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# Looking beyond banks' average interest rate risk: Determinants of high exposures

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#### 1. Introduction

We study the exposures to interest rate risk (IRR) of U.S. bank holding companies, since IRR is a systematic risk basic to all banking activities. Classic bank hedging literature suggests that elimination of easily hedgeable systematic risks is the optimal risk policy.<sup>1</sup> We examine whether banks follow this advice by maintaining low IRR exposures or, on the contrary, show economically significant IRR exposures at times. We further analyze if such high IRR exposures are related to unobserved system-wide factors and/or individual lagged bank characteristics. Insights gained from our analyses can aid regulators when surveilling banks' IRR and investors when judging banks' riskiness.

We contribute empirically to the existing research by adding the time-series dimension of IRR exposures to the analyses. Our empirical approach is based on Flannery and James (1984), who estimate each bank's interest rate beta from first-stage OLS regressions of bank stock returns and explain the resulting cross-section of IRR

#### ABSTRACT

This paper studies the magnitude and determinants of interest rate risk (IRR) of listed U.S. bank holding companies. As our first contribution, we test whether banks avoid exposures to IRR as prescribed in classic bank hedging literature. To do so, we use a state space model and Kalman filter techniques to estimate time-series of interest rate betas from bank stock returns. While the interest rate exposures of banks average close to zero, we find that individual banks at times exhibit high and significant exposures to interest rate risk. As our second contribution, we relate these high betas to lagged bank characteristics from accounting data, applying logit regressions and unconditional quantile regressions. We find that high exposures are partly systemic and comove with bank characteristics like size or leverage. This has implications for the monitoring of interest rate risk by regulators and investors as well as for the ongoing debates on the appropriate capitalization of banks.

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exposures with bank characteristics in a second-stage OLS regression. We extend this analysis in the time dimension by estimating banks' time-varying IRR betas in an econometrically consistent way using Kalman filter techniques. This allows us to circumvent econometric issues that emerge when using constant parameter or rolling window OLS in a context where changing sensitivities are to be expected.

Besides the theoretical implications for banks' optimal level of interest rate risk, the existing literature has not yet voiced expectations regarding the family or general shape of the distribution of IRR betas over banks and over time. Thus, we find the distribution of banks' IRR betas resulting from our Kalman filter approach interesting with regard to some features that are related to our research questions: the distribution is highly leptokurtic and centered around both a mean and a median close to zero. This implies that banks on average show low IRR exposures in accordance with the above-mentioned hedging theory. However, looking at the tails of the exposure distribution, we find that there are economically significant (i.e. high<sup>2</sup>) IRR betas for individual banks at some points in time.

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<sup>&</sup>lt;sup>1</sup> See, e.g. Diamond and Dybvig (1983) and Froot and Stein (1998).

<sup>&</sup>lt;sup>2</sup> We term both highly negative and highly positive IRR betas as high here and in the rest of the paper, as they pose high IRR exposures in absolute terms. If there is a need to differentiate between the direction of the exposure, this will be indicated.

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In fact, modern banking theory acknowledges and leaves room for banks retaining high exposures to IRR:<sup>3</sup> according to Allen and Santomero (1997), financial intermediation has increased in spite of a reduction in transaction costs and asymmetric information. Nevertheless, financial intermediation activities shift towards managing and sharing risks and facilitating participation in ever more complex capital markets. These services entail risk management and trading by financial intermediaries themselves. Going a step further, there are papers on the allocation of aggregate risk in the economy (e.g. Hanson, Shleifer, Stein, & Vishny, 2014; Hellwig, 1994, 1998) that recognize and rationalize risk-taking. Empirical research, too, has never doubted that banks take high net positions in IRR. As one of the latest works in this field, Begenau, Piazzesi, and Schneider (2013) explicitly estimate the net interest rate exposure of banks' portfolios using on- and off-balance sheet data.

We next analyze whether high IRR betas in the tails of the exposure distribution are related to lagged bank characteristics and/or systemic effects or whether they are mere spurious phenomena resulting from estimation error and posing no threat to banks or the banking system. As a first step, we check the switching behavior of banks in and out of the high exposure tails. Banks' business models and tactical and strategic decisions in terms of risk management usually do not change too rapidly over time. Thus, IRR betas possibly related to them should not fluctuate too strongly in and out of high exposure quantiles either. We find that there is quite a high degree of stability with respect to banks' positions in the exposure distribution. In fact, more than 64% of observations in high beta quantiles are followed by an observation in a high beta quantile of the same sign (controlling for the panel structure of our data).

