



Banks, maturity transformation, and monetary policy[☆]

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ARTICLE INFO

JEL classification:

E43
E44
E52
E58
G21
G32

Keywords:

Banks
Maturity transformation
Monetary policy
Term premium
Interest rate risk
Bank profitability

ABSTRACT

Banks engage in maturity transformation and the term premium compensates them for bearing the associated interest rate risk. Consistent with this view, I show that banks' net interest margins and term premia have comoved in the United States over the last decades. On monetary policy announcement days, bank equity falls more sharply than nonbank equity following an increase in expected future short-term rates, but also responds more positively if term premia increase. These effects are reflected in bank cash-flows and amplified for banks with a larger maturity mismatch. The results reveal that banks are not immune to interest rate risk.

1. Introduction

An inherent feature of financial intermediation is maturity transformation: banks invest in long-term assets, funded by short-term liabilities. Due to this institutional characteristic, the typical textbook view is that banks are strongly exposed to interest rate risk. When short-term rates increase, banks' cost of funding rises, and with fixed-rate assets, their profit margins shrink, which drags down their stock prices. Accordingly, the business model of banking is highly sensitive to conventional monetary policy.

However, banks can structure their balance sheets to reduce their interest rate risk exposure. On one hand, interest rates of banks' assets are not necessarily fixed but can change with short-term rates. For example, banks frequently issue business loans or household mortgages with adjustable rates (e.g., [Ippolito et al., 2018](#); [Foà et al., 2019](#)). On the other hand, banks' cost of funding does not necessarily move

one-for-one with changes in short-term rates. In particular, it has been shown that deposit rates are inherently rigid (e.g., [Hannan and Berger, 1991](#); [Neumark and Sharpe, 1992](#); [Driscoll and Judson, 2013](#)). Especially when short-term rates move up, the spread to deposit rates widens, such that deposits resemble long-term debt. Banks' market power in deposit markets can explain both the lower level and the behavior of deposit rates vis-à-vis short-term rates (e.g., [Drechsler et al., 2017](#)). Banks also actively manage their maturity profile. For example, it has been shown that banks shorten the maturity of their corporate loans when they increase their use of short-term wholesale funding (e.g., [Paligorova and Santos, 2017](#)). Given all of these features, bank profit margins may remain unchanged or even increase when the policy rate rises.

The classic view that banks are strongly exposed to interest rate risk has therefore been questioned recently. For example, [Drechsler](#)

[☆] I thank Michael Bauer, Juliane Begenau, Markus Brunnermeier, Anna Cieslak, Simon Gilchrist, Valentin Haddad, Benjamin Hébert, Arvind Krishnamurthy, Monika Piazzesi, Glenn Rudebusch, João Santos, David Sraer, Eric Swanson, and an anonymous referee for their comments; Miguel Ampudia, Falko Fecht, and Skander van den Heuvel for their discussions; Jens Christensen, Richard Crump, and Andrew Meldrum for sharing their codes and data; seminar participants at the Bank of England, the Bank of Finland, Danmarks Nationalbank, the International Monetary Fund, the Federal Reserve Bank of San Francisco, the Office of Financial Research, Sveriges Riksbank, and conference participants at the SED conference, the SITE workshop on "Banks and Financial Frictions", the 28th Finance Forum, the OFCE/Science Po Workshop "Empirical Monetary Economics", the Annual Meeting of the Swiss Society for Financial Market Research, the Day-ahead conference on Financial Markets and Institutions, the Winter Meetings of the Econometric Society, the World Congress of the Econometric Society, the EEA-ESEM Congress, the Econometrics Workshop at the Federal Reserve Bank of St. Louis, and the Royal Economic Society Annual Conference for their insights. I also thank Colton Merrill, Benjamin Shapiro, and Simon Zhu for excellent research assistance. All errors are my own. The views expressed herein are solely those of the author and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

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<https://doi.org/10.1016/j.jfi.2022.101011>

Received 13 April 2022; Received in revised form 28 September 2022; Accepted 27 October 2022

Available online 3 November 2022

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et al. (2021) provide appealing evidence that banks *do not* take on interest rate risk, despite having a large maturity mismatch. First, they show that net interest margins of U.S. banks have been insensitive to changes in the federal funds rate, the policy target rate of the Federal Reserve, or Fed for short, as replicated in Appendix Figure A.1. Second, the reaction of banks' stock prices to plausibly exogenous changes in interest rates is relatively small, and not substantially different than the typical market response. Third, in the cross-section, banks match the short-run sensitivity of their interest income and expenses to changes in the federal funds rate (see also, e.g., Hellwig, 1994; Kirti, 2020). That is, if deposits behave like long-term liabilities, it is in fact optimal to invest in long-term fixed-rate assets.

These contradictory predictions about banks' interest rate risk exposure have vastly different implications. On one hand, the real effects of a policy rate change may be amplified by altering bank net worth if bank profit margins are sensitive to changes in monetary policy. Such a prediction is consistent with recent models in which the effective risk-bearing capacity of the financial sector plays a role for the transmission of shocks (Gertler and Kiyotaki, 2010; He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014). On the other hand, if banks are insulated from interest rate risk, practitioners, policymakers, and academics could largely ignore the effects of policy rate changes on the financial sector, as well as its net worth for the propagation of monetary policy to the real economy.

In this paper, I provide new evidence on banks' interest rate risk exposure for the United States. I document four main findings, all of which result from taking into account changes in the term premium, the missing puzzle piece compared with previous empirical studies. The term premium is a natural starting point to study banks' exposure to interest rate risk, since it reflects the compensation for bearing such risk, as illustrated with a few stylized examples in the next section and standard asset pricing theory.

My first finding is that banks' net interest margins have comoved with term premia over the past few decades. Since the early 1990s, both series have been steadily declining. Over this period, banks' net interest margins fell around 2 p.p., with the relevant term premia accounting for a similar decline. The close relation is not only visible for longer-term trends, but also for high-frequency changes. Further, I show that the comovement between term premia and net interest margins is also not specific to this sample period—it equally holds for longer samples that start around the 1960s with steady increases initially. Hence, the relation between term premia and banks' net interest margins suggests that banks have historically been compensated for taking on interest rate risk. Put differently, if banks were not exposed to interest rate risk, then term premia and net interest margins should be fairly unrelated, and the evidence speaks against such a view.

Second, I analyze how banks' stock prices respond to yield changes on days of monetary policy announcements by the Federal Open Market Committee (FOMC). The identifying assumption is that monetary policy news dominates on such days (e.g., Kuttner, 2001; Gürkaynak et al., 2005; Bernanke and Kuttner, 2005). As shown previously, banks' stock prices respond only weakly to longer-term government bond yield changes. In fact, comparing the response of a bank stock index with that of a typical market index shows that the two responses are not substantially different. If anything, the bank stock index responds more positively to an increase in long-term yields, suggesting that banks are not strongly exposed to interest rate risk.

However, once such yield changes are decomposed into variations in expected short-term rates and term premia, the findings change substantially. Relative to a typical market index, banks' stock prices respond more negatively to increases in expected short-term rates but more positively to a rise in term premia. For example, bank equity falls by around 17 percent to a 100-basis-point level-increase in expected short-term rates with respect to a 2-year government bond. In comparison, nonbank equity falls by 30 percent or 4 p.p. less, and even larger differences are found for the responses to term premia. These results

show that bank equity is highly sensitive to interest rate risk, a finding that is hidden when ignoring changes in term premia.

Two identification concerns surround these results. First, term premia respond endogenously to monetary policy news and other shocks on monetary policy announcement days. Second, omitted shocks such as information releases by the Fed about the economic outlook can bias the estimates since they are correlated with the interest rate surprises as well as stock prices (e.g., Nakamura and Steinsson, 2018). To address these concerns, I show analytically that the identification approach gives consistent estimates in the absence of such omitted shocks, even if term premia endogenously adjust to monetary policy news. In the presence of correlated but omitted shocks, I show that the differential responses between bank and nonbank equity can still be consistently estimated, reinforcing the empirical results. The same holds for non-FOMC days and I show that my findings are largely unchanged if I include such observations, which increases the sample size substantially.

I show that these findings are also supported by asset pricing theory. Accordingly, bank equity should respond more negatively than nonbank equity to an increase in expected future short-term rates, but more positively to an increase in term premia. Intuitively, banks' expected cash-flow rises after an increase in term premia, and their equity response is therefore more positive relative to typical nonfinancial companies. In contrast, banks' net interest margins on legacy assets sharply decline to an increase in short-term rates, leading to a stronger fall in bank equity, even after taking into account the reduced pass-through to deposit rates and variable-rate loans. Based on a numerical example, I show that asset pricing predicts similar quantitative differences between the responses of bank and nonbank equity to a change in short-term rates as in the data, and that banks' maturity mismatch can account for them as opposed to heterogeneity in leverage between banks and nonfinancial companies.

In a third exercise, I test whether the stock price reactions are also reflected in the response of bank profit margins to term premia and expected short-term interest rate surprises. Consistent with the differential equity responses and the asset pricing predictions, I find that banks' net interest margins increase if term premia rise but decrease if expected future short-term rates increase. These responses are not offset by a reaction of noninterest income, but translate into similar movements in banks' net income. Again, such heterogeneity is hidden without a decomposition of long-term yields.

To obtain the fourth and final result, I turn to the cross-section of banks. Specifically, I analyze whether banks' stock prices respond differently to yield changes depending on their business model. Using alternative measures of banks' maturity mismatch, I show that stock prices of banks with a larger maturity mismatch respond more positively to a rise in term premia. Intuitively, banks that engage more heavily in maturity transformation benefit relatively more if the compensation for interest rate risk increases. I show that the results based on stock prices survive various robustness checks: using alternative estimates for term premia, excluding particular unscheduled FOMC meetings, using different measures for banks' maturity mismatch, controlling for other bank characteristics, and restricting the sample along several dimensions.

