Modelling demand deposits and interest rate risk sharing: Lessons from the Mexican banking regulation[*]

Mariela Dal Borgo[‡]

October 12, 2018

Abstract

Mexican banks face capital requirements for interest rate risk in the banking book based on the size of the maturity gap between assets and liabilities. In that context, this study investigates the use of an internal model that allows to lengthen the maturity of demand deposits under certain conditions. I find that banks with stable deposits and higher holdings of long-term, fixed rate assets are more likely to adopt such a model. Those banks face a higher maturity mismatch if the liability maturity is underestimated. Using micro data on commercial loans, mortgages and securities, I do not find that banks increase their repricing maturity after adopting the internal model. In turn, detailed derivative data shows no reduction in banks' use of interest rates swaps thereafter. These results imply that banks adopt the internal model to reduce the regulatory maturity gap, with the purpose to save on capital requirements. The incentives to reduce that gap could have unintended real consequences if they also result in lower asset repricing maturity.

KEYWORDS: maturity gap, interest rate risk, banks, regulatory capital, demand deposits, repricing maturity

JEL codes: E43, G21, G28

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[*]For insightful discussions, I thank Juan Fernando Ávila Embriz, Charles Calomiris, Sebastián Di Tella, Jorge Luis García Ramírez, Juan Pablo Graf Noriega, Fabrizio López Gallo Dey and Lorenzo Menna. I also thank seminar participants at the Bank of Mexico (Financial Stability), the ASBA/World Bank Research Conference, the Halle Institute for Economic Research, the Deutsche Bundesbank, the Bank of Italy and the Annual Meeting of the Latin American and Caribbean Economic Association. I am grateful to Miguel Ángel Portilla Lozano for excellent research assistance and to Jorge Gutiérrez Barajas and Roberto Toledo Cuevas for support with the data. Gabriela Gaona Cruz and several bank officers provided valuable insights regarding institutional details surrounding the adoption of the internal models by Mexican banks.

[†]*Email address:* mariela.dalborgo@banxico.org.mx

[‡]*Mailing address:* Bank of Mexico, Directorate of Financial Stability, Av. 5 de Mayo 1, Centro 06059, Cuauhtémoc, Ciudad de México, México. Tel: +52 55 5237 2000.

1 Introduction

Banks' exposure to interest rate risk can lead to large volatility in earnings and in the economic value of capital. The regulatory treatment of interest rate risk in the banking book is part of a Pillar 2 approach, which implies no capital requirements. Sucessive revisions of the Basel guidelines have considered imposing a direct capital charge, making it Pillar 1: *"The Committee remains convinced that interest rate risk in the banking book is a potentially significant risk which merits support from capital"*, *"[A Pillar 1 framework] would have the advantage of promoting market confidence in banks' capital adequacy and a level playing field internationally"* (Basel Committee on Banking Supervision 2006, 2015). Regulators measure risk exposure by the maturity gap between assets and liabilities. In the presence of a capital charge based on the size of that gap, banks could have incentives either to increase the liability maturity or to reduce the asset maturity, with potential real consequences. The Mexican regulatory framework provides an ideal setting to address these issues. It imposes capital requirements on all assets and liabilities subject to interest rate risk, including those in the banking book such as loans and deposits.[1] It follows the Basel II capitalization requirements for market risk, with higher risk weights than in the Basel framework. On average 25% of total capital requirements correspond to market risk.

In that context, the first goal of this paper is to understand what factors drive the adoption of an internal model (IM) to measure the maturity of demand deposits, also known as non-maturity deposits (NMDs), one of banks' main sources of funding.[2] The complexity to measure their maturity comes from two optionalities. First, even though depositors can withdraw the funds at any time, in practice they are very sticky. Second, banks can adjust the deposit rate in response to changes in the market rate, affecting retained volumes. Under a standardized approach (SA), the maximum maturity that banks can assume for these deposits is of 2 years. Alternatively, Basel II allows banks to measure their maturity using a more accurate IM. Under certain conditions, such model allows to extend the maturity of deposits further - up to 15 years in some cases. By the end of the sample period ten banks have adopted an IM, not returning to the SA. I find that those banks have more stable deposits and a higher share of fixed-rate, long-

[1] Only market risk in the trading book is part of Pillar 1. Since Mexican banks do not distinguish between the trading and banking books, every exposure, including positions in the banking book, is subject to market risk capital requirements. Some countries, such as Chile and Venezuela, do not even impose those capital requirements to positions in the trading book. United States only imposes a market risk capital rule to institutions with substantial trading activities.

[2] Note that Mexican banks cannot adopt an internal model to estimate the weight coefficients for market risk.

term assets, which result in a higher asset and liability maturity. Therefore, their regulatory maturity gap is larger if their actual liability maturity is underestimated under the SA.

The second goal is to understand whether the asset maturity profile changes after a bank adopts the IM. Banks could transfer less interest rate risk to firms and households by granting fixed rate loans of longer maturity, and still maintain the same regulatory maturity gap as under the SA. Using comprehensive micro data on different types of loans and securities for more than seven years, I find that banks generally do not extend their repricing maturity after accounting for a longer deposits' maturity, conditional on their stability and sensitivity. This is consistent with a reduction in the regulatory maturity gap being the main driver for the adoption of the IM.

I start by documenting some stylized facts. Banks that rely more on deposits to hedge assets are more likely to adopt the IM. They adopt it when the 2-year cap imposed by the SA becomes too short for a given asset maturity profile. In other words, those banks were exhausting the limit allowed into the 2-year band. Banks that never adopted the IM (SA banks) have a lower asset maturity for both assets and liabilities than those that eventually adopted it (IM banks). After banks adopt the IM, they reduce the gaps between assets and liabilities at every time band. The regulatory maturity gap equals 1.8 months for SA banks on average, and for IM banks declines from 2.9 to 2.6 months (before and after adoption). This implies a low balance-sheet exposure: A 1% level shock to interest rates leads to a 0.8% decline in equity value for SA banks and to a 2.3% decline for IM banks. Compared to US banks (Vuillemey 2016, Di Tella & Kurlat 2017, Drechsler et al. 2018), Mexican banks exhibit a substantially lower balance-sheet exposure. However, cash-flow exposure to interest rate risk, as measured by the size of the income gap between assets and liabilities that reprice within a year, is not substantially smaller. SA banks exhibit an income gap of 13% of total assets, and for IM banks declines from 5.1% to 1.1% after the adoption of the IM. The higher cash-flow exposure of SA banks is consistent with their higher share of short-term assets compared to IM banks.

Next, I present a simple model to capture those facts. In the model, banks face a regulatory cost that is increasing in the size of the gap between assets and liabilities with high repricing maturity (referred as long-term positions).[3] Long-term liabilities are those less sensitive to

[3]This reflects the fact that the risk weights to estimate capital requirements for market risk are smaller at lower maturities, since assets and liabilities with low repricing maturity have a small impact on balance-sheet exposure.

the market rate and also more stable. Banks pay a deposit rate that is only a fraction of the short-term market rate and operate a deposit franchise that allows them to keep stable deposits. Banks can estimate the liability repricing maturity under the SA. This imposes a cap on the estimated fraction of long-term liabilities, which may inflate the regulatory maturity gap. Alternatively, banks can adopt an IM to estimate the actual maturity of deposits, facing some extra administrative costs. The advantage is that banks can compute the regulatory costs based on a possibly smaller maturity gap. The model predicts that banks adopt the IM whenever the actual maturity of liabilities is sufficiently larger than the maximum allowed under the SA. In that case, the regulatory maturity gap is smaller under the IM than under the SA, and therefore banks face lower capital requirements using the IM.

Another important insight from the model is that banks with a low deposits' sensitivity will have a low share of short-term assets to ensure solvency when interest rates change. Since banks that adopt the IM are less sensitive to the market rate, they are also more likely to hold a low share of assets with low repricing maturity. Hence, the adoption of the IM should be observed among banks with a large maturity gap under the SA, reflecting their higher holdings of long-term assets.

To test the predictions from the model, I estimate the hazard for the time until the bank requests the approval of the IM to the regulator. Using bank-level data, I confirm that banks with a larger regulatory maturity gap between assets and liabilities are significantly more likely to apply for the IM. A 1-standard-deviation increase in the size of the maturity gap leads to a 400% increase in the rate of adoption. Looking separately at asset maturity (measured directly or proxied by the ratio of mortgages in the loan portfolio), I find that it increases the rate of adoption. Also, banks with a higher share of NMDs in total liabilities have a higher hazard and the effect is larger when deposits are more stable (but not when they are less sensitive). Finally, I confirm that the banks with a high share of short-term assets have a lower rate of adoption since they have a more sensitive income stream.

Next, I examine how are the measures of interest rate risk exposure altered after banks adopt the IM. Exploiting within bank variation, I estimate that the adoption of the IM is associated with a reduction of 1.8 months in the regulatory maturity gap, a large change relative to the sample mean of 2.8 months. At the same time, I find a significant increase in both asset and liability maturity. The increase in liability maturity is the immediate consequence of banks' higher ability to lengthen the deposits duration. The higher asset maturity could reflect the lower cost to hedge long-term assets. In turn, the regulatory measure of interest rate risk exposure declines, more likely reflecting the accounting changes, not an actual risk reduction. In line with that, I find that the adoption of the IM is associated with lower risk-weighted assets for market risk and lower capital requirements. I find weak evidence of an improvement in the capitalization index. This holds despite the fact that the regulation limits the degree to which capital requirements can decline and the capitalization index can increase after adopting the IM.

In the second part I use granular data to study more thoroughly if the adoption of the IM indeed lengthens the asset maturity profile, as found in the bank-level results. The relevant outcome is the loan repricing maturity, defined as the maturity at origination for fixed rate loans and the rate reset frequency for floating rate loans. I examine more than 12 million commercial loans, 650 thousand new mortgages and more than a 100 thousand securities. The loan-level data sets are extracted from the Mexican Credit Registry and cover the universe of business and mortgage loans granted between August 2009 and December 2016. Importantly, they report whether the interest rate is fixed or floating and the exact loan maturity. For securities I use a unique data set built from daily reports to Bank of Mexico of every security held by commercial banks between July 2010 and December 2016.

The adoption of the IM is an endogenous decision and therefore the estimates could be biased. One identification challenge is reverse causality, since the asset maturity profile actually drives the adoption of the IM: Banks with higher mortgage share adopt the IM earlier. The monthly frequency of the data helps to deal with this at least partially, since it allows to track the timing of banks' decisions. I control for any cross-sectional correlation using bank fixed effects to compare the same bank before and after the adoption of the IM. I also control for bank-specific linear time trends to rule out that the results are driven by pre-existing trends at the bank level. This could occur if banks started granting more fixed rate loans with longer maturity before adopting the IM. In addition, reverse causality is less plausible if the lending conditions are supply-driven. Thus, I isolate the supply- from the demand-side mechanisms controlling for: i) firm fundamentals, such as risk aversion or investment opportunities, using firm fixed effects; ii) time-varying firm heterogeneity, by comparing loans granted to firms that borrow from at least two banks in the same month, using month×firm fixed effects; and iii) borrower selection, by comparing the same firm borrowing from the same bank over time using bank×firm fixed effects. Similar controls are used in the models estimated for mortgage loans and securities.

Another identification challenge is to separate the exogenous component in the flexibility to slot NMDs from banks' fundamentals. In particular, deposits' stability affects the adoption of the IM and could also affect the repricing maturity. To deal with this, I exploit variation across SA banks in their flexibility to slot NMDs. The low-flexibility banks can allocate up to 10% of their NMDs into the 2-year band and the high-flexibility group up to 80%. That classification is based on the stability and sensitivity of the deposits estimated annually by the Bank of Mexico.[4] I estimate more refined and detailed measures of stability and sensitivity for each bank that vary at a higher, monthly frequency. Conditional on those estimates of the deposits' sensitivity and stability and on other observable and unobservable bank-level controls, changes in the flexibility to allocate NMDs across SA banks are plausibly exogenous to credit conditions.

I find that following the adoption of the IM, the increase in the repricing maturity of the commercial loan portfolio is driven by pre-existing trends. This result also holds for new lending relationships. When I restrict the sample to SA banks, I do not find that the high-flexibility banks grant loans with a higher repricing maturity than those with low flexibility. Since virtually every mortgage in the sample has a fixed rate, I look at their maturity at origination and at the product of maturity and volume. Including municipality fixed effects and household controls, I do not find a statistically significant increase in mortgage maturity after the adoption of the IM. Similarly, I do not find evidence of a higher repricing maturity of securities using period$\times$issuer and bank$\times$issuer fixed effects.

If banks lengthen the liability maturity and do not increase the asset maturity, they may not reduce the maturity gap if they start using derivatives less intensively. In that case, the adoption of the IM could be driven by the desire to reduce the use of derivatives. There are costs of using financial hedges, resulting from the negative carry trades, the regulatory criteria imposed on hedging tools and their technical and administrative complexity. But exploiting within bank variation, I find that banks do not significantly reduce the probability of holding interest rate swaps after adopting the IM. At the intensive margin, they do not reduce gross hedging (the ratio of swaps' notional amount over total assets) or net hedging (long minus short

[4] For each bank, the maximum fraction of NMDs that can be allocated into the 2-year band (the rest goes into bands of 1 year or less) is determined from a formula based on estimates of the stability and sensitivity. Those estimates are based on coarse assumptions (Cocozza et al. 2015), and the group allocation is dictated by discrete cutoffs, remaining fixed over the entire calendar year.

positions). This implies that the IM and derivatives are not substitute strategies.

Finally, I examine if SA and IM banks adjust the repricing maturity differently depending on the market rates. When the yield curve is steep, firms prefer to borrow short-term or at a floating rate, whereas they prefer fixed rates when the yield curve is flat (Vickery 2008, Faulklender 2005). I find that IM banks adjust better to the demand requirements than SA banks when the yield curve flattens. In such a scenario, IM banks increase the repricing maturity of commercial loans more than SA banks (but not of mortgages or securities), transferring less interest rate risk to firms. I confirm that such response is not driven by higher net hedging using swaps from IM banks. This suggests that it is plausibly driven by their edge to match fixed rate loans of longer maturity using deposits.

Overall, these findings imply that the IM for the time slotting of NMDs is mostly used by banks to obtain a capital gain. Such regulation is adopted by banks with a larger maturity gap, which do not increase the asset maturity profile thereafter nor reduce the use of derivatives. In the presence of capital requirements for interest rate risk in the banking book, the fact that banks seek to reduce the size of the maturity gap could have potential real implications. Banks are more likely to hold assets of shorter repricing maturity that transfer risk to firms and households. As a result, the bank-dependent and more financially constrained firms could become exposed to shocks in the monetary policy rate (Ippolito et al. 2016). From a financial stability perspective, a small maturity gap protects the economic value of capital but does not necessarily leads to a lower cash-flow exposure to interest rate risk. Indeed, SA banks have a smaller maturity gap than IM banks but a larger cash-flow exposure. In turn, US banks have a similarly low cash-flow exposure as Mexican banks, despite having a much larger maturity gap.

This paper contributes to the literature in several ways. To the best of my knowledge, this paper is the first to look at the banks' response to the presence of capital requirements for interest rate risk in the banking book. Relatedly, while most of the literature focuses on the adoption of a model-based approach for credit risk (Behn, Haselmann & Wachtel 2016, Behn, Haselmann & Vig 2016, Fraisse et al. 2017), here I consider the use of internal models associated to market risk. Finally, this paper studies the relationship between regulatory assumptions on NMDs' and assets' repricing maturity, using rich granular data at the loan and security level. The existing literature, including Hanson et al. (2015) and Kirti (2017), has examined the impact of the actual stability and sensitivity of the deposits using more aggregated data.

2 Literature review

The theoretical foundations of the literature that examines banks' interest rate risk management strategies start with the work by Diamond (1984).[5] He argues that banks should fully hedge that risk to reduce monitoring costs. Later on, a consensus has emerged on the desirability that banks bear some risk. The data confirm that banks do not fully hedge exposure, despite that they actively engage in risk management (Vuillemey 2016). Hellwig (1994) shows that by not financing all future consumption out of long-term investment, it is possible to exploit highly profitable short-term investment opportunities. Di Tella & Kurlat (2017) rely on a dynamic hedging strategy to explain why risk-averse banks maintain a maturity mismatch: If the interest rate goes up, banks take large losses with the expectation of higher returns on investments in the future. Drechsler et al. (2018) find that the large maturity gap held by US banks is actually helpful to maintain a low cash-flow exposure to interest rate risk. Banks achieve that low exposure by matching the interest sensitivities of income and expenses. Mexican banks also have a low cash-flow exposure, even though they hold a substantially lower maturity gap than in the US. While the purpose of this paper is not explaining the determinants of the maturity gap, the evidence on the approach to model deposits suggests that banks prefer a small gap to reduce capital requirements. This supports the conjecture that capital requirements is one of the factors behind the low maturity mismatch of Mexican financial institutions. In the US and other countries, the gap between loans and deposits does not impose capital requirements.

This paper relates directly to the literature on model-based regulation. The purpose of this paper is to understand what factors explain the use of internal models for NMDs and to uncover any unintended effects on asset repricing, rather than to take a stand on the desirability of model-based regulation. On the one hand, internal models have been criticized for being overly complex, ignoring the endogeneity of risk exposure and increasing banks incentives to misreport risks (Glaeser & Shleifer 2001, Acharya et al. 2014, Admati & Hellwig 2014, Behn, Haselmann & Vig 2016). On the other hand, internal models allow for a more accurate estimation of capital charges based on actual risk. Cocozza et al. (2015) highlight that the coarse assumptions made by regulators to model NMDs could affect the size of measured interest rate risk and could even distort the nature of banks' risk exposure. Based on that, I argue that the flexibility across

[5] A comprehensive survey of this literature can be found in Vuillemey (2016).

SA banks determined by the Mexican regulator is not perfectly correlated with the deposits' stability and sensitivity.

The present findings complement those from the literature that connects the intermediaries' funding structure with the type of contracts offered to non-financial firms. Hanson et al. (2015) argue that banks with a more stable source of funds have a comparative advantage in the holdings of fixed-income assets, such as long-term securities and loans. Kirti (2017) shows that banks grant commercial loans at floating rates because floating-rate liabilities, measured by the deposits' sensitivity to changes in the market rate, are their main funding source. By exploiting highly granular data and conditioning on deposits' sensitivity and stability, this paper shows that regulatory assumptions on deposits' maturity only incentivize banks to extend the assets' repricing maturity under specific market conditions.

