposure on net interest margin because the higher is the former, the higher is the maturity transformation activity.

Table 4: The determinants of the net interest margin: whole sample; 2006-2011 (panel A) vs. 2012-2018 (panel B)

Variables	Panel A: years 2006-2011			Panel B: years 2012-2018		
	(1)	(2)	(3)	(1)	(2)	(3)
NIM_{t-1}	0.055*** (0.012)	0.238*** (0.019)	0.216*** (0.009)	0.202*** (0.004)	0.197*** (0.007)	0.201*** (0.010)
SIZE	-0.040*** (0.003)	-0.022*** (0.022)	-0.019*** (0.001)	-0.050*** (0.003)	-0.033*** (0.003)	-0.032*** (0.003)
IRRBB	0.078*** (0.011)	0.123*** (0.009)	-	0.105*** (0.002)	0.141*** (0.004)	-
IRRBB_B	-	-	0.153*** (0.005)	-	-	0.045*** (0.017)
IRRBB_S	-	-	0.065*** (0.009)	-	-	0.015*** (0.004)
IRRBB_D	-	-	0.073*** (0.011)	-	-	0.108*** (0.035)
MT1	0.063*** (0.010)	0.060*** (0.008)	0.065*** (0.005)	0.304*** (0.005)	0.188*** (0.005)	0.196*** (0.007)
CR	-0.949*** (0.101)	-0.031 (0.060)	-0.083** (0.038)	-0.899*** (0.015)	-0.705*** (0.023)	-0.686*** (0.033)
RA	-0.002*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	-0.005*** (0.000)	-0.002*** (0.000)	-0.001** (0.000)
GDPGR	-	0.009*** (0.000)	0.009*** (0.000)	-	0.009*** ((0.000)	0.008*** (0.001)
EUR3M	-	0.041*** (0.001)	0.040*** (0.000)	-	-0.007*** (0.001)	-0.007*** (0.001)
SLOPE	-	0.049*** (0.001)	0.049*** (0.001)	-	0.061*** (0.001)	0.061*** (0.001)
CONSTANT	1.272*** (0.040)	0.614*** (0.033)	0.600*** (0.015)	1.022*** (0.036)	0.772** (0.042)	0.736*** (0.051)
# Obs.	598	598	598	728	726	726
Time fixed effects	YES	NO	NO	YES	NO	NO
Arellano-Bond test for AR(1)	-3.099	-3.971	-2.826	-4.518	-4.633	-4.691
p-value	0.002	0.000	0.005	0.000	0.000	0.000
Arellano-Bond test for AR(2)	-1.369	|-1.533	0.142	-0.7519	-1.349	0.404
p-value	0.171	0.125	0.887	0.452	0.177	0.686
Sargan test	20.472	32.876	31.277	72.551	72.387	96.969
p-value	0.367	0.283	0.553	0.622	0.596	0.511

Note: For the definition of the variables, please refer to the previous Table 1. ** and *** indicate statistically significant regression coefficients at the 5% and 1% levels.

4.2.2 The determinants of the interest rate risk exposure

Table 5 reports the results of the analysis of the determinants of interest rate risk exposure, following the model described in equation (2). In specification (1) we use as regressors the bank-specific variables employed in the study of the net interest margin. In specification (2), the two variables related to banks' active and passive operations with the ECB are also considered, and in specification (3) macroeconomic variables are added, replacing the time dummies used to account for fixed temporal effects. Once again, diagnostic tests reported at the bottom of the table regarding serial correlation and the instruments used in the GMM procedure report values that signal the absence of correlation of order 2 and the validity of the instruments.

The regression coefficient of the SIZE variable is negative and statistically significant in all the three specifications for both sub-periods. Therefore, we do not find support to the hypothesis of a higher likelihood of opportunistic behaviour at larger banks. On average, banks with a more intense maturity transformation activity appear more exposed to interest rate risk. Particularly, by separately considering each of the three specifications, we observe that the impact is larger in the years 2012-2018.

