Bridging the Gap: How Banks' Maturity Mismatch Shapes Monetary Policy Transmission*

Lorenzo Ferrante
European Central Bank
University of Zurich

Serkan Kocabaş
Universidad Carlos III de Madrid

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Abstract

This study examines how maturity mismatches in banks' balance sheets shape the transmission of monetary policy to credit supply. Linking supervisory data on approximately 1,800 euro area banks to loan-level credit records, we show that the role of maturity mismatches is highly *shock-specific*. Mismatches amplify the effects of *unconventional* but not *conventional* monetary policies. Banks with larger maturity gaps reduce lending more sharply following monetary policy surprises regarding quantitative tightening (QT) because valuation losses on long-term assets negatively affect their net worth, causing tighter leverage constraints. To rationalize these findings, we develop a medium-scale New Keynesian DSGE model featuring a segmented financial sector, where intermediaries are differentiated by their maturity gaps. This framework explains the observed asymmetry: the high-mismatch banking segment is more exposed to long-duration losses that compress net worth, tighten endogenous leverage constraints, and amplify real economic effects through an investment wedge, whereas standard policy rate shocks—which mainly affect short-term rates—generate little heterogeneity in lending responses.

JEL codes: E32, E43, E51, E52, G21
Keywords: Monetary Policy Transmission, Maturity Mismatch, Bank Lending Channel, DSGE Model

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1 Introduction

In recent years, unconventional monetary policies have shifted from being exceptional interventions to fundamental elements of central banks' toolkits. Following an unprecedented expansion of Quantitative Easing (QE) in response to the COVID-19 pandemic in 2020, which pushed central bank balance sheets to historic highs, major economies have pivoted to a phase of Quantitative Tightening (QT) or Quantitative Normalisation (QN)[1]. This historic shift calls for a more thorough investigation of the transmission mechanisms of unconventional monetary policies, especially compared to conventional monetary policies (i.e., changes in central banks' policy rates).

This study focuses on the bank lending channel and investigates how maturity mismatches in banks' balance sheets shape the transmission of conventional and unconventional monetary policies to the credit supply. The core function of banks is maturity transformation: funding long-term assets (e.g., mortgages) with shorter-term liabilities (e.g., deposits). This fundamentally entails a maturity mismatch in banks' balance sheets. We show that this mismatch is a key determinant of how monetary policy (especially unconventional) affects bank lending and, ultimately, real economic activity.

We assembled a new unbalanced panel of approximately 1,800 supervised euro area banks using quarterly Supervisory Reporting data. The dataset combines detailed financial statements (FINREP), regulatory ratios (COREP), and a maturity breakdown of inflows and outflows from the COREP "Maturity Ladder". This allows us to construct a bank-specific granular measure of the maturity gap. We merge these data with monthly loan-level information from the euro area credit registry (AnaCredit), linking each bank's financial data to information on its credit supply to firms. To identify exogenous monetary policy movements, we rely on high-frequency monetary policy shocks that capture both conventional and unconventional monetary policy surprises as constructed by Altavilla et al. (2019). The final dataset covers a six-and-a-half-year time span, from October 2018 to March 2025, at a monthly frequency.

Our empirical strategy applies local projections to estimate the cumulative effects of these shocks on bank lending. We interact the banks' maturity gap with each shock in our specification, while controlling for a comprehensive set of bank characteristics

[1] As referred to by the Member of the Executive Board of the ECB Isabel Schnabel in her speech at the ECB Conference on Money Markets 2025 (Schnabel (2025)).

(size, capital, liquidity, profitability, leverage, funding structure, and asset quality) and fixed effects (bank and country–sector-time fixed effects).

The results reveal a clear asymmetry: maturity mismatches amplify the transmission of unconventional monetary policy but not that of conventional monetary policy, demonstrating their highly *shock-specific* role. Following unexpected changes in policy rates, banks with high and low maturity gaps adjust their lending similarly. In contrast, when policy shocks affect long-term rates, as in QT episodes, banks with greater maturity mismatches reduce credit supply more sharply. Quantitatively, we estimate that banks in the upper quartile of the maturity gap distribution decrease lending by an average of 0.30 percentage points more per basis point of tightening (in cumulative terms) than those in the lower quartile. This stronger contraction reflects valuation losses on long-duration assets, a tightening of leverage constraints, and reduced net worth, which jointly compress the credit supply among banks with higher maturity mismatches.