A main contribution is to the literature that examines the effects of microprudential capital regulation on bank lending to firms. Most of this literature deals with the impact of regulatory changes in capital requirements for credit risk (Peek & Rosengren 1995, Thakor 1996, Gambacorta & Mistrulli 2004, Aiyar et al. 2014, Fraisse et al. 2017, Jiménez et al. forthcoming). Behn, Haselmann & Wachtel (2016) study the differential impact of a shock to credit risk on lending by banks that use an IM for credit risk management. Fraisse et al. (2017) exploit differences across banks in the use of IM to measure the impact of capital requirements on lending to firms.

For interest rate risk in the banking book, excluded from the risk-based capital requirements, there is almost no evidence on the effect of microprudential regulation. There is, however, some evidence on the relationship between interest rate risk management and bank lending, with a focus on the response to the monetary policy. Following an increase in the Fed funds rate, Purnanandam (2007) shows that banks using derivatives adjust less the on-balance sheet maturity gap and cut lending volume less because derivatives generate higher cash flows. Gomez et al. (2016) find that banks with a larger income gap increase credit supply more in response to an increase in the monetary policy rate due to higher profits.[6] I look instead at the impact of the microprudential regulation on the loan repricing maturity, not on loan volume. I find that in response to an increase in the short-term rate, banks using an IM for deposits grant loans

[6]The negative relation between banks' equity value and interest rates was first documented by Flannery & James (1984). English et al. (2014) show a decline in equity for a steepening of the yield curve, but banks with a larger maturity gap respond less strongly. The impact on lending of the slope surprise for banks with a different maturity gap has not been documented yet. Drechsler et al. (2017)

with higher repricing maturity than SA banks. IM banks have an edge to match those loans when their demand increase, reducing capital requirements. This result is not driven by higher holding of derivatives from IM banks. Moreover, SA banks use derivatives to increase rather than to decrease the loan exposure when the yield curve is steeper.

A central theme in the empirical literature on interest rate risk has been to determine if banks offset any on-balance sheet exposure using off-balance sheet instruments, or if both are complements to exploit potential gains from a maturity mismatch by increasing exposure. The first view is supported by Esposito et al. (2015), who find that during the global financial crisis Italian banks partially hedged on-balance sheet interest rate risk exposure using derivatives. Entrop et al. (2013) argue that the on-balance sheet gap is determined exogenously by the needs of borrowers and depositors, and only if that gap becomes sufficiently large the bank uses swaps for hedging. In support to the second view, Purnanandam (2007) shows that banks under financial distress manage interest rate risk more aggressively, using both on- and off-balance sheet positions. Begenau et al. (2015) find little evidence that derivatives are used to hedge other positions such as loans. Rampini et al. (2016) find that institutions with higher net worth do more financial hedging and also more operational hedging by holding more net floating-rate assets. Financially constrained institutions face a higher opportunity cost of hedging in terms of foregone lending (Rampini & Viswanathan 2010, 2013). My findings do not suggest either that swaps and the use of the IM for deposits are substitutes. Derivative holdings are not affected by the adoption of the IM generally, in line with Rampini et al.'s (2016) finding that the regulatory capital ratio is not the main driver of financial hedging.

3 Institutional background

3.1 Regulatory framework on interest rate risk

Interest rate risk refers to the risk to the bank's capital and earnings resulting from adverse movements in interest rates, which affects the present value and timing of future cash flows. In September 1997, the Basel Committee issued a paper on principles for the management of interest rate risk. The 2006 Mexican regulations follow the 2004 revised version of those principles (Basel Committee on Banking Supervision, 2004).[7] Loans and deposits in theory

[7] In 2016 the Committee issued a new revision to reflect changes in market and supervisory practices (Basel Committee on Banking Supervision, 2016).

should follow the capitalization rules corresponding to the bank's investment portfolio, the so-called banking book. Since in Mexico there is not distinction between banking and trading book, the capital requirements for market risk, aligned with the Basel II recommendations for the trading book, are applied to the entire banking balance.[8],[9] Market risk includes risk not only from interest rates but also from equities, foreign exchange and commodities. All of these risks increase or decrease with changes in market prices. But market risk is the incremental risk incurred from active trading strategies, especially those involving short trading horizons.

The capital requirements for market risk are not established for each operation, unlike those for credit risk, but for the portfolio structure. The operations in domestic currency with nominal interest rate include, in the asset side, the loan portfolio, and in the liability side, non-maturity and term deposits received by financial institutions. All assets and liabilities subject to interest rate risk should be slotted into a ladder of 14 time bands. Fixed rate operations are allocated to the ladder according to the residual maturity or duration.[10] Floating rate operations are allocated based on the number of days remaining until the revision of the rate or, if earlier, the expiration date. For each time band, a single short or long position is obtained by offsetting the assets and liabilities weighted by a factor estimated by the National Banking and Securities Commission (CNBV, by its Spanish acronym). The risk weights for each band are estimated on the basis of a VaR model under stress conditions. Such weights are high compared to international standards and remained the same until October 2015, when the CNBV published new coefficients (see Appendix Table B.1). Mexican banks cannot develop an internal risk model to compute those weights. The resulting weighted positions are added up, leading to the net short- or long-weighted position in the given currency. Then the net positions calculated for six different currencies are summed to calculate the whole weighted position. In the final step, this weighted position is related to capital.

[8]Those capitalization rules follow the 1996 Basel Committee on Banking Supervision rules, revised after 2000.

[9]The trading book refers to available-for-sale assets and has to be marked-to-market (fair value). The banking book refers to held-to-maturity assets on a bank's balance sheet, usually held at historical cost. Thus, the exposure of the banking book positions is due to interest payments, while for trading book positions is due to market value changes.

[10]The maturity can be replaced by the duration in the case of debt titles with fixed rate coupons, fixed rate mortgages, private instruments that generate positions equivalent to fixed rate titles and certain consumer loans.

3.2 Time slotting of non-maturity deposits

One of the most difficult tasks when measuring interest rate risk is dealing with positions in which behavioral and contractual maturity differ and positions with no stated contractual maturity. One of those positions are NMDs (sight deposits and checking and saving accounts), which can be withdrawn, sometimes without penalty, at any time. Another complication comes from the fact that the changes in the rates paid by banks are not closely correlated with the changes in market rates. Banks often move deposit rates to manage the volume of retained deposits.

In the baseline approach, NMDs should be classified in bands 1 and 2 (up to 31 days) when their interest rate is 50 per cent higher than the 28-days Cetes.[11] If the interest rate is lower, they can be allocated to bands 1 to 5 (up to 1 year). In practice, most banks pay low or zero interest rates.

Banks with four years of data are eligible for the SA, and can allocate a fraction of their NMDs up to band 6 (1 to 2 years). That fraction is established based on the following formula:

$$IS = (1 - \beta_{max}) \times (1 - \Omega)$$

where β_{max} is the sensitivity of deposit interest rates with respect to the market rate (28-days Cetes) and Ω is the larger percentage monthly decline of the deposits' balance. Based on the IS coefficient, institutions are classified into one of four groups. Banks with IS equal or smaller than zero have to follow the baseline approach. If the IS is positive but smaller than 30, banks can allocate up to 30% of the NMDs into band 6. If it is between 30 and 70 (70 and 100), they can allocate up to 45% (80%). Thus, banks have higher flexibility to allocate deposits either due to higher stability (lower $\Omega < 0$) or to a lower sensitivity to the market rate.

Institutions have the option to adopt an IM to estimate the stability and sensitivity of their deposits. Under the IM, NMDs can be allocated into higher time bands, based on maximum forecasted percentages, which can be optimized monthly within approved limits. In addition, total risk-weighted assets (RWAs) cannot drop by more than 12.5% and the ratio of net capital over total risk-weighted assets cannot increase by more than 2p.p. than under the SA. Banks also need to: 1) Demonstrate to the CNBV a solid policy for risk administration; 2) Ensure

[11] Zero-interest retail deposits can be simultaneously "sticky" and have low or even negative duration if their present value increase with market rates (Hutchinson & Pennacchi 1996).

a consistent classification of deposits in each time band for 12 months; 3) Show the historical performance of deposits' stability and sensitivity; and 4) Demonstrate the reliability of the estimates through backtesting proofs. Whenever the approval of the IM was initially denied, the inconsistencies were eventually amended.

In conversations held with bank officers, reducing capital requirements and increasing the capitalization index were mentioned as the main driver for the adoption of the IM. According to the CNBV, the administrative costs of maintaining such models are low. Some banks adopted an IM after experiencing a downgrade under the SA. Banks refrain from adopting an IM if they consider that the stability of their deposits is difficult to demonstrate, the benefits of implementing an IM are not perceived as sufficiently high, or do not know which model to implement. Some banks are not even aware of the possibility to use an IM.

Figure 1 shows the approach followed by each bank for the time slotting of NMDs over the sample period. Banks denoted as low- and high-flexibility under the SA are those that can allocate up to 10% or up to 45% to 80% respectively of their deposits into the 2-year band. The commercial bank sector comprises: i) the "G7", seven large universal banks; ii) medium-sized commercial banks that offer retail and wholesale banking services and have a broad network of branches; iii) investment banks, which do not offer retail services and focus on trading and granting commercial loans; and iv) consumption banks that use the network of retail business to which they belong to grant consumption loans and mortgages. In addition, out of six development banks, only the two smaller collect demand deposits: Banjército that provides financial services to the Mexican military personnel and Bansefi that serves the underbanked population. Figure 1 shows that under the SA, the G-7, the development banks, and some commercial and consumption banks exhibit the higher flexibility. Investment banks have in general the lowest flexibility. The IM has been adopted by all but one of the G-7 banks, by the two development banks (the others are omitted) and by two medium-sized commercial banks.

3.3 Internal model for deposits and banks' risk exposure

In this section I first present some descriptive analysis to show how banks slot different positions into the maturity ladder to compute capital requirements for market risk. Next, I examine unconditional differences in banks' measures of maturity transformation and interest rate risk.

In Panel A of Figure 2 I present the average gaps between net assets and liabilities (as a percentage of total assets) by time band. Using monthly data from January 2006 to December

2016, I pool banks that always used the SA and banks that eventually adopted the IM, before and after its adoption. Three facts stand out. First, SA banks have a lower maturity profile for both assets and liabilities than IM banks. Second, the ten banks that adopted the IM exhibit a large negative gap at band 6 (1 to 2 years) before its adoption. Thus, for those banks the 2-year cap was indeed binding: NMDs are modelled with too short an average life given the asset maturity profile. That gap also suggests that banks do not use other positions to fully offset any mismatch between loans and deposits. Finally, after adopting the IM, such gap disappears and the matching between assets and liabilities improves in general.

More granularity is obtained from Panel B, which only includes loans and NMDs as a fraction of total loans. Since data is only available from October 2015, I compare SA banks with the only two banks that adopted the IM during that period. The three charts show a large positive funding gap in band 2 (8 days to 1 month), where most floating rate loans and all non-performing loans are allocated. A positive but decreasing gap is observed for the SA banks at higher maturities, where they allocate a small fraction of NMDs. Thus, they need to use other positions to reduce that exposure, as seen in Panel A. Under the SA, the IM banks exhibit a very large negative gap in bands 5 and 6 (6 months to 2 years) and a positive gap in band 10 (5 to 7 years). The negative gap confirms the bunching of NMDs into the maximum possible maturity, whereas the positive gap corresponds to unhedged mortgage loans. After adopting the IM, the maturity of NMDs is extended up to band 10 and most of the gaps at higher maturities disappear.

Next, I compare the overall maturity or duration gap across groups, measured as the weighted average net asset minus net liability maturity, normalized by total assets:[12]

$$GAP_{b,t} = \sum_{j=1}^{14} \left(\frac{A_{b,t,j} - L_{b,t,j}}{\sum_{j=1}^{14} A_{b,t,j}} \right) M_j \tag{1}$$

where $A_{b,t,j}$ and $L_{b,t,j}$ are the value of net assets and liabilities that bank b allocates to band j in period t, and M_j is the midpoint of band j (in years).[13] By following the regulatory criteria to compute (1), I am incorporating the assumptions used to slot NMDs.

Figure 3 shows the time series of the asset and liability maturity. The maturity gap is of 1.8 months for SA banks and declines from 2.9 to 2.6 months for IM banks after adoption.

[12]The duration gap includes the cash flow timing and is a more complete and precise measure of interest rate risk exposure than the maturity gap. The Mexican regulation follow an hybrid approach that use alternatively maturity or duration for fixed rate operations (see footnote 10).

[13]M_j should be replaced by the modified duration of each band in equation 1 to measure the duration gap.

That decline is consistent with a longer liability maturity under the IM. The gaps imply that a 1% level shock to interest rates causes the value of banks' assets to decline by 0.2% relative to liabilities. Considering that the leverage of SA and IM banks are about 19% and 9%, the declines in equity value are approximately 0.8% for SA banks and 2.3% for IM banks. For a 4-year maturity gap in the US, Drechsler et al. (2018) estimate a much larger, 40% decline.

A more accurate approximation of the sensitivity of equity can be obtained by weighting the maturity gap in equation (1) by the risk weight coefficients from the Mexican regulation (W_j), so that interest rate risk exposure is given by:[14]

$$IRR_{b,t} \approx -\sum_{j=1}^{14} \left(\frac{A_{b,t,j} - L_{b,t,j}}{\sum_{j=1}^{14} A_{b,t,j}} \right) W_j \tag{2}$$

Expression (2) indicates that a bank with a positive gap between assets and liabilities (asset-sensitive) will be negatively affected by an increase in interest rates (captured by W_j). Banks with a zero gap are immunized, that is, have eliminated the effect of interest rate changes on the value of equity. The interest rate risk exposure of SA banks based on (2) equals -0.32% of total assets, whereas for IM banks almost does not change before and after adoption (-0.40% to -0.39%). These coefficients suggest a twice as large sensitivity of the equity value relative to the estimates based on (1). But this still implies that the exposure of Mexican banks' balance sheets is low, only slightly larger for IM than for SA banks.

Under an "earnings approach", interest rate risk sensitivity can be measured as the impact of a change in interest rates in banks' net interest margin (NIM) - the difference between monthly interest income and interest expenses divided by total assets and then annualized:

$$\triangle NIM_{b,t} = \sum_{j=1}^{5} \left(\frac{A_{b,t,j} - \beta L_{b,t,j}}{\sum_{j=1}^{14} A_{b,t,j}} \right) \triangle r_t \tag{3}$$

where β is the fraction of the short-term market rate, r_t, that bank b pays on its liabilities. Hence, the exposure of the NIM depends on the income or repricing gap, $\sum_{j=1}^{5} (A_{b,t,j} - \beta L_{b,t,j})$, that is, the difference between assets and liabilities that reprice or mature within a year (bands 1 to 5). A positive income gap implies that the NIM increases in response to an increase in

[14] The 2004 Basel Committee recommends to use as weighting factors the product of the approximate modified duration of each band and a 200bp parallel shift in the yield curve. The CNBV departs from those guidelines and estimates the weighting factors from a VaR model under stress conditions.

the short-term rate. While banks mostly use earnings-based measures for interest rate risk management, regulators rely on economic value measures to determine capital adequacy.

Equation (3) captures the positive relation between a bank short-term cash flows and interest rates. In turn, equation (2) captures the negative relation between a bank equity value and interest rates, taking into account the whole term structure of assets and liabilities. For banks with a large share of long-term assets, as IM banks, the maturity gap is large but the income gap is small and possibly even negative. For SA banks, the income gap amounts to 13% of total assets and for IM banks declines from 5.1% to 1.1% post-adoption. Thus, IM banks have a slightly larger maturity gap than SA banks but a smaller income gap. This implies that, while the balance sheet exposure of IM banks is higher, their cash flow exposure is smaller.

Figure 4 shows the overnight interest rate, which exhibits some volatility over the sample period, reaching a peak of 8% and a floor of 3%. Panel A breaks down the NIM into its two components, net interest income and expenses. Their sensitivity to changes in the market rate is large, and it is even larger for IM than for SA banks. But IM banks are more successful in matching that sensitivity to maintain the stability of the financial margin. Panel B confirms that the volatility of the NIM is smaller for IM banks, with standard deviations of 1.1% and 0.4% (SA and IM banks). Figure 4 also includes the banks' return on assets (ROA, net income divided by assets), another measure of profitability. The ROA of IM banks is not generally affected by movements in the short-term rate, but for SA banks declines markedly in 2008-2010.[15]

4 Data

4.1 Bank-level data

I use monthly financial statements and regulatory reports on capital information for 52 Mexican financial intermediaries available from the CNBV. Confidential data on assets and liabilities by time band comes from banks' supervisory reports to the Bank of Mexico. I report summary statistics in Panel A of Table 1 from January 2006 to December 2016, distinguishing between SA and IM banks (pre- and post-adoption). Details on the definitions of variables are provided in Appendix Table A.1.

[15]Evidence that the NIM is very stable and exhibits little comovement with interest rates or with the slope of the yield curve in the long-term can be found in Flannery (1981), English (2002), Hanweck & Ryu (2005). For Mexican banks, Maudos & Solís (2009) find that the net interest income increases with the volatility of interest rates between 1993 and 2005, a period with very high interest rate volatility.

Panel A first shows banks' aggregate maturity gap, interest rate risk exposure and income gap for operations in domestic currency with nominal interest rate, which were discussed in section 3.3. The next three variables related to regulatory capital show that, on average, IM banks have higher RWAs for market risk, a smaller capitalization index and higher capitalization requirements than SA banks. This is consistent with IM banks' higher incentives to reduce capital requirements for market risk by lengthening the deposits' maturity.

IM banks have a much larger share of mortgages in the total loan portfolio than SA banks (around 20% vs 2.5%). Mortgages typically have a fixed rate and therefore are one of the assets with higher repricing maturity in banks' portfolios. IM banks rely more on NMDs as a source of funding, which represent 25% of total liabilities before adoption and increase to 35% after adoption. For SA groups that ratio is just 17%. Smaller discrepancies are observed in the ratio of term deposits, with an average of around 20% in the three samples. Not surprisingly, the sensitivity and instability of NMDs is higher for SA than for IM banks (see Appendix C for details). The NMDs' rate sensitivity to changes in the market rate equals 12% for SA banks and for IM banks goes from 8% to 5% (before and after adoption). The differences in stability, measured as the fraction of overnight, 1-month and 2-year decline in NMDs, are much larger between SA and IM banks. Moreover, the 1-month and 2-year stability coefficients increase even further after the adoption of the IM.

