The Banking View of Bond Risk Premia *

Valentin Haddad
Princeton University & NBER

David A. Sraer
UC Berkeley, NBER & CEPR

July 5, 2015

Abstract

Banks' exposure to fluctuations in interest rates strongly forecasts excess Treasury bond returns. This result is consistent with a bank-centric view of the market for interest rate risk. Banks' activities — accepting deposits and making loans — naturally exposes their balance sheets to changes in interest rates. In equilibrium, the bond risk premium compensates banks for bearing these fluctuations: for instance, when consumers demand for fixed rate mortgages increases, banks have to scale up their exposure to interest rate risk and are compensated by an increase in bond risk premium. A key insight is that the net exposure of banks, rather than quantities of particular types of loans or deposits, reveals the risk premium.

*Haddad: vhaddad@princeton.edu; Sraer: sraer@berkeley.edu We gratefully acknowledge comments and suggestions from Augustin Landier, David Thesmar, Anna Cieslak, Giorgia Piacentino as well as seminar participants at Kellogg, Princeton, the University of Michigan, and the UNC Junior Faculty Roundtable. Charles Boissel provided excellent research assistance. All remaining errors are our own.

1 Introduction

This paper establishes a link between the balance sheet of financial institutions and time-varying risk premia in the US Treasury market. Financial institutions are large intermediaries in the market for interest-rate risk. When borrowers in the economy increase their demand for long-term or fixed-rate loans, in equilibrium, banks have to hold assets that are more exposed to interest-rate risk. Similarly, when savers increase their supply of saving deposits or variable-rate bonds, value of banks' liabilities has to become less exposed to interest rate risk. In equilibrium, banks only accommodate these shifts in the demand and supply of interest rate risk if the price of this risk adjusts. An increase in banks' average exposure to interest-rate risk should thus forecast an increase in bond risk premia. This paper offers an empirical investigation of this simple hypothesis.

We start by constructing a measure of the average bank exposure to interest-rate risk. At the bank-level, we follow Landier et al. (2015) and use the *income gap* as our measure of interest-rate risk exposure. The income gap of a financial institution is defined as the difference between the book value of all assets that either reprice, or mature, within one year, and the book value of all liabilities that mature or reprice within a year. This measure, commonly used by both banks and bank regulators, is readily available at the quarterly frequency for the 1986-2014 period through FR Y-9C filings of Bank Holding Corporations (BHC) to the Federal Reserve. The income gap provides a relevant quantification of the *net* exposure of banks' income to interest-rate risk: as shown in Landier et al. (2015), the sensitivity of banks' profits to interest rates increases significantly with their income gap, even when banks use interest rate derivatives. We use the average income gap across banks with more than \$1bn of total assets as our measure of interest-rate risk exposure of financial intermediaries.

We then run regressions of one-year excess returns on Treasuries — borrow at the one-year rate, buy a long-term bond, and sell it in one year — on the average income gap available at the beginning of the period. The estimated coefficient is significant for all maturities. With this single predictor, we find R^2 values of 20% on average across maturities. The forecasting power of the average income gap for Treasuries' excess returns is not affected by the inclusion of macroeconomic factors known to predict bond returns (Ludvigson and Ng, 2009) nor by the information contained in the yield curve available at the beginning of the period (Fama and Bliss (1987), Campbell and Shiller (1991), Cochrane and Piazzesi (2005)). It also survives a battery of robustness checks. Represented on Figure 1, this robust correlation between bonds excess returns and the average income gap is the main contribution of the paper.

We interpret this finding through the lens of a simple model of the yield curve following Greenwood and Vayanos (2014). In the model, risk-averse banks trade bonds of different maturities to maximize their risk-adjusted expected profits. Long-term bonds are risky not only because they are exposed to interest-rate risk, but also because they are exposed to exogenous demand and supply shocks created by households and firms. To accommodate positive net supply shocks to long term bonds, banks must absorb additional interest-rate risk, which they do only if the expected returns of all bonds in their portfolio increase. In equilibrium, banks' income gap, i.e. the sensitivity of banks' profits to variations in the short-rate, is negatively correlated with the bond risk premia. Since long-term bonds are more sensitive to interest-rate risk than short-term bonds, this correlation between banks' income gap and risk premia is larger, in absolute value, for bonds of longer maturities.

Our interpretation emphasizes the role of banks as marginal investors in the market for interest-rate risk. We perform several analyses to further investigate the validity of this interpretation. First, we show that by itself, the average exposure of banks' *assets* to interest-rate risk does not forecast bond risk premia in a significant way. The same result holds for the average exposure of banks' *liabilities* to interest-rate risk. Only the overall holding of interest-rate risk by financial institutions, i.e. the average income gap, significantly predicts future bond excess returns. This is consistent with our interpretation, whereby bond risk premia are only reflected in banks' *overall* portfolio holdings. In a similar fashion, we show that the average income gap responds, in the time-series, to several measured changes in the supply and demand of interest-rate risk in the economy, such as the total amount of fixed-rate mortgages net of adjustable-rate mortgages, the total supply of Treasuries or the amount of non-interest bearing deposits. Yet, these shocks to the demand and supply of interest-rate risk add no forecasting power for bond risk premia above and beyond the income gap. This is again consistent with our interpretation, since bond risk premia should depend on the aggregate net demand, captured in our analysis by the average income gap, and not on any particular components. Finally, we exploit our bank-level data to provide evidence consistent with interest-rate risk-sharing among heterogeneous banks. We split our sample of banks into 10 size-sorted groups and compute the time-series of the average income gap for these 10 groups. Despite their heterogeneity, we show that these 10 groups share a very similar evolution of their average income gap. We find similar evidence of risk-sharing among banks with different leverage or among banks located in different geographic areas.

Related Literature

Our paper relates to the long-standing literature trying to understand the pricing of interest-rate risk. Starting with Fama and Bliss (1987) and Campbell and Shiller (1991), several papers have tried to relate the price of interest rate risk to the information contained in the yield curve. Most recently, Cochrane and Piazzesi (2005) have shown that a single linear combination of forward rates forecasts bond excess returns at different maturities. Cieslak and Povala (2015) decompose the Treasury yield curve into three components: long-horizon inflation expectations related to the inflation target, transitory variation in monetary policy expectations, and a risk premium factor, which significantly forecasts excess bond returns both in and out of sample.

Another strand of this literature has explored the role of macroeconomic variables in explaining excess return on Treasuries. Piazzesi (2005) explores the role of Federal Reserve's interest rate target in a no-arbitrage affine model and shows how including the Feds target as one of the factors allows the model to match both the short and the long end of the yield curve. Ang and Piazzesi (2003) consider the role of inflation and real activity for bond excess returns. Ludvigson and Ng (2009) construct a macro factor from a monthly panel of 131 macroeconomic variables that forecast bond excess returns beyond the information contained in the yield curve. Cooper and Priestley (2009) show that the output gap, a production-based macroeconomic variable has predictive power for US excess bond returns.

A series of papers have also investigated the effects of Treasury supply on bond risk premia. Greenwood and Vayanos (2014) show empirically that the maturity-weighted-debt-to-GDP ratio is positively and significantly related to bond yields and future returns, controlling for the short rate. Baker et al. (2003) show that the maturity of new debt issues predicts excess bond returns. Hanson (2014) find that fluctuations in MBS duration generate significant variation in bond risk premia. Relative to this literature, our contribution is to shift the focus on financial institutions, which are major participants in the market for interest rate risk, and to use information on financial institutions' exposure to interest rate risk to forecast future bond returns.

In doing so, our paper also relates to the recent literature that emphasizes the crucial role of intermediaries for asset prices. Brunnermeier and Pedersen (2009) present a model where speculators' capital is a driver of equity risk premia. He and Krishnamurthy (2013) show that risk premia rise when intermediaries face more binding capital constraints. Brunnermeier and Sannikov (2014) also emphasize the important of financial intermediaries' leverage for equilibrium risk premia. Empirically, Adrian et al. (2014) construct a one factor model using the growth in leverage of US broker-dealers that prices size, book-to-market, momentum, and bond portfolios with a high R^2. Adrian et al. (2013) show evidence consistent with a dynamic pricing model based on broker-dealer leverage as the return forecasting variable and shocks to broker-dealer leverage as a cross-sectional pricing factor. Relative to this literature, our contribution is to shift the focus away from equity markets, which have been the extensive focus of the previous papers, to the market for Treasuries and to understand how information contained in intermediaries balance sheets affect bond excess returns. Further, our approach uses the actual underlying risk-exposure of intermediaries as a forecasting variable, instead of the standard focus on leverage as a proxy for this exposure.

The paper is organized as follows. Section 2 presents our theoretical framework and predictions. Section 3 describes the data we use for our empirical study. Section 4 discusses our empirical results. Section 5 concludes.

2 Theoretical Framework and Predictions

We provide a simple framework where banks play a central role in the market for interest-rate risk. This framework is useful to clarify the banking view of bond risk premia and provides guidance for our empirical analysis.

In our model, banks provide saving and borrowing instruments for households and firms. The demand for these instruments across long-term horizon — which are exposed to changes in interest rates — and short-term horizon varies over time, separately for savings and borrowing. In equilibrium, asset prices adjust so that banks accommodate these imbalances: when banks have to bear more interest rate risk, the bond risk premium increases.

Asset supply. There are two assets in positive supply in the economy. Short-term risk-free assets are in perfectly elastic supply, with exogenous rate of return r_t. The risk-free rate r_t follows a mean-reverting process:

$$dr_t = -\kappa_r \left(r_t - \bar{r}\right) dt + \sigma_r dW_{r,t}.$$

Long-lived assets, in exogenous supply S_t provide a stream of payments $e^{-\theta\tau}dt$ at each date $\tau \geq t$ like a console bond.

Those two types of assets represent the available saving and borrowing instruments to the economy: productive assets, loans, corporate bonds, deposits, commercial paper, ... This separation in two categories allows us to consider heterogeneity between short-term and long-term fixed rate instruments. Also, and this is of empirical relevance, the model allows us to consider variable rate assets. These instruments are equivalent to rolling over short-term assets and therefore can be counted jointly with the short-term assets in our model.

Finally, agents can also trade zero-coupon Treasury bonds of all maturities.[1] These zero-coupon bonds are in zero-net supply. Since bonds of all maturities are traded, the long-lived asset is redundant: a unit long position in the long-lived asset can be replicated with a portfolio consisting of $e^{-\theta\tau}$ bonds of each maturity τ. We denote by

[1]All quantities are real. It is straightforward to include an exogenous process for inflation in the model.

$P_t^{(\tau)}$ the price of the zero-coupon bond with maturity τ. We define the yield on this bond as $y_t^{(\tau)} = -\log(P_t^{(\tau)})/\tau$.

The economy is populated by two groups of agents with mass 1 each: banks and households.

Banks. In each period, there is a continuum of banks indexed by i. Denote $E_{i,t}$ the initial net worth of bank i at date t and $X_{i,t}^{(\tau)}$ its net dollar position in bonds of maturity τ. As it will be useful later on, we write $x_{i,t}^{(\tau)} = X_{i,t}^{\tau}/E_{i,t}$ the same position relative to the net worth of the bank. We drop the index i for aggregate quantities. The bank's net worth evolves according to:

$$dE_{i,t} = \int_0^\infty X_{i,t}^{(\tau)} \frac{dP_t^{(\tau)}}{P_t^{(\tau)}} d\tau + \left(E_t - \int_0^\infty X_{i,t}^{(\tau)} d\tau \right) r_t dt \tag{1}$$

Banks select their net holdings $X_t^{(\tau)}$ so as to maximize a myopic mean-variance criterion:[2]

$$\max_{\left(X_{i,t}^{(\tau)}\right)} \mathbb{E}(dE_{i,t}) - \frac{\gamma}{2E_{i,t}} var(dE_{i,t}), \tag{2}$$

where γ is a risk-aversion coefficient. This objective can be rationalized in a setting where banks form overlapping generations, living for an infinitesimal interval dt, and maximizes expected utility of final wealth as in Greenwood and Vayanos (2014).[3]

With this objective function, we capture the risk management decisions of banks without taking a particular stance on their origin. The risk-aversion parameter γ can be interpreted as coming from the actual risk aversion of the bank's manager, or driven by her career concerns. Another interpretation can be as the Lagrange multiplier on a no-default condition for the bank or on a regulatory risk constraint like value-at-risk limits.[4] The crucial underlying force for our results to hold is that banks trade off expected profits and risk in a stable way over time.

[2] Note that given the redundancy of the long-lived asset and the zero-coupon bonds, banks simply maximize their holdings of the bonds.

[3] An alternative foundation would be to assume that banks are long-lived and their myopia comes from log utility.

[4] He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), or Adrian and Shin (2013) are examples of more complete models of the risk appetite of banks.

Households and firms. Households are considered here in an extended sense: we pool them together with non-financial firms and the government. They are endowed with the entire supply of long-lived assets. In addition, households borrow from the banks at date t an exogenous amount B_t of long-lived asset and lend to the banks an exogenous amount L_t of long-term assets.[5] We define the net imbalance g_t as the difference between the ratio of long-term savings to total bank equity L_t/E_t and long-term borrowing to total bank equity $b_t = B_t/E_t$. We assume that g_t follows a mean-reverting process:

$$dg_t = -\kappa_g \left(g_t - \bar{g}\right) dt + \sigma_g dW_{g,t}.$$

Of course, the assumption of exogenous changes in households and firms portfolios is a simplification of a more complex decision problem – households and firms savings and borrowing decisions. The exogenous shocks are meant to capture the fact that those decisions are influenced by factors other than risk-return tradeoffs. For instance, changing liquidity needs, the use of incorrect heuristics, or hedging demands can affect those decisions. We come back to potential empirical counterparts of these changes in Section 4.4.2.