Taken all pieces of evidence together, my results support a view that lies in between the classic textbook case and the one that banks are not exposed to interest rate risk. While banks engage in active risk management to reduce their interest rate risk exposure, such a risk transfer is not perfect and banks are unable to offload all of the interest rate risk that they are naturally exposed to. Three immediate implications arise from my findings. First, policy rate changes can affect bank net worth and thereby amplify the real effects of monetary policy. Second, the recent decline in bank net interest margins can largely be accounted for by a reduction in interest rate risk and the associated compensation for such risk. Third, while working through a number of channels, quantitative easing may have unwanted side-effects by distorting term premia. That is because lower term premia can reduce bank profitability, bank lending, and ultimately affect the real economy.

Related literature. This paper relates to a literature on banks' exposure to interest rate risk, dating back at least to Samuelson (1945) (see Vuilleme, 2016, for a survey of the literature). A seminal contribution to the empirical literature on this topic is Flannery and James (1984). They consider the response of banks' stock returns to changes in interest rates and find that those responses depend on banks' characteristics, in particular on banks' maturity mismatch. Relative to this early contribution, English, van den Heuvel, and Zakrajšek (2018) consider the response of U.S. banks' stock prices to monetary policy surprises on FOMC announcement days, thereby focusing on responses to monetary policy news. They find that banks' stock prices are negatively exposed to surprise increases in the level and the slope of the yield curve, and both reactions are mitigated for banks with a larger maturity mismatch. However, Drechsler et al. (2021) highlight that the reaction of bank equity to monetary policy surprises is not substantially different from that of other nonfinancial companies.

In comparison, the key insight from my analysis is that long-term bond yield changes may have opposing implications for banks, depending on whether they are due to changes in future expected short-term rates or changes in term premia. Once bond yield changes are decomposed in this way, I show that bank equity is substantially more exposed to interest rate risk relative to nonbank equity, and in comparison with the estimates by English, van den Heuvel, and Zakrajšek (2018). In the cross-section of banks, the underlying change in long-term bond yields also matters: banks with a larger maturity mismatch respond more positively to an increase in term premia, but more negatively if the yield curve steepens because of an increase in expected short-term rates.

While I study how changes in term premia affect bank profit margins and their stock prices, Haddad and Sraer (2020) show that changes in banks' interest rate exposure predicts one-period bond excess returns, consistent with the view that banks remain exposed to interest rate risk.¹ Intuitively, banks are marginal investors in various fixed income markets and determine asset prices in those markets according to their own interest rate exposure (see also, e.g., Hanson, 2014). While my analysis is silent on which agents price term premia, they could possibly be driven by banks' investing behavior.

Begenau et al. (2020) also study U.S. banks' exposure to interest rate risk and credit risk by constructing a small number of spanning bonds that capture those risks. They show that banks' balance sheets have been substantially exposed to both risks. In addition, they find that banks by and large do not use derivatives to reduce their interest rate exposure.² Gomez, Landier, Sraer, and Thesmar (2021) investigate the relation between interest rate risk exposure and bank lending, showing that U.S. banks with a larger income gap — that is, more short-term interest rate sensitive assets than liabilities—reduce their lending by less following an increase in the federal funds rate. Hoffmann, Langfield, Pierobon, and Vuilleme (2019) use data for several Euro area countries and find that banks' exposure to interest rate risk is heterogeneous in the cross-section, with net worth increasing to higher interest rates for a substantial fraction of banks. Apart from these empirical contributions, Di Tella and Kurlat (2021) build a model in which banks' maturity mismatch and exposure to interest rate risk emerges as an equilibrium outcome. Their model predicts bank equity responses to interest rate shocks in the range of the numbers that I obtain.

My findings can also shed light on the discussion about bank profitability within a low or negative interest rate environment.³ I show

that low net interest margins of banks are not a recent phenomenon, but have been falling over the past three decades. I associate this pattern to the simultaneous decrease in interest rate risk and the associated compensation for it. Nonetheless, I also show that banks' return on assets is relatively stable at around 1 percent outside of financial crises over the last decades.

Overview. The next section uses several stylized examples to build intuition for the results in this paper. Section 3 provides descriptive evidence for the historical relation between banks' net interest margins and term premia. Sections 4 and 5 consider event-study approaches, estimating the responses of stock prices to changes in interest rates. Section 6 considers theoretical asset pricing predictions. Section 7 estimates impulse responses of banks' profit margins to interest rate surprises. Section 8 collects evidence on stock price responses from the cross-section of banks. Finally, Section 9 concludes and highlights several avenues and challenges for future research.

2. Stylized examples

To build intuition for the findings in this paper, I start out with a few stylized examples. Imagine a bank that borrows one dollar at the short-term market rate and invests this dollar in a safe long-term government bond, rolling over its debt until the bond matures. In expectation, the bank's profit is given by the term premium, that is, by the difference between the annual yield of an m -period zero-coupon government bond at the time of investment in period t , denoted y_t^m , and the average expected short-term rates over this horizon, denoted EH_t^m for "expectation hypothesis",

$$y_t^m = \underbrace{\frac{1}{m} E_t \left\{ \sum_{k=0}^{m-1} y_{t+k} \right\}}_{EH_t^m} + \underbrace{\tau_t^m}_{\text{Term Premium}}, \quad (2.1)$$

where y_{t+k} denotes the short-term rate in period $t+k$. Interest rate risk is the risk of fluctuations in short-term rates (the bank's cost of funding) which affect the bank's profits. The expected term premium τ_t^m compensates the bank for taking on interest rate risk—a risk compensation for engaging in an arbitrage of investing long-term, financed by borrowing short-term. In Appendix F, I use a similar example to show how the term premium is priced in equilibrium using standard consumption-based asset pricing. The theoretical nature of the term premium is the same. It compensates an investor for taking on interest rate risk. In practice, the term premium is priced by various investors that trade government bonds directly or indirectly, including banks, money market funds, pension funds, arbitrageurs, and households, for example.

In the above example, the term premium is also equal to the bank's expected net interest margin (NIM)—the difference between interest income and interest expenses per unit of (interest-earning) assets. Eq. (2.1) illustrates that a change in long-term yields can have opposing implications for banks' cash-flows depending on what drives this change. For example, after the bank invested, higher-than-expected short-term rates imply an increase in the cost of funding and therefore a fall in profits. In contrast, before a bank invests, a higher term premium that also raises long-term yields actually implies higher future profits, while also reflecting a risk compensation.⁴ Given these opposing

¹ The expected annual term premium of a long-term bond is equal to the average expected one-period bond excess returns with declining maturity.

² See also, e.g., Purnanandam (2007) and Vuilleme (2019).

³ See, e.g., Altavilla, Boucinha, and Peydró (2018), Ampudia and van den Heuvel (2019), Balloch and Koby (2020), Borio, Gambacorta, and Hoffmann (2017), Brei, Borio, and Gambacorta (2019), Brunnermeier and Koby (2019), Claessens, Coleman, and Donnelly (2018), Heider, Saidi, and Schepens (2019), Lopez, Rose, and Spiegel (2018), Ulate (2021), and Wang (2018).

⁴ All else equal, an increase in the term premium after investment actually has no effect on the profits for this bank if it intends to hold its long-term bond until maturity. In contrast, if the bank holds the long-term bond with the intention to resell it at a later point in time, an increase in the term premium is associated with a fall in the price of the bond and can therefore imply lower profits. As explained in Section 6, the current market value of future profits or dividends also decreases following an increase in the term premium due to a standard discounting effect.

effects, it is therefore important to disentangle changes in long-term yields. This simple example also highlights that there is an important difference between the term spread (current long-term yield minus current short-term yield) and the term premium (current long-term yield minus average expected future short-term rates). For example, an elevated term spread does not necessarily imply that the bank in this simple example can expect a high profit margin, since it may simply reflect an expectation that future short-term rates will increase. Hence, the distinction between term spread and term premium is particularly important for banks that need to evaluate how future short-term rates evolve when making an investment decision.

As the discussion in the introduction demonstrates, banks are not so simple in practice. In particular, banks typically borrow at rates below short-term market rates and largely invest in risky loans, as opposed to safe government bonds. To account for these additional features, consider a bank that invests in an m -period risky fixed-rate loan. The expected annual rate $E_t(r_t^m)$ on such a loan that is issued in period t can be expressed as

$$E_t(r_t^m) = y_t^m + \underbrace{\eta_t^m}_{\text{External Finance Premium}}, \tag{2.2}$$

where η_t^m gives the expected external finance premium, which compensates the bank for taking on credit risk (e.g., Bernanke et al., 1999). Further taking into account (2.1) and assuming that the bank borrows at a deposit rate r_{t+k} in period $t+k$ with $r_{t+k} < y_{t+k}$, Eq. (2.2) can be extended to

$$E_t(r_t^m) = \underbrace{\frac{1}{m} E_t \left\{ \sum_{k=0}^{m-1} r_{t+k} \right\}}_{y_t^m} + \underbrace{\mu_t^m}_{\text{Deposit Premium}} + \tau_t^m + \eta_t^m, \tag{2.3}$$

where μ_t^m denotes the expected deposit premium. The bank earns this premium due to its deposit franchise, which allows the bank to pay a deposit rate that is lower than the short-term market rate (e.g., Drechsler et al., 2017). The expected deposit premium is given by the difference between EH_t^m and the average expected deposit rates over the same horizon. For this more sophisticated bank, the expected net interest margin at time t is

$$E_t(NIM_t^m) = \mu_t^m + \tau_t^m + \eta_t^m. \tag{2.4}$$

Hence, the bank earns a profit from three distinct premia in expectation: (i) μ_t^m due to its deposit franchise, (ii) τ_t^m for taking on interest rate risk, and (iii) η_t^m for taking on credit risk. Based on Eq. (2.4), one can quantify the relative importance of each premium. According to the classic view about banking mentioned in the introduction, τ_t^m should account for a substantial fraction of banks' overall margin. In contrast, if banks are not exposed to interest rate risk, τ_t^m should be negligible, since their assets would be priced without such a risk compensation.⁵

3. Descriptive evidence

Unfortunately, none of the three premia in (2.4) are directly observable. In particular, the term premium is unknown due to the lack of direct data on the expected path of future short-term rates. In this paper, I therefore rely on estimates for τ_t^m from term structure models. To understand the importance of τ_t^m for bank profit margins, I consider data on realized net interest margins. Intuitively, if changes in term

⁵ For example, a hypothetical adjustable-rate long-term government bond with a yield that moves one-for-one with the current short-term rate has a zero term premium. Similarly, a bank that issues an adjustable-rate loan with the same feature only earns the deposit premium μ_t^m and the credit risk premium η_t^m in expectation according to Eq. (2.3).

premia are priced into rates on new loans and securities, then such movements should be reflected in variations in realized net interest margins, if banks are in fact exposed to interest rate risk. Also note that such a risk exposure should still be reflected in bank profit margins, even if banks price term premia in equilibrium or respond to term premium changes by altering their asset allocations.

