Banks Exposure to Interest Rate Risk and The Transmission of Monetary Policy*

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Abstract

We show that banks' exposures to interest rate risk, or *income gap*, play a crucial role in monetary policy transmission. While banks have, on average, positive levels of *income gap* – their assets have on average longer duration than their liabilities – there is a substantial heterogeneity in the cross-section of banks in how exposed they are to interest rate risk. In a first step, we show that the sensitivity of bank profits to interest rates increases significantly with their income gap, even when banks use interest rate derivatives. In a second step, we show that the income gap also predicts the sensitivity of bank lending to interest rates, both for commercial & industrial loans and mortgages. Quantitatively, a 100 basis point increase in the Fed funds rate would lead a bank at the 75^{th} percentile of the income gap to increase its lending by about 1.6 percentage points annually *relative* to a bank at the 25^{th} percentile. We conclude that banks' exposure to interest rate risk is an important determinant of the lending channel.

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1. Introduction

This paper explores a novel channel of monetary policy transmission. When a bank borrows short term, but lends long term at fixed rates, any increase in the short rate will reduce its cash flows; Leverage will tend to increase. Since issuing equity is expensive, the bank will have to reduce lending in order to prevent leverage from rising. This channel rests on three elements, that have been documented in the literature. First, commercial banks tend to operate with constant leverage targets (Adrian and Shin, 2010). Second, banks are exposed to interest rate risk (Flannery and James, 1984; Begeneau, Piazzesi and Schneider, 2012). Third, that there is a failure of Modilgiani-Miller which prevents banks from issuing equity easily in the short-run (see, for instance, Kashyap and Stein, 1995). In this paper, we provide robust econometric evidence that this monetary policy channel operates in a large panel of US banks. In doing so, we make three contributions to the literature.

We first document, empirically, the exposure of banks to interest rate risk. Using bank holding company (BHC) data – available quarterly from 1986 to 2011 – we measure the "income gap" of each bank, as the difference between the dollar amount of the banks assets that re-price within a year and the dollar amount of liabilities that re-price within a year, normalized by total assets. To focus on significant entities, we restrict the sample to banks with more than \$1bn of total assets. The first contribution of the paper is to document that there is substantial variations in income gap, both in the time-series and in the cross-section. Banks typically have positive income gap, which means that their assets are more sensitive to interest rates than their liabilities. However, in the cross-section, some banks appear to have a much larger exposure to interest rate risk than others: Income gap is zero at the 25^{th} percentile, while at the 75^{th} percentile, the income gap is 25 percent of total assets. There is also substantial variation in the time-series: The average income gap of banks goes from 5% in 2009 to as much as 22% in 1993.

Second, we show that banks do not fully hedge their interest rate exposure. Banks with non-zero income gaps could use interest rate derivatives –off-balance sheet instruments– so as to offset their on-balance sheet exposure. While this may be the case to a certain extent, we find strong evidence that banks maintain some interest rate exposure. In our data, income gap strongly predicts the sensitivity of profits to interest rates. Quantitatively, a 100 basis point increase in the fed funds rate would lead a bank at the 75^{th} percentile of the income gap to increase its quarterly earnings by about .02% of total assets, relative to a bank at the 25^{th} percentile of the income gap. This is to be compared to a quarterly return on assets (earnings divided by assets) of 0.20% in our sample. This result is strongly statistically significant, and resists to various robustness checks. This result echoes earlier work by Flannery and James (1984), who document the income gap explains how the stock returns of S&Ls react to changes in interest rates. While we replicate a similar result on listed bank holding companies, our focus in this paper is on income gap, bank cash flows and lending. Our results, as well as Flannery and James', thus confirm that banks only imperfectly hedge interest rate exposure, if they do so at all. This intuition is actually confirmed by recent findings by Begeneau, Piazzesi and Schneider (2012): In the four largest US banks, net derivative positions tend to amplify, not offset, balance sheet exposure to interest rate risk.

Our third contribution is to show that income gap strongly predicts how bank-level lending reacts to interest rate movements. Since interest rate risk exposure affects bank cash-flows, it may affect their ability to lend if external funding is costly. Quantitatively, we find that a 100 basis point increase in the fed funds rate would lead a bank at the 75^{th} percentile of the income gap to increase its lending by about

.4 ppt more than a bank at the 25^{th} percentile. This is to be compared to quarterly loan growth in our data, which equals 1.8%: Hence, the estimated effect is large in spite of the natural noise in our income gap measure. Moreover, this estimate is robust to various checks that we perform. In particular, it is unchanged when we control for factors previously identified in the literature as determining the rate sensitivity of lending: leverage, bank size and asset liquidity. In the cross-section of banks, these effects are larger for smaller banks, consistent with the idea that smaller banks are more financially constrained. Similarly, the effect is more pronounced for banks that report no hedging on their balance sheet –we only have notional, not net, exposure. Overall, our results suggest that the income gap significantly affects the lending channel, and therefore establish the importance of this mode of transmission of monetary policy.

Our paper is related to the literature on the bank lending channel of transmission of monetary policy. This literature seeks to find evidence that monetary policy affects the economy via credit supply. The bank lending channel is based on a failure of the Modigliani-Miller proposition for banks. Consistently with this argument, monetary tightening is shown to reduce lending by banks that are smaller (Kashyap and Stein, 1995), unrelated to a large banking group (Campello, 2002), hold less liquid assets (Kashyap and Stein, 2000), have higher leverage (Kishan and Opiela, 2000, Gambacorta and Mistrulli, 2004). We find that the "income gap" effect we document is essentially orthogonal to these effects, and extremely robust across specifications. This effect does not disappear for very large banks. In addition, via its focus on interest risk exposure, this study also relates to the emerging literature on interest rate risk in banking and corporate finance (Flannery and James, 1984, Chava and Purnanandam, 2007, Purnanandam, 2007, and Begeneau, Piazzesi, Schneider, 2012). This literature does not investigate the effect of interest rate risk on investment (corporate finance) or lending (banking).

The rest of the paper is organized as follows. Section 2 presents the data. Section **??** shows the relationship between banks income gap and the sensitivity of their profits to variations in interest rates. Section 4 analyzes the role of the income gap on the elasticity of banks lending policy to interest rates. Section 6 concludes.

2. Data and Descriptive statistics

2.1. Data construction

2.1.1. Bank-level data

We use quarterly Consolidated Financial Statements for Bank Holding Companies (form FR Y-9C) available from WRDS. These reports have to be filed with the FED by all US bank holding companies with total consolidated assets of $500 million or more. Our data covers the period going from 1986:1 to 2011:4. We restrict our analysis to all BHCs with more than $1bn of assets. The advantage of BHC-level consolidated statements is that they report, continuously from 1986 to 2011, measures of the bank's income gap (see next Section). Commercial bank-level data that have been used in the literature (Kashyap and Stein, 2000; Campello, 2002) do not have a consistent measure of income gap over such a long period.

For each of these BHCs, we use the data to construct a set of dependent and control variables. We will describe the "income gap" measure in the next Section in further detail. The construction of these variables is precisely described in Appendix A, and all variables are trimmed by removing observations that are more than 5 interquartile ranges (p75-p25) away from the median. We report summary statistics for these variables in Table 1.

There are two sets of dependent variables. First are income-related variables which we expect should be affected by movements in interest rates: net interest income and net profits. We also take non-interest income as a placebo variable, on which interest rates should in principle have no impact. We normalize all these variables by total assets. Second, we look at two variables measuring credit growth: the first one is the quarterly change in log commercial and industrial loans, while the second one is the quarterly change in log total loans.

As shown in Table 1, the quarterly change in interest income is small compared to total assets (sample s.d. is 0.001). This is due to the fact that interest rates do not change very much from quarter to quarter: On average, quarterly net interest income accounts for about 0.9% of total assets, while the bottomline (earnings) is less than 0.2%. Notice also that non-interest income is as large as interest income on average (1% of assets compared to 0.9%), but much more variable (s.d. of 0.023 vs 0.003).

Control variables are the determinants of the sensitivity of bank lending to interest rates that have been discussed in the literature. In line with Kashyap and Stein (2000), we use equity normalized by total assets, size (log of total assets) and the share of liquid securities. The share of liquid securities variable differs somewhat from Kashyap and Stein's definition (fed funds sold + AFS securities) due to differences between BHC consolidated data and call reports. First in our data, available-for-sale securities are only available after 1993; second, Fed Funds sold are only available after 2001. To construct our measure of liquid securities, we thus chose to deviate from Kashyap and Stein's exact definition and took all AFS securities normalized by total assets. Even after this modification, our liquidty measure remains available for the 1994-2011 subperiod only.

Control variables, obtained from consolidated accounts at the BHC-level, have order of magnitudes that are similar existing studies on commercial bank-level data:

average equity-to-asset ratio is 8.7% in our data, compared to 9.5% the vast majority of Campello's sample (which covers the 1981-1997 period). The share of liquid assets is 27% in our sample, compared to 32% in his sample. This is the reflection of two data differences: our sample periods barely overlap (1994-2011 compared to 1981-1997) and due to data availability constraints, we do not include fed funds sold in our measure of liquidty. Given these discrepancies, the fact that both variables have the same orders of magnitude is reassuring.