Equilibrium. To derive the equilibrium asset prices in this economy we proceed in three steps. First, guess the form of equilibrium bond prices. Second, we derive the demand for assets of various maturities by the bank. Finally, we impose the market clearing condition. We provide the details of calculations and proofs as well as verify the conjecture on the form of prices in Appendix A.1.

As in Greenwood and Vayanos (2014), we guess that yields are linear in the two risk-factors of the model, the short-rate r_t and the net supply of long-lived asset (g_t):

$$-\log\left(P_t^{(\tau)}\right) = y_t^{(\tau)} = A_r(\tau) r_t + A_g(\tau) g_t + C(\tau),$$

where $A_r(\tau)$ (resp. $A_g(\tau)$) is the exposure of the yields of bonds with maturity τ to the short-term rate r_t (resp. to the net supply of long-lived asset g_t). These coefficients

[5] We can easily relax the exogeneity assumptions and allow borrowing and lending by households to be price-elastic: this does not change the qualitative predictions of the model.

are an endogenous outcome of the model that we compute in equilibrium. Plugging in the law of motions of r_t and g_t, we obtain an expression for the expected bond returns that we note μ_t^τ.

Given this form for yields, we can easily write down the first-order conditions of banks with respect to their holdings in bonds of maturity τ:

$$\mu_t^{(\tau)} - r_t = A_r(\tau)\lambda_{r,t} + A_g(\tau)\lambda_{g,t},$$
$$\text{where } \lambda_{i,t} = \gamma\sigma_i^2 \int_0^\infty x_{i,t}^{(\tau)} A_i(\tau)d\tau, \text{ for } i = g, r.$$

This condition is akin to a standard Euler equation. The first line tells us that for a bond of a given maturity, the agent requires a risk premium proportional to the exposures ($A_i(\tau)$) of the bond to the fundamental shocks of the economy. The second line characterizes how much compensation is asked for bearing each of these risks: it is proportional to the product of the risk aversion γ, the risk σ_i^2, and the total quantity of risk borne through positions in bonds of various maturities.

Finally, the market-clearing condition determines the equilibrium position of the banks. The net position of banks has to equal the net imbalance from households' demand. Since banks are homogenous in the model, they all choose the same holdings $x_{i,t}^{(\tau)} = x_t^\tau$. Implementing long-term assets using the zero-coupon bonds, the market clearing condition becomes:

$$\forall \tau > 0, \quad x_{i,t}^\tau = g_t e^{-\theta\tau} \tag{3}$$

Plugging this market-clearing condition into the first-order condition of banks, we obtain the equilibrium risk premium.

Proposition 1. *The expected excess returns $\mu_t^{(\tau)}$ on the τ-maturity bond is proportional to the net position of banks in long-term assets $-g_t$:*

$$\mu_t^{(\tau)} - r_t = g_t \times (c_r A_r(\tau) + c_g A_g(\tau)) = -(-g_t) \times \phi(\tau), \tag{4}$$

where c_r and c_g are two constants determined in equilibrium and $\phi(\tau) > 0$.

Proof. See Appendix A.1. □

Proposition 1 shows that the risk premium on a bond of maturity τ is negatively correlated with banks net exposure to long-term assets ($-g_t$). To accommodate the positive supply shocks of long-lived assets by households, banks have to hold these long-lived assets, which is equivalent to being long a portfolio of the zero-coupon bonds. Because the price of these zero-coupon bonds decrease when interest rates increase, banks income gap become negative in equilibrium. At the same time, since holding these bonds is risky and these bonds are in zero net supply the excess returns on bonds must increase. Thus, in equilibrium, a larger net exposure is correlated with larger bond risk premia.

We can further characterize the relation of bond risk premia and the net exposure across maturities.

Proposition 2. *The expected excess returns of bonds of longer maturity are more sensitive to the net exposure of banks: $\phi(\tau)$ is strictly increasing in τ.*

Proof. See Appendix A.2. □

Proposition 2 shows that a smaller income gap will predict larger risk premia for bonds with longer maturities. When banks have to accommodate a large positive supply shock of long-lived assets, they naturally become long a portfolio of the bonds, which explains the positive risk premia on these bonds. However, longer maturity bonds are riskier – their exposure to variations in interest-rates is higher. Thus, the equilibrium risk premia on these bonds will be higher and more sensitive to changes in the net exposure of banks.

Our model thus makes two simple testable predictions: (1) a larger average net exposure of banks to long-term asset should predict larger bond risk premia (2) this effect should be stronger for long maturity bonds. In the next section, we take these two predictions to the data.

3 Data

3.1 Income Gap

To measure the net exposure of banks to long-term fixed-rate assets, we use the income gap. We construct income gap data directly from form FR Y-9C (Landier et al. (2015)). The definition of the income gap follows the definition in Mishkin and Eakins (2009):

$$\text{Income Gap} = \text{RSA} - \text{RSL} \tag{5}$$

where RSA is a measure of the amount of assets that either reprice, or mature, within one year, and RSL the amount of the liabilities that mature or reprice within a year. RSA (RSL) is the number of dollars of assets (liability) that will pay (cost) variable interest rate. Hence, the income gap measures the extent to which a bank's net interest income are sensitive to interest rates changes. Concretely, we construct the income gap using variables from schedule HC-H of form FR Y-9C, which is specifically dedicated to the interest sensitivity of the balance sheet. RSA is directly provided (item bhck3197). RSL is decomposed into four elements: Long-term debt that reprices within one year (item bhck3298); long-term debt that matures within one year (bhck3409); variable-rate preferred stock (bhck3408); interest-bearing deposit liabilities that reprice or mature within one year (bhck3296), such as certificates of deposits. Empirically, the latter is by far the most important determinant of the liability-side sensitivity to interest rates. All these items are available every year from 1986 to 2014. We scale these variables by total assets[6], and report summary statistics in Table 1. As is apparent from Table 1, on average, RSL (interest rate-sensitive liabilities) mostly consists of variable rate deposits, that either mature or reprice within a year. Long term debt typically has a fixed rate.

Our main forecasting variable for bond risk premia is the average income gap, which is computed across all banks with more than $1bn in consolidated assets. This

[6]While the model suggests to scale these variables by total equity, there are several advantages to scaling them by assets. First, the resulting variable lies between -1 and 1 and its distribution has fewer outliers. In particular, we do not have to deal with banks with negative equity. Second, this definition is consistent with Landier et al. (2015), who shows that the income gap forecasts banks' net income reaction to changes in interest rates. Importantly, scaling these variables by total equity does not affect qualitatively the results we present in this paper.

variable is available from 1984 to 2014. Figure 2 shows the time-series evolution of the average income gap (thick dark line). The average income gap is 12.6% of total assets. For the average bank, an increase in the short rate by 100bp will raise bank revenues by 0.126 percentage points of assets. About 78% of observations correspond to banks with a *positive* income gap. For these banks, an increase in interest rates yields an *increase* in cash flows.

That the average gap is positive can seem surprising because one expects banks to transform maturity, thus borrowing short and lending long. The explanation for this seemingly counterintuitive result comes partially from our treatment of deposits. In the BHC data, the item corresponding to short-term deposit liabilities (bck3296) does not include transaction deposits or savings deposits.[7] As mentioned in English et al. (2012), interest rates on these "core" deposits, while having a zero contractual maturity, are known to adjust quite sluggishly to changes in short-term market rates (Hannan and Berger (1991), Neumark and Sharpe (1992)). Therefore, despite their short maturity, it is natural to exclude them from our measure of income gap, as they will not induce direct cash-flow changes when interest rates change. However, if these "core" deposits adjust slightly to changes in Fed funds rates, our average income gap measure will over-estimate the real income gap.

This treatment of deposits, however, can only partially explain the non-negative average income gap measured in our data. If we make the assumption that all non-interest bearing deposits have short maturity as in English et al. (2012), we find that the average income gap over our sample period is zero, not negative. In fact, the positive average elasticity of banks' earnings to interest rates has already been observed in the literature. Flannery (1981) shows that the average income gap for large banks is either close to zero or positive. Flannery (1983) extends the result to small banks. More recently, English et al. (2012) shows that a 100 basis point increase in interest rates increases the median bank's net interest income relative to assets by almost 9 basis points and decreases its market value of equity by 7%. These numbers are very much in line with our average income gap of 12.6%.

One issue with our measured income gap is that we do not observe holdings in interest-rates derivatives. If banks hedge their interest-rate risk exposure through

[7] See `http://www.federalreserve.gov/apps/mdrm/data-dictionary`.

derivatives, the income gap may over-estimate banks exposure to interest-rate risk, although Begeneau et al. (2012) show that for the four largest US banks, net derivative positions tend to amplify, not offset, balance sheet exposure to interest rate risk. To assess the extent of this issue, we exploit the fact that since 1995, banks report on form FR Y-9C the notional amounts of interest derivatives they contract.[8] We compute the average income gap for banks that never report any notional amounts of interest-rates derivatives and report its time-series evolution on Figure 2 (dark dashed line). The time-series correlation of this series with the average income gap computed across all banks is 93%.

The fact that we do not observe holdings in interest-rates derivatives also explain why we do not use the *aggregate* income gap as our main forecasting variable, i.e. the asset-weighted average income gap. While this should be in theory a better predictor for financial intermediaries risk-exposure, there are good reasons to believe that the income gap measured for large banks suffers from substantial measurement error. Given the fat-tailed distribution of banks' assets, this bank-level measurement error would translate into a significant aggregate measurement error. Figure 2 plots the time-series evolution of the asset-weighted average income gap (orange line), as well as the average income gap computed across the 10 largest banks (blue line). These two series are almost identical – the top 10 banks are so large that they account for most of the variations in the asset-weighted average gap. Any mis-measure in the gap for some of these 10 banks will significantly garble our forecasting variable, which justifies our equal-weighted average income gap measure.

Another limitation of our measure of banks' exposure to interest-rate risk is that it corresponds to the exposure of their net income, and not the exposure of their equity value. While in the simple model presented in Section 2 the income gap equals the *duration* gap, the duration gap, not the income gap, would predict bond risk premia in a model where banks operate for multiple periods. Our choice here is driven by a limitation of the data. While it is possible to construct a measure of banks' maturity gap – which is closer to the duration gap – using form FR Y-9C as in English et al.

[8]Five kinds of derivative contracts are separately reported: Futures (bhck8693), Forwards (bhck8697), Written options that are exchange traded (bhck8701), Purchased options that are exchange traded (bhck8705), Written options traded over the counter (bhck8709), Purchased options traded over the counter (bhck8713), and Swaps (bhck3450).

(2012), this measure can only be constructed after 1997:Q2. This represents too short of a sample to conduct a meaningful time-series asset pricing exercise.

Despite these limitations, our income gap measure represents a significant contribution to the intermediary asset pricing literature. In this literature, financial intermediaries' risk exposures are typically summarized by their leverage (Adrian et al. (2013), Adrian et al. (2014)). This approach does not take into account the fact that different assets and liabilities are differentially exposed to aggregate sources of risk. Using the income gap, which allows for some risk-weighting of assets and liabilities, thus represents a significant improvement relative to these previous papers.

3.2 Bond Prices and other time-series variables

Bond return data are taken from the Fama-Bliss dataset available from the Center for Research in Securities Prices (CRSP) and contain observations on one- through five-year zero-coupon U.S. Treasury bond prices, $(P_t^{(n)})_{n=1\ldots5}$. We compute the yield of a bond with maturity (n) as: $y_t^{(n)} = -\frac{1}{n}\ln(P_t^{(n)})$. The log-forward rate at time t for loans between time $t+n-1$ and $t+n$ is $f_t^{(n)} = \ln(P_t^{(n-1)}) - \ln(P_t^{(n)})$. The log holding period return from buying an n-year bond at time t and selling it as an $n-1$ year bond at time $t+1$ is $r_{t\to t+1}^{(n)} = \ln(P_{t+1}^{(n-1)}) - \ln(P_t^{(n)})$. Bond excess returns are then defined as $rx_{t\to t+1}^{(n)} = r_{t\to t+1}^{(n)} - y_t^{(1)}$. Our paper focuses on a 1-year return horizon. To incorporate longer maturities into the analysis, we also use the Gurkaynak et al. (2007) series of zero-coupon treasury yields. We include maturities up to 20 years.

We also use several macroeconomic variables known to forecast bond risk premia. The output gap is defined as the difference between the real seasonally adjusted GDP (GDPC96 from the FRED database) and the real potential gdp (GDPPOT from FRED), normalized by the real seasonally adjusted GDP (Cooper and Priestley, 2009). Industrial production growth is the 1-year growth rate in industrial production (INDPRO in FRED). Inflation is the 1-year growth rate of the CPI, taken from the FRED database. Table 2 presents descriptive statistics for these variables.

4 Empirical Results

4.1 Income Gap and Excess Bond Returns: Main Results

We estimate the following linear equation using quarterly data:

$$rx^{(n)}_{t\rightarrow t+4} = a^{(n)} + b^{(n)} \times \text{Income Gap}_t + \epsilon^{(n)}_{t+4}, \quad \text{for n=2, 3, 4 and 5.} \tag{6}$$

$rx^{(n)}_{t\rightarrow t+4}$ is the excess return of a zero-coupon bond of maturity n from quarter t to quarter $t+4$, defined in Section 3.2. Income Gap$_t$ is the average income gap available at the beginning of quarter t, which corresponds to the average income gap of quarter $t-2$. To account for the overlapping nature of our return variable, we use the Hansen-Hodrick correction with 8 lags to compute our standard errors. In Section 4.2, we show that our results are similar if we compute Newey-West adjusted standard errors, or if we compute standard errors from reverse regressions (Hodrick (1992), Wei and Wright (2013)).

The estimation of Equation (6) is presented on Table 3. The average income gap significantly predicts future bond excess returns. For bonds with a 2-year maturity, $b^{(2)}$ is equal to -.13 and is statistically significant at the 5% confidence level. This effect is economically significant. A one standard deviation increase in the average income gap is associated with smaller future excess returns of 2-year maturity zero-coupon bonds by about 54 basis points, which represents 42% of the volatility of these bonds. A one standard deviation increase in the average income gap represents a 4.2 percentage point increase in the fraction of net short-term or variable rate assets, which, given an average income of 12.8% corresponds to a 32% increase in the average bank's exposure to interest rate risk.