Fig. 3.1 provides such a comparison, using data for U.S. commercial banks and a term premium estimate based on the model by Kim and Wright (2005), which is employed by the Federal Reserve Board (see Section 4.1 for details).⁶ The two series have followed each other closely over the past three decades. Over the sample, the average net interest margin for U.S. commercial banks declined from around 5 percent at its peak in the early 1990s to around 3 percent by 2015. This decline can be explained by the fall in the term premium over the same period. In fact, the term premium declined by slightly more, from around 1.8 percent to -1.2 percent, with the other components in (2.3) potentially moving in an offsetting direction over the sample. The fraction of the net interest margin that can be explained by the term premium also declined over the considered sample, from around 40 percent in the mid-1990s to close to zero around the onset of the Great Recession. The negative term premium in recent years can be explained by the absence of a lower bound on the short-term interest rate within the term structure model by Kim and Wright (2005) (see Section 4.1 for a discussion) or by the preference of certain investors, such as pension funds, for longer-maturity bonds.

Fig. 3.2 uses the same series as Fig. 3.1, but illustrates them as percentage point changes from a year ago. Again, the two series follow each other closely, with the term premium change often leading that of the net interest margin. An exception is the recent lower bound episode, possibly due to the feature that the Kim and Wright (2005) model does not account for such a constraint. Thus, term premia and net interest margins not only show similar trends over the last decades, but also move in tandem at higher frequencies.⁷

Additional evidence on the relation between term premia and net interest margins is shown in Appendix A. Figure A.3 replicates the evidence in Figs. 3.1 and 3.2, using an alternative estimate for the term premium based on the model by Adrian et al. (2013) (see Section 4.1 for details). Again, the two series show similar movements. The evidence in Figs. 3.1, 3.2, and Appendix A suggests that changes in term premia feed into subsequent changes in net interest margins relatively quickly, which can be explained by the fact that the rates on new loans and other assets can incorporate such changes at issuance, impacting a bank's interest income stream thereafter.

The estimates by Adrian et al. (2013) reach back further than the ones by Kim and Wright (2005), starting in 1961. Figure A.4 makes use of this longer time series, comparing a term premium estimate by Adrian et al. (2013) with annual historical data on bank net interest margins from the Federal Deposit Insurance Corporation (FDIC). In contrast to the sample in Fig. 3.1, the term premium has not been in steady decline, but increased from 1961 until around the early 1980s and fell thereafter. While there are some episodes during which the

⁶ The 4-year term premium is used since such a horizon roughly corresponds to the typical maturity mismatch of banks in the data (see Section 8.1 and Appendix Figure H.2). As a measure of banks' net interest margins, I take a historical series directly from St.LouisFed'sFREDdatabase, which is based on data from the Call Reports. Replicating this series with the data described in Section 8.1 yields similar estimates. In unreported work, I verify that these trends hold for banks that are active throughout the sample, the ones that are entering, and the ones that are dropping out.

⁷ Similar patterns are visible when comparing net interest margins with long-term government yields instead, as those are strongly driven by changes in term premia. However, the comovements are less precise due to the influence of future expected short-term rates as shown in Appendix Figure A.2.

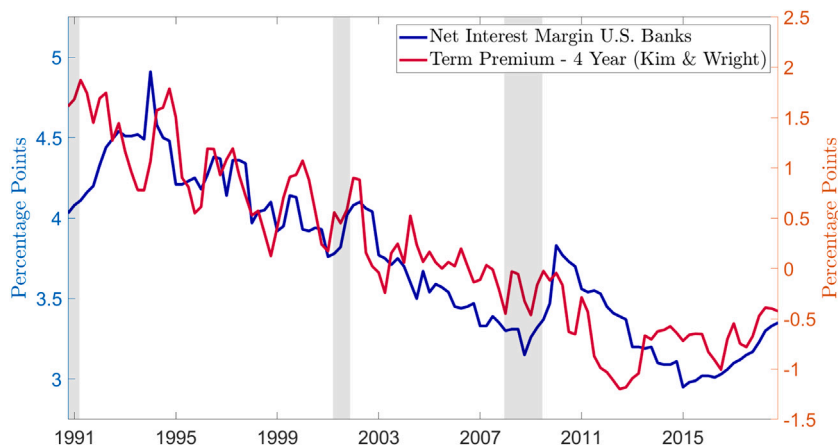


Fig. 3.1. Banks’ Net Interest Margins and the Term Premium – Levels.

Notes: The net interest margin is given by the difference between interest income and interest expenses divided by total interest-earning assets. The figure shows the net interest margin for U.S. commercial banks and is taken from St. Louis Fed’s FRED database based on data from the Call Reports (left axis). The term premium is based on estimates by Kim and Wright (2005) (right axis, see Section 4.1 for details).

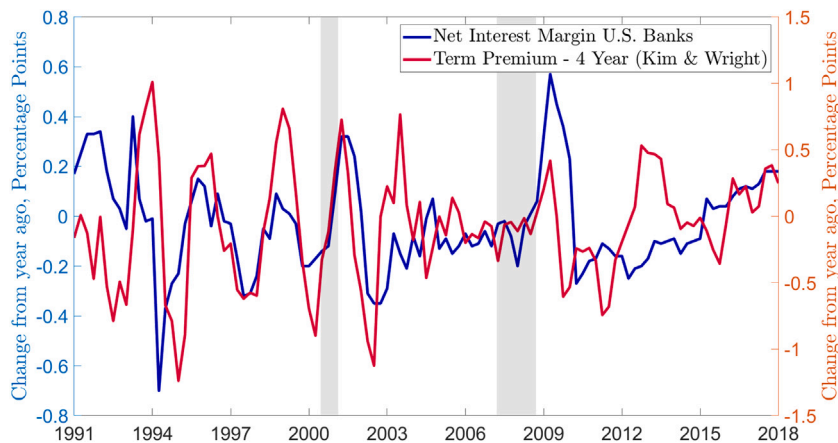


Fig. 3.2. Banks’ Net Interest Margins and the Term Premium – Differences.

Notes: The net interest margin is given by the difference between interest income and interest expenses divided by total interest-earning assets. The figure shows the net interest margin for U.S. commercial banks and is taken from St. Louis Fed’s FRED database based on data from the Call Reports (left axis). The term premium is based on estimates by Kim and Wright (2005) (right axis, see Section 4.1 for details).

term premium and the net interest margin diverge for this extended sample, for the most part, the two series show similar patterns.⁸

While there are many reasons why term premia and net interest margins change, the strong comovement between the two series over short and long windows, high and low interest rates, with changing time trends, provides evidence that they are related, as opposed to other factors explaining all of these comovements. For example, changes in just the level of interest rates, which also occurred over the sample period, cannot explain movements in banks’ net interest margins, leaving aside considerations such as a lower bound on interest rates. That is because what matters for banks is not the level per se but the margin between different interest rates. Moreover, while a decline in the cost of providing banking services over recent years may be an explanation for the downward trend in net interest margins, it is an unlikely explanation for all of the comovements given the previous rise in net interest margins that is shown in Figure A.4 and the high-frequency relations between term premia and net interest margins in Figs. 3.2 and A.3.

⁸ While the term premium and banks’ net interest margin show a strong relation, the same cannot be said about the term spread and banks’ net interest margins (see Appendix Figure A.5).

While banks’ net interest margins have been falling since the early 1990s, their return on assets (net income over total assets) has been relatively stable at around 1 percent outside of financial recessions, such as the one associated with the financial crisis of 2007–09 (see Figure A.6).⁹ Based on a longer time series reaching back to the mid-1930s, Figure A.7 shows a similar pattern, though banks’ return on assets leveled below 1 percent before 1990.¹⁰ The noticeable exceptions are three episodes of severe financial distress: the Great Depression

⁹ The sharp fall of banks’ return on assets during financial crises is largely explained by an increase in “provision for loan and lease losses” (see Appendix Figure A.6) and a rise in “goodwill impairment losses” that are part of banks’ noninterest expenses in the income statement of the Call Reports. In contrast, banks’ net interest income is not strongly affected (see Figs. 3.1 and A.6.).

¹⁰ Figure A.6 shows that the stability of banks’ return on assets over the past few decades has been due to the fact that banks’ net noninterest income has been increasing in parallel. Splitting net noninterest income into noninterest income and expenses, Figure A.8 illustrates that this trend is driven by a fall in banks’ noninterest expenses. While banks’ noninterest income also increased throughout the 1990s, it has been on a downward trend since then. Note that fees associated with loan originations are generally part of banks’ interest income in the income statement in the Call Reports. They therefore enter banks’ net interest margin. A range of other fees, such as

at the beginning of the sample, the Savings and Loans Crisis in the mid-1980s, and the 2007–09 financial crisis.

Banks may have responded to the falling term premia over the last years in two ways. First, they may have reacted by increasing their maturity mismatch, since longer-term bonds typically earn a higher premium. Appendix Figure H.2 shows such a trend. Based on the maturity gap (see Section 8.1 for details), the typical bank raised its duration mismatch by around 1.5 years over the past two decades.¹¹ Second, with term premia and deposit premia μ_t^m in Eq. (2.4) declining close to the lower bound, banks may have attempted to stabilize their net interest margins by increasing external finance premia. Wang (2018) finds evidence for such a trend, as the difference between bank loan income and a replicating treasury portfolio increased in recent years.¹²

Taken together, the evidence suggests that changes in term premia have historically been reflected in banks' net interest margins, despite the fact that their return on assets has been fairly stable outside of financial crises. The remainder of the paper takes these descriptive patterns as a motivation to analyze the behavior of banks' stock prices and income margins in response to changes in interest rates and term premia.