2.1.2. Interest Rates

We use three time-series of interest rates. In most of our regressions, we use the fed funds rate as our measure of short-term interest rate, available monthly from the Federal Reserve's website. To each quarter, we assign the value of the last month. Second, in Table 8, we also use a measure of long-term interest rates. We take the spread on the 10-year treasury bond, also available from the Fed's website. Last, we construct a measure of expected short interest rates using the Fama-Bliss (1987) series of zero coupon bond prices. For each quarter t, we use as our measure of expected short rate the forward 1-year rate as of $t-8$ (two years before). This forward is calculated using the zero coupon bond prices according to the formula $p_{2,t-8}/p_{3,t-8} - 1$, where $p_{j,s}$ is the price of the discount bond of maturity j at date s.

2.2. Exposure to Interest Rate Risk

2.2.1. Income Gap: Definition and Measurement

The income gap of a financial institution is defined as (see Mishkin & Eakins, 2009, chapters 17 and 23):

$$\text{Income Gap} = \text{RSA} - \text{RSL} \tag{1}$$

where RSA are all the assets that either reprice, or mature, within one year, and RSL are all 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, income gap measures the extent to which a bank's net interest income are sensitive to interest rates changes. Because the income gap is a measure of exposure to interest rate risk, Mishkin and Eakins (2009) propose to assess the impact of a potential change in short rates Δr on bank income by calculating: Income Gap $\times$ Δr.

This relation has no reason to hold exactly, however. Income gap is a reasonable approximation of a bank's exposure to interest rate risk, but it is a noisy one. There are several reasons for this. First, the cost of debt rollover may differ from the short rate. New short-term lending/borrowing will also be connected to the improving/worsening position of the bank on financial markets (for liabilities) and on the lending market (for assets). This introduces some noise. Second, depending on their repricing frequency, assets or liabilities that reprice may do so at moments where short rates are not moving. This will weakens the correlation between change in interest income and Income Gap $\times$ Δr. To see this, imagine that a bank holds a \$100 loan, financed with fixed rate debt, that reprices every year on June 1. This bank has an income gap of \$100 (RSA=100, RSL=0). Now, assume that the short rate increases by 100bp on February 20. Then, in the first quarter of the year, bank interest income is not changing at all, while the bank has a \$100 income gap and interest rates have risen by 100bp. During the second quarter, the short rate is flat, but bank interest income is now increasing by \$1 = 1% $\times$ \$100. For these two consecutive quarters, the correlation between gap-weighted rate changes and interest income is in fact negative. Third, banks might be hedging some of their interest rate exposure, which would weaken the link between cash flows and Income Gap $\times \Delta r$. Overall, while we expect that income gap is connected with interest rate exposure, the relationship can be very noisy due to heterogeneity in repricing dates and repricing frequencies, interacting with interest rate dynamics. Income gap is a gross approximation of interest rate exposure; its main advantage is that it is simple and available from the data.

Concretely, we construct income gap using variables from the schedule HC-H of the 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); and 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 continuously available from 1986 to 2011. This availability is the reason why we chose to work with consolidated accounts (BHC data instead of "Call" reports).

We scale all these variables by bank assets, and report summary statistics in Table 2. The average income gap is 13.4% of total assets. This means that, for the average bank, an increase in the short rate by 100bp will raise bank revenues by 0.134 percentage points of assets. There is significant cross-sectional dispersion in income gap across banks, which makes identification easier. About 78% of the observations correspond to banks with a *positve* income gap: For these banks, an increase in interest rates yields an *increase* in cash flows. A second salient feature of Table 2 is that 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.

2.2.2. Do Banks Hedge Interest Rate Risk?

In this Section, we ask whether banks use derivatives to neutralize their "natural" exposure to interest rate risk. We can check this directly in the data. The schedule HC-L of the form FR Y-9C reports, starting in 2005, the notional amounts in interest derivatives contracted by banks. 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).

We scale all these variables by assets, and report summary statistics in Table 3. Swaps turn out to be overwhelmingly the prevalent form of hedge used by banks. For the average bank, they account for about 18% of total assets. This number, however, conceals the the presence of very big outliers: a handful of banks –between 10 and 20 depending on the year– have total notional amount of swaps greater than their assets. These banks are presumably dealers. Taking out these outliers, the average notional amount is only 4% of total assets, a smaller number than the average income gap. All in all, about 60% of the observations are banks with at least some derivative exposure.

The data unfortunately only provides us with notional exposures. Thus, notional amounts may conceal offsetting positions so that the total interest rate risk exposure is minimal. To deal with this issue, we directly look at the sensitivity of each bank's revenue to interest rate movement, and check whether it is related to income gap. We do this in the next Section and find that bank revenue indeed depends on Income gap$\times$ Δr: This confirms evidence from Table 3 that banks do not hedge out all their interest rate risk.

3. Interest Risk and Cash-Flows

In this Section, we check that the sensitivity of profits to interest rate movements depends on our measure of income gap. This Section serves as a validation of our measure of income gap, but also shows that hedging, although present in the data, is limited.

By definition (1), we know that bank profits should directly be related to Income gap$\times$ Δr. We thus follow the specification typically used in the literature (Kashyap and Stein, 1995, 2000; Campello, 2002 for instance), and estimate the following linear model for bank i in quarter t:

$$\begin{aligned}\Delta Y_{it} = &\sum_{k=0}^{k=4} \alpha_k.(\text{gap}_{it-1} \times \Delta\text{fed funds}_{t-k}) + \sum_{k=0}^{k=4} \gamma_k(\text{size}_{it-1} \times \Delta\text{fed funds}_{t-k}) \\ &+ \sum_{k=0}^{k=4} \lambda_k(\text{equity}_{it-1} \times \Delta\text{fed funds}_{t-k}) + \sum_{k=0}^{k=4} \theta_k(\text{liquidity}_{it-1} \times \Delta\text{fed funds}_{t-k}) \\ &+ \sum_{k=0}^{k=4} \eta_k \Delta Y_{it-1-k} + \text{gap}_{it-1} + \text{size}_{it-1} + \text{equity}_{it-1} + \text{liquidity}_{it-1} + \text{date dummies} + \epsilon_{it}\end{aligned} \tag{2}$$

where all variables are scaled by total assets. Y_{it} is a measure of bank cash flow and value: interest income, non-interest income, earnings and market value of equity (see Appendix A for formal definitions). $\sum_{k=0}^{k=4} \alpha_k$ is the cumulative effect of interest rate changes, given the income gap of bank i. This sum is the coefficient of interest. If the income gap variable contains information on bank interest rate exposure, and as long as banks do not hedge this risk too much, we expect $\sum_{k=0}^{k=4} \alpha_k > 0$.

Consistently with the literature, we control for existing determinants of the sensitivity of bank behavior to interest rates: bank size (as measured through log assets) and bank equity (equity to assets). In one specification, we also include bank liquidity (securities available for sale divided by total assets). In all regressions, we include these controls directly, and interacted with current and four lags of interest rate changes. These controls have been shown to explain how bank lending reacts to changes in interest rates. Their economic justification in a profit equation is less clear, but since our ultimate goal is to explain the cross-section of bank lending, we include these controls in the profit equations for the sake of consistency. As it turns out, their presence, or absence, does not affect our estimates of $\sum_{k=0}^{k=4} \alpha_k$ in equation (2).

The first set of results directly looks at net interest income, which is the difference between interest income and interest expenses. This item should be most sensitive to variations in interests paid or received. We report the results in Table 4. Columns 1-5 use (quarterly) change in interest income normalized by lagged assets, as the dependent variable. Column 1 reports regression results on the total sample. The bottom panel reports the cumulative impact of an interest rate increase, $\sum_{k=0}^{k=4} \alpha_k$ and the p-value of the F-test of statistical significance. For interest income, the effect of income gap weighted changes in interest rates is strongly significant. A \$1 increase in $Gap_{it-1} \times \Delta FedFunds_t$, after 5 consecutive quarters, raises interest income by about 0.05 dollars. This suggests that income gap captures some dimension of interest exposure, albeit imperfectly so.

This effect applies across bank size, and seems unaffected by hedging. Columns 2-3 split the sample into large and small banks. "Large banks" correspond to the 50 largest BHC each date (by total assets), small banks are the rest. Both large and small banks appear to have similar exposure to interest rate: coefficients $\sum_{k=0}^{k=4} \alpha_k$ are not statistically different (p value = 0.83). Columns 4-5 split the sample into banks that have some notional exposure on interest rate derivatives and banks that report zero notional exposure. This sample split reduces the period of estimation to 1995-

2011, as interest rate derivative notional is not available from the data before 1995. It is important to note that notional derivative exposure may not mean that the bank is hedging its maturity mismatch. For instance, derivatives may be used to hedge exposure resulting from fixed income trading positions, or to only partially offset the gap. Consistently with the idea that notional exposure captures hedging behavior imperfectly, we find strong and statistically significant effects for both categories of banks. The impact of income gap on interest income is slightly smaller for banks with some derivative exposure, but the difference is not statistically significant (p value = .19). In non-reported regressions, we further restrict the sample to BHCs whose notional interest rate derivative exposure exceeds 10% of total assets (some 4,000 observations): even for this smaller sample, the income gap effect remains strongly significant and has the same order of magnitude. Overall, our results indicate that interest rate hedging is a minor force for most banks, and even most large banks. This is consistent with the findings reported in Begeneau et al. (2012) that the four largest US banks *amplify* their balance sheet exposure with derivatives, instead of offsetting them, even partially. Their evidence, along with ours, suggests that banks keep most interest rate risk exposure related to lending, perhaps because hedging is too costly.**Should we not mention the forecasting regressions after all? it raises the concern of endogeneity, but at the same time provides compelling evidence that banks do manage directional interest risk exposure**

To further validate the income gap measure, we run a “placebo test” in columns 6-10. In these columns, we use, as dependent variable, non-interest income, which contains: servicing fees, securitization fees, management fees or trading revenue. While non-interest income may be sensitive to interest rate fluctuations, there is no reason why this sensitivity should be related to income gap. Thus, with non-interest income on the LHS, we expect $\sum_{k=0}^{k=4} \alpha_k = 0$ in equation (2). Columns 6-10 of Table 4 report the result of this regression for all banks, small banks, large banks, unhedged banks and banks with some interest derivative notional. In all of these samples, income gap $\times \Delta r$ is small and statistically insignificant.