Finally, IM banks are the largest, as measured by the logarithm of total assets, but also the ones with a higher leverage, as implied by the lower equity-to-asset ratio. The liquidity ratio is also higher for IM banks (50% versus 33% for SA banks), whereas credit risk, as proxied by non-performing loans as a fraction of total assets, is slightly lower. Thus, based on those measures, IM banks are less exposed to liquidity and, to a smaller extent, credit risk.

4.2 Loan-level data

For the loan-level analysis of the second part, I use a supervisory dataset on the universe of business and mortgage loans from private banks from August 2009 to December 2016. The data set is compiled by the CNBV from monthly regulatory reports required to every bank. The data set on commercial loans include detailed characteristics of all commercial loans of any size granted to firms and individuals with entrepreneurial activity. The mortgage data set includes every loan granted by private financial institutions to households. An important advantage of both data sets is the possibility to estimate the exact loan maturity based on the origination and expiration dates. In addition, they report the issuing bank, the borrower, the loan volume and interest rate type (fixed of floating) and the reference rate for floating rate loans.

For business loans, I aggregate the observations at the firm-bank-month level, defined as a "loan". The loan-level variables are a weighted average by loan volume (i.e. the sum of the value of all outstanding loans, with positive balance, that a firm has from one bank in a given month). For loan maturity and repricing I use an inverse hyperbolic sine transformation (IHS) to deal with the presence of zeros. Loan commitment, volume, maturity and repricing are winsorized at the top 2 percent of the monthly distribution to reduce the influence of outliers.

The information on the borrower is typically only reported at the time of the loan origination. I build indicators of firm size (micro, small, medium and large) based on a weighted average of the firm's income and number of employees. Following Morais et al. (2015), I exclude from the sample loans granted to individuals with entrepreneurial activity due to arbitrary changes in their classification between commercial and consumption loans. In addition, I limit the sample to loans in domestic currency and with a nominal interest rate, the ones that can be hedged with NMDs. I finally exclude non-performing loans, since their contractual repricing maturity is not relevant to compute capitalization requirements - they are all allocated into band 2 (8 days to 1 month) - and many report a negative maturity at origination. The resulting data set contains 12,608,209 observations, with information on 222,015 firms and 42 banks. There are fewer banks than in Panel A because the two development banks lack micro data and some private banks do not grant commercial loans or stopped operations after August 2009.

Panel B of Table 1 shows that IM banks have on average the higher proportion of fixed rate loans (near 20% versus 15% for the SA group). Maturity increases more for fixed than for floating rate loans after the adoption of the IM, as expected. The repricing maturity, defined as the maturity at origination for fixed rate loans and the rate reset frequency for floating rate loans, is 4 months for SA banks. For IM banks, it increases from 4 and a half to almost 6 months after adoption. The product of the repricing maturity and the amount committed is actually smaller for IM than for SA banks, and increases slightly after the IM adoption.

For mortgage loans, I restrict the sample to new mortgages in Mexican pesos, which results in 650,053 loans granted by 24 commercial banks (development banks are excluded due to the lack of data for the entire sample period). The outstanding portfolio may not accurately capture the banks' contemporaneous strategy, given the long-term horizon of these loans. Virtually all new mortgages have a fixed rate (98.5%) and for that reason I do not report the repricing maturity, only the maturity. No substantial differences are observed across groups in the IHS transformation of mortgage maturity (in years). The increase in maturity after the adoption of the IM is marginal. Since the mortgage maturity could be mostly demand-driven, I also compute the product of maturity and volume. Banks may have more influence on volumes than on maturity via the approval of the loan-to-value ratio. As expected, IM banks exhibit higher values of this measure than SA banks, which increase further after adoption. Finally, Panel B reports some household characteristics collected at origination, namely, borrower's income and employment sector (public, private or self-employed).

4.3 Security-level data

Panel C of Table 1 presents summary statistics for 10,406 securities held by 48 commercial and development banks. There are 469 different issuers of those securities, including the federal government and financial and non-financial private institutions. Data are extracted from confidential banking reports to the Bank of Mexico from July 2010 to December 2016. Banks report daily each security held in their asset portfolio both at face and market value, along with the issuer's name, the issuance and expiration date, the interest rate and its formula (fixed or based on a reference rate) and the repricing maturity. I restrict the sample to all securities in domestic currency and select the last report available in the month. The statistics for all security characteristics are volume-weighted.

IM banks hold on average more fixed rate securities (63% to 66%) than SA banks (50%). The average maturity is higher for IM banks and differences are larger when the rate is fixed. Moreover, maturity increases more for fixed than for floating rate securities after the IM adoption. The repricing maturity is also higher for IM banks (1 and a half years after adoption) than for SA banks (10 months). The product of the repricing maturity times the securities holdings at market value is higher for IM than for SA banks, but does not increase with adoption.

5 Determinants of the internal model adoption

5.1 Model

This section presents a simple model on the banks' decision to adopt an internal model to compute the maturity of demand deposits. Time is discrete and the horizon is infinite. The bank problem is to invest in assets that maximize the present value of its profits, subject to a budget and solvency constraints, similar to Drechsler et al. (2018).

In each period the bank has to invest in assets with low and high repricing maturity in proportions α_t and $1-\alpha_t$, which for simplicity I will denote short- and long-term assets. The income from short-term assets is given by the market rate (the monetary policy rate) r_t plus a spread, which is set to zero for simplicity. The income from long-term assets is given by a rate set by the bank, r_t^a. Each bank finances issuing risk-free deposits and operates a deposit franchise at a cost of c per deposit peso. This reflects the cost of maintaining bank branches to attract and service depositors, which includes salaries, technology, rents, etc. The bank pays a deposit rate of βr_t, which is just a fraction $\beta \in (0,1)$ of the short-term market rate. Thus, $1-\beta$ can be seen as the fraction of insensitive deposits or deposits that do not vary with the short-term rate. The deposit franchise allows banks to keep a fraction $1-\Omega$ of core deposits, that is, stable deposits that are not withdrawn in the short-term. Normalized to one peso of deposits, liabilities with high repricing maturity, or long-term liabilities, equal $\theta = (1-\beta)(1-\Omega)$, being higher for banks with less sensitive and more stable deposits.[16]

Banks face a regulatory cost k, which is an increasing function $h(\cdot)$ of the gap between long-term assets and liabilities.[17] Regulatory costs are given by the absolute value of the difference:

$$k = h\left(\left|(1-\alpha_t)-\theta\right|\right) \tag{4}$$

Banks use a discount factor, m_t, to value profits. Their problem is given by:

$$V = \max_{\alpha_t} E_0 \left[\sum_{t=0}^{\infty} m_t \left[r_t\alpha_t + r_t^a(1-\alpha_t) - \beta r_t - c - k\right]\right] \tag{5}$$

$$\text{s.t. } E_0 \left\{\sum_{t=0}^{\infty} \frac{m_t}{m_0}\left[r_t\alpha_t + r_t^a(1-\alpha_t)\right]\right\} = 1 \tag{6}$$

$$\text{and } r_t\alpha_t + r_t^a(1-\alpha_t) \geq \beta r_t + c + k \tag{7}$$

Equation (6) is the budget constraint and implies that the present value of future income must

[16] This feature reflects the spirit of the Mexican regulation on deposits (see section 3.2). Drechsler et al. (2017) show that market power allows to reduce β but at the cost of more unstable flows. Appendix E derives the condition under which θ is a decreasing function of β when Ω changes negatively with β.

[17] The mismatch between short-term assets and liabilities imposes lower capital requirements because risk weights are smaller (see Appendix Table B.1). Panel A of Figure 2 shows that banks do not entirely close the gap at lower time bands. This confirms the adequacy of assuming that the mismatches at higher repricing maturities are the most important for regulatory capital.

equal its present value of one peso. Equation (7) is the solvency constraint and establishes that the bank's income must be at least equal to its interest expenses βr_t, operating costs c and regulatory costs k. This is equivalent to impose that the net interest income (NII) (interest income minus interest expenses) should be non-negative.

In period zero, the bank decides whether to adopt an IM to estimate the actual repricing maturity of deposits. This imposes a fixed administrative cost $z > 0$ so that the total regulatory cost k equals $h(\cdot) + z$. Under the IM, $h(\cdot)$ is based on the actual maturity gap, $\left|(1-\alpha_t) - \theta^{IM}\right|$. Alternatively, the bank can use the maturity estimated under the SA at no extra cost ($z = 0$), but assuming that the fraction of long-term liabilities at most equals $\overline{\theta}$. Thus, the cost $k = h(\cdot)$ is based on $\theta^{SA} = \min\left[\theta, \overline{\theta}\right]$. In that case, the actual and regulatory measures of risk exposure only coincide when the deposits' actual maturity is very short (θ sufficiently low).

If $\alpha < 1 - \theta^{SA}$, the bank adopts the IM when it leads to higher profits than the SA:

$$V_0 = \max\left[V^{IM}, V^{SA}\right] \tag{8}$$

which implies:

$$k^{IM} < k^{SA} \tag{9}$$

Proposition 1: The bank will adopt the IM when:

$$h\left[\left|(1-\alpha_t) - \theta^{IM}\right|\right] < h\left[\left|(1-\alpha_t) - \theta^{SA}\right|\right] - z \tag{10}$$

For a positive maturity gap and a given $z > 0$, condition (10) holds if $\theta^{IM} \gg \theta^{SA}$, that is, whenever the actual maturity of liabilities (θ) is sufficiently larger than the SA cap ($\overline{\theta}$). The use of a larger θ to measure the maturity gap results in lower capital requirements. Hence, Proposition 1 establishes that banks with stable and insensitive deposits will adopt the IM. The condition $\alpha < 1 - \theta^{SA}$ ensures that the maturity gap is positive under the SA. A positive maturity gap is more realistic since the actual deposits' maturity is unlikely to extend beyond the maturity of long-term assets (see Figure 3). But even in that case, banks may find optimal to adopt the IM and cap the deposits' maturity if modelled too long. Only if the gap is negative under the SA, which can happen if α is very high ("narrow banking"), then condition (10) never holds for a given $z > 0$. Below I explain why banks with low β need to choose a low α to ensure solvency, being more likely to adopt the IM.

The bank faces two solvency risks summarized by condition (7). One is the increase in the short-term market rate, r_t, which leads to higher expenses that need to be compensated with higher income. If short-term assets are sufficiently high, the bank can avoid becoming insolvent when r_t increases. The other is the risk of a decrease in the market rate, which only reduces the interest expenses but not the operating costs c or the regulatory costs k. Thus, the income must be insensitive enough so as to still cover those costs when the short-term rate falls. The higher these costs, the lower should be α_t for a bank to remain solvent in a declining interest rate scenario. Thus, I derive the following:

Proposition 2: In response to an increase (decrease) in the short-term rate, banks remain solvent if $\alpha_t - \beta \geq 0$ ($\alpha_t - \beta \leq 0$). Banks can immunize against any change in interest rates by setting $\alpha_t = \beta$.

See proof of Proposition 2 in Appendix D. Proposition 2 predicts that banks match the deposits' sensitivity, β, with the share of short-term assets to immunize against interest rate risk. From Proposition 1, banks with a small rate sensitivity and high deposit stability adopt the IM. Their low β imply that they should hold a low share of short-term assets if they want to reduce exposure to any change in interest rates. In that case, the adoption of the IM should be observed among banks with a large maturity gap under the SA resulting from a high share of long-term assets.

However, banks may not necessarily find optimal to fully immunize their exposure to interest rate risk. A sufficient condition to guarantee the bank's solvency when the short-term rate increases is $\alpha_t - \beta \geq 0$.[18] As interest rates raise, banks remain solvent by choosing a high share of short-term assets. However, the smaller β, the smaller can be that share for the banks to remain solvent. Thus, in a scenario of increasing rates, banks that adopt the IM can exhibit a comparatively higher share of long-term assets and therefore a larger maturity gap under the SA. When the short-term decreases, the solvency condition becomes $\alpha_t - \beta \leq 0$, implying that banks need a very low share of short-term assets. The smaller β, the smaller has to be that share and the higher the maturity gap under the SA. Thus, either to fully immunize against interest

[18] The left-hand side is similar to the income or repricing gap, defined in equation (3) as $\sum_{j=1}^{5} (A_{b,t,j} - \beta L_{b,t,j})$. In the model the income gap would be the difference between short-term assets (α_t) and short-term liabilities $(1 - (1 - \beta)(1 - \Omega))$.

rate volatility or to ensure solvency, banks with a lower market rate sensitivity will invest more in long-term assets. This results in a larger maturity gap under the SA and therefore in a higher probability of adopting the IM.

5.2 Empirical evidence

In this section, I examine empirically if the predictions from the model in section 5.1 hold for the ten banks that adopted the IM in Mexico between 2006 and 2016. Specifically, I estimate a semi-parametric Cox proportional hazard model for survivor time until the bank formally requests the approval of the IM to the regulator (CNBV). The effective adoption is subject to the approval of the regulator and has occurred between one to eight months after the formal request. The Cox model implies that the instantaneous probability of requesting the approval of the IM at s, given that bank b has not adopted the IM before s, equals:

$$h_{t,b}\left(s|X_{t,b}\right) = h_0\left(s\right)\exp\left(\beta X_{t,b}\right) \tag{11}$$

where $X_{t,b}$ are the characteristics of bank b at time t; β are coefficients specific to the adoption of the IM; and $h_0\left(s\right)$ is the baseline hazard of the IM adoption. I include in $X_{t,b}$ the following: i) the maturity gap between assets and liabilities; ii) the ratio of mortgages in total loans and of NMDs in total liabilities; iii) the interaction of the NMDs' ratio with the NMDs' sensitivity and 2-year stability; and iv) the income gap. In all specifications I also include bank size, the capital and liquidity ratios and credit risk.

The coefficients estimated for the time until a bank formally request the approval of the IM are presented in Table 2. The hazard for the time until its effective adoption renders generally similar results. In the last row I report the p-values of the global test for the violation of the proportional-hazards assumption or that the effect of a given covariate does not change over time. For all models, the chi-squared statistic does not lead to reject the null hypothesis that the log hazard-ratio function is constant over time.

Column 1 confirms that banks with a higher maturity gap between assets and liabilities are significantly more likely to request the approval of the IM. Those banks can adopt the IM to reduce the size of the maturity gap by estimating a longer, more-realistic maturity for NMDs. Based on the estimates from column 1, a 1-standard-deviation increase in the maturity gap, while all other variables are constant, yields hazard ratios equal to $\exp(3.9 \times .4) = 5$. This is a 400% increase in the rate of IM adoption. In addition, larger banks and those with a higher liquidity ratio request the IM approval earlier. In column 2 I look separately at aggregate asset and liability maturity. As predicted, banks that invest in long-term, fixed rate assets request the approval of the IM earlier. The negative and significant coefficient for liability maturity seems surprising given the model predictions. But this because I use the regulatory measure of liability maturity that incorporates the SA assumptions (θ^{SA}), not the actual maturity. Thus, the negative coefficient may capture the fact that banks that rely more on NMDs exhibit a shorter liability maturity under the SA. Those banks are more likely to adopt the IM to reduce the maturity mismatch.

In the next column I use the ratio of mortgages in the loan portfolio as a proxy for high asset repricing maturity. The estimates show that banks with a higher mortgage ratio apply for the IM approval earlier, as expected, and the coefficient is significant at the 1% level. The hazard ratio resulting from a 1-standard deviation increase in the mortgage ratio equals $\exp(13 \times .09) = 3.3$, a 230% impact in the rate of IM adoption. In addition, I include the NMDs ratio, which leads to a shorter liability repricing maturity under the SA relative to the actual maturity and therefore should accelerate the rate of IM adoption. As expected, the coefficient is positive and a 1-standard-deviation leads to an increase of $\exp(5 \times .21) = 2.9$, a 190% increase in the adoption rate. In column 4 I directly examine the NMDs' stability and sensitivity, a better proxy for deposits' maturity that is not influenced by the SA caps. The sample is restricted to banks with sufficient data to compute the stability and sensitivity of NMDs. I find that the main coefficient on the NMDs' ratio becomes larger and the interaction terms with the sensitivity and instability coefficients are negative, significant at the 1% level only for instability. These results confirm that the rate of adoption is decreased for banks with unstable deposits. In that same specification, the coefficient on bank size becomes negative and the one on the liquidity ratio becomes insignificant. Thus, conditional on deposits' maturity, bank size or liquidity risk do not account for the adoption of the IM.

Finally, in column 5 I examine the impact of the income gap, measured as the difference between short-term assets and liabilities. The estimated coefficient is negative and significant at the 5% level. The model does not directly relate the adoption of the IM to the income gap but to the share of assets with low repricing maturity. When looking separately at the share of short-term assets and liabilities, I confirm that the coefficient on the former is negative and significant (a 1-standard deviation increase in the share of short-term assets reduces the rate of adoption by 64%). This indicates that banks with a less sensitive income stream are more likely to adopt the IM. The coefficient on short-term liabilities is positive but insignificant, since it suffers from the same shortcomings as the regulatory measure of liability maturity in column 2.

The empirical results confirm the model predictions that the banks more likely to adopt the IM are those with a larger maturity gap, with stable NMDs and with long-term assets that produce an insensitive income stream. These banks have a lower income gap. In unreported results, I examine if the use of interest rate swaps affects the decision to use the IM. This is not part of the model predictions, but the conventional wisdom would suggest that hedging via NMDs and via swaps are substitute strategies. I estimate a negative but insignificant relationship for an indicator of holding any swap and for the share of their base amount on banks' total assets.