Interest rate risk exposure tends to decrease as the share of non-performing loans to total assets (CR) increases in the second of the two sub-periods, indicating a kind of substitution effect between credit risk and interest rate risk: as exposure to the former increases, banks tend to reduce their exposure to the latter. The sign of the regression coefficients is positive in the years 2006-2011. Anyway, the significance of the relationship confirms the importance of considering the impact of interest rate changes on both types of risk.

The level of risk aversion measured by the additional capital endowment over the minimum required (RA) appears positively correlated with interest rate risk exposure in the first of the two sub-periods, although with relatively modest coefficients. Besides being economically irrelevant, the relationship is not statistically significant in the years 2012-2018 for specifications (2) and (3).

The ratio of the ECB funding on total assets (DFB) and that of deposits at the ECB to total assets (LAB) show a change in the sign of their relationship with banks' exposure to interest rate risk over the two sub-periods. An increase in the funds borrowed from the ECB through (targeted) long-term refinancing operations results in greater interest rate risk exposure in the first sub-period, but in a reduction in the years ranging from 2012 to 2018. Deposits at the ECB appear to decrease banks' interest rate risk in the years 2006-2011, while they seem to increase it in the subsequent period.

Overall, it seems that the contribution of long-term refinancing operations, whether targeted or not, in terms of funding stability, translates into a better ability for banks to withstand potential interest rate upward shocks, which is in line with our hypothesis H3. We do not find support to hypothesis H4, according to which, by reducing the average duration of banks' assets, deposits at the ECB should have a positive effect on interest rate risk exposure. This result calls for further investigation.

An increase in slope (SLOPE) leads to a reduction in interest rate risk borne by banks, just as observed with an increase in the GDP growth rate (GDPGR), although the regression coefficients are relatively small in both cases. During the years 2006-2011, the level of interest rates (EUR3M) is positively correlated with interest rate risk, although not significantly, neither from an economic nor statistical point of view. In the years 2012-2018, however, an increase in the 3-month Euribor rate is associated with a reduction in interest rate risk exposure, with a regression coefficient not only significant at the 1% confidence level but also considerably higher, in absolute value, than that of the first sub-period: -0.072 vs. 0.001.

Table 5: The determinants of interest rate risk exposure: whole sample; 2006-2011 (panel A) vs. 2012-2018 (panel B)

Variables	Panel A: years 2006-2011			Panel B: years 2012-2018		
	(1)	(2)	(3)	(1)	(2)	(3)
$IRRBB_{t-1}$	0.149***	0.119***	0.111***	0.035***	0.109***	0.105***
	(0.009)	(0.05)	(0.007)	(0.007)	(0.011)	(0.009)
SIZE	-0.028***	-0.041***	-0.036***	-0.022***	-0.038***	-0.045***
	(0.004)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)
MT1	0.273***	0.056**	0.146***	0.368***	0.639***	0.592***
	(0.017)	(0.024)	0.012	(0.009)	(0.015)	(0.010)
CR	0.306***	0.158**	0.238***	-0.734***	-0.840***	-0.737***
	(0.112)	(0.049)	(0.046)	(0.028)	(0.029)	(0.025)
RA	0.007***	0.003***	0.005***	-0.003***	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DFB	-	0.282***	0.339***	-	-0.454***	-0.461***
		(0.040)	(0.026)		(0.017)	(0.016)
LAB	-	-0.186***	-0.099**	-	0.208***	0.206***
		(0.039)	0.039		(0.027)	(0.027)
GDPGR	-	-	-0.007***	-	-	-0.012***
			(0.000)			(0.000)
EUR3M	-	-	0.001	-	-	-0.072***
			(0.001)			(0.001)
SLOPE	-	-	-0.005***	-	-	-0.030***
			(0.002)			(0.001)
CONSTANT	0.056	0.516***	0.296***	0.134***	0.116**	0.281***
	(0.049)	(0.031)	(0.029)	(0.026)	(0.054)	(0.041)
# Obs.	561	561	561	728	728	728
Time fixed effects	YES	YES	NO	YES	YES	NO
Arellano-Bond test for AR(1)	-3.528	-2.399	-3.178	-5.314	-4.295	-4.514
p-value	0.000	0.016	0.002	0.000	0.000	0.000
Arellano-Bond test for AR(2)	-0.521	-0.606	-0.349	0.802	1.286	1.101
p-value	0.602	0.545	0.727	0.422	0.198	0.271
Sargan test	22.904	11.026	10.922	67.754	99.158	89.376
p-value	0.690	0.855	0.926	0.417	0.196	0.409