A natural next step is to look at the impact of duration gap on overall earnings and market value. We report these results in Table 5. Columns 1-5 report the effect on earnings (of which interest income is a component), while columns 6-10 report the effect on market value of equity. Both are normalized by total assets. $\sum_{k=0}^{k=4} \alpha_k$ is strongly statistically significant in all 10 specifications: duration gap explains the sensitivity of earnings and market value to interest rate for all types of banks. In column 1, the estimate shows that a \$1 increase in $Gap_{it-1} \times \Delta FedFunds_t$, after 5 consecutive quarters, raises earnings by about \$0.07. This order of magnitude is similar to the effect on interest income from Table 4. This is not surprising given that we have seen above that income gap has no impact on non-interest income. As shown in columns 2-5, this effect remains unchanged across size groups, and unaffected by the presence of derivatives. The estimated effect on market value is also highly significant and of an order of magnitude consistent with the one obtained for earnings. In column 6, a \$1 increase in $Gap_{it-1} \times \Delta FedFunds_t$ raises market value of equity by about \$1.8. Given the same shock raises earnings by \$0.07, this implies an earnings multiple of approximately 25, which is reasonable, though on the high side. As for earnings, the difference in reaction across size or hedging status is insignificant, even though hedged banks tend to react slightly less to $Gap_{it-1} \times \Delta FedFunds_t$.

In Appendix B, we replicate this estimation using an alternative procedure also present in the literature. This alternative technique proceeds in two steps. First, each quarter, one estimates the cross-sectional sensitivity of the dependent variable (here, profits; in the next Section, lending) to income gap using linear regression. In a second step, we regress the time series of these coefficients on changes in interests rates and their four lags. If income gap matters, one expects that the profits are more related to income gap when interest rates increase. As we show in Appendix B, we find that this is the case. Consistently with intuition –the two methods aim at estimating the same relationship– we find identical estimates of $\sum_{k=0}^{k=4} \alpha_k$ when we use this alternative approach. The cumulative effect of a \$1 increase in $Gap_{it-1} \times \Delta FedFunds_t$ yields a 5 cents increase in interest income and a 7 cents increase in overall earnings.

To conclude, our regressions understate banking exposure to interest rate risk. This is because the income gap measure only gives a rough estimate of the sensitivity of bank income to short interest movements. In the absence of the full distribution of repricing dates, the one year repricing items fail to capture many dimension of interest rate sensitivity. Nevertheless, the main lesson of our exercise is this variable still captures some of the sensitivity of bank profits to interest rates movements. Neither size, nor hedging, seem to be able to protect banks from directional interest risk exposure.

4. Interest Risk and Lending

4.1. Main Result

We have established that interest rate movements affect cash flows when the income gap is larger. If banks are to some extent financially constrained, these cash flows shocks should affect lending. We follow Kashyap and Stein (2000), and run the following regression:

$$\begin{aligned}\Delta\log(\text{credit}_{it}) = &\sum_{k=0}^{k=4}\alpha_k.(\text{gap}_{it-1}\times\Delta\text{fed funds}_{t-k}) + \sum_{k=0}^{k=4}\gamma_k(\text{size}_{it-1}\times\Delta\text{fed funds}_{t-k})\\ &+\sum_{k=0}^{k=4}\lambda_k(\text{equity}_{it-1}\times\Delta\text{fed funds}_{t-k}) + \sum_{k=0}^{k=4}\theta_k(\text{liquidity}_{it-1}\times\Delta\text{fed funds}_{t-k})\\ &+\sum_{k=0}^{k=4}\eta_k\Delta\log(\text{credit}_{it-1-k}) + \text{gap}_{it-1} + \text{size}_{it-1} + \text{equity}_{it-1} + \text{liquidity}_{it-1}\\ &+\text{date dummies} + \epsilon_{it}\end{aligned} \tag{3}$$

which is identical to equation as (2) except that change in log credit is the dependent variable (this is the variable used in most of the extant literature). consistently with our cash-flow regressions, all other variables are normalized by lagged assets (see Appendix A for exact definitions). $\sum_{k=0}^{k=4}\alpha_k$ is the cumulative effect of interest rate changes, given the income gap of bank i. This sum is the coefficient of interest. If the income gap variable contains information on bank interest rate exposure, and as long as banks do not hedge this risk too much, we expect $\sum_{k=0}^{k=4}\alpha_k > 0$.

Consistently with the literature, we control for existing determinants of the sensitivity of lending to interest rates: bank size, bank equity and asset liquidity (see Appendix A for definitions). In all regressions, we include these controls directly, and interacted with current and four lags of interest rate changes. These interaction terms help to measure the sensitivity of lending to interest rates. For instance, we expect high equity banks, and big banks, to be less sensitive to interest rate fluctuations (Kashyap and Stein, 1995). This is because changes in the cost of funding affect cash flows which reduces lending by financially constrained banks. Also, we expect banks with liquid assets to lend relatively more when rates go up (Kashyap and Stein, 2000). This happens because in such environments, banks lose reserves: In order to meet their requirements, they have to either sell liquid assets, issue costly debt, or reduce lending. Banks that have little debt capacity (are financially constrained) and no liquid assets have no other solution than scaling down lending.

We first run regressions without the asset liquidity control, because it is not available before 1993. We report the results in Table 6: separately for C&I loan growth (columns 1-5) and for total lending growth (columns 6-10). As before, we run regressions on the whole sample (columns 1 and 6), split the sample into large and small banks, and split the sample between banks with some interest rate derivatives and banks without. Focusing on total lending growth, we find results that are statistically significant at 1%, except for large banks. The size of the effects is significant. If we compare a bank at the 25^{th} percentile of gap (approximately 0) and a bank at the 75^{th} percentile of gap (approximately 0.25), and if the economy experiences an increase by 100bp in fed funds rate, total loans in the latter bank will grow by about .4 percentage points more than the former. This has to be compared with a sample average quarterly loan growth of about 1.8%. Note also that there is no difference in behavior between banks that are hedged and unhedged banks: The coefficient drops from 1.9 to 1.5 when we move from unhedged to hedged banks but the difference is insignificant (p value = 0.62). This is consistent with the idea banks with notional exposure do not seek to hedge their banking book (Begeneau et al, 2012). The effect has the same order of magnitude for bigger and smaller banks (1.7 versus 1.4), and the difference is insignificant (p value = 0.85). Effects are similar when we focus on C&I loans: the estimate has the same order for magnitude for large and small banks. The only difference is that the presence of derivative notional make the estimate insignificant –it was significant for total lending.

Let us now briefly discuss the controls: Overall, these controls seem to explain lending sensitivity to rates in a much less consistent way than income gap. Let us start with the size control. In the fourth to sixth rows of the bottom panel, we report the sum of the coefficients on interactions terms with size. Consistently with intuition, large banks decrease their lending less when the Fed raises the fed funds rates (the coefficient is positive). On C&I loans, the estimated effect is statistically significant (Kashyap and Stein, 1995, report a similar result on commercial bank data over the 1976-1993); but on total loans we find no significant impact and the coefficient is nearly zero. The impact of size on the reaction to monetary policy has the same order of magnitude as the income gap. If we compare banks at the 25^{th} and banks at the 75^{th} percentile of the size distribution (log of assets equal to 14.2 vs 15.9), and consider a 100bp increase in fed funds rates, the smaller bank will reduce its C&I lending by 0.3% more. So income gap explains movements C&I lending as well as bank size, and it explains movements of total lending better. Turning to the role of capitalization, rows 7 to 9 in the bottom panel of Table 6 report the sum of the coefficients on $\frac{equity_{it-1}}{assets_{it-1}}.\Delta fedfunds_{t-k}$. Estimates are in most cases insignificant and go in the wrong direction: better capitalized banks tend to reduce their lending *more* when interest rates increase. This counterintuitive result does not come from the fact that equity is correlated with size (negatively) or with income gap (positively): in unreported regressions, we have tried specifications including the interactions term with equity only, and the coefficient remained negative.