As predicted by our model, this correlation increases almost linearly with the maturity of the bond. For bonds with a 5-year maturity, $b^{(5)}$ is equal to -.5, so that a one standard deviation increase in the average income gap corresponds to a 210 basis points reduction in 5-year bond excess returns. This decrease represent about 46% of the volatility of these bonds. $b^{(3)}$, $b^{(4)}$ and $b^{(5)}$ are statistically different from 0 at the 1% confidence level. $b^{(5)}$ is statistically different from $b^{(2)}$ at the 1% confidence level. The adjusted R^2s we obtain from this forecasting regression with a single forecasting variable are high: they range from 17% using 2-year maturity bonds up to 21% for bonds with a longer maturity.

Figure 1 highlights the strong forecasting power of the average income gap for future bond returns. This figure plots the value of the average income gap available in quarter t and the excess bond returns from quarter t to quarter $t+4$, $rx^{(n)}_{t \to t+4}$ for zero coupon bonds of maturity n. Figure 1 displays a striking and robust negative correlation between the income gap series and the excess return series throughout the sample period. These results are consistent with the two predictions derived in the model of Section 2: (1) a smaller average income gap predicts larger bond risk premia (2) this effect is stronger for long maturity bonds.

In Table 4, we augment Equation (6) by including macroeconomic variables that have been shown to forecast bond risk premia: the previous year inflation rate, the previous year growth in industrial production, the current output gap, and a dummy equal to 1 for quarters that have been flagged as a recession by the NBER. Table 4 shows that the effect of the average income gap on future bond excess returns is left unaffected by the inclusion of these variables. Both the estimated $b^{(n)}$, their significance and the predictive power of the regressions are similar to those estimated in Table 3.

Cochrane and Piazzesi (2005) have shown that there is precious information contained in the yield curve to forecast bond risk premia. We thus augment Equation (6) by including the current yield of the 1-year bond and the 1, 2, 3 and 4-year forward rate as additional regressors. Table 5 presents the regression estimate. The inclusion of these additional controls increases both the magnitude and the significance of the $b^{(n)}$. $b^{(2)}$ is now estimated at -.22 and is significant at the 1% confidence level. $b^{(5)}$ is now estimated at -.75 and is also significant at the 1% confidence level. The inclusion of the information contained in the yield curve increases significantly the R^2s of these forecasting regressions, which go from around 20% in Table 3 to around 46% in Table 5. These results indicate that the information contained in the average income gap are to a large extent independent of the information contained in the yield curve as it relates to bond risk premia. We confirm this conclusion in Appendix Table I.A. 1, where we control directly for the Cochrane and Piazzesi (2005) factor instead of controlling separately for the the yield of the 1-year bond and the 4 forward rates. We construct the risk factor exactly as in Cochrane and Piazzesi (2005), except that we use a longer sample period (1964-2013). The results in Table I.A. 1 are very similar to the results in Table 5, both in terms of magnitudes and statistical significance.

4.2 Further Analysis

In this section, we present a battery of robustness checks and further analysis.

Non-parametric relation. Table 6 provides a non-parametric description of the relationship between the average income gap and future bond excess returns. In particular, this ensures that this relationship is monotonic. We split the time-series into 5 quintiles, based on the in-sample distribution of the average income gap. We then regress 1-year holding excess returns on bonds of maturity n on Quintile 1, ..., Quintile 5, where Quintile n is an indicator variable equal to 1 if the quarter belongs to the n^{th} quartile of the in-sample distribution of the income gap. Table 6 shows that for 2-year maturity bonds, excess returns are significantly lower, by 120 basis points, following quarters in the 4^{th} or 5^{th} quintile relative to quarters in the 1^{st} quintile of the income gap. For 5-year maturity bonds, relative to quarters in the 1^{st} quintile of the income gap distribution, excess returns are significantly lower following quarters in the 4^{th} quintile (by about 400 basis points) and in the 5^{th} quintile (by about 600 basis points).

Longer maturities. In Figure 3, we estimate Equation 6 for bonds of longer maturities, using the Gurkaynak et al. (2007) series of zero-coupon bonds. Panel (a) of Figure 3 reports the coefficients $b^{(n)}$, for $n = 1 \ldots 20$, as well as their 95% confidence intervals. We see that the coefficients steeply decrease for maturities from 2 to 10 years and are then approximately constant at about -.6. The estimates are all statistically significant at the 5% confidence level, except for 20-year maturity bond. Panel (b) of Figure 3 reports the corresponding adjusted R^2 for each of these regressions. The forecasting power of the income gap is the highest for bonds of maturity 3 to 5 years and then decreases with the bonds' maturity.

Across horizons. We investigate the predictive power of the income gap at various horizons. To do so we use the Fama constant maturity portfolios obtained from CRSP. These portfolios are formed every month from bonds of maturity ranging in a one year interval. We report results for bonds with maturity between 4 and 5 years. We compute returns across horizons by computing the log excess returns of a strategy rolling over the portfolio of long-term bonds in excess of a strategy rolling over risk-free assets. Panel (a) of Figure 4 reports the coefficients of the predictive regression using the average income gap at monthly horizons ranging between 1 month and 4 year. The coefficient steadily increases with the horizon until it stabilizes at approximately -1 after the 3-year horizon. After 3 months, the coefficients are all statistically significant at the 5% confidence level. Panel (b) of Figure 4 reports the corresponding adjusted R^2 for each of these regressions. The forecasting power is increasing across maturities at shorter maturities, roughly stable at 30% between a 2 and 3-year horizon and then starts to decay slowly. These patterns are consistent with the observation that the average income gap exhibits an autocorrelation of 77% at the annual frequency. Longer horizons cumulate the effect of the predictive power obtained at short horizons, but this predictive power decays due to mean reversion.

Real-time prediction. Cieslak and Povala (2014) document that the predictive power found in full sample may not be observable to economic agents in real time. To understand whether this is a concern for our analysis, we construct a real-time version of our predictor. At each date t, we estimate a regression of bond excess returns using all data available up to that point. We use the estimated coefficients of this regression in conjunction with the gap at date t to construct a real time predictor of returns between t and $t+1$. We start the estimation in 1991, after 5 years of data are available. Table 8 reports the estimation of a regression of bond excess returns on this real time predictor. When the sample period is very large, the coefficient estimate should be 1. In finite sample, the limited amount of data generates measurement error, which biases the estimate toward 0. Despite the short sample period used in our case, we report coefficient estimates that are away from 0, ranging from 0.33 for 2-year bonds to 0.44 for 5-year bonds. The coefficients for maturities 3 years and above are significant at the 10% level and for 5-year bonds at the 5% level. The adjusted R^2

range from 6.8% to 9.7%. While more moderate than the full sample estimates, these results indicate a significant predictive power of the income gap in real time.

Alternative standard errors. We repeat our baseline test using alternative standard errors. First, we estimate Equation (6) using Newey-West standard errors allowing for 8 quarter lags. The results, reported in I.A. Table 2 are extremely close to our baseline specification. We also consider the reverse regression method of Hodrick (1992) and Wei and Wright (2013). To do so, we construct one quarter holding period return using the GSW yield curves. We regress them on a moving sum of the average income gap:

$$rx^{(n)}_{t\to t+1} = a^{(n)} + \tilde{b}^{(n)} \times \sum_{\tau=0}^{3} \text{Income Gap}_{t-\tau} + \epsilon^{(n)}_{t+1}, \quad \text{for } n = 2, 3, 4, 5. \tag{7}$$

Rejecting the null that $\tilde{b}^{(n)} = 0$ is equivalent to reject the null that $b^{(n)} = 0$ in Equation (3). In I.A. Table 3 we see that using this conservative approach, we reject the null of no predictability at the 5% level for bonds of maturity $2, 3$ and 4 years, and at 10% for bonds of maturity 5 years.

4.3 Average Income Gap and Future Yields

Realized excess returns on bonds can be high because current yields are high or because realized future yields are low:

$$\underbrace{y^{(n)}_t - y^{(1)}_t}_{\text{current yield}} = \frac{1}{n} \underbrace{rx^{(n)}_{t+4}}_{\text{excess return}} + \frac{n-1}{n} \underbrace{\left(y^{(n-1)}_{t+4} - y^{(1)}_t\right)}_{\text{future yield}} \tag{8}$$

We have shown in Section 4.2 that the current average income gap predicts future excess returns on bonds, even controlling for current yields. It is thus natural to hypothesize that the average income gap forecasts future yields: a high income gap today should in principle forecasts high yield in the future. One possible interpretation of such an effect would be through endogenous monetary policy, i.e. if the Fed Fund rates respond in the future to the current average income gap. To test this hypothesis, we estimate the following linear regression:

$$y_{t+4}^{(n)} = \alpha^{(n)} + \beta^{(n)} \times \text{Income Gap}_t + \gamma^{(n)} \times y_t^{(1)} + \omega_{t+4}^{(n)}, \quad \text{for n=1, 2, 3, 4 and 5} \tag{9}$$

We again use the Hansen-Hodrick correction with 8 lags to compute the standard errors of the coefficients estimated from Equation (9). The estimated coefficients are shown in Table 7. Across all maturities, the $\beta^{(n)}$ are positive, around .2 and statistically significant different from 0 at the 1% confidence level. Holding the current yield constant, a one standard deviation increase in the average income gap leads to an increase in future yields of maturity 1 to 5 years of about 84 basis points, which is about 32% of the standard deviation of yields in the time-series. The predictive power of the average income gap on future yields is high: across the 5 maturities, the regression's adjusted R^2 is about 80% (without controlling for the current yield, the adjusted R^2 is around 50% across the 5 maturities). This strong relation is shown on Figure 5, where we simply plot the following time-series: $(\text{Income Gap}_t, y_{t+4}^{(n)})$ for n=1,. . . ,5.

Our analysis shows that the average income gap is an unspanned factor. It is informative about future excess bond returns and rates beyond the information contained in the current yield curve. While this type of behavior may appear puzzling, Joslin et al. (2014) show that it is consistent with the absence of arbitrage opportunities on the Treasury market. To understand wether this property reflects economic forces or is a statistical artifact, we consider two further tests. In unreported analysis, we add nonlinear transformations of the current yield curve in our predictive regressions. We interact the level and slope of the yield curve and find that the income gap is not subsumed by these additional factors. Cieslak and Povala (2014) document that some apparently unspanned factors lose their predictive sample when using them to do real-time predictions. The results of Section 4.2 suggest this is not an issue in our case. A remaining question, beyond the scope of this paper, is why the average income gap predicts excess returns and future yields with offsetting magnitudes.

4.4 Interpretation of the Results

The model developed in Section 2 provides a simple interpretation of our results. Banks' average income gap reflects the equilibrium exposure of banks to interest-rate risk. In equilibrium, banks only accept to hold this risk if its price is sufficiently attractive – thus a low average income gap is associated in equilibrium with high excess returns on Treasuries. We propose in this section two simple tests to reject this interpretation.

4.4.1 The Income Gap and its Components

Our first tests simply estimates separately the power of the asset and liability components of the income gap in forecasting bonds' excess returns. Figure 6 shows the average bank-level ratio of assets that either reprice or mature within a year normalized by total consolidated assets (in blue), as well as the opposite of the average bank-level ratio of liabilities that either reprice or mature within a year normalized by total consolidated assets (in red).

If the forecasting power of the income gap comes only from, say, its asset side (the blue line), then our interpretation cannot be valid: in our theory, only the banks' total portfolio exposure should forecast bonds' excess returns; since the liability side of the gap does significantly vary in the time-series, such a result would show this is not the case and thus invalidate our hypothesis.

To implement this test, we simply replace the Income Gap in Equation 6 by its two components: "Non-exposed assets" is the average bank-level ratio of assets that either reprice or mature within a year normalized by total consolidated assets; "-Non-exposed liabilities" is the opposite the average bank-level ratio of liabilities that either reprice or mature within a year normalized by total consolidated assets. The results are reported in Table 9. For brevity, we only report the estimated coefficients when the dependent variable is the excess return on 5-year maturity bonds. Column (1) simply replicates the results of Column (4), Table 3. Column (2) and (3) show that taken individually, the two components of the average income gap do not forecast robustly future bond excess returns. The estimated coefficients have low statistical significance and are small in magnitudes. In column (4), we include the two components simultaneously in the regression. Both coefficients then become statistically significant and of a magnitude close to that of the income gap alone. Thus, consistent with our preferred interpretation, only the overall exposure of the average financial intermediary explains bond risk premia.

4.4.2 Demand Shocks and Bond Risk Premia

Our second test is similar in spirit, but instead of looking at the components of banks' interest-rate risk portfolio, we considers several measures of the "demand" for various savings and borrowing instruments – the supply/demand shocks of long-lived assets in the model of Section 2. These quantities each affect the amount of interest-rate risk that banks must bear in equilibrium. However, each of these quantities should have a limited ability to predict future bond returns. In particular, none of these shocks should have a significant forecasting power for bond risk premia above and beyond the average income gap. Indeed, as per our model, with shifting demand for various borrowing and saving instruments, a sufficient statistic for bond risk premia is the net interest rate risk held by banks, captured by the income gap. Empirically, we consider three such observable shifts in quantities: (1) the aggregate demand for adjustable-rate mortgages (2) the aggregate demand for deposits (3) the aggregate supply of government bonds.