4. Evidence from stock indices

In this section, I show how the returns of stock indices respond to yield changes on FOMC announcement days. I compare the response of an index that represents the U.S. banking sector, the so-called KBW Bank Index, with the response of the Standard and Poor's (S&P) 500 Index, adjusted to exclude all commercial banks. To various surprise changes in government bond yields of different maturities, the response of both indices is relatively small in absolute terms and the KBW Bank Index does not respond more strongly than the adjusted S&P 500. Based on these results, banks and other large corporations do not seem particularly exposed to interest rate risk, and if anything, banks are less exposed. However, I show that these conclusions change once yield changes are decomposed. Bank equity responds more negatively to surprise increases in short-term rates, but more positively to a rise in term premia, and these differences are masked by looking at simple yield changes only.

4.1. Data and sample

I focus on changes in yields, term premia, and stock returns at the daily frequency because that is the highest frequency for which term premia estimates are available. All changes are based on closing-day prices on the day of the FOMC announcement relative to the previous trading day.¹³

servicing and securitization fees, are part of banks' noninterest income. Source: <https://www.ffiec.gov/forms031.htm>.

¹¹ At the same time, the declining term premium may have been the reason why a large share of smaller (community) banks that relied more heavily on maturity transformation went out of business or were consolidated under the roof of bank holding companies. Over the past three decades, the number of commercial banks in the U.S. declined from around 12,500 to around 4500 (Source: Call Reports).

¹² Note that such a trend is not visible for corporate bond spreads, as illustrated in Figure B.1 which shows the credit spread and excess bond premium series by Gilchrist and Zakrajsek (2012).

¹³ Typically, the previous trading day is the day just before the announcement. In two instances, 4/18/1994 and 11/12/1997, the windows are larger, covering two- and three-day changes, respectively. All of the following results are robust to excluding those two meetings. As stated in the text, the FOMC announcement on 9/17/2001 is excluded from all estimations, since financial markets were closed from 9/11/2001 until 9/17/2001.

Treasury yield data. The analysis requires data on financial markets' expectations of nearby short-term rates, which are targeted by the Federal Reserve, and data on longer-term government bond yields. I approximate the former using secondary market rates for 3-month Treasury bills (T-bills). These indicate the market's expectations of short-term rates over the coming three months, and term premia are generally negligible at this horizon. In comparison with expected rates on even shorter maturities, for example as extracted from futures prices on the current month's federal funds rate, the 3-month T-bills have the following advantage: they are less affected by policy actions that reflect only the timing of rate changes from one meeting to the next, but rather represent actual level changes in nearby short-term rates (see also Bernanke and Kuttner, 2005). The longer-term government bond yield data are taken from Gürkaynak, Sack, and Wright (2007). In particular, I use yield data for the 2-year, 5-year, and 10-year Treasury bonds. These maturities are chosen because they correspond to the range of banks' maturity mismatch, as explained in more detail in Section 8.1, and because they allow for a comparison with the estimates in English et al. (2018).

Term premia estimates. For the United States, two estimates for daily term premia are publicly available that cover the entire sample period that I consider and that are commonly used in the literature: those of the term structure model by Kim and Wright (2005) and the ones by Adrian et al. (2013).¹⁴ The publicly available estimates by Adrian et al. (2013) are based on yield data starting in 1961. To account for structural changes over time, I reestimate their model, starting the sample at the same time as the one by Kim and Wright (2005) (1990:M7) and ending it before the financial crisis in 2008/09 (2007:M12). The term premia estimates of the two models are shown in Appendix Figures B.2 and B.3. All series show a declining trend over the past three decades. For the main analysis, I rely on the estimates by Kim and Wright (2005) and check the robustness of my findings to using the data by Adrian et al. (2013) instead.¹⁵ The underlying term structure models for these two estimates differ according to their estimation method, the yield data employed, the number of factors extracted from the yield data, the sample starting period, and the use of survey data to discipline expected short-term rates. Li, Meldrum, and Rodriguez (2017) provide a comparison and show that the use of survey data explains most of the differences for the final term premia estimates.

Stock returns. I obtain daily stock prices for the KBW Bank Index from Yahoo Finance.¹⁶ The KBW Bank Index is a benchmark stock index of the banking sector. The index was developed by the investment bank Keefe, Bruyette and Woods. It includes a weighting of 24 banking stocks, mainly including large financial institutions as opposed to smaller regional banks. As a comparison group representing other large

¹⁴ The data from Kim and Wright (2005) and Adrian et al. (2013) are available at:

<https://www.federalreserve.gov/pubs/feds/2005/200533/200533abs.html>
https://www.newyorkfed.org/research/data_indicators/term_premia.html.

¹⁵ The model by Kim and Wright (2005) is a latent three-factor Gaussian term structure model. The estimation includes 3- and 6-months T-bill rates, 12-, 24-, 48-, 84-, and 120-months Treasury yields from Gürkaynak, Sack, and Wright (2007), and the model is augmented with Blue Chip surveys of the 3-month T-bill yield expected in 6 months, 1 year, and 6–11 years. The survey data improves identification of the latent factors and reduces small-sample problems (see also Kim and Orphanides, 2012). While beneficial for the decomposition into term premia and average expected future short-term rates, the inclusion of survey data comes at the cost of computational speed. In contrast, the model by Adrian et al. (2013) allows for a computationally fast estimation and does not rely on history-dependent survey data, and I make use of these differences and obtain bootstrap estimates based on the model by Adrian et al. (2013) (see Appendices C and D for details).

¹⁶ The data are available at: <https://finance.yahoo.com/quote/%5EBkx/>.

nonfinancial firms, I use the S&P 500 Index but exclude all commercial banks to avoid the possibility that any price movements reflect the behavior of the banking sector.¹⁷ While the companies in those two indices still differ across a number of characteristics apart from their maturity mismatch, which may drive some of the differences of the stock prices responses, the following results show that the relative reactions substantially change across regressions setups, specifically, once yield changes are decomposed into movements in term premia and expected short-term rates. For both indices, I exclude dividends to compute daily stock returns.

Sample period. Throughout, I focus on the sample period 1994:M1-2007:M12 for three reasons. First, I choose the sample start because, from 1994 onward, the Fed released a statement immediately after each FOMC meeting. Until 1994, changes to the target rate had to be inferred by the size and type of open market operations. Hence, it might have taken market participants some time to absorb the relevant information and the daily trading-day windows to extract the surprises might be too restrictive. Second, I choose the end of the sample to exclude the period of financial distress in 2008/09 and the effective-lower bound (ELB) episode that followed. The ELB period is particularly problematic when using the term premia estimates by Kim and Wright (2005) and Adrian et al. (2013), since these models do not explicitly account for a lower bound on the short-term interest rate. Therefore, 2007:M12 is chosen as an end date.¹⁸ Third, for the period 1994:M1-2007:M12, employment reports were rarely released on FOMC announcement days, as opposed to the time before 1994 (see, e.g., Bernanke and Kuttner, 2005, and Gürkaynak et al., 2005). Such macroeconomic news releases would imply a threat to the identification given the daily trading windows (see also Gürkaynak et al., 2005). In fact, only the FOMC announcement on February 18, 1994, took place on the same day as an employment report release. All of the following results are robust to excluding this meeting from the sample.

Specific FOMC announcements. For the main analysis, I consider all FOMC meetings between 1994:M1 and 2007:M12, apart from the announcement on September 17, 2001. That is because all financial markets in New York were closed from September 11, 2001, to September 17, 2001, hence, the identifying assumption that monetary policy news dominates over these days seems unreasonable. Below, I show that my results are robust to excluding other unscheduled FOMC meetings-August 10, 2007, and August 17, 2007-because these FOMC announcements focused on providing details about liquidity policies (e.g., the Term Auction Facility) or communicated awareness of ongoing economic events and did not announce policy changes. The announcement on October 15, 1998, followed unusual developments in financial markets associated with the deteriorating situations in Russia and Asia and the near collapse of Long-term Capital Management. Hence, the associated 25 basis points cut can be understood as pure signal to financial markets. I therefore exclude this meeting as well for the robustness checks.

¹⁷ To this end, I gather data for historical constituents of the S&P 500 and their stock prices from the Wharton Research Data Services. Commercial banks with SIC Codes that start with 60 or 61 and 6712 are excluded and the index is recomputed by adding up all of the individual firm market values on any given day. To ensure that this procedure reflects the actual index, I also compute an index that leaves in commercial banks. For the FOMC announcements days in the following section, the correlation of the returns of the original S&P 500 and the “bottom-up” calculation is 0.9989. However, after excluding commercial banks, this correlation only changes to 0.9951, implying that the exclusion of banks does not make a substantial difference. In contrast, the correlation coefficient between the KBW Index and the S&P 500 is 0.86, but 0.98 between the KBW Index and the excluded banks in the S&P 500.

¹⁸ A potential concern is that markets expected the ELB to bind in the future at the end of the sample. However, based on the estimates from Kim and Wright (2005), I find that average expected future short-term rates were well above 3 percent for the 1- to 10-year maturities on 12/31/2007 and always above 1 percent throughout the estimation sample (1994:M1-2007:M12).

4.2. Results

As a first pass, I compute the response of the returns of the KBW Bank Index and the adjusted S&P 500 Index on day t of an FOMC announcement, denoted by R_t , to daily yield changes. Since the distinction between level and slope changes is particularly relevant for banks, I estimate the regression

$$R_t = \alpha + \beta_1 \Delta Y_t^{3M} + \beta_2 (\Delta Y_t^m - \Delta Y_t^{3M}) + u_t, \quad (4.1)$$

where ΔY_t^{3M} denotes the yield change of the 3-month T-bill and ΔY_t^m is the yield change of a government bond with maturity m . The regression coefficients have the following interpretation. The coefficient β_2 captures the return response to a slope surprise, that is, an increase in ΔY_t^m holding ΔY_t^{3M} constant. In turn, β_1 represents an increase in ΔY_t^{3M} , holding $(\Delta Y_t^m - \Delta Y_t^{3M})$ constant, that is, a level shift in the yield curve that changes Y_t^{3M} and Y_t^m by the same amount. Importantly, the slope surprise in (4.1) represents a slope change in the term spread: the difference between current long-term yields and current short-term yields.