Note: For the definition of the variables, please refer to the previous Table 1. ** and *** indicate statistically significant regression coefficients at the 5% and 1% levels.

5. Additional analysis and robustness checks

5.1 Additional analysis

Since we have two types of banks in our sample, we run an additional analysis to investigate whether there are differences in the relations among the variables of interest between the group of cooperative banks and the group of joint-stock intermediaries. To do that, we modify the models in equations (1) and (2) by introducing a dummy variable COOP, which equals 1 in the case of cooperative credit institutions, and 0 for joint-stock banks, and some interaction terms. Particularly, in our analysis of the determinants of our sample banks' NIM, we use COOP × IRRBB to investigate potential differences in the impact of the overall exposure to the interest rate risk in the banking book, COOP × IRRBB_B, COOP × IRRBB_S and COOP × IRRBB_ D, to examine whether there is a difference between cooperative and joint-stock banks in terms of the impact on the net interest margin of the IRRBB exposure stemming from collecting deposits and issuing loans to customers, that associated with the securities portfolio, and the exposure induced by the use of derivatives, respectively. COOP × MIT1 is added in both models presented in equations (1) and (2) to detect potential differences in the impact of the maturity transformation activity on both banks' profitability and interest rate risk exposure, whereas we add in the model of equation (2) studying the determinants of the interest rate risk exposure the interaction terms COOP × DFB and COOP × LAB to examine differences in the relation of the deposits that our banks collect from or have at the European Central Bank and their interest rate risk exposure, respectively. As far as the determinants of net interest margin are concerned, the regression coefficients of the variable COOP × IRRBB in Table 6 show that the positive impact of banks' overall exposure to interest rate risk on their NIM is larger for cooperative banks in the years 2012-2018 for specifications (1) and (2), even if this difference with joint-stock companies is only marginally significant at the 10% confidence level. We do not observe any difference for the impact on NIM of the single components of the overall exposure to interest rate risk: none of the coefficients of the variables COOP × IRRBB_B, COOP × IRRBB_S and COOP × IRRBB_D is statistically significant. Furthermore, there is no statistically significant difference in the impact of the maturity transformation activity on cooperative banks' net interest margin, with the only exception of the regression coefficient of the variable COOP × MT1 in the specification (2) for years 2012-2018, which is however marginally significant at the 10% confidence level. Table 7 reports the results of the analysis of potential differences between the two groups of banks in terms of the determinants of their exposure to the interest rate risk in the banking book. The regression coefficients of the variable COOP × DFB are positive and statistically significant at the 1% confidence level in specifications (2) and (3) for the years ranging from 2006 to 2011. They are not only much smaller but are also marginally significant at the 10% confidence level for the years 2012-2018. Overall, this suggests that the positive impact of the deposits collected from the ECB on IRRBB exposure is stronger for cooperative banks than for joint-stock ones in the first set of years, whereas no difference is found in the relations discussed in the previous section during the years 2012-2018. In the case of cooperative banks, the negative impact of deposits at the ECB is less negative than that observed for joint-stock banks in the years 2006-2011, i.e., the regression coefficients of the interaction term COOP × LAB are positive and statistically significant at the 1% confidence level in specifications (2) and (3) of Panel A, whereas we do not observe any difference for the second sub-period. Overall, we do not observe significant differences between the two groups of banks included in our sample. We argue that, irrespective of their different nature, which allows us to distinguish between cooperative banks and joint-stock companies, it is the type of activity they run as providers of mainly traditional financial products and services to local communities that makes our banks so similar.