The determinants of the choice between fixed-rate and variable rate mortgages by households are multiple and can evolve over time. This choice involves a risk-return trade-off and households may use simple imprecise heuristics do make decisions (Koijen et al., 2009). This choice also reflects partly the desire of households to manage their liquidity, which may also depend on aggregate factors (Chen et al., 2013). To measure the demand for adjustable-rate mortgages, we use the Monthly Interest Rate Survey and compute the quarterly ratio of adjustable-rate mortgage issuance to total mortgage issuance. To the extent that, as in our model, shifts in households' demand are the source of some of these variations, an increase in the ratio of adjustable-rate mortgages in total mortgage issuance forces banks to hold more of these variable-rate mortgages, which, everything else equal, should decrease banks' average income gap. Figure 7 shows that there is in fact a positive correlation — of 59% — between the share of adjustable-rate mortgages in mortgage issuance and the average income gap, at least until 2006. Of course, this unconditional positive correlation does not have to be present, since other shifts in the demand for other components of banks' balance sheets may force them to adjust their income gap in an opposite direction.

The second source of variation we measure is the average of the quarterly bank-level ratio of non interest-bearing deposits normalized by total consolidated assets. When households increase their relative demand for non interest-bearing deposits, banks end up in equilibrium being funded with more liabilities that are not interest-rate sensitive. Thus, everything else equal, their income gap increases. As for adjustable-rate mortgages, there are many determinants of the demand for non interest-bearing deposits, each of which is likely to vary in the time-series. Depositors have a choice between many stores of wealth, which, beyond a standard risk-return trade-off, will be determined by liquidity considerations (Tobin (1956), Baumol (1952)) or demand for safety (Krishnamurthy and Vissing-Jorgensen, 2012). For instance, the fraction of non interest-bearing deposits exhibits a correlation of 46% with the HP-filtered monetary aggregate M1. Figure 8 shows the time-series evolution of non interest-bearing deposits and its positive correlation — of 64% — with the average income gap.

The final shock we consider is the aggregate supply of government bonds. We use the maturity-weighted supply of treasuries, normalized by GDP, as in Greenwood and Vayanos (2014). By varying the supply of long-term bonds in the economy, the government may shift the availability of interest-rate risk. For instance, to fund an expansionary fiscal policy, the government will increase the Treasury supply and in equilibrium, the income gap of banks should decrease. Figure 9 show the time-series evolution of the maturity-weighted Treasuries supply measure. Given the low frequency fluctuations in Treasuries supply, this series does not exhibit much correlation with the average income gap.

Equipped with these measured fluctuations in the supply/demand of interest-rate risk emanating from other agents in the economy, we perform the following test. We first investigate whether by themselves, these factors forecast bond risk premia. To do so, we replace, in Equation (6), the average income gap by each of these "demand" factors. Then, we ask whether the forecasting power of these factors survive once we include the average income gap in the forecasting regression. The estimated coefficients are presented on Table 10. Column (1) and (5) show that the share of adjustable-rate mortgages, as well as the maturity-weighted Treasuries supply measure of Greenwood and Vayanos (2014), are not significantly correlated with future bonds excess returns over our sample period. Thus, unsurprisingly, column (2) and (6) of Table 10 show that the forecasting power of the average income gap is not affected by the inclusion of these two variables in Equation (6). Column (3) shows that the average ratio of non interest-bearing deposits normalized by consolidated assets does forecast negative excess returns on 5-year maturity treasuries. However, column (4) shows that the average income gap subsumes all the forecasting power embedded in the non interest-bearing deposit measure. On the one hand, once the income gap is controlled for, non interest-bearing deposits do no longer correlate with bond risk premia; on the other hand, the income gap remains a statistically significant predictor of bond risk premia, and its economic magnitude is left unchanged.

These results are consistent with the bank-centric view proposed in our model. The net exposure to interest rate risk borne by banks, as measured by the average income gap, appears to better capture variations in expected excess bond returns than quantities of particular types of financial assets.

4.5 Risk-Sharing Evidence

We now exploit information on income gap at the bank level to study the time-series behavior of the income gap across heterogeneous banks. In our model, the equilibrium risk premium adjusts so that banks are collectively willing to bear the interest rate risk supplied by other agents in the economy. Even if banks face customers with heterogeneous demand, they can use financial markets to share interest rate risk. To the extent that banks have similar risk preferences, they would end up with the same net exposure. Therefore, even across heterogeneous banks, one would expect to find common variations in the income gap, close to that captured by the average income gap. We consider different sources of heterogeneity across banks and investigate the commonality of fluctuations in the income gap across these heterogeneous groups over time.

We start by describing the cross-sectional variation in the gap over time. Panel (a) of Figure 10 represents the time series of the 10th, 25th, 50th, 75th, and 90th percentile of the cross-sectional distribution of the gap each quarter. There is substantial cross-sectional variation in income gap across banks: the interquartile range is typically of 20%. However, the whole distribution appears to shift up and down over time, suggesting common variation. Panel (b) reinforces this point: it presents the demeaned time series of the various percentile. Those series are all strongly positively related.

The first dimension of bank heterogeneity we consider is size. We split banks in 10 groups based on decile of total assets. Figure 11 represents the average income gap for each size group. All series are remarkably similar to the average income gap except for the largest size group, for which we do not capture accurately the income gap, most likely because of their use of interest rate derivatives. The correlation with the average income gap is about 85% for each size group except the fourth (72%) and the tenth (18%).

We repeat this comparison across 9 geographic regions of the United States. Because of heterogeneity in local economic conditions, one would expect banks in different localizations to face different demand for interest rate exposure. Figure 12 shows in contrast that across these 9 regions, banks share similar net exposure to changes in interest rate. The local average income gap all exhibit a strong correlation with the national average income gap. All correlations are between 80% and 90% except for the South-West Center (Panel 8, 63%) and the Mountain region (Panel 4, 45%). The latter is the only substantial deviation, likely caused by individual measurement error as the Mountain region has the lowest number of banks in our sample, between 7 and 23 per quarter.

Finally, we compare banks that vary directly in the composition of their balance sheets. For each bank, we compute the equity-to-assets ratio and deposits-to-assets ratio. Book leverage is defined as the ratio of book equity over consolidated assets. The fraction of deposits is the ratio of checking deposits to total assets. For each of those characteristics, we split our sample in two groups. The Panel (a) of Figure 13 presents the average income gap of banks sorted on equity-to-assets. The top group has an average ratio of 10% and the bottom one of 7%. The average income gap for each group do not exhibit any substantial deviation from each other. Panel (b) compares the two groups based on deposits-to-assets. The average level for the ratio for the two groups are 8% and 17%. Over time, the two series also exhibit a strong positive correlation.

Overall, these additional results on risk-sharing are consistent with our favorite interpretation, detailed in Section 2. The income gap exhibits strong common variation across banks of different size, style or localization. Interpreted through the lens of the model, this evidence is consistent with risk-sharing across banks. This risk-sharing results in all banks having a common time-varying target exposure, determined by the equilibrium interest rate risk premium.

5 Conclusion

While banks are central intermediaries in the market for interest rate risk, they are notably absent of the standard empirical analyses of bond risk premia. Our paper attempts to fill this gap in the literature. We show that the net exposure of the banking sector to interest rate risk, as measured through banks' average income gap, strongly forecasts future bond excess returns. The economic magnitude of this forecastability is large: when banks increase their holding of short-term or variable rate assets by 4.2 percentage points (as a function of their total assets), the 1-year excess returns of 5-year maturity bonds decrease by 54 basis points. This relationship is stronger for bonds with longer maturities and survives a battery of robustness checks.

Our results are consistent with a bank-centric view of bond risk premia. In our term-structure model, risk-averse banks absorb shocks to the demand and supply of short-term and long-term assets; in equilibrium, the price of interest rate risk adjusts so that banks are collectively willing to bear this interest rate risk and banks' holdings forecast bond risk premia. Consistent with this interpretation, we show that only the average income gap forecast bond risk premia, and not its liability or asset components. We also show that isolated shocks to the realized net demand/supply of interest rate risk in the economy do not bring additional forecasting power to our average income gap measure.

While our analysis focuses on the predictability of bond risk premia, it also uncovers that the average income gap forecasts future yields. We believe that exploring further this relationship between the average income gap and future yields is an important question for future research. How does monetary policy respond to changes in the average income gap? Does the average income gap forecasts real aggregate outcomes? Why does the average income gap predict excess returns and future yields with offsetting magnitudes? We intend to pursue these questions in future work.

References

ADRIAN, T., E. ETULA, AND T. MUIR (2014): "Financial Intermediaries and the Cross-Section of Asset Returns," *The Journal of Finance*, 69, 2557–2596.

ADRIAN, T., E. MOENCH, AND H. S. SHIN (2013): "Leverage asset pricing," Staff Reports 625, Federal Reserve Bank of New York.

ADRIAN, T. AND H. S. SHIN (2013): "Procyclical leverage and value-at-risk," *Review of Financial Studies*, hht068.

ANG, A. AND M. PIAZZESI (2003): "A no-arbitrage vector autoregression of term structure dynamics with macroeconomic and latent variables," *Journal of Monetary Economics*, 50, 745–787.

BAKER, M., R. GREENWOOD, AND J. WURGLER (2003): "The maturity of debt issues and predictable variation in bond returns," *Journal of Financial Economics*, 70, 261–291.

BAUMOL, W. J. (1952): "The Transactions Demand for Cash: An Inventory Theoretic Approach," *The Quarterly Journal of Economics*, 66, 545–556.

BEGENEAU, J., M. PIAZZESI, AND M. SCHNEIDER (2012): "The Allocation of Interest Rate Risk in the Financial Sector," Working paper, Stanford University.

BRUNNERMEIER, M. K. AND L. H. PEDERSEN (2009): "Market Liquidity and Funding Liquidity," *Review of Financial Studies*, 22, 2201–2238.

BRUNNERMEIER, M. K. AND Y. SANNIKOV (2014): "A Macroeconomic Model with a Financial Sector," *American Economic Review*, 104, 379–421.

CAMPBELL, J. Y. AND R. J. SHILLER (1991): "Yield Spreads and Interest Rate Movements: A Bird's Eye View," *Review of Economic Studies*, 58, 495–514.

CHEN, H., M. MICHAUX, AND N. ROUSSANOV (2013): "Houses as ATMs? Mortgage Refinancing and Macroeconomic Uncertainty," NBER Working Papers 19421, National Bureau of Economic Research, Inc.

CIESLAK, A. AND P. POVALA (2014): "Expecting the fed," *Working paper*.

——— (2015): "Expected Returns in Treasury Bonds," *Review of Financial Studies*.

COCHRANE, J. H. AND M. PIAZZESI (2005): "Bond Risk Premia," *American Economic Review*, 95, 138–160.

COOPER, I. AND R. PRIESTLEY (2009): "Time-Varying Risk Premiums and the Output Gap," *Review of Financial Studies*, 22, 2801–2833.

ENGLISH, W. B., S. J. V. DEN HEUVEL, AND E. ZAKRAJSEK (2012): "Interest rate risk and bank equity valuations," Finance and Economics Discussion Series 2012-26, Board of Governors of the Federal Reserve System (U.S.).

FAMA, E. F. AND R. R. BLISS (1987): "The Information in Long-Maturity Forward Rates," *American Economic Review*, 77, 680–92.

FLANNERY, M. J. (1981): "Market interest rates and commercial bank profitability: An empirical investigation," *The Journal of Finance*, 36, 1085–1101.

——— (1983): "Interest Rates and Bank Profitability: Additional Evidence: Note," *Journal of Money, Credit and Banking*, 355–362.

GREENWOOD, R. AND D. VAYANOS (2014): "Bond Supply and Excess Bond Returns," *Review of Financial Studies*, 3, 663–713.

GURKAYNAK, R. S., B. SACK, AND J. H. WRIGHT (2007): "The U.S. Treasury yield curve: 1961 to the present." *Journal of Monetary Economics*, 54, 2291–2304.

HANNAN, T. H. AND A. N. BERGER (1991): "The Rigidity of Prices: Evidence from the Banking Industry," *American Economic Review*, 81, 938–45.

HANSON, S. G. (2014): "Mortgage convexity," *Journal of Financial Economics*, 113, 270–299.

HE, Z. AND A. KRISHNAMURTHY (2013): "Intermediary Asset Pricing," *American Economic Review*, 103, 732–70.

HODRICK, R. J. (1992): "Dividend Yields and Expected Stock Returns: Alternative Procedures for Inference and Measurement," *Review of Financial Studies*, 5, 357–86.

JOSLIN, S., M. PRIEBSCH, AND K. J. SINGLETON (2014): "Risk premiums in dynamic term structure models with unspanned macro risks," *The Journal of Finance*, 69, 1197–1233.

KOIJEN, R. S., O. V. HEMERT, AND S. V. NIEUWERBURGH (2009): "Mortgage timing," *Journal of Financial Economics*, 93, 292–324.

KRISHNAMURTHY, A. AND A. VISSING-JORGENSEN (2012): "The Aggregate Demand for Treasury Debt," *Journal of Political Economy*, 120, pp. 233–267.

LANDIER, A., D. SRAER, AND D. THESMAR (2015): "Banks Exposure to Interest Rate Risk and The Transmission of Monetary Policy," Tech. rep., HEC Paris.

LUDVIGSON, S. C. AND S. NG (2009): "Macro Factors in Bond Risk Premia," *Review of Financial Studies*, 22, 5027–5067.

MISHKIN, F. AND S. EAKINS (2009): *Financial Markets and Institutions*, Pearson Prentice Hall, 6 ed.

NEUMARK, D. AND S. A. SHARPE (1992): "Market Structure and the Nature of Price Rigidity: Evidence from the Market for Consumer Deposits," *The Quarterly Journal of Economics*, 107, 657–80.

PIAZZESI, M. (2005): "Bond Yields and the Federal Reserve," *Journal of Political Economy*, 113, 311–344.

TOBIN, J. (1956): "The Interest-Elasticity of Transactions Demand For Cash," *The Review of Economics and Statistics*, 38, pp. 241–247.

WEI, M. AND J. H. WRIGHT (2013): "Reverse Regressions And Long-Horizon Forecasting," *Journal of Applied Econometrics*, 28, 353–371.