The estimation results are shown in Table 4.1. Several observations stand out. First, all of the estimated coefficients are not statistically different from zero at conventional confidence levels.¹⁹ Second, the R^2 are relatively low. Third, the response of the S&P 500 is more negative compared with the response of the KBW Bank Index at various maturities. To slope surprises, these results suggest that the banking sector may benefit from an increase in the term spread, in particular with respect to longer maturities, given the positive β_2 coefficients for the 5-year and the 10-year maturities. However, the more positive responses to level surprises indicate that the banking sector is actually *less* exposed to interest rate risk compared with other nonbank firms in the S&P 500. And fourth, for both indices, the responses to a level surprise become more positive the longer the maturity, a puzzling finding since one would expect the opposite: if interest rates remain elevated for longer, stock prices should be more negatively affected.

Next, I show that the previous regression setup misses a key distinction: long-term yields move either because of changes in future expected short-term rates or because of changes in term premia, that is,

$$\Delta Y_t^m = \Delta E H_t^m + \Delta T P_t^m, \quad (4.2)$$

where $\Delta E H_t^m$ denotes the change in the expectation-hypothesis component, or the average expected future short-term rates over horizon m , and $\Delta T P_t^m$ denotes the change in the expected term premium for a government bond of maturity m (see Eq. (2.1)). Regression (4.1) can therefore be adapted to

$$R_t = \alpha + \beta_1 \Delta Y_t^{3M} + \beta_2 (\Delta E H_t^m - \Delta Y_t^{3M}) + \beta_3 \Delta T P_t^m + u_t. \quad (4.2)$$

In (4.2), β_1 and β_2 represent the responses to level and slope increases in expected future short-term rates, and β_3 gives the response to an increase in term premia.²⁰ Using the estimates by Kim and Wright (2005), Table 4.2 shows the results based on the regression setup in

¹⁹ The quantitative results and statistical significance in Table 4.1 depend on the daily frequency. Appendix Table C.1 replicates regression (4.1), but uses high-frequency changes for ΔY_t^{3M} and ΔY_t^m based on 30-minute windows (10 min before and 20 min after an announcement). In comparison with Table 4.1, the estimated coefficients $\hat{\beta}_i$ are statistically significant at conventional confidence levels. However, in comparison with Table 4.2 that separates out term premium changes, the estimated coefficients are still smaller in absolute terms, suggesting that term premia play a role even at higher frequencies.

²⁰ In contrast to Hanson and Stein (2015) and Nakamura and Steinsson (2018), changes in the expected path of future short-term rates and term premia are used as regressors instead of dependent variables in the regression (4.2), and treated as data. As it is well known, there is substantial model and estimation uncertainty attached to such estimates. However, in the case that the estimates that I use contain classical measurement error, the estimated

Table 4.1
Response of stock returns to level and slope surprises.

m =	KBW Index			S&P 500		
	2-year	5-year	10-year	2-year	5-year	10-year
ΔY_t^{3M}	-3.29 (3.94)	-2.12 (4.19)	-0.75 (4.81)	-4.14 (2.54)	-3.46 (2.67)	-3.35 (3.06)
$\Delta(Y_t^m - Y_t^{3M})$	-0.30 (3.60)	1.38 (3.80)	2.71 (4.25)	-0.73 (2.29)	0.39 (2.64)	0.45 (2.98)
R^2	0.01	0.02	0.02	0.05	0.05	0.05
Meetings	118	118	118	118	118	118

Notes: Estimation results for regression (4.1), where R_t is given by the return of the KBW Bank Index or the S&P 500 (excluding banks). Sample: 1994:M1-2007:M12, excluding FOMC announcement on 9/17/2001. White standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4.2
Response of stock returns to level, slope, and term premia surprises.

m =	KBW Index			S&P 500		
	2-year	5-year	10-year	2-year	5-year	10-year
ΔY_t^{3M}	-16.65** (7.16)	-31.00** (13.78)	-41.20** (19.66)	-12.77** (5.26)	-24.05** (9.51)	-33.47** (13.06)
$\Delta(EH_t^m - Y_t^{3M})$	-20.99** (9.23)	-36.26** (16.74)	-46.26** (22.78)	-14.09** (6.53)	-26.46** (11.26)	-36.04** (14.87)
ΔTP_t^m	21.12** (10.19)	23.45** (10.18)	25.14** (10.95)	13.11* (7.80)	15.82** (7.57)	17.75** (7.99)
R^2	0.08	0.09	0.08	0.11	0.13	0.13
Meetings	118	118	118	118	118	118

Notes: Estimation results for regression (4.2), where R_t is given by the return of the KBW Bank Index or the S&P 500 (excluding banks), and ΔEH_t^m and ΔTP_t^m are based on estimates from Kim and Wright (2005). Sample: 1994:M1-2007:M12, excluding FOMC announcement on 9/17/2001. White standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(4.2). Strikingly, the estimated coefficients $\hat{\beta}_1$ and $\hat{\beta}_2$ have opposite signs compared with $\hat{\beta}_3$, and all are statistically different from zero at standard confidence levels for various maturities. In comparison with the estimation results in Table 4.1, the magnitudes of all coefficients and the R^2 increase substantially for both indices.

A level or slope increase in future expected short-term rates lowers stock returns for both indices. In contrast, a rise in expected term premia is associated with higher stock returns. The absolute responses of bank equity are larger to each of those yield changes. For example, a 100-basis-points increase in the level of future expected short-term rates over the next 2 years leads to a drop in equity prices of around 17 percent for the banking sector and around 13 percent for the adjusted S&P 500. Hence, bank equity shows a roughly 30 percent or 4 p.p. stronger response.²¹ At the same maturity, to a 100-basis-points increase in the term premium, the bank equity response is 61 percent or 8 p.p. larger than the nonbank equity response (21 vs. 13 percent). The estimated coefficients $\hat{\beta}_1$ and $\hat{\beta}_2$ therefore suggest that bank cash-flows are more sensitive to interest rate risk, and the coefficients $\hat{\beta}_3$ indicate that bank profits respond more to changes in the compensation for interest rate risk. The following sections discuss under which conditions these estimates are well identified, the economic interpretation of the results, and whether they are supported by asset pricing theory. Appendix C reports robustness checks to alternative term premia estimates and the exclusion of specific emergency FOMC meetings.

coefficients are biased towards zero, less precise, and can be seen as conservative lower bound estimates. My results are also unaffected if the estimates of the level of expected future short-term rates and term premia are biased but their changes around FOMC announcements are not. Appendix D also considers bootstrapped estimates using the Adrian et al. (2013) model.

²¹ In comparison, English et al. (2018) find that bank stock returns fall by less, around 8 percent to a 100-basis-point level-increase of the 2-year government bond yield, without the decomposition into future expected short-term rates and term premia (see Table 1 therein).

5. Identification

Under which conditions does regression (4.2) identify the true causal effects? In Appendix E, I derive the following propositions to address this question. Changes in average expected future short-term rates are driven by monetary policy news and plausibly exogenous on FOMC announcement days. However, term premia are endogenous and may even reflect a response to expected future short-term rates. Nonetheless, regression (4.2) can still give consistent estimates even if one allows for such an endogenous response of term premia. The necessary condition is that the exogenous variation in term premia, that is unrelated to short-term rates, does not move stock prices through another channel. This condition is equivalent to the absence of an omitted variable bias, as summarized in Proposition 1. Also note that the estimates still have a causal interpretation under the conditions in Proposition 1, even if banks partly price term premia or respond to term premium changes. That is because rational equity investors can take term premium changes as given and understand future bank behavior, pricing equity according to both.

Proposition 1. *The effects of future expected short-term rates and term premia on stock returns are consistently estimated based on regression (4.2) using ordinary least squares, in the absence of omitted shocks that are correlated with stock returns and the regressors in (4.2).*

A particular reason why regression (4.2) may be subject to an omitted variable bias is due to the information effect of monetary policy. On announcement days, the Fed may release private information about its economic outlook and stock prices may respond to the information release in addition to the interest rate shock (e.g., Nakamura and Steinsson, 2018). An omitted Fed “information shock” may have a direct effect on stock prices, while also moving bond prices and term premia. In fact, such an omitted shock can explain the positive effect of term premia on the S&P 500 in Table (4.2). To positive news about growth prospects, investors move out of longer-maturity bonds into shorter-maturity bonds or stocks, thereby raising term premia on longer-maturity bonds. Stock prices increase due to the additional demand for equity or because they reflect changes in growth expectations, giving rise to a positive relation between equity and term premia.