In Table 7, we include the asset liquidity control, which restricts the sample to 1993-2011. In spite of this dramatic drop in power, our results resist well. For C&I lending growth, they remain statistically significant at 5% in for all banks, small banks, and banks without derivative exposure. For total lending growth, estimates are statistically significant at 1% for all specification but large banks. For total lending growth, the point estimate for large banks is similar to the estimate for small banks, but it is much less precise –a possible consequence of a smaller sample size. For both credit growth measures, the difference between large and small banks is insignificant.

Asset liquidity does not, however, come in significant in these regressions, and has the "wrong" sign: banks with more liquid assets tend to reduce their lending more when interest rates increase, but the effect is not precisely estimated. The discrepancy with Kashyap and Stein's results comes from the fact that we are using BHC data, instead of commercial bank data. BHC data report a consistent measure of income gap, while commercial bank data fail to do so. Our use of BHC data has two consequences: First, we work at a different level of aggregation. But most importantly, our regressions with liquidity controls go from 1993 to 2011, while Kashyap and Stein's sample goes from 1977 to 1993. It is possible that reserves requirement have become less binding over the past 20 years.

To conclude, we find that income gap explains very well the cross-section of bank lending sensitivities to interest rates. This relationship is strongly significant, and holds more consistently across specifications than the effect of size, leverage or liquid assets. Income gap seem to matter less for larger banks, in particular for C&I credit, consistent with the idea that larger banks are less credit constrained. Interest derivative exposure does not appear to reduce the effect of income gap.

5. Discussion

5.1. Credit Multiplier

This Section uses interest rate shocks to identify the credit multiplier of banks in our sample. To do this, we reestimate a version of equation (3) where the dependent variable is defined as quarterly *increase* in $ loans normalized by lagged assets. It thus differs slightly from the measure we have been using in the previous Section (quarterly change in log loans) which commonly is used in the literature. The advantage of this new variable is that it allows to directly interpret the sum of interacted coefficients $\sum_{k=0}^{k=4} \alpha_k$ as the \$ impact on lending of \$1 increase in the interest-sensitive income gap $\times \Delta r$. We can then directly compare the \$ impact on lending to the \$ impact on cash-flows as estimated in Table 4. The ratio is a measure of the credit multiplier.

We obtain a credit multiplier of about 11, i.e. a \$1 increase in cash flows leads to an increase in lending by \$11. Using the normalized loan change at the depend variable, we find a cumulative effect of .81 (p-value = .002). This effect is strong and statistically significant, which is not a surprise given the results of Table 6 –only the scaling variable changes. This estimate means that a \$1 increase in gap $\times \Delta r$ leads to an increase of lending by \$.81. At the same time, we know from Table 4 that the same \$1 increase generates an earnings shock of \$0.07. Hence, assuming that lending sensitivity to interest only comes through the cash flow shock, this yields a multiplier of 0.81/0.07=11.5. This order of magnitude is slightly lower than bank leverage in the sample: the average asset-to-equity ratio is 13.1 in the data. Given that cash-flows are also additional reserves, the credit multiplier we get is consistent with existing reserve requirements in the US which are around 10 for large banks. These estimates do, however, need to be taken with caution since lending may be affected by gap $\times \Delta r$ through channels other than cash flows, as we now discuss.

5.2. Short vs long rates: Cash flow vs Collateral Channel

A possible alternative interpretation of our results is that income gap is a noisy measure of the duration gap. The duration gap measures the difference of interest rate sensitivity between the *value* of assets and the *value* of liabilities (Mishkin & Eakins, 2009). Changes in interest rates may therefore affect the value of a bank's equity. Changes in the value of equity may in turn have an impact on how much future income a bank can pledge to its investors. For a bank with a positive duration gap, an increase in interest rates raises the value of equity and therefore its debt capacity: it can lend more. This alternative channel also relies on a failure of the Modigliani-Miller theorem for banks, but it does not go through cash flows; it goes through bank value. This is akin to a balance sheet channel, à la Bernanke-Gertler (1989), but for banks.

Directly measuring duration gap is difficult and would rely on strong assumptions about the duration of assets and liabilities. Instead, we rely on the fact that the effect of interest rates on bank value should be channeled via long-term interest rates. To see this, assume that there are two periods $t = 0, 1$. $t = 0$ corresponds to "today", while $t = 1$ is the "long term". Assets of face value A pay a coupon R_0 at date 0, and $1 + R_1$ at date 1. Liabilities –with face value L– costs a coupon r_0 at date 0, and $1 + r_1$ in the future. The value of this bank's equity is given by:

$$MVE = (AR_0 - Lr_0) + \frac{A(1 + ER_1) - L(1 + Er_1)}{1 + \rho} \tag{4}$$

where ρ is the long term interest rates, used to discount future cash flows. The income gap corresponds to the part of A and L that are linked to short term interest rates (when R_0 and r_0 are linked to the short rate). By definition, the duration gap is the semi-elasticity of MVE to changes in long-term interest rates ρ. While we cannot measure duration gap directly, we use the fact that duration affects value through changes in long-term interest rates.

We test for the presence of a balance-sheet channel in Table 8. In equation (3), we add interaction terms between income gap –as a proxy for duration gap– and five lags of long term interest rates (we take the yield on 10 year treasuries). The coefficients on these interaction terms are reported in the lower part of the top panel. In the bottom panel, we report the sum of these coefficients (the cumulative impact of interest rates) and their p-value. In this Table, we report results for interest income, market value of equity, and the two measures of lending growth. The sample contains all banks.

We find no evidence that long term interest rates affect bank cash flows, value or lending. If anything, the cumulative effect goes in the opposite direction to what would be expected if income gap was a proxy for duration gap. Estimates of the income gap effect are unaffected by the inclusion of the long rate interaction terms. This test seems to suggest that monetary policy affects bank lending via income gap induced cash flows shocks, much more than shocks to banks' collaterals. The power of test is however, limited by the fact that we do not directly measure the duration gap.

5.3. Expected vs Unexpected Movements in Interest Rates

In this Section, we focus on unexpected changes in short interest rates. A possible explanation for our results is that banks adapt their income gap in anticipation of short rate movements. Well-managed banks, who anticipate a rate increase, increase their income gap before monetary policy tightens. Then, their earnings increase mechanically; At the same time, their lending is less affected by a higher rate environment because they are better managed in a first place, not because their earnings are sustained. If however, the rate increase is unexpected, this possible explanation does not hold anymore. This is why we break down the effect of rate changes into an expected part and an unexpected part.

To measure expected rate changes, we use forward short rates obtained from the

Fama-Bliss data. For the short rate in t, we take as a measure of expected rate the forward interest rate demanded by the market at $t-2$, in order to lend between t and $t+1$. We then add, to regression (3), interaction terms between income gap and 5 lags of changes in expected short rates. We report regression results in Table 9 for two measures of cash-flows, and two measures of credit growth. The sample contains all banks.

We find that our results are mostly driven by the unexpected component of the short rate. When controlling for income gap interacted with expected change in the short rate, our estimate is unchanged. The cumulative impact of the short rate change, $\sum_{k=0}^{k=4} \alpha_k$, reported in the first line of the bottom panel of Table 9, remains unchanged compared to our previous estimates, and strongly statistically significant. The cumulative impact of the *expected* rate change, reported in the third line of the bottom panel, is much smaller in magnitude, and never statistically significant (the minimum p-value being .67).

This is unsurprising given the well documented failure of the expectation hypothesis (Fama and Bliss, 1987): even though they are the best forecast of future short rates, forward rates have very little predictive content. Consistently with the literature, in our data, the correlation between forward and effective short rates is .3 in levels (short rates are persistent), but only -0.01 in quarterly changes. Overall, if banks do not have much more information than the market, they have little ability to forecast future changes in the short rate, and therefore adapt their income gap to take advantage of this. Results from Table 9 confirm this in a regression framework.

6. Conclusion

First, this paper shows that banks retain significant exposure to interest rate risk. Our sample consists of quarterly data on US bank holding companies from 1986 to 2011. We measure interest-sensitivity of profit through income gap, which is the difference between assets and liabilities that mature in less than one year. The average income gap in our sample is 13.5% of total assets, but it exhibits significant cross-sectional variation. Income gap strongly predicts how bank profits will react to movements in interest rates.

Second, we find that bank exposure to interest rate risk has implications on the transmission of monetary policy. When the Federal Reserve increases short rates, this affects bank cash flows, and their lending policy. In other words, income gap explains the sensitivity of lending to interest rates. This variable has a stronger impact than previously identified factors, such as leverage, bank size or even asset liquidity. Furthermore, we find evidence consistent with the fact that the main channel is a cash-flow effect, not a collateral channel: Interest rates impact lending because they affect cash-flows, not because the affect the market value of equity.

Our results suggest that the allocation of interest rate exposure across agents (banks, households, firms, government) may explain how an economy responds to monetary policy. Looking at interest rate exposure helps to predict which agents are going to benefit, and which agents are going to suffer, from changes in short interest rates. Hence, monetary policy has strong redistributive effects. Provided economic agents face liquidity constraints, conventional monetary policy may affect real economic activity in a way that have received little attention so far.