As a next step in analyzing the relationships of IRR betas with bank characteristics, we apply two different approaches: logit-style regressions and unconditional quantile regressions developed by Firpo, Fortin, and Lemieux (2009). The former can give an indication of what bank characteristics influence the probability of a bank-quarter being in the high beta quantiles of the exposure distribution. The latter allow for a differentiated analysis of links of the entire distribution of high IRR betas with bank characteristics, because relationships between the dependent variable and covariates are estimated at every unconditional quantile of the dependent variable.

We find only few weak relationships for the center of the IRR beta distribution, where low IRR exposures prevail. This makes sense economically, because these low exposures are the result of banks following the above-mentioned classic bank hedging theory. Banks following implications of this theory shield themselves from IRR by hedging activities, thereby decoupling IRR exposures from their sources.

In contrast, high IRR betas in the tails of the exposure distribution show economically meaningful and statistically significant relationships with lagged bank characteristics and time-fixed effects for both approaches, logit and quantile regressions. This indicates that high IRR betas are not purely random or spurious effects that can be ignored. They rather represent a consequence of the development of individual banks' characteristics, e.g. the degree of leverage or the intensity of derivative usage, that are also to some degree associated with business models or risk management policies. High IRR betas are also significantly related to time-fixed effects representing unobserved systemic shifts that broadly affect the cross-section of banks.

Summarizing the individual results, leverage shows a symmetric effect on both high beta tails of the exposure distribution: it is related to an increase in the probability of exhibiting both highly negative or highly positive IRR betas in quantile regressions. Similarly, for quantile regressions, leverage is linked to increases of both negative and positive tail quantiles of IRR betas as well. This symmetric boost for high IRR exposures from leverage is visible for the financial crisis period, too. This finding corroborates the need for adequate and comprehensive capitalization of banks also with regard to term transformation and IRR on the banking book and thus adds to current discussions on further developments of capital regulation.

Greater bank size shows an asymmetric effect on the tails of the exposure distribution: it is associated with a higher (lower) probability of exhibiting highly negative (positive) IRR betas in logit regressions. Although less pronounced for times of crisis, unconditional quantile regression results mirror this asymmetric effect and show a shift to more negative IRR betas for greater size as well. This indicates that greater size, although traditionally associated with positive effects on risk, like greater potential for scale economies in risk management and regional and product diversification, is related to a shift towards more negative IRR exposures that are characteristic for traditional (i.e. positive) term transformation. These findings should be taken into consideration in the ongoing discussions on financial stability.

Another interesting link concerns the intensity of interest rate derivative usage. Over the entire sample period, but not for the crisis subperiod, it is related positively to the positive beta tail (both in terms of probability and tail values). As this is the part of the IRR beta distribution where banks have decoupled themselves from the traditional term transformation, this link serves as an indication of banks' intention when using IRR derivatives.

Other variables show more mixed results for the different approaches and (sub)sample periods. For example, the positive link of a greater traditional term transformation with the negative tail of the exposure distribution (both in terms of probability and tail values) is significant throughout only for the crisis subperiod. Nevertheless, this result for maturity mismatch is in line with the latest theoretical literature on financial intermediation (e.g. Brunnermeier & Oehmke, 2013; Farhi & Tirole, 2012), which sees an aggregate maturity mismatch at the heart of the recent banking crisis.

Overall, our approach sheds further light on the extent and determinants of IRR exposures of banks. We show that at some points in time some banks have economically significant IRR exposures that are related to system-wide unobserved effects and bank characteristics like leverage, size, intensity of derivative usage or term transformation. This indicates that banks' significant IRR exposures can be identified to some degree by such leading indicators of high exposures, thereby helping regulators and investors to evaluate the IRR exposures of banks. Our findings also add to ongoing discussions on adequate bank capitalization and size.

The rest of the paper is organized as follows: Sections 2 and 3 give a short overview of the related literature and describe the data. Estimation of IRR betas is covered in Section 4. Section 5 contains the second-stage analyses explaining high IRR betas with lagged bank characteristics, which in turn are described in Section 5.1. Section 5.2 describes the regression design for the second stage. Sections 5.3 and 5.4 show results for logit and unconditional quantile regressions, including robustness (Section 5.4.2) and financial crisis subperiod analyses (Section 5.4.3). Section 6 concludes with possible applications of our findings.

#### 2. Related literature

As mentioned above, our analysis rests on the basis of the fundamental paper by Flannery and James (1984), who investigated

<sup>3</sup> An earlier stage model by Deshmukh, Greenbaum, and Kanatas (1983), too, rationalizes risk-neutral banks taking on interest rate risk as a reaction to levels of loan and borrowing rates and associated volatilities.

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