5.3 Interest rate risk and regulatory capital after IM adoption

In this section I examine if the adoption of the IM reduces the maturity gap and, as a result, the estimated risk exposure used to compute capital requirements. This will provide additional evidence on banks' motivation behind the adoption of the IM. For that purpose, I estimate the following model for bank b in month t:

$$Y_{b,t} = \beta_1 IntMod_{b,t-1} + \beta_2 X_{b,t-1} + \gamma_t + \gamma_b + \varepsilon_{b,t} \tag{12}$$

where $Y_{b,t}$ stands for the maturity gap and interest rate risk exposure, defined in (1) and (2) respectively. The regressor of interest, $IntMod_{b,t-1}$, is a dummy that takes value one after bank b starts using the IM for the time slotting of NMDs and zero otherwise. In $X_{b,t-1}$ I include time-varying bank-level controls lagged one period, namely, bank size, the capital and liquidity ratios, credit risk, the ratio of NMDs and term deposits in total liabilities. To account for potential sources of selection into the IM, in $X_{b,t-1}$ I also include the more refined estimates of the deposits' sensitivity and stability (see Appendix C) and the ratio of mortgage loans in total bank loans. By controlling for period (i.e. month-year) fixed-effects (FE), γ_t, I account for all the aggregate shocks that can affect the outcome variable across banks in a given month. I examine the effect of changes in the regulation for the same bank using bank FE, γ_b. The error term is denoted as $\varepsilon_{b,t}$ and I cluster the standard errors at the bank level using the wild cluster bootstrap.

Table 3 presents the results for the maturity gap in columns 1 to 3. In the cross-section, banks using an IM have a significantly larger maturity gap than SA banks. But adding bank FE, the adoption of the IM is associated to a significant decline in that gap. Restricting the sample to the ten banks that eventually adopted the IM in column 3, the negative coefficient remains significant at the 5% level. This confirms that the result is not driven by the choice of the control group. Based on the estimates of column 3, adopting the IM leads to a reduction of 0.15 years in the maturity gap, a large impact (68%) relative to the sample mean of the dependent variable (0.23 years). In the next columns, I look at asset and liability maturity separately and find that both increase significantly after the adoption of the IM. From columns 5 and 7, the estimated coefficients represent an increase of 24% and 47% relative to the sample means of the dependent variables (1.121 and 0.89 years). The decline is larger for liabilities, since the IM should only affect directly the estimated deposits' maturity. The increase in asset maturity suggests that banks could be adjusting the asset side of the balance sheet as well. Finally, in columns 8 to 10 I examine the effects on interest rate risk exposure and the results mirror those in columns 1 to 3. The estimated coefficient changes from negative to positive after including bank FE, representing a 48% decline in risk exposure relative to the sample mean. This provides additional evidence that banks adopt the IM to reduce the regulatory measure of risk exposure.

Table 4 examines capital requirements and the capitalization index. If IM banks are able to reduce the maturity gap, their RWAs should decline. This will lead to smaller capital requirements and to a higher capital ratio. In columns 1 to 4 I estimate equation (12) for the logarithm of RWAs for market risk. Controlling only for bank and period FE, column 1 shows that the coefficient of interest is negative and significant at the 5% level. The result, however, is not robust to the inclusion of bank-level controls. In columns 3 and 4 I restrict the sample to IM banks. In column 4 I further restrict the sample to 24 months before and after each bank adopts the IM to capture the short-term impact. Only in column 4 the results are negative and significant, suggesting that the adoption of the IM is associated with slightly lower RWAs for market risk ($0.09 millions). Columns 5 to 8 show that the impact on the capitalization index is significantly positive, except in column 7. From column 8, the capitalization index experiences an improvement of 0.6p.p. - the regulation set a cap on that increase of 2p.p. relative to the index resulting from the SA. In columns 9 to 12 I examine if the adoption of the IM results in lower capital requirements, which in turn cannot drop by more than 12.5% relative to the requirements under the SA. The estimated coefficients are negative, but not significant after including the bank-controls. The evidence in Table 4 is consistent with a moderate reduction in capital requirements for market risk and a slight improvement in the capitalization index following the adoption of the IM.

6 The internal model for deposits and assets' maturity

Banks with the approval to use an IM for the time slotting of NMDs have a comparative advantage to increase asset maturity thereafter, without incurring in higher capital requirements. Bank-level data suggests that IM banks indeed lengthen asset maturity. However, this could simply reflect more long-term investment opportunities for IM banks, independent of their ability to hedge loans' risk exposure. To disentangle whether such result is demand or supply driven, it is necessary to examine more granular data. I first look at commercial loans to exploit the presence of firms borrowing from multiple banks for identification. Since mortgages are the main long-term, fixed-rate loan portfolio for many banks, I also examine the maturity of new mortgages. Finally, I look at the repricing maturity of securities held by banks, less influenced by demand conditions. In particular, the "held to maturity" portfolio of securities is one of the main sources of interest rate risk in the banking industry.

6.1 Commercial loans

For commercial loans, I estimate the following specification:

$$Y_{i,b,t} = \beta_1 IntMod_{b,t-1} + \beta_2 X_{b,t-1} + \gamma_i + \gamma_t + \gamma_b + \varepsilon_{i,b,t} \tag{13}$$

where the dependent variable Y is defined for the fixed rate fraction, maturity, and repricing maturity of loans granted by bank b to firm i in period t. The regressor of interest, $IntMod_{b,t-1}$, is the same as in equation (12). For loan maturity, I modify equation (13) by interacting $IntMod_{b,t-1}$ with an indicator that takes value 1 for loans from a firm-bank pair that always had a fixed rate. In $X_{b,t-1}$ I include the same time-varying bank-level controls as in equation (12). γ_i are firm FE that control for unobserved time-invariant firm heterogeneity, replaced by firm size indicators in alternative specifications. γ_t represents month fixed effects, γ_b are bank FE that control for time-invariant bank characteristics and $\varepsilon_{i,b,t}$ is the error term. Standard errors are double clustered at the period and bank×industry level. The expected sign of β_1 - or the interaction coefficient in the model for loan maturity - is positive. Banks can increase the loan repricing maturity if fixed-rate, long-term loans can be cross-hedged with NMDs after adopting an IM.

Since the adoption of the IM is an endogenous decision, the estimated coefficient could be biased. One identification concern comes from reverse causality if holding loans with high repricing maturity make banks more susceptible to adopt the IM. Actually, in sections 5.1 and 5.2 I present theoretical arguments and empirical evidence supporting such claim. Another identification problem arises if the loan repricing maturity and the ability to lengthen deposits' maturity under the IM are jointly determined by unobserved factors. To disentangle if banks increase the asset repricing maturity even further after adopting the IM, I exploit the monthly frequency of the data to accurately track the timing of banks' decisions. Importantly, I include bank-specific linear time trends, $\gamma_{b,t}$, to control for any pre-existing trend within each bank. The possibility of reserve causality is further diminished if the results are not demand-driven. Thus, I exploit the granularity of the loan-level data to separate demand from supply as explained below. Finally, I exploit changes in the flexibility to slot NMDs within SA banks exclusively. Those changes in flexibility result from the estimates of NMDs' sensitivity and stability by Bank of Mexico, which may not be perfectly correlated with the actual values. First, the estimates are based on coarse assumptions and modelling risk could bias the results (Cocozza et al. 2015). Second, the coefficients are estimated annually and do not capture the within year dynamics. Third, similar estimated values may result in different flexibility because of the discrete cutoffs for group allocation. Thus, conditional on more refined monthly estimates of sensitivity and stability and on other bank controls, assignment into SA groups is plausibly exogenous.

Columns 1 to 6 of Table 5 shows the estimates for the fraction of fixed rate loans. Including bank FE (column 1), banks show a significantly higher probability of granting fixed rate loans after adopting the IM. In column 2 I restrict the sample to firms borrowing from at least two banks in a given month including period×firm FE, $\gamma_t \times \gamma_i$. This controls for time-varying firm fundamentals such as investment opportunities and balance sheet characteristics. The estimated coefficient is positive and significant at the 1% level but slightly smaller than in column 1. The firms that in a given period have loans with multiple banks represent 46% of the firms in the dataset and tend to be larger than firms with only one lender, which could bias the results. Thus, following Morais et al. (2015), I also remove unobserved borrower shocks with state×industry×period FE (column 3). This specification estimated in the entire sample examines, within the same month, loan rates charged to firms from the same state and industry. Since the difference with the coefficient estimated in column 2 is small, the subsample of firms in column 2 could be seen as representative of the entire sample.

There could be borrower selection if IM banks attract firms that demand fixed rate loans. Thus, in column 4 I compare the same firm borrowing from the same bank over time by controlling for bank×firm FE, $\gamma_b \times \gamma_i$. This not only controls for unobserved, time-invariant firm or bank heterogeneity, but also for bank-firm relationships. The estimated coefficient becomes slightly smaller and indicates that the fixed rate fraction increases by almost 8p.p. after the lender adopts the IM. However, after adding state-specific linear trends (column 5), the coefficient of interest reduces to 3p.p., being statistically different from the one in column 4. This implies an increase of 8% in the sample mean of the dependent variable (33%). A similar impact is found in the sample of IM banks (column 6). Thus, I cannot rule out that the effects are driven by pre-existing trends - banks with a higher fraction of fixed rate loans adopted the IM.

In the remaining columns the dependent variable is the IHS of loan maturity.[19] In column 7 I examine firms with multiple banking relationships and find that maturity does not change after banks adopt an IM on average. However, the interaction of the IM dummy with a fixed rate indicator in column 8 shows that maturity increases for fixed rate loans after banks adopt the IM (significant at the 1% level). In column 9 I control for bank and firm FE in the entire sample and the coefficient becomes smaller but remain positive and significant.[20] Accounting for linear time trends (columns 10 and 11), the interaction coefficient becomes even larger, indicating that maturity increases by an additional 9% (all the sample) or 3% (IM banks) when the loan has a fixed rate and is granted by an IM bank.

Table 6 shows the results for the IHS of loan repricing maturity, the main outcome that should be affected ultimately. In the first two columns, the estimated coefficient is positive as expected, but declines considerably and becomes insignificant after adding bank-specific linear trends (columns 3 and 4). Thus, the positive association between the maturity of fixed rate loans and the use of the IM estimated in Table 5 does not translate into an overall higher repricing maturity. This reflects that two-thirds of the loan portfolio have a floating rate, which typically reprices every 28 days. In the last four columns, I estimate the same specifications for the product of the loan repricing maturity and amount committed. The results corroborate that banks do not grant commercial loans with higher repricing maturity after adopting the IM.

[19] Since the IM could affect the interest rate type violating the ignorability assumption, I restrict the sample to firms that always had fixed or floating interest rate with a given bank.

[20] I cannot add bank×firm FE, given that the sample restriction implies little firm-bank variation over time.

In Appendix Table B.2 I restrict the sample to banks that never adopted the IM. I compare the conditions of loans granted by SA banks with high versus low flexibility. High-flexibility banks are expected to grant more fixed rate loans and loans with higher repricing maturity. The results do not support this hypothesis, since the coefficient of interest does not take a positive sign in general. Even if the effects are not observed in the entire portfolio, it is possible that banks are adjusting the conditions of new loans. In Appendix Table B.3 I reestimate the results in the sample of new loans, but I ind a similar as in the sample of outstanding loans. The positive effects on the fixed rate fraction and on the repricing maturity become insignificant and even negative after including bank-specific linear time trends.[21] Only the maturity of fixed rate loans is higher for IM banks in both specifications.

6.2 Mortgage loans and securities

Since mortgages are the main category of fixed rate, long-term loans in banks' portfolios, banks may benefit greatly to hedge their exposure using NMDs. Thus, in Table 7 I estimate the same specification as in equation (13) for the maturity of new mortgage loans, where γ_i denotes municipality FE. I also include household level controls (income and indicators for employment sector) to capture heterogeneity across households. Standard errors are double clustered at the period and bank×employment sector level. Looking at the IHS of mortgage maturity, the estimated coefficients are positive across specifications but not precisely estimated. In columns 4 and 5, which account for bank-specific linear time trends, they are significant at the 10% level. Banks may adjust the loan volume more than the maturity, which is likely to be pre-determined by the product specifications. Thus, in columns 6 to 10 I consider the product of maturity and volume at origination, but the estimated positive coefficients remain insignificant across models.

Securities are another important source of banks' risk exposure that can be hedged with NMDs. Thus, in Table 8 I estimate equation (13) for the probability of a fixed rate, maturity and repricing of securities. In column 1 I use bank and issuer×period FE, so that the sample is restricted to issuers for which more than one security is reported in a given month or for which the same security is held by at least two banks. By comparing securities from the same issuer in

[21] The models for the fixed rate fraction are estimated using ordinary least squares (OLS) despite that it is bounded between 0 and 1. The large number of fixed effects over several dimensions would give rise to an incidental parameter problem when using a non-linear model, whereas the OLS coefficients are still consistent. The results, however, are robust to using a Logit model in the sample of new loans.

a given period, I control for time-varying unobserved heterogeneity at the issuer level. By using bank×issuer FE, in column 2 I control for the endogeneity of the bank-issuer relationship - a bank may be more likely to hold government bonds, with a higher probability of a fixed rate. In this way, I compare securities from the same issuer held by a given bank over time. Looking at the probability of a fixed rate, the estimated coefficient for the IM dummy takes a positive sign but is not precisely estimated in general. Columns 4 to 7 show results for securities' maturity, where there is no robust evidence that the interaction coefficient with the fixed rate indicator is significantly positive. Finally, the remaining columns show that the repricing maturity and its product with securities' market value are not affected by the use of the IM.

In summary, banks with a higher flexibility to allocate NMDs do not increase the repricing maturity of loans or securities holdings. This could be explained if hedging via NMDs' and via derivatives are substitute strategies. In that case, banks may use derivatives to hedge the assets' exposure under the SA and switch to deposits after adopting the IM, holding the asset maturity and the overall risk exposure constant. Thus, the use of derivatives should decline after the adoption of the IM. Appendix Figure B.1 shows banks' holdings of interest rate swaps, the most common interest rate derivative held by Mexican banks.[22] Panel A shows that the use of swaps is much more common among IM than SA banks. Eight out of ten IM banks had always held swaps, whereas that proportion reduces to less than 50% for SA banks and it is even lower after excluding investment banks. Thus, SA banks not only are less able to do natural hedging using NMDs, but they also are less likely to do financial hedging using derivatives. In Panel B, following Rampini et al. (2016) I define gross hedging as the ratio of the notional amount divided by banks' total assets. At this intensive margin, SA banks use derivatives more before 2010, but differences with IM banks become considerably small thereafter. Finally, I consider a proxy for net hedging, that is, long minus short positions that hedge against increases in the reference interest rate or reductions in the term spread. Net swap holdings are defined as the difference between pay-fixed minus pay-floating interest rate swaps, normalized by bank's total assets. A positive value corresponds to a net pay-fixed position that shortens the maturity of the loan portfolio or lengthens the effective duration of the bank's floating-rate deposits. If the

[22] Banks classify most derivatives as for trading purposes, in part due to the higher regulatory costs to classify them as for hedging purposes. In practice, even those classified as for trading can be used for hedging. I exclude swaps where the counterparty is a non-financial firm or an individual (8% of the total notional amount), which reflect firms' and households' hedging needs.

IM and derivatives are substitutes, banks may reduce their net pay-fixed position after adopting the IM. Panel C shows that IM banks hold a balanced net hedging strategy regardless of market conditions. In contrast, SA banks' net hedging position fluctuates more over time.

Using bank-level data, in Appendix Table B.4 I estimate equation (12), where the outcome variables are a binary indicator for interest rate swap holdings (columns 1 to 4), and the measures of gross hedging (columns 5 to 8) and net hedging (columns 9 to 12). A negative sign for the IM dummy is consistent with the view that the IM and swaps are substitutes. At the extensive margin, the sign for the IM indicator is negative, except in the cross-section without bank-level controls. However, it is not significant when including bank FE. For gross hedging, the coefficient on the IM is positive after including bank controls but generally insignificant. For net hedging, the estimates are imprecise and do not render a clear pattern either. These results indicate that there is no strong relationship between the use of the IM and financial hedging. In particular, there is no evidence that they are substitute strategies. In unreported results, I do not find that swap maturity decreases after banks adopt the IM, which would occur if the substitute view prevails.

7 Heterogeneous response to changes in market conditions

Even though IM banks do not lengthen the assets' repricing maturity on average, they may do it depending on the benefits of maturity transformation. When the yield curve becomes steeper, banks prefer holding assets with higher repricing maturity, whereas firms and households are better off by taking debt that reprice more often. Therefore, if the demand prevails in equilibrium, banks should grant loans of lower repricing maturity. In that scenario, IM banks do not have an edge to match the loan sensitivity relative to SA banks. Conversely, when the yield curve flattens, the attractiveness of loans with lower repricing maturity increases for banks but decreases for firms and households. In that case, the use of the IM does provide an edge to accommodate the demand for fixed rate, long-term loans.

Appendix Figure B.2 shows that between March 2013 and December 2014, the monetary policy rate followed a downward trend and the yield curve became steeper. An increase in the short term rate and a flattening of the yield curve were observed between January and December 2016. Thus, to examine the effect of a steepening (flattening) in the yield curve, I consider the period going from January 2011 to December 2014 (January 2014 to December 2016). I restrict the sample to new loans and securities, where the effects should show up earlier, and estimate the following difference-in-difference model for each subperiod:

$$Y_{i,b,t} = \beta_1 IntMod_{b,t_0} \times Post_t + \beta_2 Post_t + \beta_3 IntMod_{b,t_0} + \beta_4 X_{b,t-1} + \gamma_b \times \gamma_i + \gamma_{b,t} + \varepsilon_{i,b,t} \quad (14)$$

where $Post_t$ is a dummy that takes value one after March 2013 (steepening) and after January 2016 (flattening). Since market conditions could affect the decision to adopt the IM biasing the estimates, $IntMod_{b,t_0}$ is a dummy that takes value one for banks using an IM by February 2013 (steepening) and December 2015 (flattening), that is, one month before the change in the slope of the yield curve. The model is estimated for the IHS of the loan repricing maturity (commercial loans and securities) and maturity (mortgages). The covariates in $X_{b,t-1}$ are the same as in equation (12). If β_1 is negative when the yield curve becomes steeper and positive when it becomes flatter, IM banks accommodate more to the loan conditions demanded by firms and households. That is, IM banks reduce more than SA banks the repricing maturity when the yield curve becomes steeper and increase it more when the yield curve flattens.