7. References

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8. Tables

Table 1: Summary Statistics: Dependent and Control Variables

	mean	sd	p25	p75	count
Net interest income / assets	0.009	0.003	0.008	0.010	35799
Non interest income / assets	0.010	0.023	0.004	0.011	35829
Earnings / assets	0.002	0.005	0.002	0.003	35829
Market value of equity / assets	0.155	0.183	0.093	0.190	18390
Δ Interest	0.000	0.001	-0.000	0.000	33201
Δ Non-interest	0.002	0.005	0.001	0.004	31583
Δ Earnings	0.000	0.001	-0.000	0.000	32175
Δ Market Value	0.004	0.024	-0.008	0.016	17453
Δ log(C&I loans)	0.015	0.089	-0.028	0.054	33624
Δ log(total loans)	0.018	0.047	-0.006	0.038	33964
Log of assets	15.273	1.367	14.224	15.936	35829
Equity to assets ratio	0.087	0.042	0.069	0.097	35829
Fraction Liquid assets	0.224	0.124	0.139	0.284	26443

Note: Summary statistics are based on the quarterly Consolidated Financial Statements (Files FR Y-9C) between 1986 and 2010 restricted to US bank holding companies with total consolidated assets of $1Bil or more.

Table 2: Income Gap and Its Components

	mean	sd	p25	p75	count
Income Gap =	0.134	0.186	0.016	0.252	35545
Assets maturing/resetting < 1 year	0.437	0.149	0.343	0.532	35827
- Liabilities maturing/resetting < 1 year =	0.302	0.150	0.201	0.383	35545
Short Term Liabilities	0.291	0.151	0.189	0.371	35823
+ Variable Rate Long Term Debt	0.010	0.025	0.000	0.009	35698
+ Short Maturity Long Term Debt	0.001	0.006	0.000	0.000	35673
+ Prefered Stock	0.000	0.002	0.000	0.000	35561

Note: Summary statistics are based on the quarterly Consolidated Financial Statements (Files FR Y-9C) between 1986 and 2010 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 3: Summary Statistics: Derivatives Hedges of Interest Rate Risk

	mean	sd	p25	p75	count
Futures	0.027	0.172	0.000	0.000	24783
Forward Contracts	0.038	0.258	0.000	0.002	24799
Written Options (Exchange Traded)	0.010	0.080	0.000	0.000	24767
Purchased Options (Exchange Traded)	0.015	0.133	0.000	0.000	24765
Written Options (OTC)	0.030	0.187	0.000	0.002	24793
Purchased Options (OTC)	0.032	0.180	0.000	0.000	24818
Swaps	0.184	1.393	0.000	0.048	35351
At least some I.R. hedging	0.607	0.489	0.000	1.000	24762

Note: Summary statistics are based on Schedule HC-L of the quarterly Consolidated Financial Statements (Files FR Y-9C) between 2005 and 2010 restricted to US bank holding companies with total consolidated assets of $1Bil or more. Schedule HC-L is not available prior to 2005. The variables report notional amounts in each kind of derivatives at the bank holding-quarter level and are all scaled by total consolidated assets (bhck2170). Variables are defined as follows: Futures contracts = bhck8693/bhck2170; Forward contracts = bhck8697/bhck2170; Written options (exchange traded) = bhck8701/bhck2170; Purchased options (exchange traded) = bhck8705/bhck2170; written options (OTC) = bhck8709/bhck2170; Purchased options (OTC) = bhck8713/bhck2170; Swaps=bhck3450/bhck2170. HEDGED is a dummy equal to one if a bank has a positive notional amount in any of the seven types of interest hedging derivatives in a given quarter.

Table 4: Interest Rate Shocks and Interest Income

	ΔInterest$_{it}$					ΔNon Interest Income$_{it}$				
	All	Small	Big	No Hedge	Some Hedge	All	Small	Big	No Hedge	Some Hedge
$Gap_{it-1} \times \Delta FedFunds_t$	.018***	.018***	.016	.035***	.014	-.0083	-.0077	-.036	-.029	.013
	(3)	(2.9)	(.77)	(3.3)	(1.6)	(-.54)	(-.51)	(-.47)	(-1.4)	(.45)
$Gap_{it-1} \times \Delta FedFunds_{t-1}$	.039***	.039***	.027*	.031***	.047***	.04**	.042**	.11	.071***	.0066
	(6.3)	(5.9)	(1.7)	(3.1)	(4.9)	(2.4)	(2.5)	(1.5)	(3.1)	(.2)
$Gap_{it-1} \times \Delta FedFunds_{t-2}$	.0035	.0033	.02	.0077	-.00023	.0033	.0012	-.037	-.00013	.00046
	(.76)	(.67)	(1.5)	(.96)	(-.034)	(.24)	(.09)	(-.44)	(-.0062)	(.017)
$Gap_{it-1} \times \Delta FedFunds_{t-3}$	.0078	.005	.022	-.0057	.013*	-.013	-.02	.013	-.039	.028
	(1.6)	(1)	(1.5)	(-.64)	(1.9)	(-.99)	(-1.5)	(.23)	(-1.5)	(1.3)
$Gap_{it-1} \times \Delta FedFunds_{t-4}$	-.0083*	-.0075	-.023	.0032	-.021***	-.031**	-.018	-.087	-.0028	-.075**
	(-1.8)	(-1.6)	(-1.5)	(.43)	(-3.2)	(-2)	(-1.3)	(-1.1)	(-.16)	(-2.3)
N	28588	24931	3657	8237	12770	22671	20993	1678	7704	8699
r2	.11	.11	.12	.13	.094	.91	.91	.91	.9	.89
Sum of gap coefficients	.05	.05	.06	.07	.05	0	0	-.03	0	-.02
p-value of gap coefficients	0	0	0	0	0	.58	.85	.69	.96	.32
p-value of equality test		.83		.19			.71		.44	
Sum of size coefficients	0	0	0	0	0	0	0	-.02	0	0
p-value of size coefficients	0	0	.23	.63	0	.25	.66	.17	.61	.22
Sum of equity coefficients	0	-.01	.02	0	.05	.14	.07	.48	-.04	.4
p-value of equity coefficients	.88	.83	.88	.92	.09	.2	.5	.2	.76	.05

Note: All variables are defined in the text. All items are normalized by total assets laggedt by 1 quarter. Columns (1)-(5) use, as a dependent variable, the quarterly change in interest income divided by lagged total assets (Interest$_{it}$-Interest$_{it-1}$)/(Assets$_{it-1}$). Columns (6)-(10) use change in *non* interest income normalized by lagged assets. Columns(1) and (6) report estimates for the entire sample; columns (2-3) and (6-7) break down the sample into small and big banks. Columns (4-5) and (9-10) break down the sample into banks for which gross interest rate derivative position are positive, or equal to zero. All regressions is the same set of right-hand-side variables. The coefficients of interest are interaction terms between income gap (lagged by one quarter), contemporaneous change in Fed fund rate, as well as four lags of interest rate change. We report these five coefficient in the Table. Following Kashyap and Stein (2000), we further include as controls: four lags of the dependent variable, calendar time dummies, as well as $gap_{it-1}\times$ trend, $log(assets_{it-1})$, book equity$_{it-1}$)/assets$_{it-1}$), as well as their interaction with contemporaneous and four lags for change in interest rates. Error terms are clustered at the bank level. The bottom panel reports the sum of coefficients for rate changes interacted with: bank size and bank equity. These should be interpreted as the differential cumulative effect of interest rates. Below each of these sums, we report the p-value of a test of significance. Below these tests, we report a test of equality of these sums across subsamples (big vs small banks, hedged vs unhedged banks. These equality tests use the SURE procedure to nest the two equations in a single model.

Table 5: Earnings and Market Value

	$\Delta Earnings_{it}$					$\Delta MarketValue_{it}$				
	All	Small	Big	No Hedge	Some Hedge	All	Small	Big	No Hedge	Some Hedge
$Gap_{it-1} \times \Delta FedFunds_t$	.031***	.031***	.071*	.041***	.038**	.68**	.76**	.57	1.4***	.78*
	(3.6)	(3.5)	(1.7)	(2.8)	(2.4)	(2.1)	(2.2)	(.57)	(2.6)	(1.8)
$Gap_{it-1} \times \Delta FedFunds_{t-1}$	.032***	.035***	-.015	.051***	.028*	.46	.41	1	.71	.74*
	(3.2)	(3.4)	(-.41)	(2.7)	(1.8)	(1.5)	(1.2)	(1.1)	(1.1)	(1.7)
$Gap_{it-1} \times \Delta FedFunds_{t-2}$	.0022	.0042	-.029	-.018	.019	.18	.18	-.23	.65	-.062
	(.25)	(.45)	(-1.1)	(-1.1)	(1.4)	(.59)	(.55)	(-.28)	(1.1)	(-.14)
$Gap_{it-1} \times \Delta FedFunds_{t-3}$	.011	.0079	.045	.017	.0093	.16	.094	.27	-.9*	.9**
	(1.3)	(.91)	(1.4)	(.97)	(.67)	(.56)	(.32)	(.24)	(-1.7)	(2.5)
$Gap_{it-1} \times \Delta FedFunds_{t-4}$	.0017	.0014	.019	.013	-.012	.27	.31	.18	.82*	-.33
	(.21)	(.16)	(.61)	(.83)	(-.87)	(1.3)	(1.4)	(.2)	(1.8)	(-.97)
N	26992	23453	3539	7856	11975	15556	13372	2184	4684	7931
r2	.21	.22	.25	.24	.22	.33	.33	.43	.34	.35
Sum of gap coefficients	.07	.07	.09	.1	.08	1.8	1.8	1.8	2.6	2
p-value of gap coefficients	0	0	.01	0	0	0	0	.04	0	0
p-value of equality test		.74		.36			.94		.37	
Sum of size coefficients	0	0	0	0	0	.04	-.03	.03	0	.08
p-value of size coefficients	0	0	.94	.48	.05	.12	.53	.72	.94	.02
Sum of equity coefficients	.15	.17	.16	-.03	.27	3.8	4	4	4.8	4.4
p-value of equity coefficients	.17	.13	.57	.75	.18	.17	.2	.51	.38	.15