Tables

Table 1: Income Gap and Its Components

	mean	sd	p25	p75	count
Income Gap =	0.126	0.187	0.012	0.243	47043
Assets maturing/resetting $<$ 1 year	0.426	0.152	0.325	0.525	47424
- Liabilities maturing/resetting $<$ 1 year =	0.299	0.157	0.191	0.384	47043
Short Term Liabilities	0.288	0.157	0.180	0.374	47420
+ Variable Rate Long Term Debt	0.010	0.027	0.000	0.008	47253
+ Short Maturity Long Term Debt	0.001	0.005	0.000	0.000	47207
+ Prefered Stock	0.000	0.002	0.000	0.000	47063

Note: Summary statistics are based on the quarterly Consolidated Financial Statements (Files FR Y-9C) between 1986 and 2014 restricted to US bank holding companies with total consolidated assets of $1Bil or more. The variables are all scaled by total consolidated assets (bhck2170) and are defined as follows: Interest Sensitive Liabilities =(bhck3296+bhck3298+bhck3409+bhck3408)/bhck2170; Interest Sensitive Assets=(bhck3197)/bhck2170; Short Term Liabilities=bhck3296/bhck2170; Variable Rate Long Term Debt=bhck3298/bhck2170; Short Maturity Long Term Debt=bhck3409/bhck2170; Prefered Stock=bhck3408/bhck2170

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	P25	P50	P75
Income Gap	109	.128	.042	.092	.122	.163
$y^{(1)}$	111	.041	.026	.015	.046	.059
$y^{(2)}$	111	.043	.025	.018	.047	.063
$y^{(3)}$	111	.046	.025	.023	.048	.063
$y^{(4)}$	111	.048	.024	.027	.05	.066
$y^{(5)}$	111	.05	.023	.03	.051	.069
$rx^{(2)}$	108	.008	.013	-.001	.007	.016
$rx^{(3)}$	108	.015	.025	-.002	.015	.031
$rx^{(4)}$	108	.021	.036	-.005	.02	.047
$rx^{(5)}$	108	.025	.045	-.012	.026	.059
IP growth	107	.022	.042	.011	.029	.045
Inflation	111	.028	.013	.02	.028	.036
Output gap	111	-.014	.024	-.025	-.01	.003

Note: Quarterly data over the 1986-2014 period. The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $y^{(n)}$ is the yield of Fama-Bliss zero-coupon bonds of maturity n. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity of maturity n. IP growth is the 1-year growth rate in industrial production (INDPRO in FRED). Inflation is the 1-year growth rate of the CPI, taken from the FRED database. Output gap is defined as the difference between the real seasonally adjusted GDP (GDPC96 from the FRED database) and the real potential gdp (GDPPOT from FRED), normalized by the real seasonally adjusted GDP.

Table 3: Income Gap and Bond Excess Returns

	(1)	(2)	(3)	(4)
	$rx^{(2)}$	$rx^{(3)}$	$rx^{(4)}$	$rx^{(5)}$
Income Gap	-0.13**	-0.29***	-0.40***	-0.50***
	(0.06)	(0.10)	(0.12)	(0.13)
Constant	0.02***	0.05***	0.07***	0.09***
	(0.01)	(0.01)	(0.02)	(0.02)
Observations	106	106	106	106
Adjusted R^2	0.174	0.216	0.211	0.208

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity of maturity n. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 4: Income Gap and Bond Excess Returns : Controlling for Macroeconomic Conditions

	(1) $rx^{(2)}$	(2) $rx^{(3)}$	(3) $rx^{(4}$	(4) $rx^{(5)}$
Income Gap	-0.12**	-0.27***	-0.37***	-0.46***
	(0.05)	(0.10)	(0.13)	(0.15)
Inflation	0.24	0.35	0.39	0.39
	(0.16)	(0.29)	(0.40)	(0.46)
IP growth	-0.04	-0.06	-0.05	-0.01
	(0.06)	(0.11)	(0.15)	(0.19)
Output gap	0.04	0.06	-0.01	-0.09
	(0.09)	(0.16)	(0.21)	(0.23)
NBER recession	0.00	0.00	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.02)
Constant	0.02**	0.04***	0.06***	0.07***
	(0.01)	(0.01)	(0.02)	(0.02)
Observations	104	104	104	104
Adjusted R^2	0.216	0.218	0.186	0.173

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity of maturity n. IP growth is the 1-year growth rate in industrial production (INDPRO in FRED). Inflation is the 1-year growth rate of the CPI, taken from the FRED database. Output gap is defined as the difference between the real seasonally adjusted GDP (GDPC96 from the FRED database) and the real potential gdp (GDPPOT from FRED), normalized by the real seasonally adjusted GDP. NBER recession is a dummy equal to 1 for quarters flagged as a recession by the NBER. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 5: Income Gap and Bond Excess Returns : Controlling for the Yield Curve

	(1) $rx^{(2)}$	(2) $rx^{(3)}$	(3) $rx^{(4)}$	(4) $rx^{(5)}$
Income Gap	-0.22***	-0.44***	-0.62***	-0.75***
	(0.05)	(0.08)	(0.12)	(0.15)
$y^{(1)}$	-0.24	-0.70	-1.29	-1.82
	(0.33)	(0.63)	(0.89)	(1.16)
$f^{(1)}$	-0.43	-0.48	0.13	1.17
	(0.71)	(1.36)	(1.94)	(2.53)
$f^{(2)}$	1.20*	2.17	1.75	0.70
	(0.70)	(1.33)	(1.89)	(2.43)
$f^{(3)}$	0.52	0.75	1.65	1.71
	(0.39)	(0.75)	(1.07)	(1.39)
$f^{(4)}$	-0.79**	-1.31*	-1.64	-1.02
	(0.38)	(0.72)	(1.02)	(1.28)
Constant	0.02***	0.04***	0.06***	0.07***
	(0.01)	(0.01)	(0.02)	(0.02)
Observations	106	106	106	106
Adjusted R^2	0.464	0.465	0.443	0.404

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity n. $y^{(1)}$ is the yield of 1-year maturity bonds. $f^{(n)}$ is the forward rate for bonds between date $t+n-1$ and date $t+n$, where t is the current quarter. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 6: Income Gap and Bond Excess Returns (in %): Quintiles of Income Gap

	(1)	(2)	(3)	(4)
	$rx^{(2)}$	$rx^{(3)}$	$rx^{(4)}$	$rx^{(5)}$
Quintile Low	1.23***	2.70***	4.01***	5.24***
	(0.40)	(0.72)	(0.97)	(1.14)
Quintile 2	1.30***	2.44***	3.22***	3.51***
	(0.40)	(0.73)	(1.01)	(1.23)
Quintile 3	1.46***	2.54***	3.33***	3.49***
	(0.41)	(0.74)	(1.01)	(1.22)
Quintile 4	0.03	0.28	0.65	1.07
	(0.40)	(0.73)	(0.99)	(1.18)
Quintile High	0.01	-0.21	-0.31	-0.53
	(0.41)	(0.74)	(0.98)	(1.14)
Observations	106	106	106	106
Adjusted R^2	0.206	0.218	0.198	0.186

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. Quintile n is a dummy equal to 1 for quarters where the average income gap belongs to the n^{th} quintile of its in-sample distribution. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity n. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 7: Income Gap and Future Yields

	(1) $y_{t+4}^{(1)}$	(2) $y_{t+4}^{(2)}$	(3) $y_{t+4}^{(3)}$	(4) $y_{t+4}^{(4)}$	(5) $y_{t+4}^{(5)}$
Income Gap	0.24***	0.24***	0.22***	0.21***	0.19***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
$y_t^{(1)}$	0.69***	0.68***	0.67***	0.66***	0.63***
	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)
Constant	-0.02***	-0.02***	-0.01**	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	105	105	105	105	105
Adjusted R^2	0.842	0.852	0.851	0.840	0.822

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $y_{t+4}^{(n)}$ is the yield in quarter t+4 on Fama-Bliss zero-coupon bonds of maturity n. $y_t^{(1)}$ is the current yield of the 1-year maturity bond. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 8: Income Gap and Bond Excess Returns : In Real Time

	(1)	(2)	(3)	(4)
	$rx^{(2)}$	$rx^{(3)}$	$rx^{(4)}$	$rx^{(5)}$
Predicted excess return	0.33	0.40*	0.40*	0.44**
	(0.24)	(0.22)	(0.22)	(0.23)
Constant	0.00	0.01	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Observations	81	81	81	81
Adjusted R^2	0.068	0.097	0.084	0.078

Sample period: 1991-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. Predicted return is computed using the current value of the income gap and the coefficients from a regression of realized excess returns on the income gap using all data available until that point. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table 9: Asset and Liability Risk Exposure and Bond Excess Returns

	(1)	(2)	(3)	(4)
	$rx^{(5)}$	$rx^{(5)}$	$rx^{(5)}$	$rx^{(5)}$
Income Gap	-0.50***			
	(0.13)			
Non-exposed assets		-0.12		-0.46***
		(0.13)		(0.12)
- Non-exposed liabilities			-0.29*	-0.67***
			(0.16)	(0.16)
Constant	0.03***	0.03***	0.02***	0.02***
	(0.01)	(0.01)	(0.01)	(0.00)
Observations	106	106	106	106
Adjusted R^2	0.208	0.011	0.066	0.239

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity n. Non-exposed Assets is the average bank-level ratio of assets that either reprice or mature within a year normalized by total consolidated assets. - Non-exposed liabilities is the opposite of the average bank-level ratio of liabilities that either reprice or mature within a year normalized by total consolidated assets. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

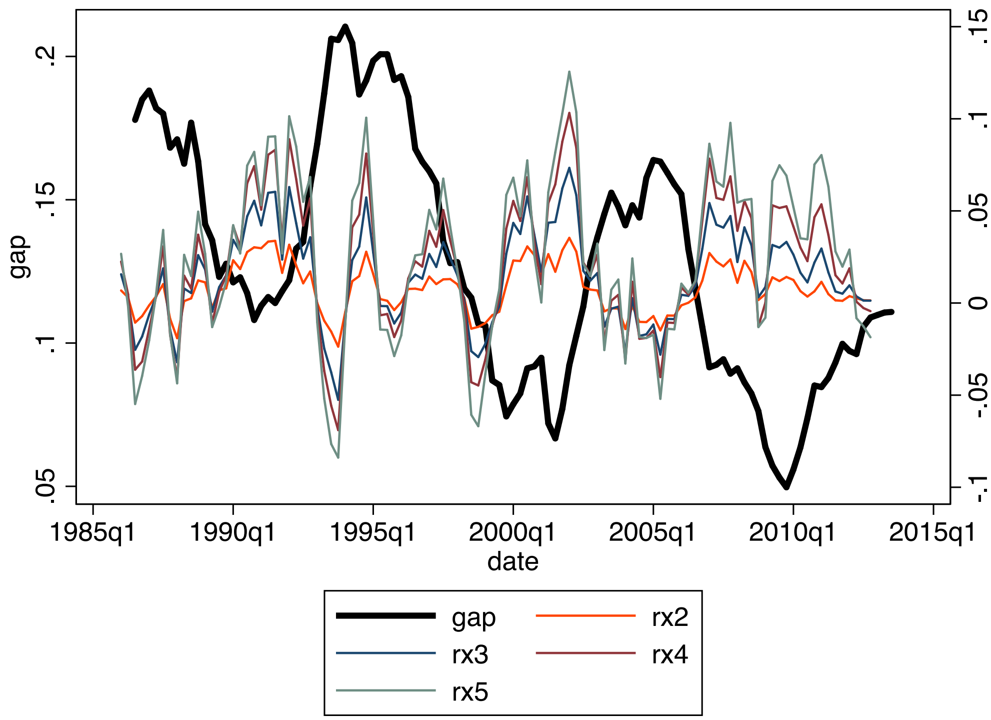
Table 10: Asset and Liability Risk Exposure and Bond Excess Returns

	(1)	(2)	(3)	(4)	(5)	(6)
	$rx^{(5)}$	$rx^{(5)}$	$rx^{(5)}$	$rx^{(5)}$	$rx^{(5)}$	$rx^{(5)}$
Income Gap		-0.74***		-0.47***		-0.54***
		(0.19)		(0.17)		(0.14)
ARM fraction of issuance	-0.02	0.08*				
	(0.04)	(0.04)				
Non int. bearing deposits			-0.76**	-0.11		
			(0.35)	(0.41)		
Mat.-weighted Debt / GDP					-0.00	0.00
					(0.01)	(0.01)
Constant	0.03**	0.09***	0.12***	0.10**	0.04	0.08***
	(0.02)	(0.02)	(0.04)	(0.04)	(0.03)	(0.02)
Adjusted R^2	-0.003	0.284	0.117	0.201	-0.003	0.210

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(5)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of 5-year maturity. ARM fraction of issuance is the quarterly ratio of total issuance of adjustable-rate mortgages to total mortgage issuance, from the Monthly Interest Rate Survey. Non int. bearing deposits is the average of the quarterly bank-level ratio of non interest-bearing deposits normalized by total consolidated assets. Mat.-weighted Debt / GDP is the maturity-weighted Treasuries supply measure of Greenwood and Vayanos (2014). Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