Table 5.1
Response of stock returns — Differences between KBW and S&P 500.

m =	KBW-S&P 500		
	2-year	5-year	10-year
ΔY_t^{3M}	-3.88* (0.08)	-6.94 (0.12)	-7.73 (0.20)
$\Delta(EH_t^m - Y_t^{3M})$	-6.90** (0.05)	-9.79 (0.10)	-10.22 (0.18)
ΔTP_t^m	8.01** (0.02)	7.62** (0.03)	7.39* (0.05)
R^2	0.03	0.02	0.02
Meetings	118	118	118

Notes: Estimation results for regression (4.2), where R_t is given by the return of the KBW Bank Index minus the return of the S&P 500 (excluding banks), and ΔEH_t^m and ΔTP_t^m are based on estimates from Kim and Wright (2005). Sample: 1994:M1-2007:M12, excluding FOMC announcement on 9/17/2001. P-values in parentheses are based on one-sided tests with the null hypothesis that $\hat{\beta}_1 > 0$, $\hat{\beta}_2 > 0$, and $\hat{\beta}_3 < 0$, using White standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Such an omitted shock may not only be a Fed “information shock” but could also represent some other macroeconomic news release or changes in investors’ risk-attitudes. In Appendix E, I show that regression (4.2) gives biased estimates in the presence of such omitted shocks, which cannot be immediately resolved without direct observations of those shocks or instruments for the endogenous regressors. However, if the omitted shock has a homogeneous direct effect on stock prices of two companies or indices, a reasonable assumption with respect to the mentioned macroeconomic shocks which likely affect financial and nonfinancial companies similarly through non-interest rate channels, then the bias is the same for the two companies or indices. Intuitively, when taking the difference of the two estimates, the bias cancels out, giving a consistent estimate of the difference and allowing for heterogeneous responses to term premia and short-term rates, as summarized in Proposition 2. I therefore reestimate regression (4.2) using the difference in the return of the KBW Index and the adjusted S&P 500 as a dependent variable. Table 5.1 shows the results. For the 2-year maturity, $\hat{\beta}_1$, $\hat{\beta}_2$, and $\hat{\beta}_3$ are all statistically different from zero at typical confidence levels.²²

Proposition 2. *The difference in the effects of future expected short-term rates and term premia on stock returns of two companies or indices are consistently estimated based on regression (4.2) using ordinary least squares, even in the presence of omitted shocks that are correlated with stock returns and the regressors in (4.2), if these omitted shocks have a homogeneous direct effect on the stock returns of the two companies or indices.*

A remaining concern is that the three regressors in (4.2) are fairly strongly correlated, potentially giving biased estimates for the relatively small sample of FOMC announcement days in Tables 4.2 and 5.1. For example, the correlation coefficients at the 2-year maturity are -0.75 between ΔY_t^{3M} and $(\Delta EH_t^m - \Delta Y_t^{3M})$, 0.44 between $(\Delta EH_t^m - \Delta Y_t^{3M})$ and ΔTP_t^m , and 0.10 between ΔY_t^{3M} and ΔTP_t^m , and the ones at the 5- and 10-year maturities are similar.²³ In Appendix E, I show that the previous identification argument generalizes to non-FOMC days. As long as structural shocks affect bank and nonbank equity heterogeneously through future expected short-term rates and term premia, but not through another channel, the difference in the return responses can be consistently estimated based on regression (4.2). Extending the sample in this way yields results that are similar

²² An alternative approach to account for the Fed information effect is to exclude observations with nonstandard stock price responses. Following Jarocinski and Karadi (2020), I omit meetings with positive (negative) equity reactions of the S&P 500 following a monetary policy tightening (easing). Appendix Tables C.4 and C.5 show that the results not only remain but intensify with this additional restriction.

²³ Appendix Table H.7 provides summary statistics of different variables on FOMC announcement days.

to the benchmark estimates as shown in Table 5.2, which covers 2878 observations as opposed to the original 118 policy announcement days.²⁴ By and large, bank equity responds more negatively to slope and level changes related to future expected short-term rates, but more positively to changes in term premia, and the statistical significance largely improves for this extended sample.

What do the results in Tables 4.2 and 5.1 reveal about banks’ exposure to interest rate risk, and how do they compare to the small and insignificant estimates in Table 4.1? The stronger absolute responses of bank equity relative to nonbank equity in Table 5.1 suggest that banks’ cash-flow is particularly sensitive to a change in short-term rates or term premia. The next section shows that such relative responses are also supported by asset pricing theory. Intuitively, higher-than-expected short-term rates imply a reduction of net interest margins on banks’ legacy assets-exposing banks to interest rate risk. Moreover, counterfactuals show that the stronger equity responses are quantitatively too large to be explained by the fact that banks are simply more leveraged compared with nonfinancial firms. In contrast, higher term premia raise net interest margins on newly acquired loans (see Eq. (2.3)). These predictions are also confirmed based on impulse responses of bank profit margins in Section 7. Regression (4.1) masks the heterogeneous effects of ΔEH_t^m and ΔTP_t^m since the two offset each other in this regression setup.²⁵

6. Asset pricing predictions

Are the results so far supported by asset pricing theory? In Appendix F, I derive several theoretical predictions on the relation between stock prices, term premia, and short-term rates, which reinforce the previous empirical findings.

Prediction #1. To an increase in the term premium, bank stock returns respond more positively compared with typical nonfinancial companies.

²⁴ Combining FOMC and non-FOMC days, the correlation coefficients at the 2-year maturity are -0.72 between ΔY_t^{3M} and $(\Delta EH_t^m - \Delta Y_t^{3M})$, 0.37 between $(\Delta EH_t^m - \Delta Y_t^{3M})$ and ΔTP_t^m , and 0.21 between ΔY_t^{3M} and ΔTP_t^m , and the ones at the 5- and 10-year maturities are similar.

²⁵ If an unexpected increase in future expected short-term rates also raises term premia, such a channel may provide banks with an additional “hedge” against interest rate risk. While a positive correlation between ΔEH_t^m and ΔTP_t^m at various maturities indicates such a relation, it may also be due to a correlated Fed information effect shock. A surprise monetary tightening implies positive news about the future path of the economy, investors move out of longer-maturity bonds into shorter-maturity bonds or stocks, thereby raising term premia on longer-maturity bonds. Hence, such a hedge may not exist to a pure monetary policy shock that is orthogonal to a Fed information shock.

Table 5.2
Differences between KBW and S&P 500 (Including non-FOMC days).

m =	KBW-S&P 500		
	2-year	5-year	10-year
ΔY_t^{3M}	-2.03** (0.05)	-6.53*** (0.00)	-11.63*** (0.00)
$\Delta(EH_t^m - Y_t^{3M})$	-2.95** (0.01)	-8.12*** (0.00)	-13.56*** (0.00)
$\Delta T P_t^m$	-0.70 (0.28)	1.93* (0.09)	3.68** (0.01)
R^2	0.01	0.01	0.01
Observations	2,878	2,878	2,878

Notes: Estimation results for regression (4.2), where R_t is given by the return of the KBW Bank Index minus the return of the S&P 500 (excluding banks), and ΔEH_t^m and $\Delta T P_t^m$ are based on estimates from Kim and Wright (2005). The sample covers all one-day changes in returns and interest rates (FOMC and non-FOMC days) from 1993:M2 to 2007:M12, where the start of the sample is determined by the beginning of the KBW-index. P-values in parentheses are based on one-sided tests with the null hypothesis that $\beta_1 > 0$, $\beta_2 > 0$, and $\beta_3 < 0$, using White standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As illustrated in Appendix F.1, term premia affect stock prices through three distinct channels: (i) discounting, (ii) cash-flow, and (iii) risk-compensation. The relative response of bank equity versus nonbank equity is therefore determined by how strongly stock prices react through each of the three channels. The discounting channel is relatively standard: higher term premia imply that future dividends are discounted more heavily, depressing current market values. While this channel affects all stock prices in a similar way, banks and nonbanks differ with respect to the cash-flow channel. Intuitively, bank net interest margins increase if the term premium rises as explained in Section 2. In contrast, nonfinancial firms are unlikely to experience higher cash-flows after a rise in the term premium since they do not engage in the same arbitrage as banks.²⁶ If anything, higher term premia likely result in higher interest expenses for most firms, dragging down cash-flows. Thus, bank stock returns should respond more positively compared with typical nonfinancial companies following an increase in the term premium through the cash-flow channel. As shown in Appendix F.1, such a differential response persists even after taking into account the discounting and risk-compensation channels, resulting in Prediction #1, which is confirmed by the results in Tables 4.2 and 5.1.

Prediction #2. To an increase in short-term rates, bank stock returns respond more negatively compared with typical nonfinancial companies.

In Appendix F.2, I derive a standard decomposition of the response of stock prices to a monetary policy shock into news about future real rates, dividends, and equity risk premia. Using a numerical example to a 100-basis-points increase of short-term real rates over 2 years allows for a comparison of the response of bank and nonbank equity as predicted by theory. To obtain an estimate of the banks' dividend response, I match the relevant parameters to the data on banks' net interest margins, their maturity mismatch that accounts for variable-rate loans, their typical leverage, and the pass-through of policy rate changes to banks' interest expenses, taking into account the stickiness of deposit rates. Even under various conservative assumptions, the response of bank dividends is substantially more negative than that of nonbank dividends typically observed in the data. Intuitively, since banks borrow using short-term liabilities, their net interest margin on legacy assets strongly declines after an increase in short-term rates, impacting stock prices through lower dividends. The dividend reactions

²⁶ The term premium compensates banks for engaging in an arbitrage, buying long-term bonds financed by rolling over short-term bonds. If such an arbitrage can be executed at no extra costs, then the present discounted value of it should be zero in equilibrium and remain unchanged when term premia move. A positive relation between bank equity and term premia as in Table 4.2 can be reconciled by portfolio rebalancing and the Fed information effect as explained in Appendix F.1.

translate in stock price responses with a comparable difference as found in Table 4.2, resulting in Prediction #2.

The theoretical decomposition also allows to consider two counterfactuals. First, even if banks have a similar leverage as nonbanks, their stock price response is substantially stronger, suggesting that the observed differences can be accounted for by banks' maturity mismatch. Second, assuming that deposit rates respond one-for-one with policy rate changes-as suggested by the "textbook view" mentioned in the introduction-roughly doubles the percentage difference between the responses of bank and nonbank equity. While a substantial increase, it is not an outsized value, indicating that the estimated differences already reveal a sizeable interest rate exposure of banks.

7. Banks' income responses to interest rate surprises

The empirical evidence on banks' stock price responses and the theoretical asset pricing predictions suggest that bank profit margins decline to an increase in future expected short-term rates, but rise if term premia increase. In this section, I test whether that is the case by estimating impulse responses of banks' profit margins to interest rate surprises. To this end, I construct quarterly shock series for term premia and short-term rates. This is achieved by adding up the individual interest rate surprises around FOMC announcement days that occur within a particular quarter, as in Romer and Romer (2004). Given these shock series, I estimate a set of local projections that corresponds to the regression setup (4.2) following Jordà (2005),

$$Margin_{t+h} - Margin_{t-1} = \alpha^h + \beta_1^h Y_t^{3M} + \beta_2^h (EH_t^m - Y_t^{3M}) + \beta_3^h T P_t^m + u_t^h \quad \text{for } h = 0, 1, \dots \quad (7.1)$$

where $T P_t^m$ denotes the quarterly term premium shock for maturity m , $E H_t^m$ is the shock to the expectation-hypothesis component of long-term yields in period t for maturity m , and Y_t^{3M} is the shock to the 3-month Treasury bill. The dependent variable denotes the change in a profit margin from $t - 1$ to $t + h$. I consider aggregate series for the net interest margin and net income. The net interest margin is given by the difference between interest income and interest expenses divided by total interest-earning assets. Net income is the return on total assets. Both series are taken from St. Louis Fed's FRED database based on data from the Call Reports for all U.S. commercial banks.