Note: All variables are defined in the text. All items are normalized by total assets laggedt by 1 quarter. Columns (1)-(5) use, as a dependent variable, the quarterly change in Earnings divided by lagged total assets (Earnings$_{it}$-Earnings$_{it-1}$)/(Assets$_{it-1}$). Columns (6)-(10) use change in *non* market value of equity normalised by lagged assets. Columns(1) and (6) report estimates for the entire sample; columns (2-3) and (6-7) break down the sample into small and big banks. Columns (4-5) and (9-10) break down the sample into banks for which gross interest rate derivative position are positive, or equal to zero. All regressions is the same set of right-hand-side variables. The coefficients of interest are interaction terms between income gap (lagged by one quarter), contemporaneous change in Fed fund rate, as well as four lags of interest rate change. We report these five coefficient in the Table. Following Kashyap and Stein (2000), we further include as controls: four lags of the dependent variable, calendar time dummies, as well as $gap_{it-1}\times$ trend, $log(assets_{it-1})$, book equity$_{it-1}$)/assets$_{it-1}$), as well as their interaction with contemporaneous and four lags for change in interest rates. Error terms are clustered at the bank level. The bottom panel reports the sum of coefficients for rate changes interacted with: bank size and bank equity. These should be interpreted as the differential cumulative effect of interest rates. Below each of these sums, we report the p-value of a test of significance. Below these tests, we report a test of equality of these sums across subsamples (big vs small banks, hedged vs unhedged banks. These equality tests use the SURE procedure to nest the two equations in a single model.

Table 6: Interest Rate Shocks and Lending: Size and equity ratio interacted control

	Δlog(C&I)					Δlog(Total Loans)				
	All	Small	Big	No Hedge	Some Hedge	All	Small	Big	No Hedge	Some Hedge
$Gap_{it-1} \times \Delta FedFunds_t$	.013	.18	-2	.036	-.58	-.42	-.5	1.2	-.34	-.05
	(.02)	(.25)	(-.99)	(.03)	(-.56)	(-1.2)	(-1.4)	(.67)	(-.61)	(-.095)
$Gap_{it-1} \times \Delta FedFunds_{t-1}$	.82	.72	2.6*	.7	1.1	.67**	.82**	-.45	1.4**	.24
	(1.2)	(.96)	(1.7)	(.55)	(1)	(2)	(2.4)	(-.3)	(2.6)	(.45)
$Gap_{it-1} \times \Delta FedFunds_{t-2}$	1.1	1.1	.92	.2	.66	.6*	.74**	-1.4	.41	.17
	(1.6)	(1.4)	(.53)	(.14)	(.7)	(1.8)	(2.1)	(-1.1)	(.89)	(.29)
$Gap_{it-1} \times \Delta FedFunds_{t-3}$	1.4**	1.3*	1.5	3.3**	1.9**	.61*	.72**	-.3	1.2**	.81
	(2)	(1.7)	(.73)	(2)	(2.2)	(1.9)	(2.3)	(-.16)	(2.4)	(1.5)
$Gap_{it-1} \times \Delta FedFunds_{t-4}$	-1.3**	-1.2*	-1.6	-1.7	-2.4***	-.023	-.36	2.6*	-.73	.36
	(-2.1)	(-1.8)	(-.77)	(-1.2)	(-2.6)	(-.073)	(-1.1)	(1.7)	(-1.5)	(.74)
N	29614	25577	4037	8440	12994	29274	25505	3769	8364	12706
r2	.097	.095	.17	.081	.12	.2	.22	.14	.23	.2
Sum of gap coefficients	2	2	1.4	2.6	.72	1.4	1.4	1.7	1.9	1.5
p-value of gap coefficients	0	0	.58	.03	.5	0	0	.23	0	0
p-value of equality test		.79		.25			.85		.62	
Sum of size coefficients	.23	.19	.96	.15	.29	0	.02	.36	-.18	.07
p-value of size coefficients	0	.2	0	.74	.01	.95	.76	.09	.34	.23
Sum of equity coefficients	-12	-12	-12	2.6	-22	-4.7	-4.9	-1.4	-4.3	-9.1
p-value of equity coefficients	.05	.07	.52	.76	0	.23	.24	.88	.09	.04

Note: All variables are defined in the text. Columns (1)-(5) use, as a dependent variable, the quarterly change in log commercial & industrial loans. Columns (6)-(10) use change in *non* log total loans. Columns(1) and (6) report estimates for the entire sample; columns (2-3) and (6-7) break down the sample into small and big banks. Columns (4-5) and (9-10) break down the sample into banks for which gross interest rate derivative position are positive, or equal to zero. All regressions is the same set of right-hand-side variables. The coefficients of interest are interaction terms between income gap (lagged by one quarter), contemporaneous change in Fed fund rate, as well as four lags of interest rate change. We report these five coefficient in the Table. Following Kashyap and Stein (2000), we further include as controls: four lags of the dependent variable, calendar time dummies, as well as $gap_{it-1}\times$ trend, $log(assets_{it-1})$, book equity$_{it-1}$)/assets$_{it-1}$), as well as their interaction with contemporaneous and four lags for change in interest rates. Error terms are clustered at the bank level. The bottom panel reports the sum of coefficients for rate changes interacted with: bank size and bank equity. These should be interpreted as the differential cumulative effect of interest rates. Below each of these sums, we report the p-value of a test of significance. Below these tests, we report a test of equality of these sums across subsamples (big vs small banks, hedged vs unhedged banks. These equality tests use the SURE procedure to nest the two equations in a single model.

Table 7: Robustness: Controlling for Liquidity

	Δlog(C&I)					Δlog(Total Loans)				
	All	Small	Big	No Hedge	Some Hedge	All	Small	Big	No Hedge	Some Hedge
$Gap_{it-1} \times \Delta FedFunds_t$	.063	.43	-5.2**	.79	-.89	-.052	-.19	2.4	.1	.071
	(.083)	(.53)	(-2)	(.64)	(-.85)	(-.13)	(-.5)	(.99)	(.18)	(.13)
$Gap_{it-1} \times \Delta FedFunds_{t-1}$	.58	.39	3.8*	.023	1.3	.37	.57	-.74	1.1**	.3
	(.73)	(.46)	(1.7)	(.019)	(1.2)	(.97)	(1.4)	(-.43)	(2)	(.56)
$Gap_{it-1} \times \Delta FedFunds_{t-2}$	.7	.63	2.5	.44	.35	.52	.68*	-1.8	.32	.1
	(.87)	(.74)	(1.1)	(.32)	(.35)	(1.4)	(1.7)	(-1.1)	(.7)	(.18)
$Gap_{it-1} \times \Delta FedFunds_{t-3}$	2.6***	2.4***	2.7	2.8*	1.9**	.67*	.78**	-1.4	.89*	.6
	(3.2)	(2.8)	(1.4)	(1.7)	(2.3)	(1.8)	(2.1)	(-.67)	(1.7)	(1.2)
$Gap_{it-1} \times \Delta FedFunds_{t-4}$	-2.2***	-2.1**	-3.8	-1.6	-2.5***	-.029	-.46	4.1*	-.47	.37
	(-2.9)	(-2.5)	(-1.4)	(-1.1)	(-2.7)	(-.084)	(-1.4)	(1.9)	(-.95)	(.79)
N	22784	19966	2818	8440	12991	22423	19794	2629	8364	12703
r2	.094	.091	.19	.082	.12	.2	.22	.14	.23	.2
Sum of gap coefficients	1.7	1.8	.05	2.5	.25	1.5	1.4	2.5	1.9	1.4
p-value of gap coefficients	.03	.03	.98	.05	.82	0	0	.17	0	0
p-value of equality test		.6		.19			.55		.56	
Sum of size coefficients	.39	.36	1.2	.14	.26	.04	.04	.49	-.19	.06
p-value of size coefficients	0	.03	0	.75	.02	.44	.58	.04	.3	.29
Sum of equity coefficients	-12	-10	-21	3	-22	-3.1	-2.8	-2.8	-4	-8.7
p-value of equity coefficients	.1	.16	.27	.73	0	.4	.49	.7	.11	.04
Sum of liquidity coefficients	-2.1	-1.6	-3.7	-.34	-4.4	-.75	-.9	.01	-.15	-.78
p-value of liquidity coefficients	.15	.29	.34	.87	.03	.27	.21	.99	.88	.38

Note: All variables are defined in the text. Columns (1)-(5) use, as a dependent variable, the quarterly change in log commercial & industrial loans. Columns (6)-(10) use change in *non* log total loans. Columns(1) and (6) report estimates for the entire sample; columns (2-3) and (6-7) break down the sample into small and big banks. Columns (4-5) and (9-10) break down the sample into banks for which gross interest rate derivative position are positive, or equal to zero. All regressions is the same set of right-hand-side variables. The coefficients of interest are interaction terms between income gap (lagged by one quarter), contemporaneous change in Fed fund rate, as well as four lags of interest rate change. We report these five coefficient in the Table. Following Kashyap and Stein (2000), we further include as controls: four lags of the dependent variable, calendar time dummies, as well as $gap_{it-1}\times$ trend, $log(assets_{it-1})$, book equity$_{it-1}$)/assets$_{it-1}$), liquid assets$_{it-1}$)/assets$_{it-1}$) as well as their interaction with contemporaneous and four lags for change in interest rates. Error terms are clustered at the bank level. The bottom panel reports the sum of coefficients for rate changes interacted with: bank size, bank equity, and bank liquidity. These should be interpreted as the differential cumulative effect of interest rates. Below each of these sums, we report the p-value of a test of significance. Below these tests, we report a test of equality of these sums across subsamples (big vs small banks, hedged vs unhedged banks. These equality tests use the SURE procedure to nest the two equations in a single model.