In columns 1 to 4 of Table 9 the dependent variable is the repricing maturity of new commercial loans. When the yield curve becomes steeper (2013:M3-2014:M12), column 1 shows that IM banks are less likely to grant fixed rate loans than SA banks. But after accounting for bank-specific time trends in column 2, the coefficient is only significant at the 10% level. Columns 3 and 4 show that when the yield curve becomes flatter (2014:M1-2016:M12), IM banks grant loans with a higher repricing maturity. After January 2016, the repricing maturity increases by 0.12 years for IM banks relative to SA banks, which represents an increase in the sample mean of about 43%. In columns 5 to 8 I estimate the same specifications for mortgage maturity. The interaction coefficients take the same signs as in columns 1 and 4, but become insignificant with the inclusion of bank-specific linear time trends. Finally, when I estimate the models for the repricing maturity of securities, the coefficients are generally non-significant across specifications. Appendix Figure B.2 confirms these findings. SA banks are more likely to modify the repricing of commercial loans than IM banks, which exhibit a more stable path over time (Panel A). For mortgages (Panel B), the adjustments in maturity are driven by pre-existing trends. For securities (Panel C), differences are indistinguishable across groups.

The previous findings suggest that IM banks accommodate better the repricing maturity of commercial loans to the demand requirements when the yield curve flattens. In that scenario, IM banks have an advantage to hedge fixed-rate loans of longer maturity using NMDs. Another explanation for that result is that IM banks use derivatives more to hedge loans with higher repricing maturity. In particular, they may be taking a net pay-fixed position when the yield curve flattens. In Appendix Table B.5 I estimate equation (14) at the bank-level using net hedging as the dependent variable. I find that IM banks increase their net pay-fixed position when the yield curve becomes flatter relative to SA banks (and reduce it when the yield curve becomes steeper). The estimates, however, are not statistically significant. This support the interpretation that the higher loans' repricing maturity when the yield curve flattens can be attributed to the use of the IM and not to financial hedging.

8 Conclusion

There is limited evidence on the main drivers and consequences of adopting a model-based approach for the modelling of demand deposits, an important source of stable and cost-effective funding. Using bank-level data, I find that the banks with higher costs of following the SA are more likely to adopt a model-based approach. Those are banks with more stable deposits and a higher share of fixed-rate, long term assets. Following its adoption, banks experience a reduction in the regulatory maturity gap between assets and liabilities and on capital requirements up to a limit set by the regulation. After adopting the IM, banks have an advantage to hedge the exposure of fixed-rate, long term loans using demand deposits. However, using micro data from credits and securities held by Mexican banks, I do not find an increase in their repricing maturity in general. Such increase is only observed for IM versus SA banks when market conditions fuel the demand for fixed-rate, long-term loans. According to the guidelines from the Basel Committee on Banking Supervision (2016), the maturity cap for core deposits under the SA should increase up to five years. Based on the present results, this will lead to regulatory capital gains for Mexican banks, but will not translate into a higher asset repricing maturity.

These results have important implications for the design and implementation of micro prudential regulation. Despite its apparent benefits, the IM for deposits will not be adopted by banks that cannot obtain a capital gain, such as those with volatile deposits or with a high share of short-term assets. This uncovers a strong preference for a small regulatory maturity gap among Mexican banks, which could result in a small effective gap. From a financial stability perspective, a small maturity gap does not eliminate the risk of earnings volatility. The Basel Committee on Banking Supervision (2016) notes that banks could face earnings volatility risk, even if they minimize their economic value risk by matching the repricing of assets with liabilties. To reduce earnings volatility risk, banks need to combine economic value measures with earnings-based measures that focus on changes to future profitability. On the other hand, a small gap resulting from a low asset repricing maturity could increase firms' and households' exposure to interest rate and refinancing risk (Ippolito et al. 2016). Thus, the present findings suggest that the Mexican capitalization requirements for market risk may be too stringent for positions in the banking book, such as loans and deposits. This is in line with the recommendations from the International Monetary Fund (2012) for Mexico that interest rate risk in the banking book should be singled out from the market risk capital rules, in line with a Pillar 2 approach.

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Table 1: Summary statistics

	Standard approach banks		Internal model banks Before adoption		Internal model banks After adoption	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Panel A: Bank-Level Variables						
Maturity gap (years)	0.153	0.436	0.239	0.257	0.216	0.310
Asset maturity (years)	0.702	0.921	1.000	0.500	1.271	0.587
Liability maturity (years)	0.549	0.863	0.760	0.490	1.056	0.536
Interest rate risk exposure (% total assets)	-0.320	0.826	-0.397	0.523	-0.387	0.662
Income or repricing gap (% total assets)	0.127	0.270	0.045	0.069	0.011	0.066
Short-term assets (% total assets)	0.864	0.179	0.783	0.116	0.743	0.124
Short-term liabilities (% total assets)	0.737	0.244	0.738	0.129	0.732	0.130
log(RWAs for market risk) (mill MXN $)	6.955	2.109	10.192	1.649	10.297	1.919
Capitalization index	0.429	0.867	0.160	0.046	0.174	0.050
log(Capitalization requirements) (mill MXN $)	6.264	1.690	9.053	1.512	9.106	2.148
Mortgage loan ratio	0.022	0.065	0.192	0.096	0.206	0.160
NMDs (% total liabilities)	0.156	0.222	0.247	0.097	0.346	0.098
Term deposits (% total liabilities)	0.160	0.213	0.212	0.096	0.194	0.092
NMDs' sensitivity	0.106	0.253	0.076	0.079	0.050	0.144
NMDs' overnight decline (%)	0.159	0.205	0.049	0.031	0.077	0.054
NMDs' 1-month decline (%)	0.664	0.353	0.205	0.320	0.105	0.072
NMDs' 2-year decline (%)	0.821	0.245	0.320	0.283	0.273	0.169
log(Assets) (mill MXN $)	9.487	1.601	12.176	1.349	12.295	1.713
Capital ratio	0.191	0.194	0.096	0.042	0.094	0.041
Liquidity ratio	0.341	0.237	0.504	0.148	0.500	0.218
Non-performing loans (% total assets)	0.018	0.031	0.009	0.006	0.007	0.006
Nr. of observations	**4,262**		**789**		**531**	

Notes. This table shows summary statistics (mean and standard deviation) for SA and IM banks (before and after adoption). Panel A shows summary statistics at the bank level extracted from regulatory reports and from banks' balance sheets. All data are monthly for the period from January 2006 to December 2016. Variables are defined in Appendix Table A.1.

Table 1: Summary statistics (cont.)

	Standard approach banks		Internal model banks Before adoption		Internal model banks After adoption	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Panel B: Loan-Level Variables						
Dependent variables for commercial loans (bank-firm-period)						
Fixed interest rate fraction	0.153	0.345	0.191	0.363	0.230	0.390
IHS(Maturity) (years) - fixed rate	1.642	0.954	1.502	0.763	1.699	0.753
IHS(Maturity) (years) - floating rate	1.554	0.841	1.458	0.727	1.478	0.782
IHS(Repricing maturity) (years)	0.328	0.652	0.373	0.626	0.471	0.736
IHS(Repricing maturity × Amount committed)	15.987	2.153	15.402	2.149	15.537	2.413
Nr. of observations	**1,504,089**		**4,342,200**		**6,761,920**	
Firm characteristics (bank-firm)						
Micro enterprise	0.407	0.488	0.500	0.494	0.547	0.494
Small enterprise	0.472	0.495	0.424	0.488	0.395	0.485
Medium enterprise	0.058	0.233	0.038	0.191	0.031	0.172
Large enterprise	0.062	0.242	0.038	0.191	0.028	0.165
Nr. of observations	**52,806**		**150,893**		**253,549**	
Dependent variables for new mortgages (bank-household-period)						
IHS(Maturity) (years)	3.002	0.427	2.909	0.250	2.923	0.201
IHS(Maturity × Volume)	17.392	0.680	17.531	0.735	17.654	0.705
Nr. of observations	**36,051**		**263,583**		**350,419**	
Household characteristics (bank-household)						
IHS(Income) (MXN $)	10.395	0.743	10.517	0.829	10.629	0.835
Public sector employee - federal (%)	0.009	0.095	0.132	0.338	0.109	0.311
Public sector employee - state (%)	0.006	0.077	0.032	0.176	0.025	0.155
Public sector employee - municipal (%)	0.001	0.034	0.011	0.105	0.010	0.101
Private sector employee (%)	0.857	0.350	0.730	0.444	0.775	0.417
Self-employed (%)	0.122	0.327	0.090	0.285	0.081	0.273
Nr. of observations	**36,051**		**263,581**		**350,417**	
Panel C: Security-Level Variables						
Dependent variables (bank-security-period)						
Fixed interest rate	0.499	0.500	0.663	0.473	0.634	0.482
IHS(Maturity) (years) - fixed rate	1.524	1.321	2.049	0.993	2.299	0.983
IHS(Maturity) (years) - floating rate	2.237	0.501	2.246	0.414	2.438	0.482
IHS(Repricing maturity) (years)	0.843	1.171	1.406	1.216	1.507	1.310
IHS(Repricing maturity × Market value holdings)	19.663	3.338	22.460	3.694	22.130	3.887
Nr. of observations	**51,155**		**18,440**		**35,043**	

Notes. This table shows summary statistics (mean and standard deviation) for SA and IM banks (before and after adoption). Panel B shows statistics for all outstanding commercial loans from the R04 C reports and the corresponding firm characteristics. Commercial loans with no stated maturities are excluded from the corresponding statistics. Non-performing loans are dropped from the sample. Panel B also shows statistics for all new mortgage loans from the R04 H reports and the corresponding household characteristics. Loans granted by development banks are excluded from the sample in Panel B. Panel C summarizes all securities held by commercial and two development banks, issued by the government and by financial and non-financial institutions. All loan and security characteristics are volume weighted. Loan maturity, repricing, volume and amount committed are winsorized at the top 2 percent of the distribution. All data are monthly for the period from August 2009 to December 2016, except securities data that start on July 2010. Variables are defined in Appendix Table A.1.

Table 2: Determinants of the time until adoption of the internal model

	(1)	(2)	(3)	(4)	(5)	(6)
Maturity gap	3.878**					
	(1.682)					
Asset maturity		3.913**				
		(1.656)				
Liability maturity		-3.945**				
		(1.724)				
Mortgage loan ratio			12.981***			
			(3.954)			
NMDs' ratio			4.983***	30.044***		
			(1.888)	(11.278)		
NMDs' sensitivity				-.183		
				(3.807)		
NMDs' instability				-7.303***		
				(2.830)		
NMDs' ratio × NMDs' sensitivity				-14.995		
				(19.928)		
NMDs' ratio × NMDs' instability				-108.216***		
				(40.710)		
Income gap					-5.091**	
					(2.399)	
Short-term assets						-5.918**
						(2.745)
Short-term liabilities						3.914
						(2.480)
log(Assets)	.914***	.913***	.919***	-.936**	.919***	.877***
	(.224)	(.224)	(.301)	(.452)	(.180)	(.177)
Capital ratio	-10.308	-10.579	-2.905	12.011	3.004	2.289
	(9.474)	(9.233)	(4.974)	(16.299)	(4.504)	(4.004)
Liquidity ratio	4.954**	4.844*	6.397***	8.706	5.134**	5.878**
	(1.969)	(2.637)	(2.480)	(6.352)	(2.091)	(2.350)
Credit risk	19.503	19.068	-52.365	-173.702*	-.363	6.991
	(21.561)	(22.665)	(61.832)	(97.178)	(18.340)	(19.079)
Restricted mean survival time (yrs)	9.866	9.866	9.866	9.866	9.866	9.866
Conditional mean survival time (yrs)	6.233	6.233	6.233	6.233	6.233	6.233
Pseudo R-squared	.394	.394	.586	.622	.333	.341
Observations	4,968	4,968	4,968	3,221	4,968	4,968
Global test chi-squared	.341	.203	.994	.420	.383	.576

Notes. This table shows the coefficients (not hazard ratios) from a Cox proportional hazards model for the time until a bank request the approval of the IM. Bank controls are the the maturity gap between assets and liabilities and their corresponding values (columns 1 and 2), the ratios of mortgage loans over total loans and of NMDs' over total liabilities (column 3), the sensitivity and 2-year stability of NMDs (column 4), and the income gap and its corresponding components (columns 5 and 6). All specifications also include the logarithm of bank assets and the ratios of capital, liquid assets and non-performing loans in total assets. Data are of monthly frequency from January 2006 to December 2016. In column 4 I use observations for banks that have at least 48 months of NMDs' data to compute their stability and sensitivity. Restricted mean survival time is the time in years until request for the IM approval, restricted to the longest follow-up time (11 years). The conditional mean is the time in years until the IM request for the subsample of IM banks. The last row reports the p-values from a chi-square global test for the violation of the proportional-hazards assumption, using Shoenfeld residuals. Robust standard errors adjusted for clustering at the bank-level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 3: Adoption of the internal model and interest rate risk exposure

Dependent variable:	Maturity gap			Asset maturity		Liability maturity		IRR exposure		
			IM banks		IM banks		IM banks			IM banks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Internal Model$_{t-1}$	.048**	-.155***	-.150***	.145***	.271***	.299***	.420***	-.135***	.167***	.186***
	(3.334)	(-3.683)	(-3.538)	(1.449)	(3.596)	(3.132)	(7.066)	(-4.361)	(2.137)	(2.433)
Mean dep. var.	.172	.172	.228	.802	1.121	.630	.892	-.337	-.337	-.388
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
R-squared	.077	.046	.227	.108	.459	.118	.515	.098	.059	.221
Observations	5,460	5,460	1,286	5,460	1,286	5,460	1,286	5,460	5,460	1,286

Notes. The dependent variables are the difference between assets and liabilities' maturity (columns 1 to 3), asset maturity (columns 4 and 5), liability maturity (columns 6 and 7), and interest rate risk exposure (columns 8 to 10), all normalized by total assets and for operations in domestic currency with nominal interest rate. Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. Bank controls in $t-1$ include bank size, the capital and liquidity ratios in total assets, credit risk, the ratios of NMDs and term deposits in total liabilities, the ratio of mortgage loans in total loans, and NMDs' sensitivity and stability and their interactions. All variables are described in Appendix Table A.1. In the columns denoted "IM banks" the sample is restricted to banks that eventually adopted the IM over the sample period. Bank-level data are of monthly frequency from January 2006 to December 2016. Cluster-robust t-statistics (wild bootstrap, 9,999 replications) at the bank level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 4: Capital adequacy ratio and capital requirements

Dependent variable:	log(RWAs for market risk)				Net capital / Total RWAs				log(Capitalization requirements)			
			IM banks				IM banks				IM banks	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Internal Model$_{t-1}$	-.529***	.003	.048*	-.089**	.168***	.100**	.003	.006**	-.446***	-.037	-.010	-.016
	(-2.628)	(.034)	(.454)	(-1.057)	(2.964)	(1.750)	(.610)	(1.978)	(-2.821)	(-.789)	(-.206)	(-.739)
Mean dep. var.	7.748	7.748	10.239	10.344	.357	.357	.166	.151	6.948	6.948	9.080	9.329
Bank-level controls$_{t-1}$	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.256	.670	.713	.491	.065	.100	.465	.359	.512	.850	.944	.856
Observations	5,484	5,484	1,310	397	5,484	5,484	1,310	397	5,484	5,484	1,310	397

Notes. The dependent variables are the logarithm of risk-weighted assets for market risk (columns 1 to 4), the capital adequacy ratio (columns 5 to 8), and the logarithm of capital requirements (columns 9 to 12). Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. Bank controls in $t-1$ include bank size, the liquidity ratio in total assets, credit risk, the ratios of NMDs and term deposits in total liabilities, the ratio of mortgage loans in total loans, and NMDs' sensitivity and stability and their interactions. All variables are described in Appendix Table A.1. In the columns denoted "IM banks" the sample is restricted to banks that eventually adopted the IM over the sample period. In columns 4, 8 and 12, the sample is further restricted to 24 months before and after each bank's adoption of the IM. Bank-level data are of monthly frequency from January 2006 to December 2016. Cluster-robust t-statistics (wild bootstrap, 9,999 replications) at the bank level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 5: Fixed rate fraction and maturity of commercial loans

Dependent variable:	Fixed rate						IHS(Maturity)				
						IM banks					IM banks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Internal Model$_{t-1}$	.121***	.097***	.112***	.078***	.028**	.024**	.022	-.047*	.011	-.100***	-.066***
	(.020)	(.015)	(.020)	(.012)	(.014)	(.012)	(.021)	(.025)	(.022)	(.024)	(.019)
Internal Model$_{t-1}$ × FixRate$_t$								.150***	.063***	.084***	.034**
								(.020)	(.019)	(.016)	(.015)
FixRate$_t$								.250***	.281***	.260***	.283***
								(.015)	(.018)	(.020)	(.019)
Mean dep. var.	.333	.328	.332	.332	.332	.312	1.611	1.611	1.688	1.688	1.715
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	No	Yes	No	No	No	No	No	No	No	No
Period FE	Yes	No	No	Yes	No	No	No	No	Yes	No	No
Bank FE	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Bank × Firm FE	No	No	No	Yes	Yes	Yes	No	No	No	No	No
Period × Firm FE	No	Yes	No	No	No	No	Yes	Yes	No	No	No
Period × State × Industry FE	No	No	Yes	No	No	No	No	No	No	No	No
Bank × Linear time trend	No	No	No	No	Yes	Yes	No	No	No	Yes	Yes
R-squared	.035	.026	.032	.024	.008	.011	.027	.073	.053	.034	.039
Observations (000's)	13,168	6,086	13,166	13,160	13,160	11,524	2,484	2,484	7,538	7,538	6,035

Notes. The dependent variables are the average share of a loan with fixed interest rate for a firm-bank pair (columns 1 to 6) and the firm's average inverse hyperbolic sine transformation of loan maturity (columns 7 to 11). Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. In columns 8 to 11, the IM dummy is interacted with an indicator for fixed rate loans. Bank controls in $t-1$ include bank size, the capital and liquidity ratios, credit risk, the ratios of NMDs and term deposits in total liabilities, the ratio of mortgage loans in total loans, the NMDs' sensitivity and stability and their interactions. Firm controls are dummies for firm size. All variables are described in Appendix Table A.1. In the columns denoted "IM banks" the sample is restricted to banks that eventually adopted the IM over the sample period. Data are of monthly frequency for the period from August 2009 to December 2016 and in columns 7 to 11 the sample is restricted to firms that always had either fixed or floating rate loans with a given bank. In columns 2, 7 and 8 I use observations for firms that have loans with at least two banks in a given month. Robust standard errors adjusted for clustering at the bank×industry and year-month level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 6: Repricing maturity of commercial loans