Table 6: The determinants of the net interest margin: cooperative banks vs. joint-stock banks; 2006-2011 (panel A) vs. 2012-2018 (panel B)

Variables	Panel A: years 2006-2011			Panel B: years 2012-2018		
	(1)	(2)	(3)	(1)	(2)	(3)
NIM_{t-1}	0.567***	0.465***	0.501***	0.689***	0.555***	0.570***
	(0.027)	(0.030)	(0.031)	(0.015)	(0.016)	(0.025)
SIZE	-0.022***	-0.023***	-0.018***	-0.009***	-0.008***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)
COOP	0.000	0.005	0.009	-0.003	-0.003**	0.002
	(0.005)	(0.006)	(0.012)	(0.003)	(0.001)	(0.002)
IRRBB	0.008***	0.003	-	-0.017***	-0.003	-
	(0.003)	(0.004)		(0.004)	(0.003)	
IRRBB_B	-	-	0.010	-	-	0.002
			(0.006)			(0.005)
IRRBB_S	-	-	0.029	-	-	-0.005
			(0.032)			(0.005)
IRRBB_D	-	-	0.010	-	-	-0.006
			(0.013)			(0.005)
MT1	0.002	-0.002	0.000	0.003**	0.005***	0.006*
	(0.002)	(0.003)	(0.005)	(0.001)	(0.002)	(0.003)
COOP × IRRBB	-0.007	-0.003	-	0.015*	0.005*	-
	(0.006)	(0.004)		(0.011)	(0.003)	
COOP × IRRBB_B	-	-	-0.006	-	-	0.000
			(0.006)			(0.005)
COOP × IRRBB_S	-	-	-0.008	-	-	0.007
			(0.033)			(0.005)
COOP × IRRBB_D	-	-	-0.008	-	-	0.009*
			(0.014)			(0.005)
COOP × MIT1	-0.003	-0.004	-0.001	-0.000	-0.004*	-0.005
	(0.007)	(0.003)	(0.006)	(0.001)	(0.003)	(0.003)
CR	0.060***	0.092***	0.050***	0.002	-0.015***	-0.017***
	(0.010)	(0.012)	(0.012)	(0.002)	(0.001)	(0.002)
RA	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDPGR	-	0.000 (0.000)	0.000** (0.000)	-	0.000*** (0.000)	0.000*** (0.000)
EUR3M	-	0.001*** (0.000)	0.001*** (0.000)	-	0.002*** (0.000)	0.002*** (0.000)
SLOPE	-	-0.001*** (0.000)	-0.001*** (0.000)	-	0.000*** (0.000)	0.000*** (0.000)
CONSTANT	0.031*** (0.006)	0.018** (0.008)	0.010 (0.014)	0.023*** (0.004)	0.016*** (0.003)	0.011*** (0.003)
# Obs.	578	578	578	721	721	721
Time fixed effects	YES	NO	NO	YES	NO	NO
Arellano-Bond test for AR(1)	-2.991	-3.867	-2.688	-3.999	-4.336	-4.469
p-value	0.001	0.000	0.003	0.000	0.000	0.000
Arellano-Bond test for AR(2)	-1.196	|-1.421	0.124	-0.695	-1.428	0.389
p-value	0.151	0.122	0.776	0.399	0.154	0.556
Sargan test	19.742	29.678	30.165	71.465	70.278	93.434
p-value	0.355	0.277	0.499	0.589	0.531	0.489

Note: COOP is a dummy variable which equals 1 for cooperative banks and 0 for joint-stock banks. COOP × IRRBB, COOP × IRRBB_B, COOP × IRRBB_S, COOP × IRRBB_D are interaction terms of the dummy COOP and IRRBB, IRRBB_B, IRRBB_S and IRRBB_D, respectively. For the definition of the other variables, please refer to the previous Table 1. *, ** and *** indicate statistically significant regression coefficients at the 10%, 5% and 1% levels.