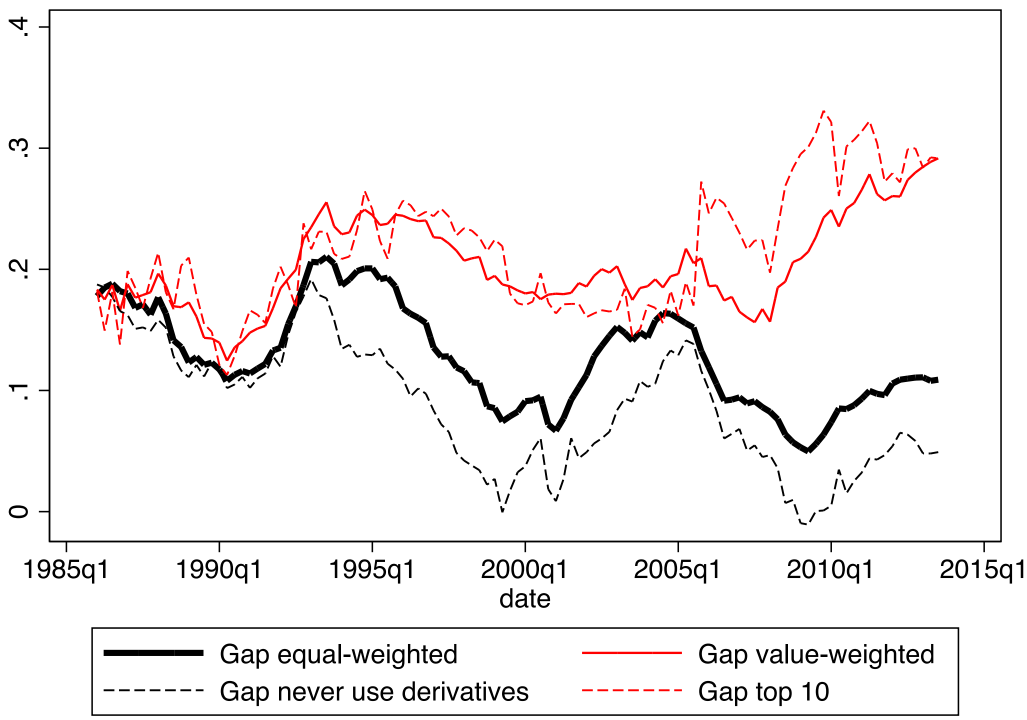
Figures

Figure 1: Average Income Gap and Future Bond Excess Returns



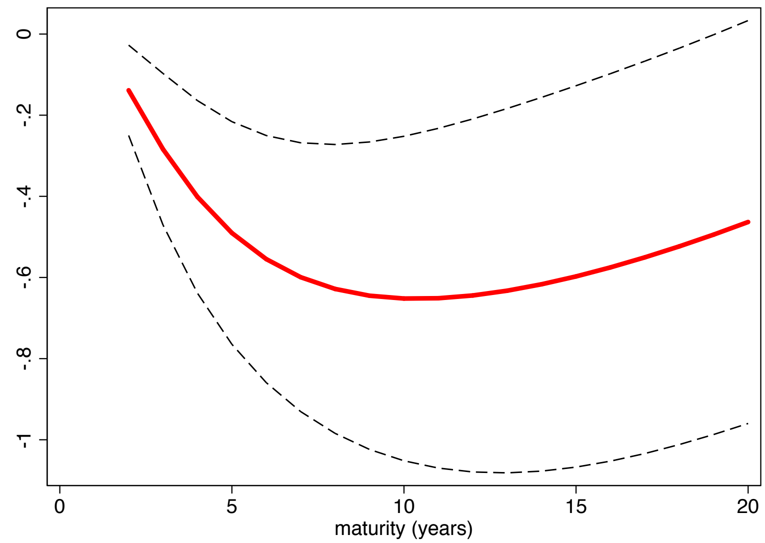
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. "gap" is the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. rxn is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity n.

Figure 2: Time-series of the Average Income Gap

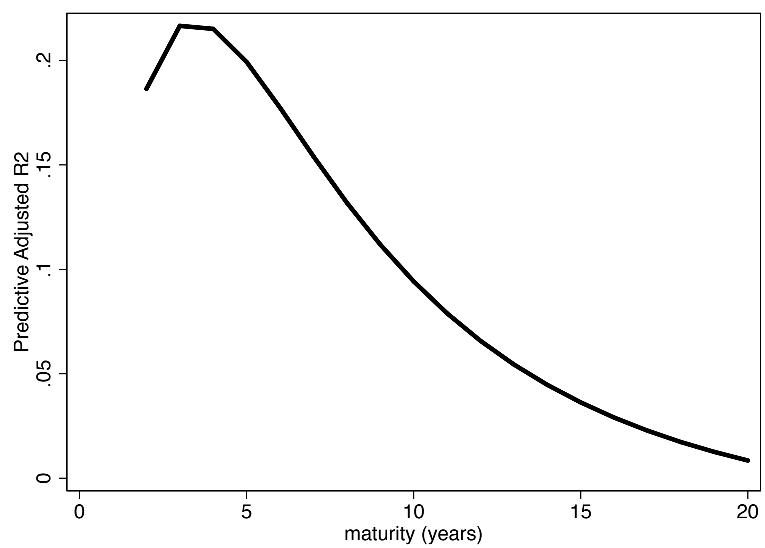


Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The solid black line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. The solid red line represents the weighted-average income gap, where BHCs' total consolidated assets are used as weights. The dotted black line represents the average income gap across banks that never reports derivative positions in their financial statements. The dotted red line represents the average income gap across the 10 largest banks.

Figure 3: Longer Maturities



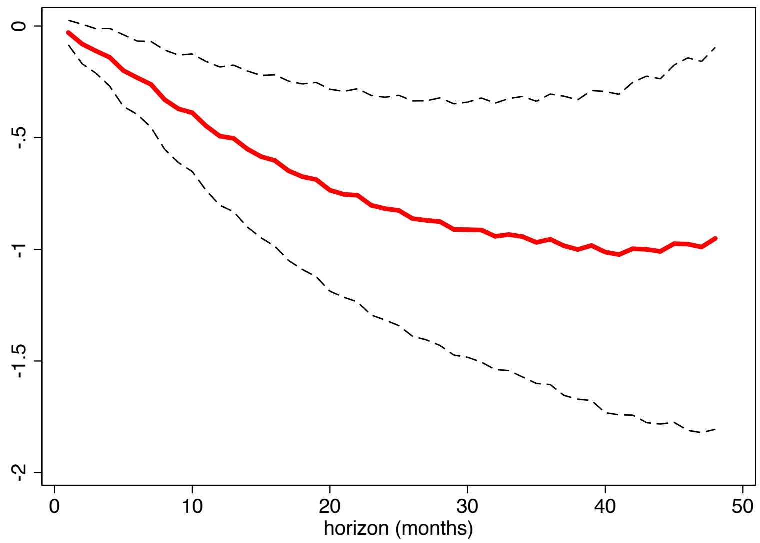
(a) Coefficients



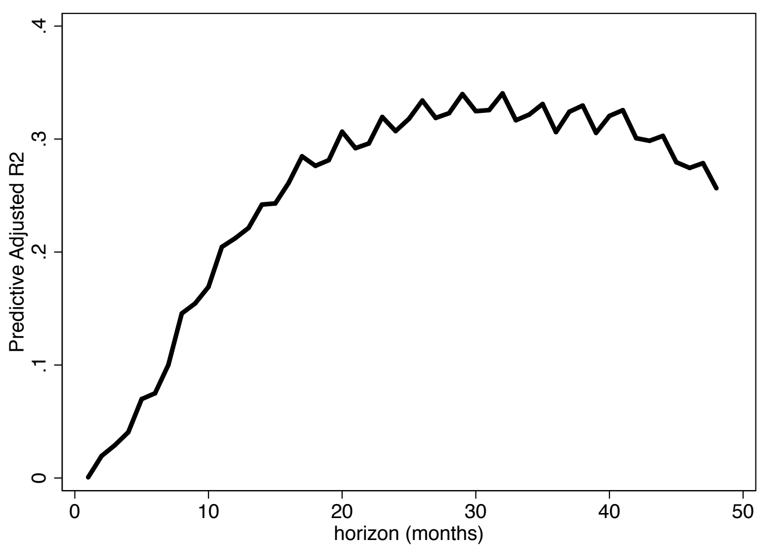
(b) Adjusted R^2

Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income gap is the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. We regress the excess 1-year holding return of zero-coupon bonds of maturity n on the average income gap. We obtain zero-coupon bond series with long maturities from Gurkaynak et al. (2007). Panel (a) of the figure reports, for each maturity n, the coefficient on the average income gap, as well as its 95% confidence interval. Panel (b) reports the corresponding R^2 of each of these regressions.

Figure 4: Across horizons



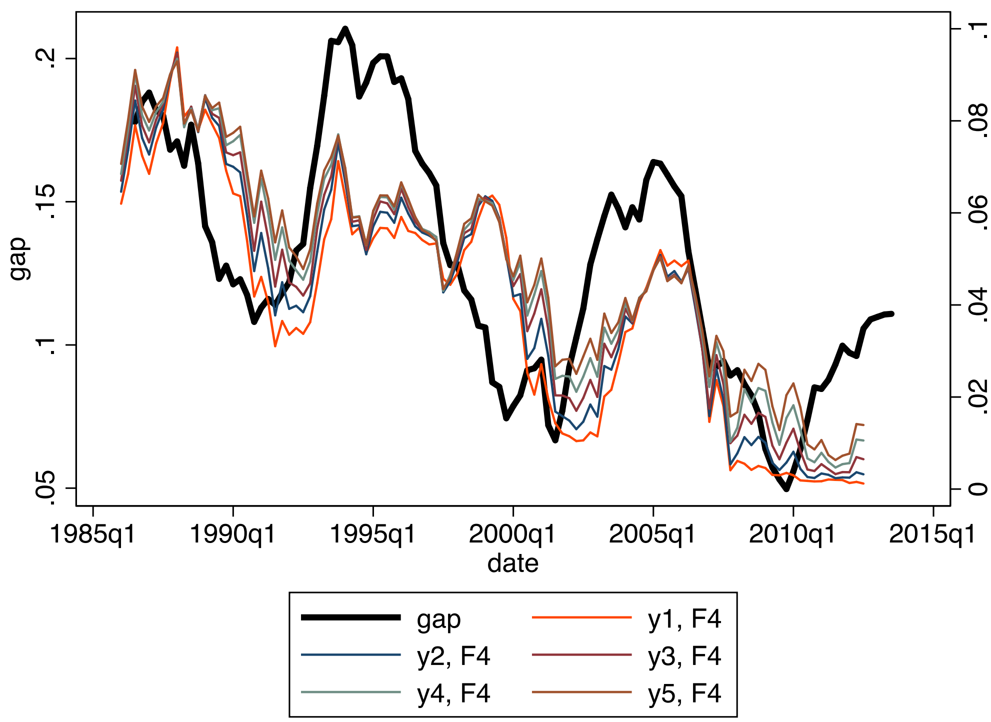
(a) Coefficients



(b) Adjusted R^2

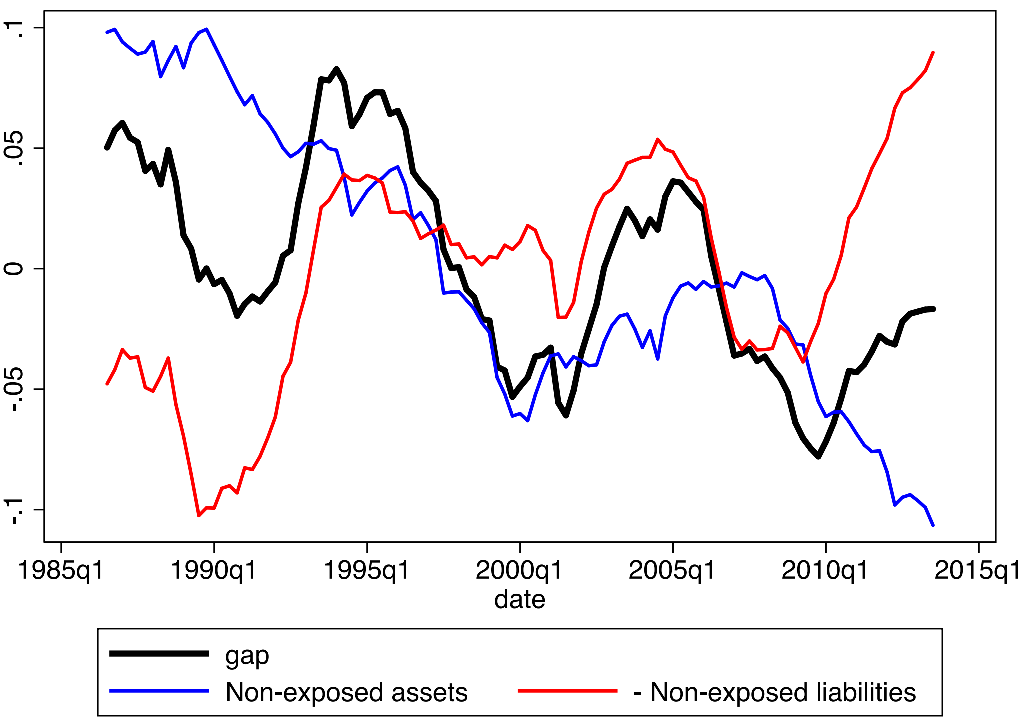
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income gap is the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. We regress the rolling excess return over h months of a strategy long the constant maturity portfolio with maturities between 4 and 5 years in excess of the 1-month risk-free rate. We obtain the constant maturity portfolio from the Fama files at CRSP. Panel (a) of the figure reports, for each horizon h, the coefficient on the average income gap, as well as its 95% confidence interval. Panel (b) reports the corresponding R^2 of each of these regressions.