	IHS(Repricing)				IHS(Repricing × Amount committed)			
				IM banks				IM banks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Internal Model$_{t-1}$	.167***	.148***	.021	.009	.336***	.390***	.130**	.131**
	(.029)	(.020)	(.030)	(.026)	(.058)	(.039)	(.055)	(.051)
Mean dep. var.	.663	.670	.670	.638	13.397	13.005	13.005	12.905
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	No	Yes	No	No	No	Yes	No	No
Bank FE	Yes	No	No	No	Yes	No	No	No
Bank × Firm FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Period × Firm FE	Yes	No	No	No	Yes	No	No	No
Bank × Linear time trend	No	No	Yes	Yes	No	No	Yes	Yes
R-squared	.024	.025	.006	.010	.014	.011	.004	.007
Observations	5,691,479	12,433,342	12,433,342	10,931,851	5,691,479	12,433,342	12,433,342	10,931,851

Notes. The dependent variables are the firm's average inverse hyperbolic sine transformation of loan repricing maturity (columns 1 to 4) and of the product of loan repricing maturity and amount committed (columns 5 to 8). Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. Bank controls are the same as in Table 5. All variables are described in Appendix Table A.1. In the columns denoted "IM banks" the sample is restricted to banks that eventually adopted the IM over the sample period. Data are of monthly frequency for the period from August 2009 to December 2016. In columns 1 and 5 I use observations for firms that have loans with at least two banks in a given month. Robust standard errors adjusted for clustering at the bank×industry and year-month level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 7: Maturity of new mortgage loans

Dependent variable:	IHS(Maturity)					IHS(Maturity × Volume)				
					IM banks					IM banks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Internal Model$_{t-1}$	.012	.011	.013	.040*	.050*	.017	.038	.030	.001	.008
	(.025)	(.025)	(.023)	(.021)	(.029)	(.064)	(.062)	(.056)	(.044)	(.045)
Mean dep. var.	2.935	2.936	2.935	2.935	2.922	17.031	17.039	17.032	17.032	17.035
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	No	Yes	No	No	Yes	No	Yes	No	No
Bank FE	Yes	Yes	No	No	No	Yes	Yes	No	No	No
Bank × Municipality FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Period × Municipality FE	No	Yes	No	No	No	No	Yes	No	No	No
Bank × Linear time trend	No	No	No	Yes	Yes	No	No	No	Yes	Yes
R-squared	.046	.025	.033	.035	.041	.276	.244	.248	.242	.244
Observations	650,040	634,214	648,068	648,068	612,511	650,040	634,214	648,068	648,068	612,511

Notes. The dependent variables are the inverse hyperbolic sine transformation of maturity (columns 1 to 5) and of the product of maturity and loan volume (columns 6 to 10) of each new mortgage granted by commercial banks. Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. Bank controls are the same as in Table 5. Household controls are the IHS of borrower's income and dummies for the borrower's employment sector (public, private or self-employed). All variables are described in Appendix Table A.1. In the columns denoted "IM banks" the sample is restricted to banks that eventually adopted the IM over the sample period. Data are of monthly frequency for the period from August 2009 to December 2016. In columns 2 and 7 I use observations for municipalities that have taken new loans with at least two banks in a given month. Robust standard errors adjusted for clustering at the bank×borrower's employment sector and year-month level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 8: Securities holdings: Probability of fixed rate, maturity and repricing maturity

	Fixed rate			IHS(Maturity)				IHS(Repricing maturity)			IHS(Repricing maturity × Holdings)		
			IM banks				IM banks			IM banks			IM banks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Internal Model$_{t-1}$	.010	.008	.034*	.003	-.165**	-.159**	-.092**	.003	-.054	-.047	.200	.042	.094
	(.021)	(.022)	(.019)	(.047)	(.078)	(.064)	(.041)	(.067)	(.077)	(.074)	(.217)	(.145)	(.168)
Internal Model$_{t-1}$ × FixRate$_t$					.398**	.203	-.057						
					(.167)	(.151)	(.137)						
FixRate$_t$					-.527***	-.461***	-.169						
					(.112)	(.120)	(.118)						
Mean dep. var.	.416	.410	.409	1.978	1.978	1.998	2.179	.771	.769	.899	16.833	16.790	16.816
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No
Period × Issuer FE	Yes	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No
Bank × Issuer FE	No	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Bank × Linear time trend	No	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R-squared	.003	.001	.002	.004	.044	.036	.015	.002	.001	.001	.005	.001	.001
Observations	94,921	99,470	53,420	94,921	94,921	99,470	53,420	94,921	99,470	53,420	94,921	99,470	53,420

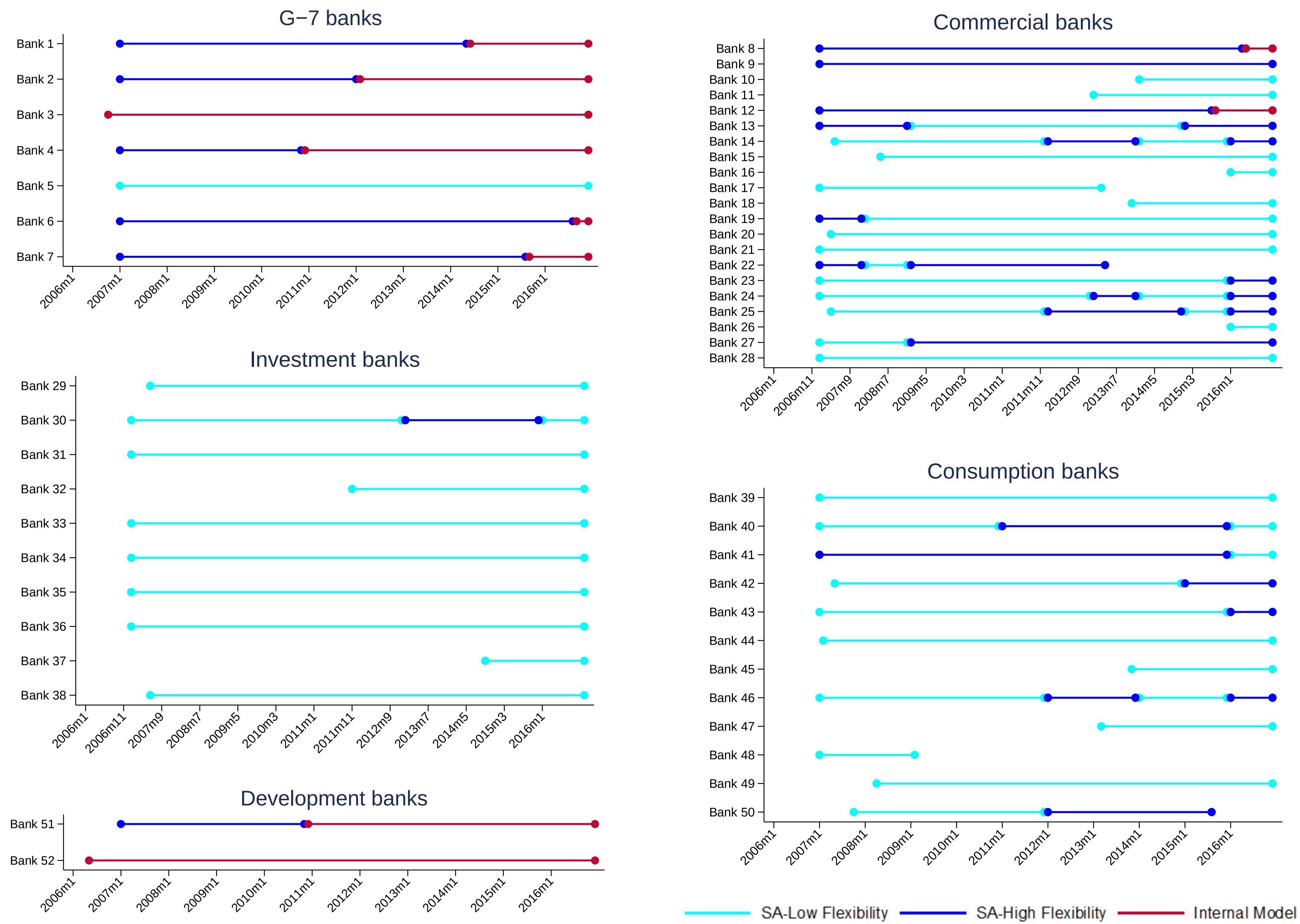
Notes. The dependent variables are a fixed rate indicator (columns 1 to 3), and the inverse hyperbolic sine transformation of maturity (columns 4 to 7), repricing maturity (columns 8 to 10) and the product of repricing maturity and the market value (columns 11 to 13) for each security held by banks. Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. In addition, in columns 5 to 7 the IM dummy is interacted with an indicator for fixed rate loans. Bank controls are the same as in Table 5. All variables are described in Appendix Table A.1. In the columns denoted "IM banks" the sample is restricted to banks that eventually adopted the IM over the sample period. Data are of monthly frequency for the period from July 2010 to December 2016. In columns 1, 4, 5, 8 and 11 I use observations for issuers that have more than one outstanding security in a given month or with the same security held by at least two banks. Robust standard errors adjusted for clustering at the bank×sector of the issuer (government, bank, private sector) and year-month level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 9: Heterogeneous response to a steepening and flattening of the yield curve

Dependent variable:	Commercial loans: IHS(Repricing)				Mortgages: IHS(Maturity)				Securities: IHS(Repricing)			
Sample period:	2011:M1-2014:M12		2014:M1-2016:M12		2011:M1-2014:M12		2014:M1-2016:M12		2011:M1-2014:M12		2014:M1-2016:M12	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\text{IntMod}_{2013:M2} \times \text{Steepening}_t$	-.114***	-.060*			-.061***	-.039			.073	.130		
	(.031)	(.031)			(.021)	(.035)			(.067)	(.083)		
$\text{IntMod}_{2015:M12} \times \text{Flattening}_t$			.067***	.121**			.141**	.081			-.006	.049
			(.023)	(.049)			(.068)	(.076)			(.103)	(.051)
Steepening_t		.051*				.068**			-.051	-.094		
		(.028)				(.030)			(.049)	(.069)		
Flattening_t				-.039				-.077			.005	.004
				(.027)				(.081)			(.031)	(.028)
Mean dep. var.	.290	.290	.284	.284	2.949	2.949	2.982	2.982	.341	.341	.301	.301
Bank controls_{t-1}	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	-	-	-	-	Yes	Yes	Yes	Yes	-	-	-	-
Period FE	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Bank × Firm FE	Yes	Yes	Yes	Yes	-	-	-	-	-	-	-	-
Bank × Municipality FE	-	-	-	-	Yes	Yes	Yes	Yes	-	-	-	-
Bank × Issuer FE	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes
Bank × Linear time trend	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	.010	.004	.012	.010	.046	.031	.045	.020	.004	.004	.002	.002
Observations	1,348,414	1,348,414	961,079	961,079	354,903	354,903	327,490	327,490	11,157	11,157	6,001	6,001

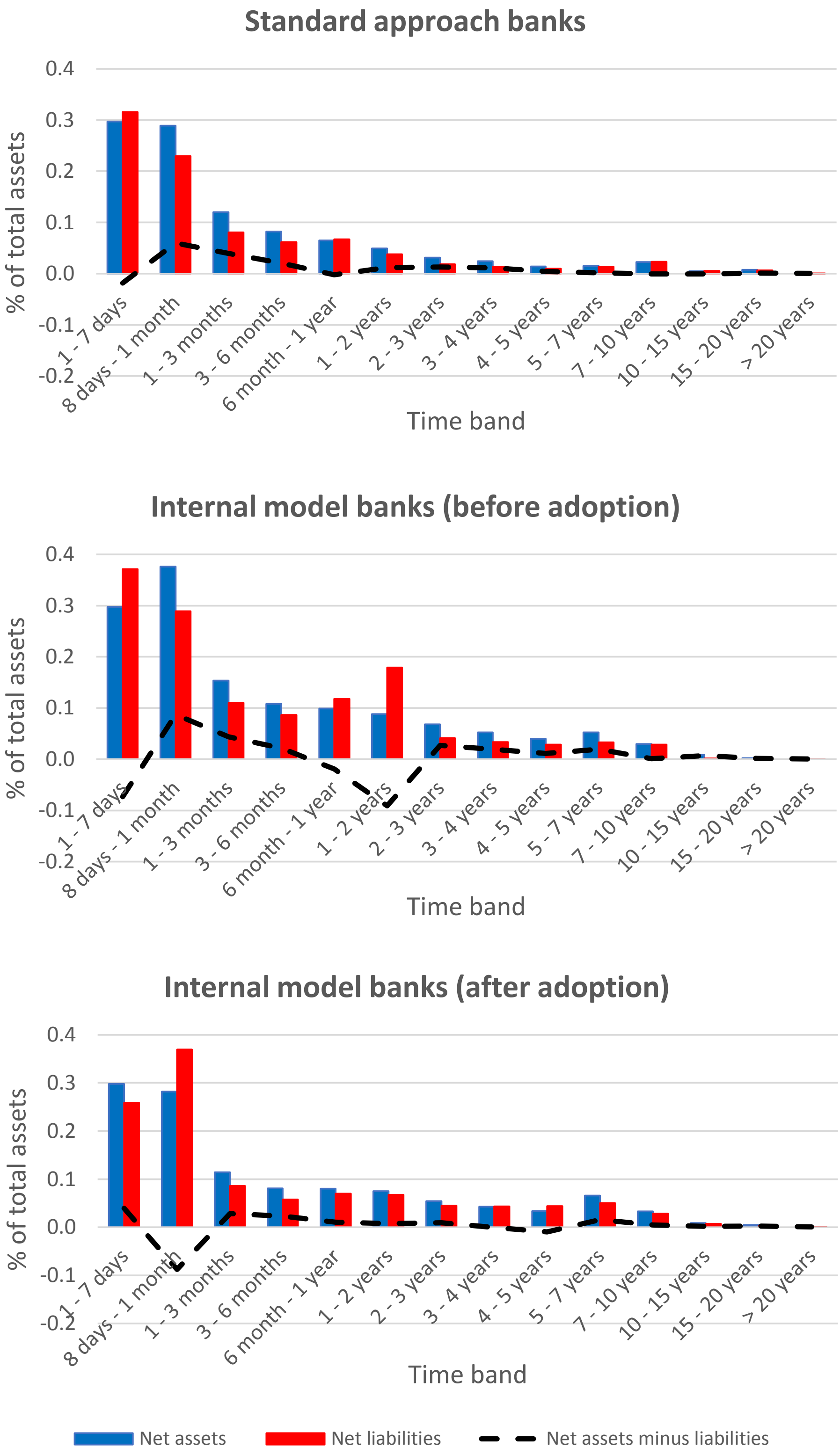
Notes. The dependent variables are the inverse hyperbolic sine transformation of the repricing maturity of commercial loans (columns 1 to 4), of mortgage maturity (columns 5 to 8) and of the securities' repricing maturity (columns 9 to 12). IntMod are dummies for banks following the IM by February 2013 or December 2015. Interaction terms with the IntMod dummies are included for an indicator of a steepening (flattening) of the yield curve that takes value one after March 2013 (January 2016). Bank controls are the same as in Table 5. Household controls are the IHS of borrower's income and dummies for the borrower's employment sector (public, private or self-employed). All variables are described in Appendix Table A.1. Data are of monthly frequency for the period from January 2011 to December 2014 (January 2014 to December 2016). The samples are restricted to new loans and new securities. Robust standard errors adjusted for clustering at the year-month level and at the bank×industry (columns 1 to 4), bank×borrower's employment sector (columns 5 to 8) and bank×sector of the issuer (columns 9 to 12) levels are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Figure 1: Banks' approach for the time slotting of NMDs



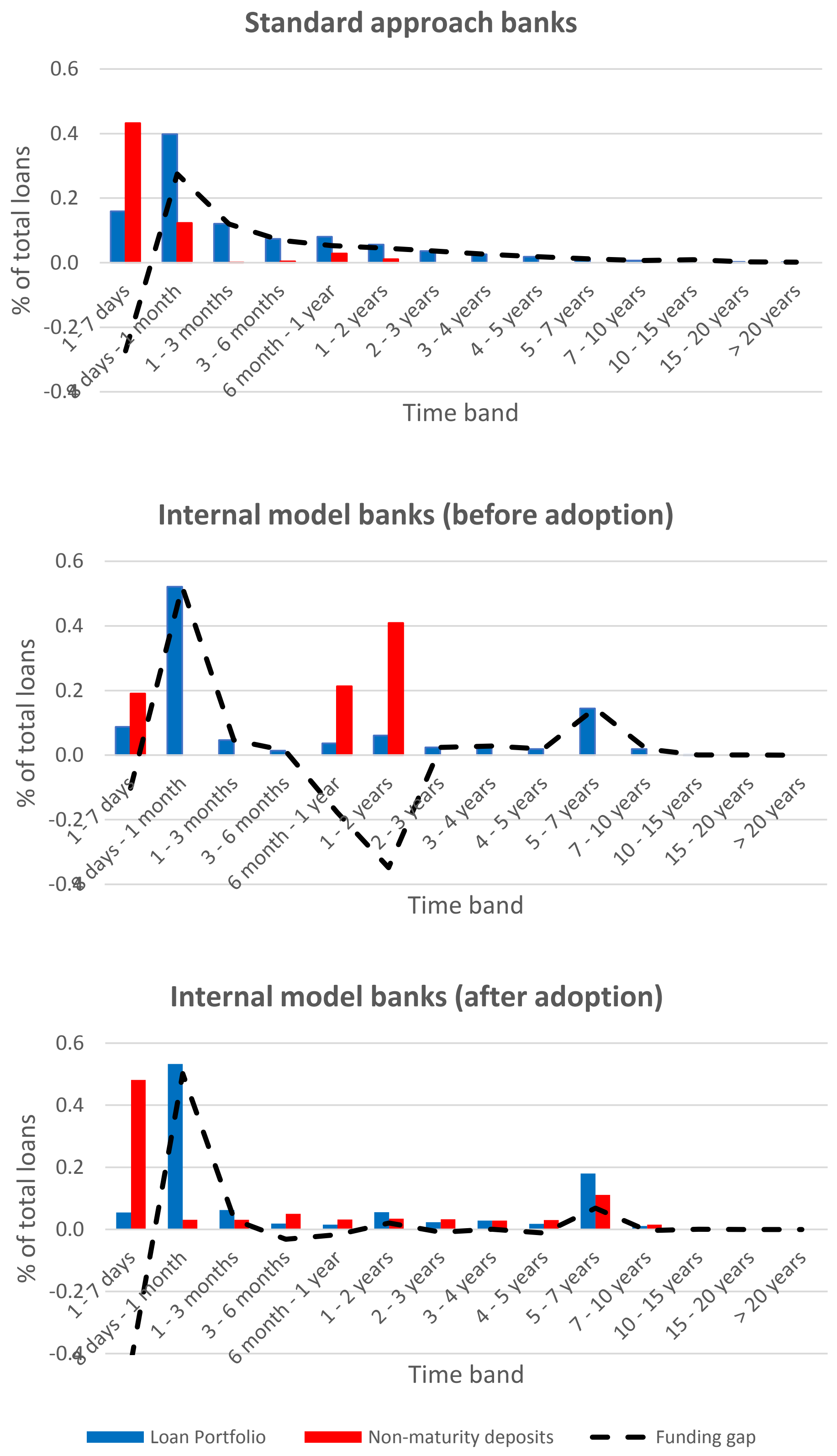
Notes. This figure shows the approach adopted by each bank in the sample for the time slotting of non-maturity deposits between January 2006 and December 2016. SA-low flexibility are banks under the SA that can allocate up to 0% or 10% of their deposits into band 6 (1 to 2 years). SA-high flexibility are banks under the SA that can allocate up to 45% or 80% into band 6. Internal model indicates the dates following the regulator's approval of the IM for a given bank.