Table 7: The determinants of interest rate risk exposure: cooperative banks vs. joint-stock banks; 2006-2011 (panel A) vs. 2012-2018 (panel B)

Variables	Panel A: years 2006-2011			Panel B: years 2012-2018		
	(1)	(2)	(3)	(1)	(2)	(3)
$IRRBB_{t-1}$	0.092*** (0.027)	0.049** (0.022)	0.067*** (0.021)	0.149*** (0.016)	0.165*** (0.019)	0.152*** (0.019)
SIZE	-0.380*** (0.086)	-0.185*** (0.071)	-0.020 (0.082)	-0.021*** (0.006)	0.010 (0.012)	-0.051*** (0.015)
MT1	0.483*** (0.080)	0.105*** (0.040)	0.146*** (0.047)	0.335*** (0.012)	0.215*** (0.028)	0.639*** (0.020)
CR	1.233 (0.012)	1.649*** (0.433)	0.985** (0.476)	-0.035 (0.012)	0.146* (0.077)	-0.794* (0.359)
RA	0.010*** (0.000)	0.008*** (0.003)	0.008*** (0.002)	-0.005*** (0.000)	-0.002*** (0.000)	-0.003*** (0.001)
DFB	-	1.374*** (0.465)	1.484*** (0.542)	-	-0.122** (0.053)	-0.0630*** (0.089)
LAB	-	-0.390** (0.164)	-0.156** (0.107)	-	0.225 (0.380)	0.501* (0.428)
COOP	0.056 (0.051)	-0.078* (0.049)	-0.063 (0.039)	0.028 (0.024)	-0.074* (0.043)	-0.020 (0.040)
COOP × DFB	-	1.770*** (0.425)	1.558*** (0.514)	-	0.146* (0.080)	0.186* (0.130)
COOP × LAB	-	1.454*** (0.211)	1.121*** (0.265)	-	-0.108 (0.381)	-0.161 (0.239)
GDPGR	-	-	-0.008*** (0.001)	-	-	-0.018*** (0.001)
EUR3M	-	-	-0.005*** (0.002)	-	-	-0.056*** (0.005)
SLOPE	-	-	-0.026***	-	-	-0.029***

			(0.005)			(0.002)
CONSTANT	-0.446***	-0.166	-0.313***	0.029	0.094	0.042
	(0.132)	(0.119)	(0.122)	(0.049)	(0.112)	(0.111)
# Obs.	578	526	526	721	720	720
Time fixed effects	YES	YES	NO	YES	YES	NO
Arellano-Bond test for AR(1)	-3.282	-2.129	-3.178	-4.973	-4.467	-4.617
p-value	0.000	0.013	0.001	0.001	0.001	0.002
Arellano-Bond test for AR(2)	-0.498	-0.592	-0.387	0.802	1.302	1.198
p-value	0.703	0.623	0.683	0.410	0.201	0.312
Sargan test	21.812	10.987	10.391	68.001	98.741	88. 736
p-value	0.590	0.768	0.872	0.524	0.183	0.413

Note: COOP is a dummy variable which equals 1 for cooperative banks and 0 for joint-stock banks. COOP × DFB and COOP × LAB are interaction terms of the dummy COOP and DFB and LAB, respectively. For the definition of the other variables, please refer to the previous Table 1. *, ** and *** indicate statistically significant regression coefficients at the 10%, 5% and 1% levels.

5.2 Robustness checks

Tables 8 and 9 report the results of the robustness tests we have run by replacing the variable MT1, i.e., the inverse of the NSFR, with the ratio of the loans granted to over the deposits collected from customers (MT2). They show that the relations among our variables of interest, as for both the determinants of our banks' profitability and their exposure to interest rate risk in the banking book are confirmed. In comparing Table 8 and Table 9 with Table 4 and Table 5, respectively, we do observe that regression coefficients appear to be smaller when the maturity transformation is measured through our MT2 variable, even if the sign and the overall statistical significance are confirmed.