Figure 5: Average Income Gap and Future Bond Yields



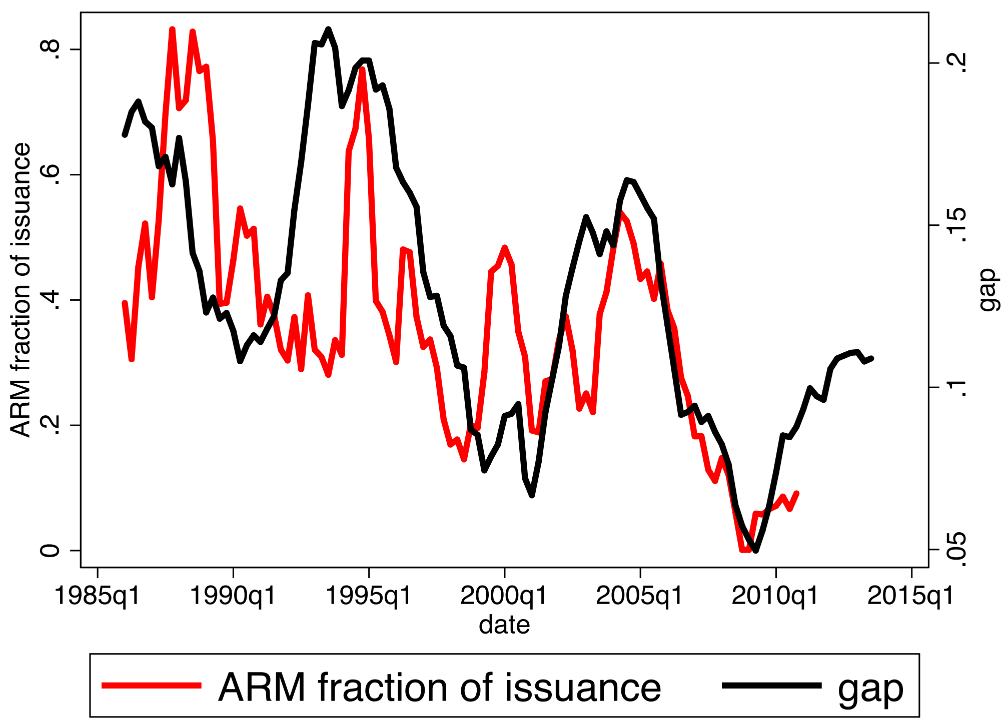
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. "gap" is the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. "yn, F4" is equal to $y_{t+4}^{(n)}$, the yield of Fama-Bliss zero-coupon bonds of maturity n at date $t+4$.

Figure 6: Asset and Liability Components of the Income Gap



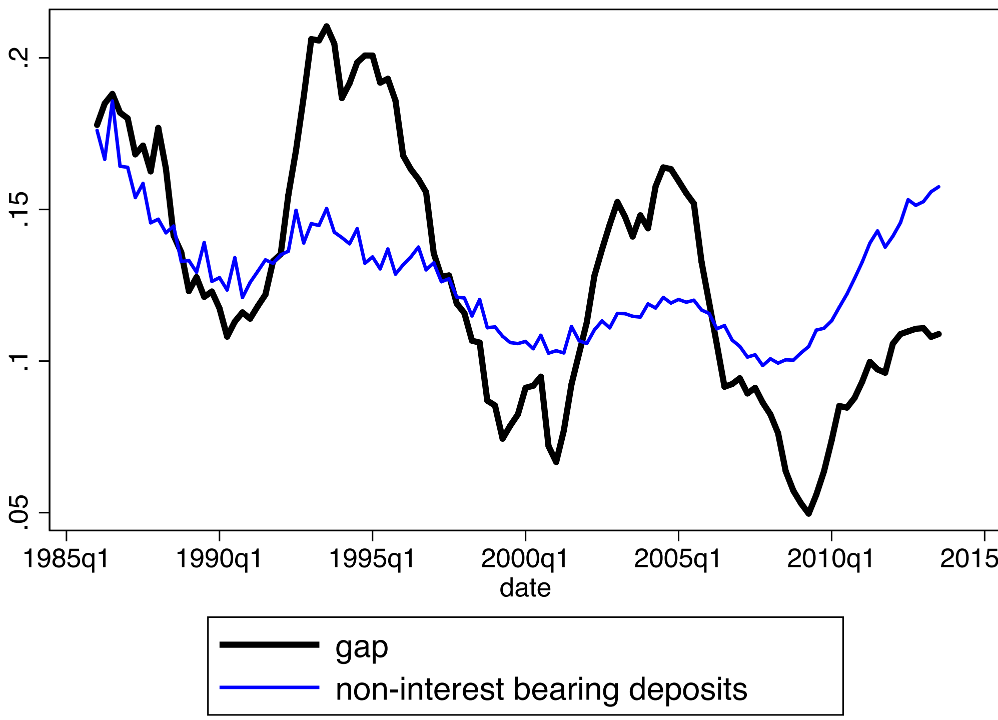
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The dark line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. The blue line represents the average bank-level ratio of assets that either reprice or mature within a year normalized by total consolidated assets. The red line represents the opposite of the average bank-level ratio of liabilities that either reprice or mature within a year normalized by total consolidated assets.

Figure 7: Income Gap and Share of Adjustable-Rate Mortgages



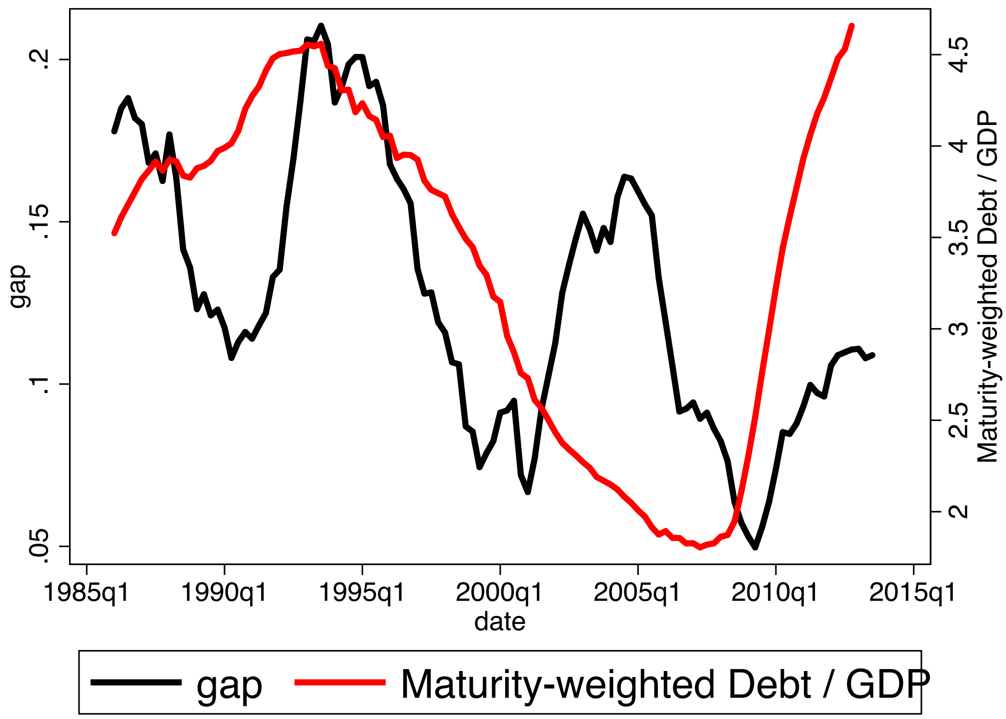
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The dark line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. The red line represents the quarterly ratio of issuance of adjustable-rate mortgages normalized by total issuance of mortgages. It is computed from the Monthly Interest Rate Survey.

Figure 8: Income Gap and Share of non Interest-Bearing Deposits



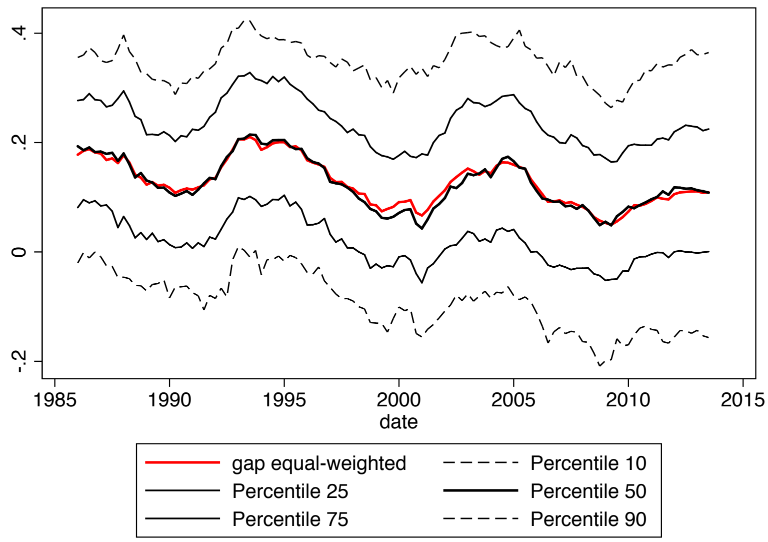
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The dark line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. The blue line represents the average of the quarterly bank-level ratio of non interest-bearing deposits normalized by total consolidated assets.

Figure 9: Income Gap and the Supply of Treasuries

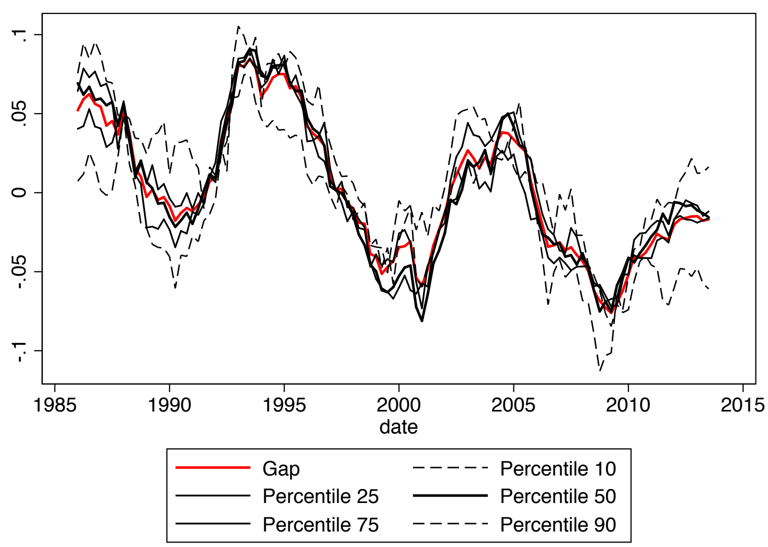


Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The dark line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. The red line is the maturity-weighted Treasuries supply measure of Greenwood and Vayanos (2014).