Table 8: Short rate vs Long-Short Rates

	ΔInterest Income	ΔMarket Value	Δlog(C&I)	Δlog(Total Loans)
$Gap_{it-1} \times \Delta FedFunds_t$	.02***	.67*	.058	.09
	(2.9)	(1.8)	(.071)	(.22)
$Gap_{it-1} \times \Delta FedFunds_{t-1}$	.037***	.59*	.54	.68*
	(5.8)	(1.7)	(.69)	(1.9)
$Gap_{it-1} \times \Delta FedFunds_{t-2}$	.0025	.42	.59	.67
	(.49)	(1.2)	(.72)	(1.6)
$Gap_{it-1} \times \Delta FedFunds_{t-3}$	.008	.29	1.6**	.44
	(1.4)	(.86)	(2.1)	(1.2)
$Gap_{it-1} \times \Delta FedFunds_{t-4}$	-.008*	.085	-1	-.11
	(-1.7)	(.34)	(-1.4)	(-.31)
$Gap_{it-1} \times \Delta 10years_t$	-.00046	.051	-.11	-.95***
	(-.1)	(.2)	(-.17)	(-2.8)
$Gap_{it-1} \times \Delta 10years_{t-1}$	-.0039	-.026	.34	-.53
	(-.79)	(-.094)	(.5)	(-1.3)
$Gap_{it-1} \times \Delta 10years_{t-2}$	.0042	-.32	.65	-.54
	(.96)	(-1.2)	(.97)	(-1.5)
$Gap_{it-1} \times \Delta 10years_{t-3}$	-.0026	-.48*	.64	-.28
	(-.58)	(-1.8)	(.95)	(-.77)
$Gap_{it-1} \times \Delta 10years_{t-4}$	.0023	-.32	-.3	.41
	(.5)	(-1.3)	(-.48)	(1.2)
N	28588	15556	29614	29274
r2	.11	.33	.098	.21
Sum of coefficients: Fed Funds	.05	2	1.8	1.8
p-value	0	0	.05	0
Sum of coefficients: long rate	0	-1.1	1.2	-1.9
p-value	.96	.14	.52	.08

Note: All variables are defined in the text. Dependent variables are: quarterly change in interest income normalized by total assets (column 1), quarterly change in market value of equity (column 2), quarterly change in log C&I loans (column 3), and quarterly change in log total loans (column 4). All regressions use the same set of right-hand-side variables. The coefficients of interest are interaction terms between income gap (lagged by one quarter) and five lags of short rate change, and interactions between income gap and five lags of long rate (the spread on the 10 year treasury bond) changes. We report these $2 \times 5 = 10$ coefficients in the Table. Following Kashyap and Stein (2000), we further include as controls: four lags of the dependent variable, calendar time dummies, as well as $gap_{it-1}\times$ trend, $log(assets_{it-1})$, book equity$_{it-1}$)/assets$_{it-1}$), as well as their interaction with the five lags of long and short rate changes. Error terms are clustered at the bank level. The bottom panel of the Table reports the sum of coefficients for interaction of gap with short (first line) and long rate (third line). p-values of significance tests for these sums are reported below their values.

Table 9: Realized vs Rates and Expected Rates

	ΔInterest Income	ΔEarnings	Δlog(C&I)	Δlog(Total Loans)
$Gap_{it-1} \times \Delta FedFunds_t$	.018***	.035***	.054	-.41
	(2.8)	(3.8)	(.08)	(-1.1)
$Gap_{it-1} \times \Delta FedFunds_{t-1}$	.038***	.03***	.66	.62*
	(6.2)	(3)	(.91)	(1.8)
$Gap_{it-1} \times \Delta FedFunds_{t-2}$	.003	.0025	1.1	.59*
	(.63)	(.28)	(1.6)	(1.8)
$Gap_{it-1} \times \Delta FedFunds_{t-3}$	.0074	.0096	1.3*	.53
	(1.5)	(1.1)	(1.8)	(1.6)
$Gap_{it-1} \times \Delta FedFunds_{t-4}$	-.0084*	.0014	-1.3*	-.017
	(-1.8)	(.17)	(-1.9)	(-.052)
$Gap_{it-1} \times \Delta ExpectedFF_t$	.00062	.0017	.4	.27
	(.21)	(.37)	(1)	(1.3)
$Gap_{it-1} \times \Delta ExpectedFF_{t-1}$	-.00048	-.00036	-.18	-.21
	(-.18)	(-.079)	(-.43)	(-1.1)
$Gap_{it-1} \times \Delta ExpectedFF_{t-2}$	-.0013	.011***	-.32	-.18
	(-.46)	(2.7)	(-.76)	(-.85)
$Gap_{it-1} \times \Delta ExpectedFF_{t-3}$	-.00088	-.007	-.52	-.12
	(-.33)	(-1.5)	(-1.3)	(-.6)
$Gap_{it-1} \times \Delta ExpectedFF_{t-4}$	-.0012	-.00098	.33	.092
	(-.41)	(-.21)	(.83)	(.43)
N	28588	26992	29614	29274
r2	.11	.22	.099	.21
Sum of coefficients: Fed Funds	.05	.07	1.8	1.3
p-value	0	0	.02	0
Sum of coefficients: forward rate	0	0	-.29	-.13
p-value	.68	.67	.79	.8

Note: All variables are defined in the text. Dependent variables are: quarterly change in interest income normalized by total assets (column 1), quarterly change in market value of equity (column 2), quarterly change in log C&I loans (column 3), and quarterly change in log total loans (column 4). All regressions use the same set of right-hand-side variables. The coefficients of interest are interaction terms between income gap (lagged by one quarter) and five lags of short rate change, and interactions between income gap and five lags of forward rate changes. The forward rate in quarter t is defined as the forward rate taken at $t-8$, for loans between t and $t+4$ and measures the expected 1 year rate in t, as predicted by the market 2 years before quarter t. We report these $2 \times 5 = 10$ coefficients in the Table. Following Kashyap and Stein (2000), we further include as controls: four lags of the dependent variable, calendar time dummies, as well as $gap_{it-1}\times$ trend, $log(assets_{it-1})$, book equity$_{it-1}$)/assets$_{it-1}$), as well as their interaction with the five lags of short and forward rate changes. Error terms are clustered at the bank level. The bottom panel of the Table reports the sum of coefficients for interaction of gap with short (first line) and

A. Variable Definitions

This Section describes the construction of all variables in detail. i is an index for the bank, t for the quarter.

A.1. Bank-level Variables

This Section gathers the variables constructed using the Consolidated Financial Statements of Bank Holding Comanies (form FR Y-9C). Note that flow variables (interest and non-interest income, earnings) are defined each quarter "year to date". Hence, each time we refer to a flow variable, we mean the *quarterly*, not year-to-date, flow. To transform a year-to-date variable into a quarterly one, we take the variable as it is for the first quarter of each year. For each quarter $q = 2, 3, 4$, we take the difference in the year-to-date variable between q and $q - 1$.

- Δ**Interest**$_{it}$: Change in interest income = [interest income (bhck4107) at t + interest expense (bhck4073) at $t - 1$ - interest income (bhck4107) at $t - 1$ - interest expense (bhck4073) at t] / (total assets (bhck2170) taken in $t - 1$]. Note that bhck4073 and bhck4107 have to be converted from year-to-date to quarterly as explained above.

- Δ**Non Interest**$_{it}$: Change in non interest income = [non interest income (bhck4079) at t - non interest income (bhck4079) at $t - 1$] / (total assets (bhck2170) taken in $t - 1$]. Note that bhck4079 has to be converted from year-to-date to quarterly as explained above.

- Δ**Earnings**$_{it}$: Change in earnings = [earnings (bhck4340) at t - earnings (bhck4340) at $t - 1$] / (total assets (bhck2170) taken in $t - 1$]. Note that bhck4340 has to be converted from year-to-date to quarterly as explained above.

- **ΔValue$_{it}$**: Change in interest income = [Equity market value at t - Equity market value at $t-1$] / (total assets (bhck2170) taken in $t-1$]. Equity market value is obtained for publicly listed banks after matching with stock prices from CRSP. It is equal to the number of shares outstanding (shrout) $\times$ the end-of-quarter closing price (absolute value of prc).