Table 8: The determinants of the net interest margin: whole sample; 2006-2011 (panel A) vs. 2012-2018 (panel B); new measure of maturity transformation

Variables	Panel A: years 2006-2011			Panel B: years 2012-2018		
	(1)	(2)	(3)	(1)	(2)	(3)
NIM_{t-1}	0.590*** (0.026)	0.471*** (0.000)	0.464*** (0.000)	0.660*** (0.017)	0.487*** (0.000)	-0.494*** (0.000)
SIZE	-0.026*** (0.001)	-0.023*** (0.000)	-0.020*** (0.000)	-0.008*** (0.000)	-0.005*** (0.000)	-0.005*** (0.000)
IRRBB	0.001** (0.001)	0.002** (0.001)	-	0.005*** (0.000)	0.001*** (0.000)	-
IRRBB_B	-	-	0.004*** (0.000)	-	-	0.001* (0.063)
IRRBB_S	-	-	0.017*** (0.000)	-	-	0.001** (0.001)
IRRBB_D	-	-	0.009*** (0.002)	-	-	0.002** (0.014)
MT2	0.011*** (0.000)	0.016*** (0.006)	0.012** (0.008)	0.044*** (0.000)	0.023*** (0.000)	0.073*** (0.000)
CR	0.055*** (0.010)	0.078*** (0.000)	0.062*** (0.000)	-0.008*** (0.002)	-0.012*** (0.000)	-0.013*** (0.000)
RA	0.000*** (0.000)	0.000 (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
GDPGR	-	0.000* (0.088)	0.000 (0.090)	-	0.000*** (0.000)	0.000*** (0.001)
EUR3M	-	0.001*** (0.000)	0.001*** (0.000)	-	-0.003*** (0.000)	-0.002*** (0.000)
SLOPE	-	0.021*** (0.000)	0.031*** (0.000)	-	-0.014*** (0.000)	-0.019*** (0.000)
CONSTANT	0.027*** (0.000)	0.019*** (0.000)	0.022*** (0.000)	0.020*** (0.000)	0.017*** (0.000)	0.018*** (0.000)
# Obs.	578	578	578	723	723	721
Time fixed effects	YES	NO	NO	YES	NO	NO
Arellano-Bond test for AR(1)	-2.873	-3.652	-2.586	-4.152	-3.965	-4.324
p-value	0.003	0.007	0.006	0.005	0.008	0.009
Arellano-Bond test for AR(2)	-1.289	|-1.437	0.124	-0.689	-1.427	0.399
p-value	0.121	0.152	0.753	0.523	0.201	0.621
Sargan test	19.827	31.631	30.829	70.113	70.763	95.696
p-value	0.252	0.321	0.479	0.549	0.632	0.421

Note: For the definition of the variables, please refer to the previous Table 1. ** and *** indicate statistically significant regression coefficients at the 5% and 1% levels.

Table 9: The determinants of interest rate risk exposure: whole sample; 2006-2011 (panel A) vs. 2012-2018 (panel B); new measure of maturity transformation