Figure 10: Cross-Sectional Distribution of the Income Gap



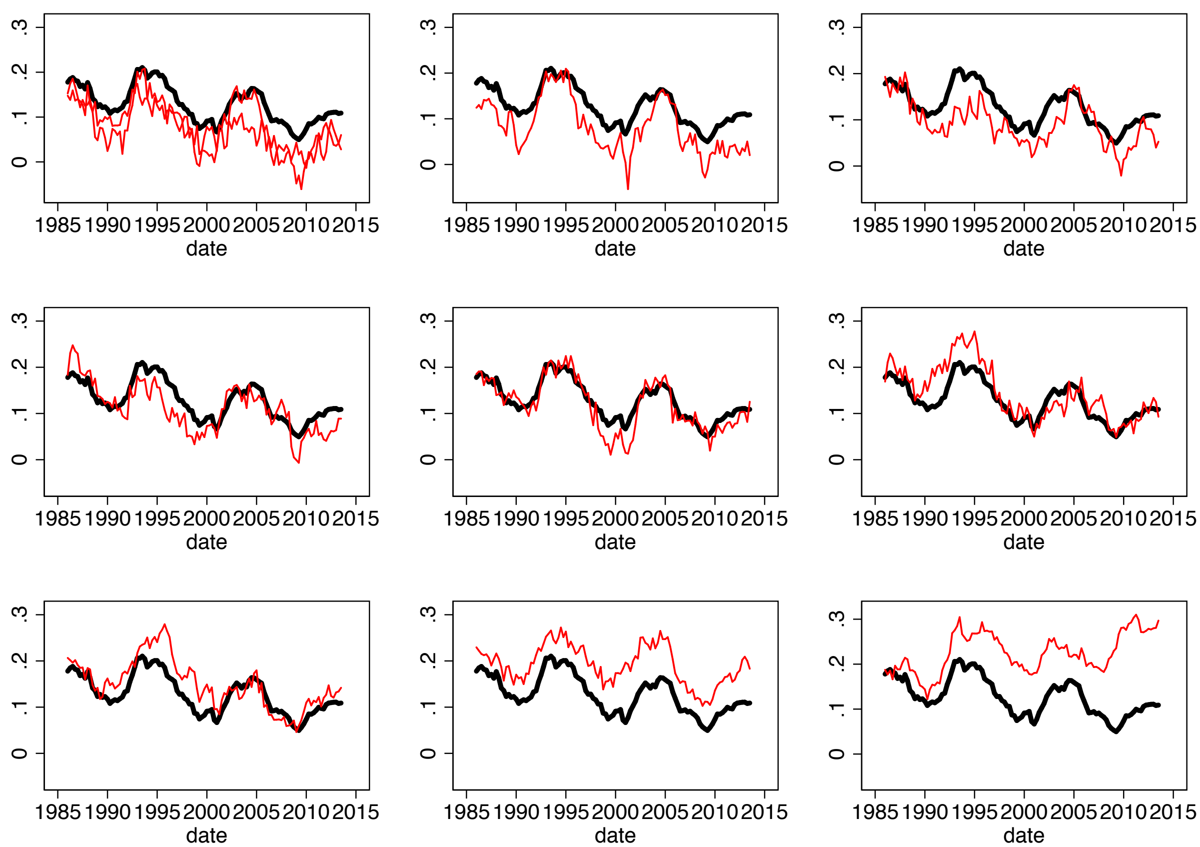
(a) Raw Distribution



(b) Demeaned

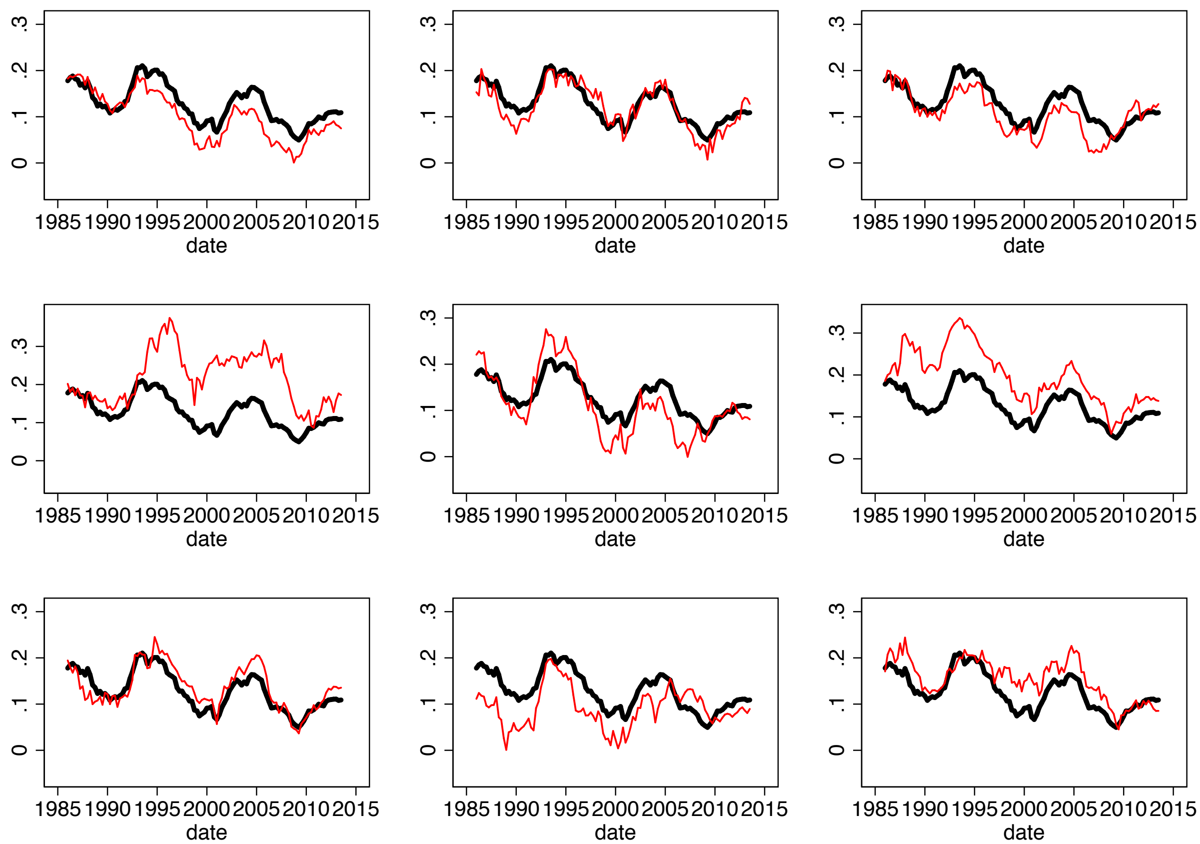
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. We compute the various percentile of the income gap in each date on the top panel. The bottom panel presents the demeaned time-series.

Figure 11: Income Gap across Bank Sizes



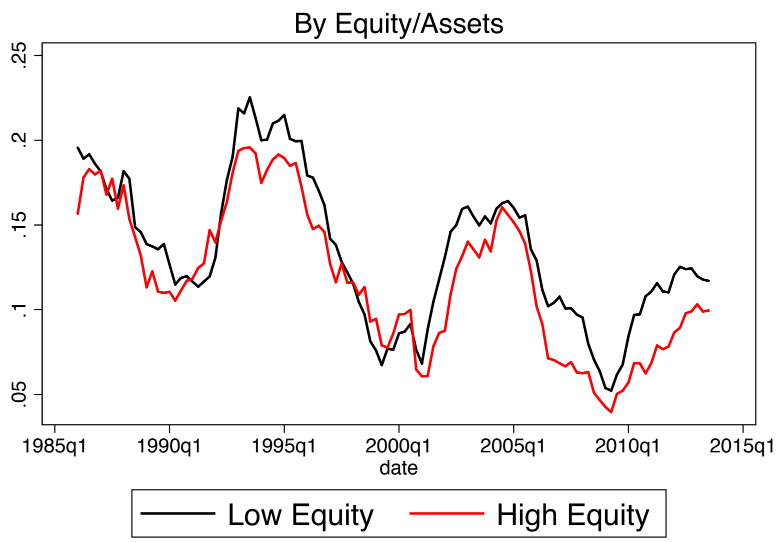
Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The dark line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. Each panel corresponds to the average income gap within a decile of total consolidated assets, in increasing order. We represent the first two deciles on the first panel.

Figure 12: Income Gap across U.S. Regions

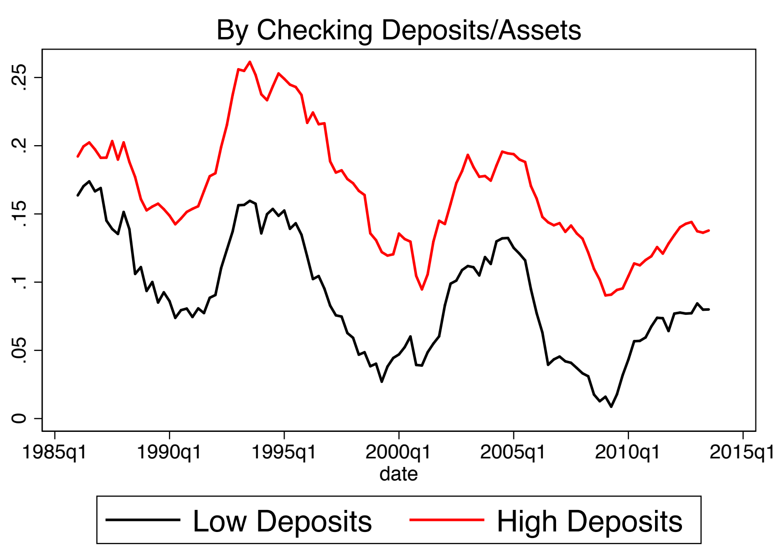


Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. The dark line represents the average income gap, computed across all US bank holding companies with total consolidated assets of $1Bil or more. Each panel corresponds to the average income gap within one of 9 regions of the US.

Figure 13: Income Gap across Bank Characteristics



(a) Equity/Assets



(b) Checking Deposits/Assets

Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Panel (a) represents the average income gap for banks split in two groups based on the average value of the ratio of book equity to consolidated assets. Panel (b) represents the average income gap for banks split in two groups based on the average value of the ratio of checking deposits to assets.

A Proofs

A.1 Proofs of Proposition 1

The banks first-order condition is simply:

$$\begin{aligned} \mu_t^{(\tau)} - r_t &= A_r(\tau)\lambda_{r,t} + A_g(\tau)\lambda_{g,t} \\ \lambda_{i,t} &= \gamma\sigma_i^2 \int_0^\infty x_t^{(\tau)} A_i(\tau) d\tau \end{aligned}$$

We can express $\mu_t^{(\tau)}$, the returns on a τ-maturity bond using the law of motions:

$$\mu_t^{(\tau)} = A_r'(\tau)r_t + A_g'(\tau)g_t + C'(\tau) + A_r(\tau)\kappa_r\left(r_t - \bar{r}\right) + A_g(\tau)\kappa_g(g_t - \bar{g}) + \frac{1}{2}A_r(\tau)^2\sigma_r^2 + \frac{1}{2}A_g(\tau)^2\sigma_g^2$$

Identifying the terms in g_t, r_t and the constant, we obtain a set of ODEs. Solving the ODEs, we obtain:

$$\begin{aligned} A_r(\tau) &= \frac{1 - e^{-\kappa_r\tau}}{\kappa_r} \\ A_g(\tau) &= \frac{Z}{\kappa_r}\left(\frac{1 - e^{-\hat{\kappa}_g\tau}}{\hat{\kappa}_g} - \frac{e^{-\kappa_r\tau} - e^{-\hat{\kappa}_g\tau}}{\hat{\kappa}_g - \kappa_r}\right) \\ Z &= \gamma^2\sigma_r^2 I_r \\ I_r &= \int_0^\infty \frac{1 - e^{-\kappa_r\tau}}{\kappa_r} e^{-\theta\tau} d\tau = \frac{1}{\kappa_r}\left(\frac{1}{\theta} - \frac{1}{\theta + \kappa_r}\right) \end{aligned}$$

and $\hat{\kappa}_g$ solves:

$$\begin{aligned} \hat{\kappa}_g &= \kappa_g - \gamma^2\sigma_r^2\sigma_g^2 I_r \int_0^\infty \frac{1}{\kappa_r}\left(\frac{1 - e^{-\hat{\kappa}_g\tau}}{\hat{\kappa}_g} - \frac{e^{-\kappa_r\tau} - e^{-\hat{\kappa}_g\tau}}{\hat{\kappa}_g - \kappa_r}\right) e^{-\theta t} d\tau \\ \hat{\kappa}_g &= \kappa_g - \gamma^2\sigma_r^2\sigma_g^2 I_r \frac{1}{\kappa_r}\left(\frac{1}{\hat{\kappa}_g}\left(\frac{1}{\theta} - \frac{1}{\theta + \hat{\kappa}_g}\right) - \frac{1}{\hat{\kappa}_g - \kappa_r}\left(\frac{1}{\theta + \kappa_r} - \frac{1}{\theta + \hat{\kappa}_g}\right)\right) \end{aligned}$$

We can also solve for the risk premia:

$$\begin{aligned} \lambda_{r,t} &= g_t\gamma\sigma_r^2\left(\frac{1}{\theta} + \frac{1}{\theta + \kappa_r}\right) = g_t c_r \\ \lambda_{g,t} &= g_t\gamma\sigma_g^2\frac{Z}{\kappa_r}\left(\frac{1}{\hat{\kappa}_g}\left(\frac{1}{\theta} - \frac{1}{\theta + \hat{\kappa}_g}\right) - \frac{1}{\hat{\kappa}_g - \kappa_r}\left(\frac{1}{\theta + \kappa_r} - \frac{1}{\theta + \hat{\kappa}_g}\right)\right) = g_t c_g \\ \mu_t^{(\tau)} - r_t &= g_t\left(c_r A_r(\tau) + c_g A_g(\tau)\right) \end{aligned}$$

This last equation provides the result in Proposition 1.

A.2 Proofs of Proposition 2

Thanks to Proposition 1, we know that $\phi(\tau) = \psi \times (c_r A_r(\tau) + c_g A_g(\tau))$, where ψ is a constant.
We have trivially that: $\frac{\partial A_r(\tau)}{\partial \tau} > 0$.
We easily get that: $\frac{\partial A_g(\tau)}{\partial \tau} = \frac{\kappa_r}{\hat{\kappa}_g - \kappa_r}\left(e^{-\kappa_r \tau} - e^{-\hat{\kappa}_g \tau}\right) > 0$
So that ϕ is increasing with maturity τ.

B Additional Tables

Table IA. 1: Income Gap and Bond Excess Returns : Controlling for the CP factor

	(1) $rx^{(2)}$	(2) $rx^{(2)}$	(3) $rx^{(2)}$	(4) $rx^{(2)}$
Income Gap	-0.163***	-0.343***	-0.490***	-0.605***
	(0.0473)	(0.0799)	(0.101)	(0.113)
CP factor	0.00324**	0.00633**	0.00986***	0.0119***
	(0.00116)	(0.00203)	(0.00267)	(0.00315)
Constant	0.0284***	0.0585***	0.0833***	0.102***
	(0.00633)	(0.0106)	(0.0134)	(0.0148)
Observations	106	106	106	106
Adjusted R^2	0.314	0.361	0.388	0.373

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity of maturity n. CP factor is the Cochrane and Piazzesi (2005) factor and is constructed as in Cochrane and Piazzesi (2005) over the 1964-2013 period. Standard errors are computed using the Hansen-Hodrick correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table IA. 2: Income Gap and Bond Excess Returns: Newey-West Standard Errors

	(1)	(2)	(3)	(4)
	$rx^{(2)}$	$rx^{(3)}$	$rx^{(4)}$	$rx^{(5)}$
Income Gap	-0.13**	-0.29***	-0.40***	-0.50***
	(0.05)	(0.09)	(0.12)	(0.14)
Constant	0.02***	0.05***	0.07***	0.09***
	(0.01)	(0.01)	(0.02)	(0.02)
Observations	106	106	106	106
Adjusted R^2	0.174	0.216	0.211	0.208

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. $rx^{(n)}$ is the excess 1-year holding return of Fama-Bliss zero-coupon bonds of maturity of maturity n. Standard errors are computed using the Newey-West correction with 8 lags. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.

Table IA. 3: Income Gap and Bond Excess Returns: Reverse Regressions

	(1) $rx^{(2)}$	(2) $rx^{(3)}$	(3) $rx^{(4)}$	(4) $rx^{(5)}$
Income Gap (Reverse)	-0.01**	-0.02**	-0.03**	-0.03*
	(0.01)	(0.01)	(0.01)	(0.02)
Constant	0.01***	0.02***	0.02***	0.02***
	(0.00)	(0.01)	(0.01)	(0.01)
Observations	106	106	106	106
Adjusted R^2	0.038	0.037	0.033	0.027

Sample period: 1986-2014. Note: The bank-level income gap is computed from the quarterly Consolidated Financial Statements (Files FR Y-9C) and is defined as the difference between the amount of assets that either reprice, or mature, within one year, and the amount of the liabilities that mature or reprice within a year, all scaled by total consolidated assets. Income Gap is the average bank-level income gap. Income Gap (Reverse) is the sum of the values of Income Gap for the current and past three quarters. $rx^{(n)}$ is the excess 3-month holding period return on a zero-coupon bonds of maturity of maturity n computed using GSW yield curves. Standard errors are computed are computed using the Huber-White sandwich estimator. *, **, and *** means statistically different from zero at 10, 5 and 1% level of significance.