- **Δlog(C&I loans$_{it}$)**: commercial and industrial loan growth = log[C&I loans to US adressees (bhck1763) at t + C&I loans to foreign adressees (bhck1764) at t] - log[C&I loans to US adressees (bhck1763) at $t-1$ + C&I loans to foreign adressees (bhck1764) at $t-1$].

- **Δlog(Total loans$_{it}$)**: Total loan growth = log [Total loans (bhck2122) at t] - log[Total loans (bhck2122) at $t-1$].

- **ΔEarnings$_{it}$**: Change in earnings = [earnings (bhck4340) at t - earnings (bhck4340) at $t-1$] / (total assets (bhck2170) taken in $t-1$]. Note that bhck4340 has to be converted from year-to-date to quarterly as explained above.

- **Gap$_{it-1}$**: Income gap = [assets that reprice or mature within one year (bhck31970) - interest bearing deposits that reprice or mature whithin one year (bhck3296) - long term debt that reprices within one year (bhck3298) - long term debt that matures within one year (bhck3409) - variable rate preferred stock (bhck3408)] / total assets (bhck2170)

- **Equity$_{it-1}$**: Equity ratio = 1 - [total liabilities (bhck2948) / total assets (bhck2170)]

- **Size$_{it-1}$**: log (total assets (bhck2170))

- **Liquidity**$_{it-1}$: Liquidity ratio = [Available for sale securities (bhck1773)+ Held to Maturity Securities (bhck1754)] / total assets (bhck2170)

A.2. Times series Variables

This Section gathers different measures of interest rates used in the paper.

- Δ**Fed Funds**$_t$: First difference between "effective federal funds" rate at t and $t-1$. Fed funds rates are available monthly from the Federal Reserve's website: each quarter, we take the observation corresponding to the last month.

- Δ**10yrs**$_t$: First difference between yields of 10 year treasury securities at t and $t-1$, available from the Federal Reserve's website.

- Δ**Expected FF**$_t$: Change in past "expected" 1 year interest rate between $t-1$ and t. Expected 1 year rate at t is obtained from the forward rate taken at $t-8$ (two years ago), for a loan between t and $t+3$ (for the coming year). This forward rate is computed using the Fama-Bliss discount bond prices. At date $t-8$, we take the ratio of the price of the 2-year to the 3-year zero-coupon bond, minus 1.

B. Time-Series Regressions

We provide here estimates using an alternative specification also used in the literature (Kashyap and Stein, 2000, Campello, 2002).

B.1. Methodology

We proceed in two steps. First, we run, *separately for each quarter*, the following regression:

$$X_{it} = \gamma_t gap_{it-1} + controls_{it} + \epsilon_{it} \tag{5}$$

where X_{it} is a cash flow or lending LHS variable.$controls_{it}$ include: $X_{it-1}, ..., X_{it-4}$, $log(assets_{it-1})$, $\frac{equity_{it-1}}{assets_{it-1}}$. From this first step, we obtain a time-series of X to gap sensitivity γ_t.

In our second step, we regress γ_t on change in fed funds rate and four lags of it, as well as four quarter dummies:

$$\gamma_t = \sum_{k=0}^{k=4} \alpha_k.\Delta fedfunds_{t-k} + quarterdummies_t + \epsilon_{it} \tag{6}$$

Again, we expect that $\sum_{k=0}^{k=4} \alpha_k > 0$: in periods where interest rates increase, high income gap firms tend to make more profits, or lend more.

We report the results using the new methodology in Tables B.1, B.2 and **??**. Results are a little bit weaker using this approach, but have the same order of magnitude. Results on profits and cash flows are still all significant at the 1% level of significance, and have the same order of magnitude. Results on lending, controlling for size and leverage, but not for liquidity, remain significant at the 1 or 5% level for total lending growth. They become a bit weaker, albeit still significant at the 5% level for the whole sample, for C&I loans. Controlling for liquidity reduces the sample to 1994-2011 (BHC data do not report liquidity holdings before 1994), so it reduces the sample size by a third. Significance weakens, but income gap effects on total lending remains statistically significant at the 5% level for the whole sample and small firms, as well as firms with some interest rate derivative exposure. This alternative estimation procedure provides estimates with very similar orders of magnitude.

B.2. Results

Table B.1: Time Series Approach: Profits

	$\Delta Interest_{it}$					$\Delta Earnings_{it}$				
	All	Small	Big	No Hedge	Some Hedge	All	Small	Big	No Hedge	Some Hedge
$\Delta FedFunds_t$	.016**	.018**	.0026	.0069	.037***	.032***	.031***	.04*	.059***	.038**
	(2.3)	(2.3)	(.2)	(.77)	(3)	(3.4)	(3)	(2)	(4.2)	(2.3)
$\Delta fedfunds_{t-1}$	.029***	.025***	.044***	.037***	.012	.029***	.035***	.0043	.014	.048***
	(3.8)	(3)	(3.1)	(4)	(.86)	(2.8)	(3)	(.19)	(.96)	(2.7)
$\Delta fedfunds_{t-2}$	.0055	.0062	.0013	.0011	.014	-.017*	-.011	-.04*	.00013	-.03*
	(.74)	(.75)	(.097)	(.12)	(1)	(-1.7)	(-1)	(-1.8)	(.009)	(-1.8)
$\Delta fedfunds_{t-3}$	.0095	.0021	.023*	.011	-.012	.019**	.0094	.054***	.0083	.018
	(1.4)	(.27)	(1.8)	(1.2)	(-.92)	(2)	(.91)	(2.7)	(.57)	(1.1)
$\Delta fedfunds_{t-4}$	-.008	-.003	-.017	-.018**	.0027	.0086	.0062	.029	.011	.015
	(-1.3)	(-.43)	(-1.5)	(-2.1)	(.22)	(1)	(.66)	(1.6)	(.81)	(.93)
N	93	93	93	63	63	93	93	93	63	63
ar2										
Sum of coefficients	.05	.04	.05	.03	.05	.07	.07	.08	.09	.08
p-value	0	0	0	0	0	0	0	0	0	0

In columns 1-5, we use change in interest income (divided by assets) as the dependent variable. In columns 6-10, we focus on change in Net Income (divided by book equity). All results come from a two-step procedure. First, for each quarter from 1986 to 2011, we regress the depend variable on four lags of itself, $log(assets_{it-1})$ and the income gap gap_{it-1}. We obtain a time series of coefficients on gap_{it-1}, called $\gamma_{\Delta X}$ where ΔX is the relevant dependent variable. We then regress $\gamma_{\Delta X}$ on $\Delta fedfunds_{t-k}$ for all $k = 0, 1, 2, 3, 4$ and four quarter dummies.

Table B.2: Time Series Approach: Lending Growth with Size, Equity controls

	Δlog(C&I loans)					Δlog(Total loans)				
	All	Small	Big	No Hedge	Some Hedge	All	Small	Big	No Hedge	Some Hedge
$\Delta FedFunds_t$	.57	1.1	-1.6	-.25	1.8	-.06	-.3	.053	.23	.07
	(.61)	(1.1)	(-.94)	(-.23)	(.98)	(-.13)	(-.61)	(.053)	(.35)	(.085)
$\Delta fedfunds_{t-1}$	.76	.4	2.1	.18	.32	.18	.03	.84	.039	1.2
	(.72)	(.35)	(1.2)	(.16)	(.16)	(.34)	(.055)	(.74)	(.056)	(1.4)
$\Delta fedfunds_{t-2}$	.77	.53	-.54	.71	-.95	.69	1.3**	-.85	-.29	.65
	(.76)	(.49)	(-.3)	(.63)	(-.49)	(1.4)	(2.5)	(-.79)	(-.42)	(.75)
$\Delta fedfunds_{t-3}$	.94	.98	.56	2.3*	2.9	.37	.18	-.014	.6	.73
	(.98)	(.96)	(.33)	(2)	(1.5)	(.78)	(.36)	(-.014)	(.88)	(.86)
$\Delta fedfunds_{t-4}$	-1	-.51	-1.1	-2.5**	-1.3	.15	.083	1.1	.8	-.46
	(-1.2)	(-.56)	(-.73)	(-2.3)	(-.71)	(.34)	(.19)	(1.2)	(1.3)	(-.57)
N	93	93	93	63	63	93	93	93	63	63
ar2										
Sum of coefficients	2	2.5	-.5	.44	2.8	1.3	1.3	1.1	1.4	2.2
p-value	.04	.02	.77	.69	.15	0	.01	.3	.04	.01

In columns 1-5, we use growth of C&I loans as the dependent variable. In columns 6-10, we focus on total loans growth. All results come from a two-step procedure. First, for each quarter from 1986 to 2011, we regress the depend variable on four lags of itself, $log(assets_{it-1})$, $\frac{equity_{it-1}}{assets_{it-1}}$, and the income gap gap_{it-1}. We obtain a time series of coefficients on gap_{it-1}, called $\gamma_{\Delta X}$ where ΔX is the relevant dependent variable. We then regress $\gamma_{\Delta X}$ on $\Delta fedfunds_{t-k}$ for all $k = 0, 1, 2, 3, 4$ and four quarter dummies.