The results for regression (7.1) at the 5-year maturity are shown in Fig. 7.1. In response to a positive level or slope shock to expected future short-term rates, banks' net interest margins fall and these responses are statistically different from zero at the 95 percent confidence level several quarters after the shock. The net interest margin responses translate into similar net income reactions, though the absolute responses are slightly smaller due to the alternative denominator (total assets vs. total interest-earning assets) and possibly due to offsetting

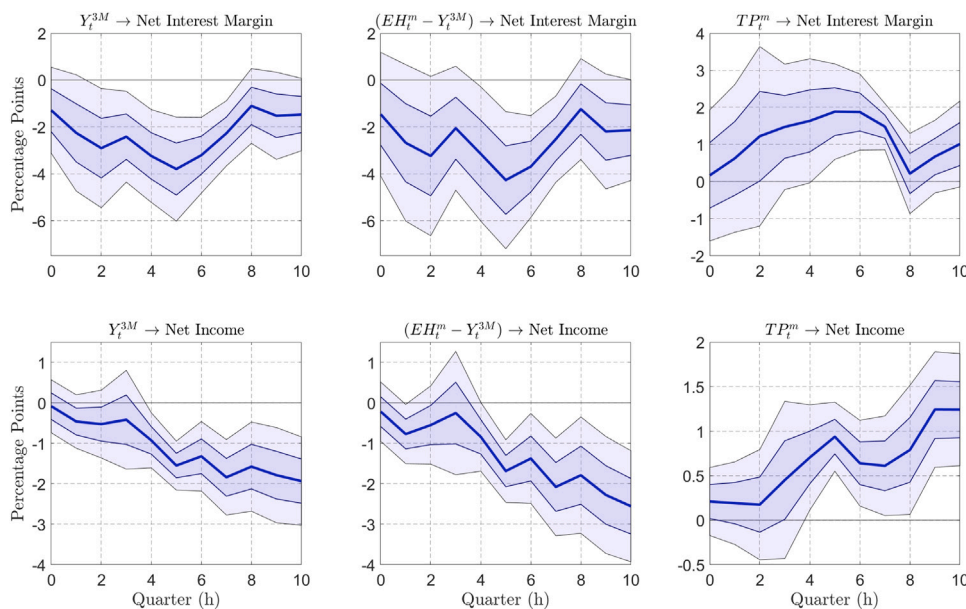


Fig. 7.1. Impulse Responses of Bank Profit Margins.
Notes: Estimation results for regressions (7.1), where EH_t^m and TP_t^m are based on estimates from Kim and Wright (2005) for $m=5$ -year. Sample: 1994:Q1-2007:Q4, excluding FOMC announcement on 9/17/2001. 95 and 68 percent confidence bands shown, using Newey and West (1987) standard errors.

responses of noninterest income. In contrast, in response to a positive term premium shock, banks’ net interest margins rise. Again, the response manifests itself into a similar net income reaction.²⁷ These findings are consistent with the previous stock price responses and the asset price predictions. The typical bank experiences lower cash flows when expected future short-term rates rise, but the opposite after an increase in the term premium.

In Appendix G, I test again how the responses differ when ignoring the decomposition of long-term bond yields. Figure G.1 shows the responses to level and slope shocks in long-term yields, resembling regression (4.1). The profit margins decline to a positive level yield surprise, but they are substantially smaller and less precise compared with the ones in Fig. 7.1. The responses to slope surprises are close to zero and largely insignificant, illustrating again the importance of the decomposition. Besides the documented margin responses, stock prices also react to changes in loan quantities. Appendix Figure G.2 shows that bank loans decrease following a level or slope surprise to expected short-term rates, but increase following a rise in the term premium, thereby reinforcing the margin effects. These responses are less precise but statistically significant at the one-standard-deviation confidence intervals.

8. Evidence from bank-level stock returns

In Section 4, I have shown that bank equity responds stronger in absolute terms to changes in future expected short-term rates and term premia on FOMC announcement days compared with nonbank equity. This section documents that these effects differ in the cross-section of banks depending on the maturity profile of their balance sheets. In particular, stock returns of banks with a larger maturity mismatch increase more in response to a rise in term premia, but also decline more strongly following an increase in future expected short-term rates.

²⁷ I find that the results equally hold for the 2-year and 10-year maturities, when using bank-level data as described in Section 8.1, and remain similar when including additional controls in regression (7.1). In particular, I check and confirm the robustness of the results to including up to three previous quarters of term premium shocks, expected future short-term rate shocks, and the one-year change in the respective dependent variable.

Both of these results are supported by asset pricing theory, as shown in Appendix F.

8.1. Data

I start from a list of U.S. financial institutions provided by the New York Fed that gives a mapping of identifiers; this allows me to link bank-level stock price data with balance sheet information.²⁸ For the following analysis, I restrict the sample to bank holding corporations (BHCs). For BHCs, two measures of maturity mismatch are commonly used in the literature: the income gap and the maturity gap. I use both measures since each of them comes with advantages and disadvantages.

Stock prices. Daily stock price data are obtained from the Wharton Research Data Services, and I exclude dividends to compute daily stock returns. As above, I restrict the sample to all stock returns with one-day trading windows apart from the two exceptions stated in footnote 4.1.

Income gap from Y-9c. The Consolidated Financial Statements or FR Y-9C filings for BHCs contain information on the value of book assets (RA) and liabilities (RL) that reprice or mature within the next year. Based on these data, the one-year income gap for bank i at time t can be derived, which is defined as

$$\text{Income gap}_{i,t} = \frac{RA_{i,t} - RL_{i,t}}{\text{Total Assets}_{i,t}} \quad (8.1)$$

The advantage of this measure is that the data are available for a relatively long sample (since 1986:Q2) and that it applies to all interest-earning assets and liabilities of a BHC. A disadvantage is that this measure is silent on the maturity or repricing of all balance sheet items beyond the one-year horizon. Gomez et al. (2021) and Haddad and Sraer (2020) use this measure in related work. Appendix H provides additional information on the data source and the variables that are used.

²⁸ The list gives a mapping between PERMCO and RSSD identifiers and can be found at: https://www.newyorkfed.org/research/banking_research/datasets.html.

Maturity gap from call reports. The second measure is the maturity gap, which is based on data from the Call Reports for U.S. banks. The maturity or repricing data in the Call Reports are more detailed than in the Y-9C. They allocate various balance sheet items into ranges of maturities beyond the one-year limit. Following English et al. (2018), I use the midpoint of each range as the maturity m_j for the value of all assets or liabilities within category j .²⁹ The maturity gap for bank i at time t is defined as the difference between the weighted maturity of all covered assets and liabilities,

$$\text{Maturity Gap}_{i,t} = \sum_j m_{A,j} \frac{\text{Asset}_{j,i,t}}{\sum_j \text{Asset}_{j,i,t}} - \sum_j m_{L,j} \frac{\text{Liability}_{j,i,t}}{\sum_j \text{Liability}_{j,i,t}}, \quad (8.2)$$

and Appendix G considers alternative definitions to check the robustness of the following findings. While the maturity data in the Call Reports are more granular for balance sheet items that are covered, they also have several disadvantages in comparison with the income gap from the Y-9C filings. First, the data are only available for certain types of assets and liabilities. Second, the data only start in 1997:Q2. Third, to relate the data to the BHCs' stock prices, the balance sheet information of various bank subsidiaries has to be aggregated up to the BHC-level. Appendix H provides additional information on the data sources and the aggregation. Tables H.3 and H.4 list the variables that are used and the maturity weights $m_{A,j}$ and $m_{L,j}$ in Eq. (8.2).

Sample and descriptive evidence. For the following analysis, I use a sample of BHCs, for which the aggregation based on the Call Report data gives comparable total balance sheet sizes as the Y-9C data (see Appendix H for details). In this regard, I consider domestic data only and exclude all balance sheet and income items from foreign subsidiaries to ensure that the results are not driven by trends from abroad. Appendix Figure H.1 shows the historical evolution of the average income gap and compares it with an equivalent measure based on the Call Report data. The two follow each other closely. Figure H.2 shows the evolution of the typical maturity gap and its distribution over time. Table H.6 reports the correlations of the various maturity mismatch measures. Notably, the income gap and the maturity gap are negatively correlated.

8.2. Results

As a first pass, I replicate regressions (4.1) and (4.2) using the bank-level stock price data. The results are shown in Appendix Tables I.1 and I.2. They are similar compared with the ones in Tables 4.1 and 4.2. However, the absolute magnitudes of the coefficients are lower. I find that this is due to the inclusion of BHCs with smaller market capitalization. For example, when restricting the pooled sample to the top 10 percent based on firm market capitalization (see Appendix Table I.3), the coefficients are close to the ones in Table 4.2.

Next, I use the balance sheet information described in the previous section in combination with the bank-level stock price data. To ensure that the balance sheet variables do not incorporate a response to the announcement itself, I associate all balance sheet variables from the quarter prior to an FOMC meeting with each respective announcement. To test the hypothesis that BHCs are differentially affected by a surprise change in term premia depending on their maturity mismatch, regression (4.2) is extended to

$$R_{i,t} = \alpha_i + \beta_1 \Delta Y_t^{3M} + \beta_2 (\Delta E H_t^m - \Delta Y_t^{3M}) + \beta_3 \Delta T P_t^m + \beta_4 \Delta T P_t^m \cdot I G_{i,t} + \beta_5 I G_{i,t} + u_{i,t}, \quad (8.3)$$

where $R_{i,t}$ denotes the trading-day window stock return for bank i , α_i is a bank-specific fixed effect, and $I G_{i,t}$ denotes bank i 's income gap in the

quarter prior to the announcement on day t . The income gap variable is normalized to standard deviation one and mean zero for each respective estimation sample, which simplifies the interpretation of the regression coefficients and allows to assess their economic importance easily. The results for regression (8.3) at the 2-, 5-, and 10-year maturities are shown in columns (i)–(iii) of Table 8.1, and the estimation output with respect to the maturity variable itself is omitted for brevity in all following tables.