Variables	Panel A: years 2006-2011			Panel B: years 2012-2018		
	(1)	(2)	(3)	(1)	(2)	(3)
$IRRBB_{t-1}$	0.105*** (0.024)	0.051*** (0.019)	0.049*** (0.017)	0.255*** (0.020)	0.190*** (0.023)	0.143*** (0.014)
SIZE	-0.316*** (0.077)	-0.347*** (0.074)	-0.458*** (0.100)	0.092*** (0.006)	0.055*** (0.014)	0.024** (0.010)
MT2	0.069*** (0.020)	0.074*** (0.014)	0.024*** (0.009)	0.158*** (0.007)	0.161*** (0.012)	0.300*** (0.006)
CR	2.248*** (0.694)	1.217*** (0.443)	1.168*** (0.456)	0.022 (0.043)	0.121* (0.072)	-0.755*** (0.046)
RA	0.011*** (0.002)	0.009*** (0.002)	0.006** (0.003)	-0.003*** (0.000)	-0.001* (0.001)	-0.005*** (0.001)
DFB	-	0.025** (0.060)	0.554*** (0.099)	-	-0.129*** (0.026)	-0.028** (0.008)
LAB	-	-1.053*** (0.134)	-0.678*** (0.150)	-	0.088** (0.036)	0.096*** (0.031)
GDPGR	-	-	-0.010*** (0.001)	-	-	-0.002** (0.001)
EUR3M	-	-	-0.001 (0.002)	-	-	-0.066*** (0.004)
SLOPE	-	-	-0.022*** (0.005)	-	-	-0.019*** (0.001)
CONSTANT	0.117 (0.152)	0.178** (0.083)	0.353*** (0.116)	0.180*** (0.023)	0.162*** (0.044)	0.261*** (0.029)
# Obs.	578	526	526	723	722	722
Time fixed effects	YES	YES	NO	YES	YES	NO
Arellano-Bond test for AR(1)	-3.221	-1.987	-2.871	-4.789	-3.952	-3.532
p-value	0.004	0.023	0.005	0.003	0.009	0.016
Arellano-Bond test for AR(2)	-0.493	-0.594	-0.481	0.782	1.019	1.093
p-value	0.519	0.455	0.659	0.391	0.183	0.186
Sargan test	22.439	10.763	10.219	63.543	97.128	85.635
p-value	0.592	0.762	0.638	0.289	0.153	0.297

Note: For the definition of the variables, please refer to the previous Table 1. ** and *** indicate statistically significant regression coefficients at the 5% and 1% levels.

6. Conclusions

This study shows that an increased maturity transformation and a higher exposure to interest rate risk in the banking book are positively associated with banks' net interest margin. By analysing the components of interest rate risk exposure, we observe that in the years 2012-2018, the influence of the one stemming from traditional intermediation activity and that associated with the securities portfolio decreases, whereas the one caused by the derivatives positions increases. During the same years, the impact of maturity transformation on the net interest margin shows a significant increase. A more intense maturity transformation activity increases interest rate risk, with a stronger impact during the years 2012-2018. ECB funding determines a raise in interest rate risk exposure in the years 2006-2011, whereas it negatively correlates in the period 2012-2018, thus suggesting that, due to the increased stability of their funding, our sample banks show a better ability to withstand potential increases in interest rates.

Considering the change of the Euro area's monetary policy stance, our findings provide interesting insights into the dynamics involving maturity transformation, profitability, and interest rate risk. The new scenario in which they now run their business calls for a revision of the strategies banks adopted to address the prolonged period of exceptionally low interest rates and requires to carefully assess their ability to cope with the monetary policy normalization process. Identifying and monitoring banks potentially more exposed to interest rate increases is an important priority for policymakers and supervisory authorities; these are two crucial activities to avoid the dangerous negative consequences associated with the conclusion of (T)LTRO programs and the adoption of a restrictive monetary policy such as the one started in the summer of 2022.

Our results should be taken with caution. The sample used in this paper cannot be considered as representative of the entire Italian banking, sector since it is made up of local banks acting on a provincial or regional level. Though many, these banks do not represent the majority of the overall total assets of the Italian banking system. Nevertheless, we do believe it is important to specifically focus also on such a type of banks to tackle the issues we consider in this research, due to the role they have in alleviating small and medium firms' and households' credit constraints. This matters especially in some areas of certain countries which, like Italy, though included into the group of developed countries, are characterized by geographical areas that are not covered by the largest banking groups,

neither domestic nor foreign ones. Consequently, our results might give insights that are useful for countries whose banking sectors see the presence of a significant number of small- and medium-sized banks providing traditional financial products and services, like France, Germany and Spain, among the European ones.

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