Figure 2:
Panel A: Net assets and liabilities by time band



Notes. This figure shows the average net assets, net liabilities and the gap between assets and liabilities (all normalized by total assets) for operations subject to market risk, in domestic currency and with nominal interest rate. Positions that can be compensated, such as derivatives, are netted out. Standard approach banks are those that used the standard approach for the time slotting of NMDs over the entire sample period. Internal model banks are all banks that eventually adopted the internal model over the sample period, with the averages computed before and after its adoption. The time bands are the ones used to compute the capital requirements for market risk. The averages are computed using monthly confidential data from banks' supervisory reports to the Bank of Mexico from January 2006 to December 2016.

Figure 2:
Panel B: Loans and NMDs by time band



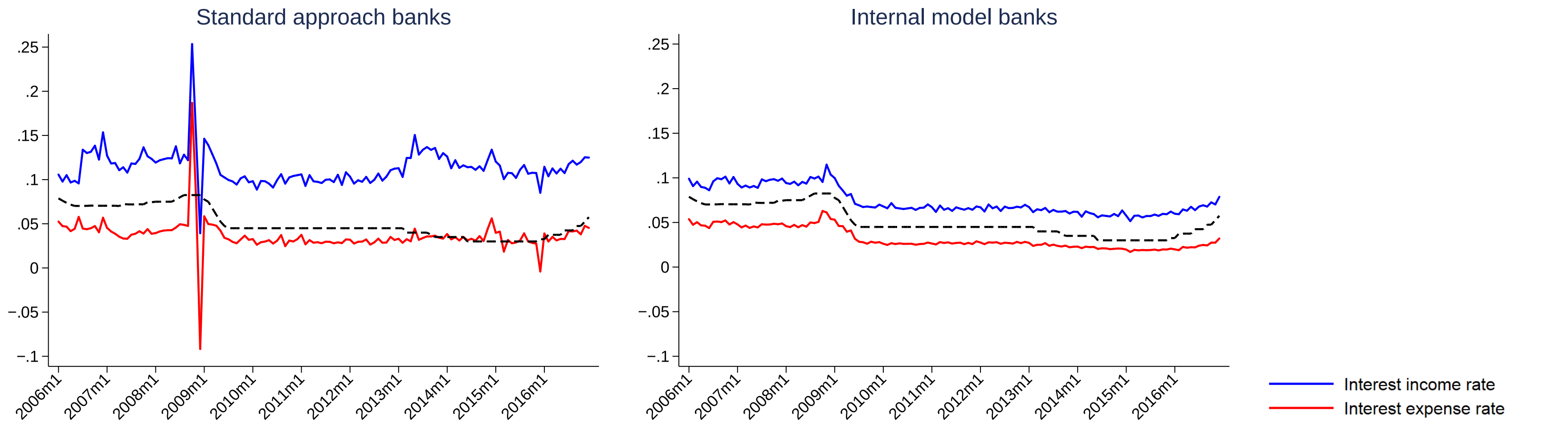
Notes. This figure shows the average loans, NMDs and the gap between loans and NMDs (all normalized by total loans) for operations subject to market risk, in domestic currency and with nominal interest rate. The averages are computed using monthly bank-level data. Standard approach banks are those that used the standard approach for the time slotting of NMDs over the entire sample period. Internal model banks only include two banks that adopted the internal model between October 2015 and December 2016. The time bands are the ones used to compute the capital requirements for market risk. The averages are computed using monthly confidential data from banks' supervisory reports to the Bank of Mexico from October 2015 to December 2016.

Figure 3: Average maturity of aggregate bank assets and liabilities

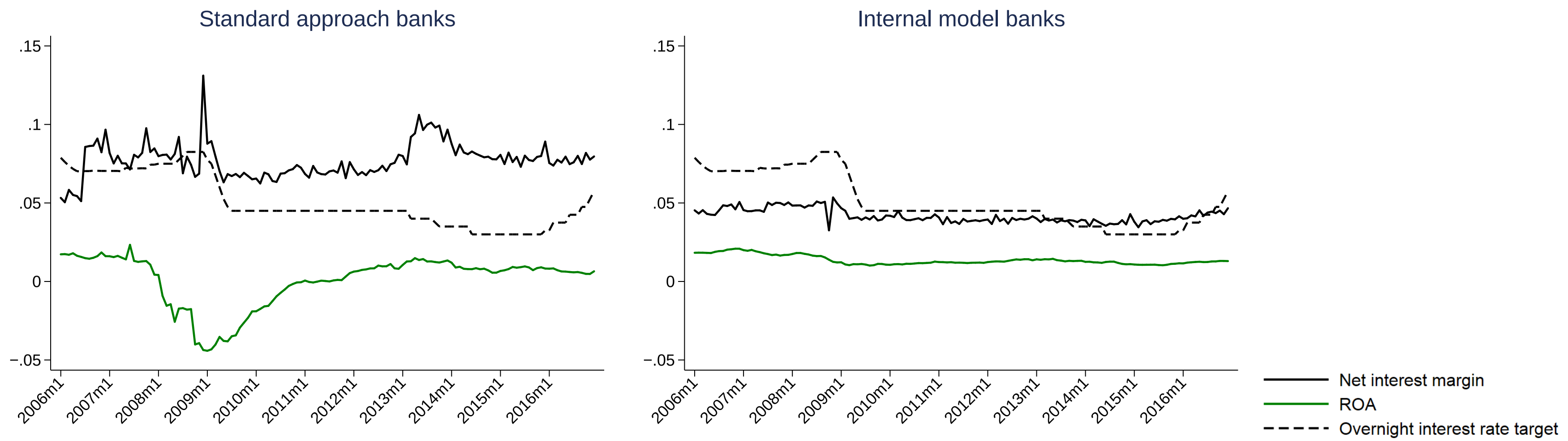
Notes. This figure shows the average asset and liability maturity and the average maturity gap (in years) for SA banks and for each IM bank. Asset and liability maturity are computed as $\sum_{j=1}^{14} A_{b,t,j} M_j / \sum_{j=1}^{14} A_{b,t,j}$ and $\sum_{j=1}^{14} L_{b,t,j} M_j / \sum_{j=1}^{14} A_{b,t,j}$, and the difference between the two is the maturity gap described in equation (1). The vertical line indicates the date of adoption of the IM. The maturities are computed using monthly bank level data from January 2006 to December 2016.

Figure 4: Bank's profitability: Net interest margin and ROA

Panel A: Interest income and interest expense rates



Panel B: Net interest margin and ROA



Notes. This figure plots interest income and interest expense rates in Panel A and net interest income (NIM) and return on assets (ROA) in Panel B for SA and IM banks. The interest income and interest expense rates equal monthly interest income and expenses, divided by total assets and then annualized. The NIM equals the difference between interest income and interest expense rates and the ROA equals net income divided by assets. Both panels also show the overnight interest rate target. All data are monthly from banks' financial statements, from January 2006 to December 2016.

Appendix A. Definitions and sources

Table A.1: Definitions of Bank-, Loan- and Security- Level Variables

This table summarizes the main variables used in the paper. Bank-level variables are extracted from the CNBV and from confidential reports to Bank of Mexico. Commercial loan- and firm-level variables come from the R04 C report and mortage- and household-level variables come from the R04 H report. Security-level variables come from confidential reports to Bank of Mexico.

Variable	Description
Bank-Level Variables	
Maturity gap (years)	Sum across time bands of the product of the maturity midpoint of each band and the gap between assets and liabilities, normalized by total assets in domestic currency with nominal interest rate.
Asset / liability maturity (years)	Sum across time bands of the product of the maturity midpoint of each band and the assets / liabilities, normalized by total assets in domestic currency with nominal interest rate.
Interest rate risk exposure	Negative of the sum across time bands of the product between the weight coefficients for market risk (see Table B.1) and the gap between assets and liabilities, normalized by total assets in domestic currency with nominal interest rate.
Income or repricing gap	Sum across time bands of the gap between assets and liabilities that reprice or mature within a year, normalized by total assets in domestic currency with nominal interest rate.
Short-term assets / liabilities	Sum across time bands of assets / liabilities that reprice or mature within a year, normalized by total assets in domestic currency with nominal interest rate.
log(RWAs for market risk) (mill MXN $)	Logarithm of the capital requirements for market risk times 12.5 (i.e. the reciprocal of the minimum capital ratio of 8%).
Capitalization index	Ratio of a bank's net capital over its total risk-weighted assets (RWAs for market, credit and operational risks).
log(Capitalization requirements) (mill MXN $)	Logarithm of total value of the sum of minimum capital requirements for market, credit and operational risks.
Mortgage loan ratio	Ratio of mortgage loans over total performing loans.
NMDs ratio	Ratio of NMDs of the general public over total liabilities. NMDs comprise sight deposits (with and without interest), deposits in saving accounts and deposits in checking accounts (with and without interest).
Term deposits ratio	Ratio of time deposits of the general public over total liabilities.
NMDs' sensitivity	Weighted-average of the 28-day Cetes rate pass-through to the NMDs' rate within one month. See Appendix C for details.
NMDs' overnight / 1-month / 2-year decline	Fraction of NMDs that declines overnight (non-core component)/within one month/two years. See Appendix C for details.
log(Assets) (mill MXN $)	Logarithm of the bank total assets.
Capital ratio	Ratio of total stockholders' equity over total assets.

Variable	Description
Liquidity ratio	Ratio of liquid assets over total assets. Liquid assets is the sum of cash and balances from Central Bank, due from other financial institutions, trading securities, available-for-sale securities, held-to-maturity securities and unearned income from securities.
Credit risk	Ratio of a bank's non-performing loan portfolio over total assets.
Loan- and Firm-Level Variables (commercial loans)	
Fixed-rate fraction	Average share of bank loans with fixed interest rate, weighted by loan volume.
IHS(Maturity) (years)	Inverse hyperbolic sine transformation of the average maturity at origination, weighted by loan volume.
IHS(Repricing maturity) (years)	Inverse hyperbolic sine transformation of the maturity at origination of a fixed rate loan and rate reset frequency of a floating rate loan, weighted by loan volume.
IHS(Repricing maturity × Amount committed)	Inverse hyperbolic sine transformation of the product of the repricing maturity and the total value of committed credit (millions of Mexican pesos).
Micro / small / medium / large enterprise	Dummy variable equal to one if the sum of the 90% of the firm's income and the 10% of employees' number is smaller or equal than 4.6 / between 4.6 and 95 / between 95 and 250 / greater than 250.
Mortgage- and Household-Level Variables (new loans)	
IHS(Maturity) (years)	Inverse hyperbolic sine transformation of the maturity at origination, weighted by loan volume.
IHS(Maturity × Volume)	Inverse hyperbolic sine transformation of the maturity and volume at origination, weighted by loan volume.
IHS(Income) (MXN $)	Inverse hyperbolic sine transformation of the borrower's income at origination.
Public sector employee	Dummy variable indicating whether the borrower works for some public organization (federal, state or municipal).
Private sector employee	Dummy variable indicating whether the borrower works for a firm not controlled by the government.
Self-employed	Dummy variable indicating whether the borrower is not a wage worker.
Security-Level Variables	
IHS(Maturity) (years)	Inverse hyperbolic sine transformation of the maturity at origination of a given security.
IHS(Repricing maturity) (years)	Inverse hyperbolic sine transformation of the maturity at origination for a fixed rate security and the rate reset frequency for a floating rate security.
IHS(Repricing maturity × Market value holdings)	Inverse hyperbolic sine transformation of the product of the repricing maturity and the market value of a security held by a bank (millions of Mexican pesos).

Appendix B. Additional Tables

Table B.1: Weighting factors to compute market risk capital requirements

Bands	Residual time to maturity or duration	Weighting factors	
		Jan-06 to Sep-15	Oct-15 to date
1	1 to 7 days	0.12%	0.02%
2	8 days to 1 month	0.25%	0.10%
3	1 to 3 months	0.62%	0.31%
4	3 to 6 months	1.12%	0.64%
5	6 months to 1 year	2.22%	1.25%
6	1 to 2 years	3.87%	2.43%
7	2 to 3 years	5.03%	4.02%
8	3 to 4 years	6.59%	5.61%
9	4 to 5 years	9.53%	7.03%
10	5 to 7 years	12.47%	9.25%
11	7 to 10 years	16.49%	13.92%
12	10 to 15 years	19.67%	19.86%
13	15 to 20 years	22.85%	22.90%
14	more than 20 years	26.03%	26.10%

Notes. The weighting factors for each time band are estimated by the CNBV to compute capital requirements for market risk for operations with nominal interest rate in domestic currency.

Table B.2: SA banks and commercial loans' maturity

Dependent variable:	Fixed rate		IHS(Maturity)		IHS(Repricing)		IHS(Repricing × Committment)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SA-HighFlex$_{t-1}$	-.007*	-.002	-.029	-.034**	-.056***	-.025**	.000	-.057
	(.004)	(.002)	(.022)	(.016)	(.015)	(.012)	(.055)	(.053)
SA-HighFlex$_{t-1}$ × FixRate$_t$			-.045	-.019				
			(.032)	(.031)				
FixRate$_t$			.247***	.249***				
			(.039)	(.039)				
Mean dep. var.	.472	.472	1.576	1.576	.901	.901	13.737	13.737
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	No	Yes	No	Yes	No	Yes	No
Bank FE	No	No	Yes	Yes	No	No	No	No
Firm FE	No	No	Yes	Yes	No	No	No	No
Bank × Firm FE	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Bank × Linear time trend	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	.004	.011	.027	.086	.013	.027	.028	.043
Observations	1,501,951	1,501,951	1,376,799	1,376,799	1,501,491	1,501,491	1,501,491	1,501,491

Notes. The dependent variables are the average share of a loan with fixed interest rate for a firm-bank pair (columns 1 and 2) and the firm's average inverse hyperbolic sine transformation of loan maturity (columns 3 and 4), of loan repricing maturity (columns 5 and 6) and of the product of loan repricing maturity and amount committed (columns 7 and 8). SA-LowFlex is a dummy for banks following the SA in $t-1$ that can allocate a maximum of 0 or 10% of their NMDs into the 2-year band. In columns 3 and 4, the SA-LowFlex dummy is interacted with an indicator for fixed rate loans. Bank controls are the same as in Table 5. All variables are described in Appendix Table A.1. Data are of monthly frequency for the period from August 2009 to December 2016. The sample is restricted to loans from banks that did not adopt the IM and, in columns 3 and 4, to loans from firms that always had either fixed of floating rate loans with a given bank. Robust standard errors adjusted for clustering at the bank×industry and year-month level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table B.3: New commercial loans

Dependent variable:	Fixed rate		IHS(Maturity)		IHS(Repricing)		IHS(Repricing × Committment)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Internal Model$_{t-1}$	.058***	-.009	-.194***	-.137***	.099***	-.044	.330***	-.038
	(.021)	(.019)	(.029)	(.039)	(.037)	(.048)	(.107)	(.110)
Internal Model$_{t-1}$ × FixRate$_t$			.163***	.136***				
			(.041)	(.044)				
FixRate$_t$			.326***	.351***				
			(.032)	(.034)				
Mean dep. var.	.168	.168	1.193	1.193	.307	.307	12.079	12.079
Bank controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	No	Yes	No	Yes	No	Yes	No
Bank FE	No	No	Yes	Yes	No	No	No	No
Firm FE	No	No	Yes	Yes	No	No	No	No
Bank × Firm FE	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Bank × Linear time trend	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	.013	.028	.055	.075	.021	.039	.022	.052
Observations	2,454,955	2,454,955	783,221	783,221	2,403,682	2,403,682	2,403,682	2,403,682

Notes. The dependent variables are the average share of a loan with fixed interest rate for a firm-bank pair (columns 1 and 2) and the firm's average inverse hyperbolic sine transformation of loan maturity (columns 3 and 4), of loan repricing maturity (columns 5 and 6) and of the product of loan repricing maturity and amount committed (columns 7 and 8). Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. In columns 3 and 4, the IM dummy is interacted with an indicator for fixed rate loans. Bank controls are the same as in Table 5. All variables are described in Appendix Table A.1. Data are of monthly frequency for the period from August 2009 to December 2016. The sample is restricted to new loans and in columns 3 and 4 to loans from firms that always had either fixed of floating rate loans with a given bank. Robust standard errors adjusted for clustering at the bank×industry and year-month level are reported in parentheses. *$p<0.10$; **$p<0.05$; ***$p<0.01$.