Positive level and slope surprises in short-term rates affect bank stock returns again negatively. In contrast, an increase in term premia has the opposite sign. However, this effect depends on a bank's maturity mismatch prior to an FOMC announcement day. Stock returns of banks with a smaller income gap, that is, fewer assets relative to liabilities that reprice over the next year, respond more to an increase in term premia. The coefficient $\hat{\beta}_4$ is estimated to be statistically significant at the 5 percent confidence level for various maturities and economically sizable. For the 2-year maturity, a 100-basis-points increase in the term premium is associated with 1.5 p.p. higher stock return for a bank with an income gap that is one standard deviation smaller within the estimation sample. Going from the 5th to 95th percentile in the sample distribution of the income gap implies a return difference of around 4.5 p.p., that is, around 50 percent of the stock return response for a bank with an average income gap based on Table 8.1.³⁰ Thus, heterogeneity in banks' maturity profile explains a sizeable fraction of the response of their stock prices to changes in term premia.

Columns (iv)–(vi) test whether these results may be driven by other bank characteristics. To this end, I interact $\Delta T P_t^m$ with a number of additional bank controls and include each as a separate regressor in (8.3). The bank-specific variables are the loan-to-asset share, demand and savings deposits, time deposits (both relative to total liabilities), market leverage, and bank size measured by the natural log of total real assets. The estimations show that the absolute size of the coefficient and its significance actually strengthen with the additional controls. Taken together, these results suggest that banks with a larger maturity mismatch—a smaller income gap—benefit more from an increase in term premia. The next regression repeats the previous one,

$$R_{i,t} = \alpha_i + \beta_1 \Delta Y_t^{3M} + \beta_2 (\Delta E H_t^m - \Delta Y_t^{3M}) + \beta_3 \Delta T P_t^m + \beta_4 \Delta T P_t^m \cdot M G_{i,t} + \beta_5 M G_{i,t} + u_{i,t}, \quad (8.4)$$

but uses the maturity gap (MG) instead of the income gap. The results for (8.4) are shown in Table 8.2. The estimated coefficients $\hat{\beta}_1$, $\hat{\beta}_2$, and $\hat{\beta}_3$ are similar compared with the ones in Table 8.1. In contrast, the coefficient $\hat{\beta}_4$ on the interaction term $\Delta T P_t^m \cdot M G_{i,t}$ is estimated to be positive. The opposite sign is explained by the fact that the income gap and the maturity gap are negatively correlated (see Appendix Table H.6). Again, the effects are economically sizable. To a 100-basis-points higher term premium at the 2-year maturity, a one-standard-deviation larger maturity gap is associated with a higher stock return of around 1.1–1.3 p.p., depending on the inclusion of various interactions of $\Delta T P_t^m$ with other bank controls. A disadvantage of the maturity gap is that it does not cover maturity data on all assets and liabilities. Based on estimates of the missing information, Appendix Table I.8 shows that $\hat{\beta}_4$ in regression (8.4) increases to 1.9–2.1 for the various maturities and is statistically different at the 1 percent confidence level, with the P5-P95 sample difference of the maturity gap again accounting for around 50 percent of the response of a bank with an average maturity gap. Thus, whether one uses the income gap or the maturity gap, the results remain much the same, both in quantitative importance and statistical significance.

Appendix I collects further evidence and robustness checks: (i) comparisons with the regressions and maturity gap definition by English

²⁹ For the open-ended maturity buckets larger than 3 years and larger than 15 years, maturities of 5 and 20 years, respectively, are assumed. See Appendix Tables H.3 and H.4 for details.

³⁰ Appendix Table H.7 provides summary statistics for the maturity variables on FOMC announcement days.

Table 8.1
Response of stock returns to level, slope, and term premia surprises.

m =	(i) 2-year	(ii) 5-year	(iii) 10-year	(iv) 2-year	(v) 5-year	(vi) 10-year
ΔY_t^{3M}	-6.76** (3.28)	-11.27* (6.28)	-13.98 (8.97)	-6.93** (3.15)	-11.32* (6.09)	-13.66 (8.76)
$\Delta(EH_t^m - Y_t^{3M})$	-7.63* (4.11)	-12.33 (7.46)	-14.92 (10.21)	-7.91* (4.04)	-12.42* (7.33)	-14.59 (10.05)
ΔTP_t^m	9.36** (4.36)	9.43** (4.48)	9.69** (4.87)	9.57** (4.21)	9.48** (4.32)	9.58** (4.69)
$\Delta TP_t^m \cdot IG_{i,t}$	-1.50** (0.62)	-1.24** (0.49)	-1.29** (0.51)	-1.73*** (0.59)	-1.49*** (0.47)	-1.63*** (0.48)
Bank Controls				✓	✓	✓
R-squared	0.04	0.04	0.04	0.05	0.05	0.05
Observations	34,231	34,231	34,231	34,020	34,020	34,020
Banks	852	852	852	852	852	852
Meetings	118	118	118	118	118	118

Notes: Estimation results for regression (8.3), where ΔEH_t^m and ΔTP_t^m are based on estimates from Kim and Wright (2005). Sample: 1994:M1-2007:M12, excluding FOMC announcement on 9/17/2001. $IG_{i,t}$ is normalized to standard deviation one and mean zero for each estimation. Columns (iv)–(vi) include additional control variables: the interactions between ΔTP_t^m and various bank characteristics (see text for details). Standard errors in parentheses are two-way clustered by banks and meetings. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8.2
Response of stock returns to level, slope, and term premia surprises.

m =	(i) 2-year	(ii) 5-year	(iii) 10-year	(iv) 2-year	(v) 5-year	(vi) 10-year
ΔY_t^{3M}	-7.63** (3.44)	-12.61* (6.96)	-14.91 (10.58)	-7.49** (3.30)	-12.20* (6.68)	-14.13 (10.13)
$\Delta(EH_t^m - Y_t^{3M})$	-9.48** (4.37)	-14.53* (8.41)	-16.56 (12.17)	-9.35** (4.30)	-14.11* (8.17)	-15.82 (11.75)
ΔTP_t^m	12.82*** (4.61)	12.18** (4.69)	12.21** (5.17)	12.45*** (4.47)	11.70** (4.55)	11.55** (5.04)
$\Delta TP_t^m \cdot MG_{i,t}$	1.14** (0.44)	0.92** (0.37)	0.77* (0.44)	1.30** (0.57)	0.96* (0.50)	0.70 (0.56)
Bank Controls				✓	✓	✓
R-squared	0.04	0.04	0.04	0.04	0.05	0.05
Observations	27,938	27,938	27,938	27,760	27,760	27,760
Banks	731	731	731	731	731	731
Meetings	90	90	90	90	90	90

Notes: Estimation results for regression (8.4), where ΔEH_t^m and ΔTP_t^m are based on estimates from Kim and Wright (2005). Sample: 1997:M4-2007:M12, excluding FOMC announcement on 9/17/2001. $MG_{i,t}$ is normalized to standard deviation one and mean zero for each estimation. Columns (iv)–(vi) include additional control variables: the interactions between ΔTP_t^m and various bank characteristics (see text for details). Standard errors in parentheses are two-way clustered by banks and meetings. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

et al. (2018), (ii) alternative term premia estimates, and (iii) excluding specific unscheduled FOMC meetings. One additional finding is that the stock price of banks with larger maturity mismatch responds more negatively to an increase in future expected short-term rates. Intuitively, such banks are locked in for longer when their cost of funding increases.

9. Conclusion

Through active risk management, banks structure their balance sheets to offload the interest rate risk that they are naturally exposed to. In this paper, I provide new evidence for the United States to show that this risk transfer to banks' creditors and borrowers is not perfect. Part of the aggregate interest rate risk remains with the banking sector.

In support of this view, I show that (i) banks' net interest margins have historically comoved with term premia; (ii) their stock prices fall more sharply in response to an increase in expected future short-term rates compared with the typical market response, but also responds more positively if term premia increase; (iii) both of these responses are amplified for banks that engage more heavily in maturity transformation; and (iv) banks' net interest margins rise following term premium shocks, but fall in reaction to an increase in future expected short-term rates.

Several fascinating avenues and challenges for future research emerge from this paper. First, as documented throughout, the term premium is quantitatively important for bank profitability. The term premium was also the focus of quantitative easing that central banks

around the world have used over the past several years. While quantitative easing works through various channels, one side effect is that it may reduce bank profit margins by lowering term premia. In turn, suppressed bank profitability can reduce bank lending and thereby affect overall economic activity. Understanding the quantitative importance of these channels is key to assess the overall effectiveness of quantitative easing. Second, it would be useful to build a structural model of financial intermediation, in which the term premium is an endogenous general equilibrium outcome, and subsequently use the model to replicate the findings in this paper. Related to the first point, such a model could shed light on the question of whether quantitative easing may have the mentioned unwanted effects.

Last, my results highlight the importance of differentiating between average expected short-term rates and term premia when analyzing the effects of long-term interest rate changes on stock prices. Future research that aims to apply such decompositions faces at least two challenges. First, the state of the art within the high-frequency identification literature is to use 30-minute event windows, but the highest frequency at which term premia estimates are available is at the daily frequency. Second, I rely on term premia estimates from term structure models that are publicly available. It is well-known that the estimation of term premia is challenging. Existing models often produce different level estimates and considerable uncertainty remains around any estimate. Understanding these differences and their importance for the response of stock prices remains a difficult but important challenge for future research.

Data availability

I will make a data and replication package on my website.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.jfi.2022.101011>.

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