Table B.4: Holdings of interest rate swaps

	Whether hold swaps				Notional amount/total assets				Pay-fixed minus pay-floating/total assets			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Internal Model$_{t-1}$	.122	-.254**	-.070	-.105	-.011*	.012*	.002	.004	.008	-.008	-.013	.031
	(.545)	(-3.360)	(-1.197)	(-1.631)	(-2.169)	(2.265)	(.487)	(1.104)	(.263)	(-.268)	(-.213)	(.528)
Mean dep. var.	.514	.514	.514	.488	.011	.011	.011	.009	.085	.085	.085	.110
Bank-level controls$_{t-1}$	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Excludes investment banks	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
R-squared	.005	.557	.090	.134	.009	.395	.106	.092	-.000	.043	.060	.163
Observations	5,042	5,042	5,042	4,380	2,590	2,590	2,590	2,137	2,587	2,587	2,587	2,134

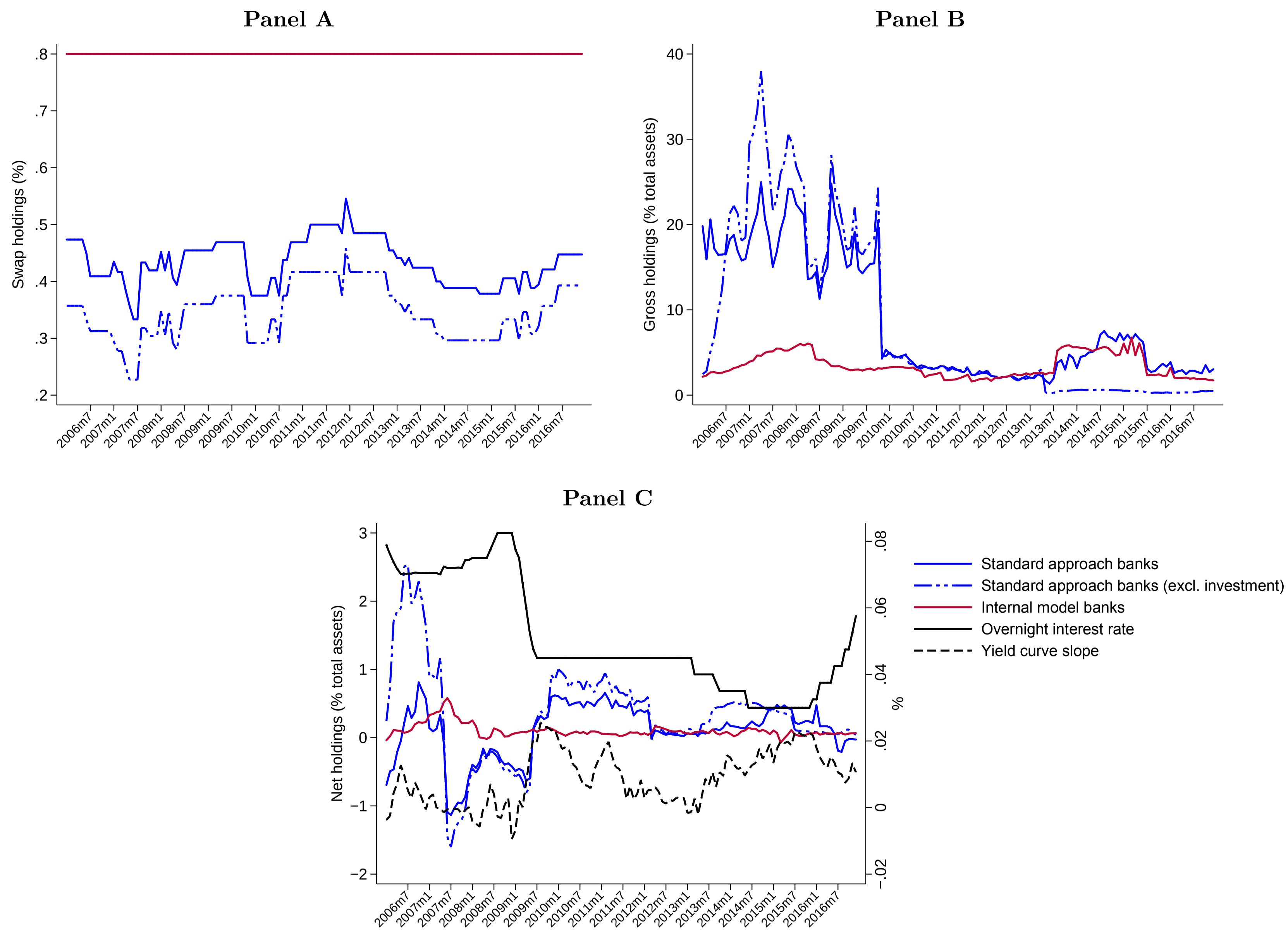
Notes. The dependent variables are an indicator of whether a bank holds any interest rate swap in domestic currency with nominal interest rate (columns 1 to 4) and, conditional on holding such swaps, the ratio of swaps' total notional amount over bank's total assets (columns 5 to 8) and the difference in the notional amount between pay-fixed minus pay-floating interest rate swaps over bank's total assets (columns 9 to 12). Only swaps in domestic currency with nominal interest rate and with a counterparty that is not a firm or household are included. Internal Model is a dummy for banks following the IM for the time slotting of NMDs in $t-1$. Bank controls are the same as in Table 5. Data are of monthly frequency for the period from January 2006 to December 2016. Investment banks are dropped from the sample in columns 4, 8 and 12. Cluster-robust t-statistics (wild bootstrap, 9,999 replications) at the bank level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table B.5: Heterogeneous response to a steepening and flattening of the yield curve: Net hedging using interest rate swaps

Sample period:	2011:M1-2014:M12		2014:M1-2016:M12	
	(1)	(2)	(3)	(4)
$\text{IntMod}_{2013:M2} \times \text{Steepening}_t$	-.044	-.060		
	(-1.034)	(-1.438)		
$\text{IntMod}_{2015:M12} \times \text{Flattening}_t$			.113	.018
			(1.676)	(.518)
$\text{IntMod}_{2013:M2}$	.032	-		
	(.736)			
$\text{IntMod}_{2015:M12}$			.027	-
			(1.051)	
Mean dep. var.	.073	.073	.096	.096
Bank-level controls_{t-1}	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Bank FE	No	Yes	No	Yes
R-squared	.413	.152	.179	.073
Observations	844	844	643	643

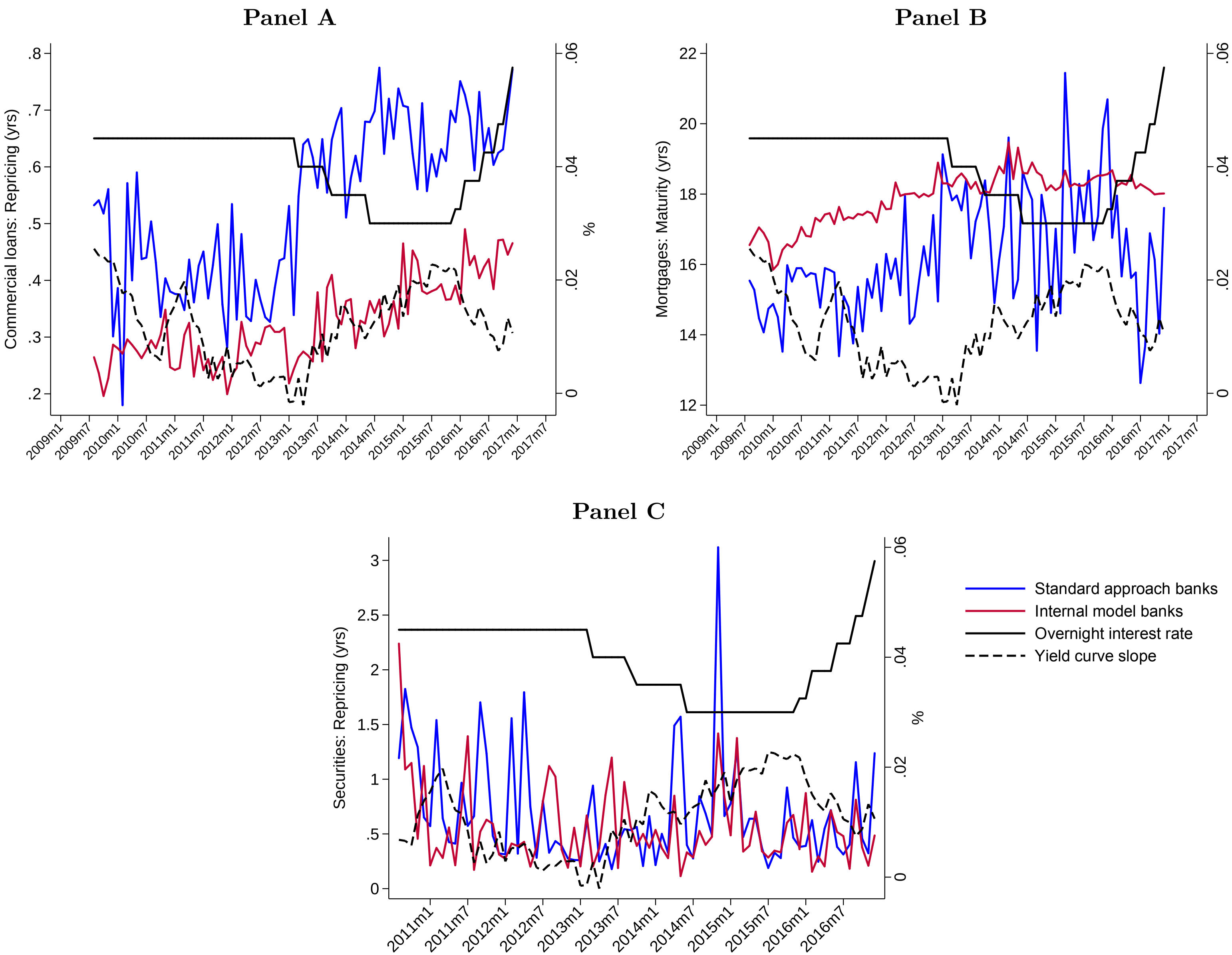
Notes. The dependent variable is a measure of net swap holdings, constructed as the difference in the notional amount between pay-fixed minus pay-floating interest rate swaps over bank's total assets. Only swaps in domestic currency with nominal interest rate and with a counterparty that is not a firm or household are included. IntMod are dummies for banks following the IM by February 2013 or December 2015. Interaction terms with the IntMod dummies are included for an indicator of a steepening (flattening) of the yield curve that takes value one after March 2013 (January 2016). Bank controls are the same as in Table 5. Data are of monthly frequency for the period from January 2011 to December 2014 (columns 1 and 2) and from January 2014 to December 2016 (columns 3 and 4). Cluster-robust t-statistics (wild bootstrap, 9,999 replications) at the bank level are reported in parentheses. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Figure B.1: Interest rate swap holdings of SA and IM banks



Notes. This figure shows the fraction of banks holding any interest rate swap (Panel A), the average ratio of swaps' total notional amount over bank's total assets (Panel B) and the average ratio of the difference in the notional amount between pay-fixed minus pay-floating interest rate swaps over bank's total assets (Panel C) for SA banks, SA exclusive of investment banks and IM banks. Only swaps in domestic currency with nominal interest rate and with a counterparty that is not a firm or household are included. In the right-hand scale, Panel C shows the overnight interest rate target and the slope of the yield curve. The slope of the yield curve is defined as the difference between the 5 year Government bond yield and the 28-day TIIE. All data are for the period from January 2006 to December 2016.

Figure B.2: Market rates and repricing maturity of new loans and securities



Notes. This figure shows the average repricing maturity of new commercial loans (Panel A), the average loan maturity of new mortgages (Panel B) and the average repricing maturity of new securities (Panel C) for SA and IM banks (left-hand scale). Each panel also shows the overnight interest rate target and the slope of the yield curve (right-hand scale). The slope of the yield curve is defined as the difference between the 5 year Government bond yield and the 28-day TIIE. The volume-weighted averages are computed using monthly loan level data from August 2009 to December 2016 (Panels A and B) and monthly security level data from July 2010 to December 2016 (Panel C).

Appendix C. Estimates of NMDs' sensitivity and stability

Here I summarize the methodology followed to estimate NMDs' sensitivity and stability, based on Cocozza et al. (2015). For the NMDs' sensitivity to the market rate I use an error-correction model to allow for adjustments when the deposit rate is not at its equilibrium level. The equation to examine changes in the short-run dynamics of the deposit rate, $r_{b,t}$, in response to changes in the market rate, R_t, is given by:

$$\triangle r_{b,t} = \alpha_0 + \alpha_1 \triangle R_t + \delta \left(r_{b,t-1} - \beta R_{t-1} - \kappa \right) + u_{b,t} \tag{A.1}$$

where α_1 is the short-term pass-through coefficient that measures the impact of changes in the market rate to the deposits' rate in the same period. The term in parenthesis, $r_{b,t-1} - \beta R_{t-1} - \kappa$, is the residual of the long-run relationship between the deposit and the market rate. If the deposit rate differs from βR_{t-1} in $t-1$, in period t it is adjusted to the long-run relationship with adjustment speed δ. β is the cointegration parameter, measuring the degree of pass-through in the long-term, α_0 and κ are constants, and $u_{b,t}$ is the error term. I test for stationarity of the error term using the Dickey-Fuller unit root test.

In the regulatory approach, equation (A.1) is replaced by an $AR(1)$ model of $r_{b,t}$ on R_t in levels, where the value of the coefficient of interest is determined by its 95 percent confidence interval. That model is estimated annually for the volume-weighted average deposit rate using data for the past 48 months. I instead conduct a recursive estimation of (A.1) for each bank, each account's deposit rate and each year-month using data since January 2001 up to time t, implying that the window size grows every period. To give more weight to recent periods, I use an exponential weighting based on the formula $w = \exp(-TimeElapsed/T)$, where $TimeElapsed$ is the time span between the modeling and observation month and T is the time-constant for the decay rate, set at 24 months. Out of the five NMDs' accounts, the regressions are only estimated for the three that pay an interest. The bank-level measure of NMDs' sensitivity is the volume-weighted average of the coefficients estimated for each account, where zero corresponds to the two accounts without interest rate.

Deposits' stability is estimated based on a parametric VaR as in Cocozza et al. (2015), where the risk factor is the cyclical component of NMDs. The X-13ARIMA-SEATS program (U.S. Census Bureau, 2017) is used to remove the seasonal component from the original series and to separate the cyclical component, CV_t, from the trend, TV_t. The cyclical component can be obtained from the following lognormal transformations:

$$CV_t = \ln(AV_t) - \ln(TV_t) \tag{A.2}$$

where AV_t is the actual (seasonally-adjusted) volume. For a confidence level α, CV^* is the critical value of CV_t, such that the probability that CV_t exceeds CV^* is $1-\alpha$. AV^* is the corresponding actual volume. By replacing CV^* and AV^* in (A.2) and after some manipulations:

$$AV^* = \exp(CV^*)\, TV_t \tag{A.3}$$

Under a Variance/Covariance VaR approach and assuming that CV is normally distributed, the critical value can be expressed as a function of the mean, μ_{CV}, and standard deviation, σ_{CV}, of the cyclical component and the normal z score, z_α:

$$CV^* = \mu_{CV} - \sigma_{CV} z_\alpha \tag{A.4}$$

Substituting (A.4) into (A.3), the difference between TV_t and AV^* is given by:

$$TV_t - AV^* = TV_t\left[1 - \exp(\mu_{CV} - \sigma_{CV} z_\alpha)\right] \tag{A.5}$$

This expression can be interpreted as the maximum decline in volume resulting from the cyclical component, given a confidence level α. The NMDs' decline profile can be calculated using the square-root rule.[23] For unitary volumes, the decline profile at time t is given by:

$$dp_t = 1 - \exp\left(k\mu_{CV} - \sigma_{CV} z_\alpha \sqrt{k}\right) \tag{A.6}$$

where k corresponds to the different time horizons for which the decline profile is estimated. dp_0 is a proxy for the non-core component of NMDs in percentage points. I also compute dp_1 and dp_{24}, which give the cumulative decline after 1 month and 2 years. The confidence level is set at the 99 percent. Note that in this approach, the risk factor is given by the difference between the trend value TV_t and the NMDs' actual value AV^* at the same time t. In the regulatory approach,

[23] If the fluctuations in a stochastic process are independent of each other, then the volatility will increase by the square root of time.

the risk factor is instead the difference in the values of the same variable AV_t at t and $t-1$.

Since the mean and the standard deviation are not necessarily stable over time, I compute both of them using a sample that starts in January 2001 and ends at time t. Then I obtain the decline profile for each year-month of the sample. In addition, to give more weight to recent periods, I perform the same computations but with a moving window of 48 months that ends at time t. The measures of dp_0, dp_1 and dp_{24} used throughout the paper are given by the average of the decline profiles obtained with the growing sample and with the 48-month sample.

Appendix D. Proof of Proposition 2

Consider $\delta(r_t) = r_t\alpha_t + r_t^a(1-\alpha_t) - \beta r_t - c - k$ and the solvency constraint $\delta(r_t) \geq 0$ for $r_t \epsilon\, [0,1]$.

If $\delta(\rho) \geq 0$ holds at a particular point ρ, it holds for all $r_t \geq \rho$ if δ is increasing in the interval $r_t \epsilon\, [\rho, 1]$. δ is increasing if $\delta'(r_t) \geq 0$, that is, when $\alpha_t - \beta \geq 0$.

If $\delta(\rho) \geq 0$ holds at a particular point ρ, it holds for all $r_t \leq \rho$ if δ is decreasing in the interval $r_t \epsilon\, [0, \rho]$. δ is decreasing if $\delta'(r_t) \leq 0$, that is, when $\alpha_t - \beta \leq 0$.

If $\delta(\rho) \geq 0$ holds at a particular point ρ, it holds for all $r_t \gtreqless \rho$ if δ is constant in the interval $r_t \epsilon\, [0, 1]$. δ is constant if $\delta'(r_t) = 0$, that is, when $\alpha_t - \beta = 0$. ⊠

Appendix E. Relating the stability and sensitivity of deposits

In the basic model from section 5.1, β and Ω and therefore the long-term liabilities (θ) are fixed. Drechsler et al. (2017) show that market power allows to reduce β at the cost of more unstable deposits, that is, higher Ω. As the spread with the market rate increases (low β), bank deposits become more volatile. Thus, we can model deposits' stability as a negative function of the deposits' sensitivity, $\Omega = \Omega(\beta)$ and find how the long-term liabilities, defined as $\theta = (1-\beta)(1-\Omega(\beta))$, vary with changes in β. By taking the first derivative of θ with respect to β we get:

$$\frac{d\theta}{d\beta} = \Omega - 1 - (1-\beta)\,\Omega_\beta$$

The previous condition is negative whenever $\Omega < 1 + (1-\beta)\,\Omega_\beta$. If $\Omega_\beta < 0$, the lower is β, the more stable need to be the deposits (lower Ω) so that the liability maturity decreases with β. This implies that long-term liabilities are higher for banks with lower deposit sensitivity and higher stability.