To rationalize these empirical findings, we extend the New Keynesian DSGE models of Gertler and Karadi (2011) and Gertler and Karadi (2013) by introducing segmented financial intermediaries characterized by heterogeneous maturity structures. To isolate the impact of balance sheet heterogeneity, we remain agnostic about the production side and model symmetric firms that differ only in how they are financed. We follow Allen and Gale (1994) and Gertler and Kiyotaki (2010a) by restricting specific firms to borrow exclusively from specific types of intermediaries: one segment is funded by intermediaries with a high maturity gap, and the other by intermediaries with a low maturity gap. Following a quantitative tightening shock, financial intermediaries in the high-maturity-gap segment experience severe valuation losses on their long-term assets. This decreases their net worth and disproportionately tightens their endogenous leverage constraints, creating a wider investment wedge that crowds out private lending and generates deeper, more persistent declines in investment and output. By contrast, following a standard policy rate shock, which primarily moves short-term rates, funding conditions and lending dynamics across the two financial segments remain remarkably similar, mirroring the limited heterogeneity observed in our empirical data.

We further examine the transmission of non-monetary disturbances—specifically technology and financial liquidity shocks—and find that the maturity mismatch structure creates 'systemic fragility'. The financing segment populated by high-maturity-gap financial intermediaries not only amplifies the contractionary effects of negative shocks but also dampens the expansionary effects of positive shocks. For instance, in response to an adverse liquidity shock, the high-maturity-gap segment proves significantly more vulnerable, experiencing a sharper contraction in credit availability than its low-mismatch counterpart. Conversely, in the face of a positive technology shock, these heavily mismatched intermediaries act as a financial bottleneck; being locked into long-term assets prevents them from aggressively expanding credit, thereby stifling the potential economic boom.

Together, these findings demonstrate that the maturity structure of banks' balance sheets is an important state variable shaping the transmission of both monetary and non-monetary shocks. From a monetary policy perspective, maturity mismatch acts as a powerful amplifier of balance sheet-based unconventional policies—where transmission operates heavily through liquidity and valuation channels—but remains largely neutral under conventional, rate-based policy. Beyond monetary policy, our results underscore that financial sector heterogeneity arising from maturity mismatches is critical for macroeconomic stability. A banking system dominated by high maturity gaps inherently amplifies negative financial shocks while simultaneously constraining the credit expansion necessary to fully capitalize on positive technological developments.

By connecting detailed supervisory data with a structural model of banking behavior, this study underscores that monitoring and managing maturity mismatches is essential—not only for microprudential oversight of individual banks, but also for calibrating the macroeconomic impact of the central bank's policy tool mix and for assessing how non-policy disturbances propagate through the financial system.

The remainder of this paper is organized as follows. Section 2 reviews the related literature and positions this study within the broader context. Section 3 describes the supervisory and loan-level dataset used to construct the bank-specific maturity gap measure, outlines our empirical strategy based on local projections, and presents the main findings regarding the differential impacts of conventional and unconventional monetary policies. Section 4 develops the New Keynesian DSGE model featuring segmented financial intermediaries differentiated by their maturity gaps. Section 5 discusses the model's simulation results regarding the effects of monetary and non-monetary shocks. Section 6 concludes.

2 Literature Review

The recent conduct of monetary policy, which has seen significant deviations from traditional policy rules (Nakamura et al., 2025), has renewed interest in the specific transmission channels of both conventional and unconventional monetary policy tools. This context heightens the need to understand the structural features of the banking system that shape policy impact.

Banks' core function of maturity transformation—funding long-term assets with short-term, callable liabilities—is fundamentally linked to the transmission of monetary policy. The foundational theoretical work of Diamond and Dybvig (1983) established the dual nature of this activity: it is the mechanism by which banks provide liquidity, but simultaneously exposes them to fragility and runs. This inherent balance sheet structure creates a direct link to monetary policy through the interest rate risk channel (Van den Heuvel, 2002). This channel shows that when policy rates rise, banks with a large portfolio of fixed-rate long-term assets funded by short-term deposits suffer from net worth erosion (through lower net-interest margins) as funding costs rise faster than asset yields. In turn, this capital hit can force a contraction in lending, thereby amplifying the intended policy tightening.

However, this theoretical link has been met with a nuanced and seemingly contradictory empirical literature on whether maturity mismatches ultimately amplify or attenuate monetary policy. A large and growing body of work provides clear evidence of **amplification**, stemming from both sides of the balance sheet. On the asset side, Purnanandam (2007) showed that US banks with large, *unhedged* maturity gaps "cut their lending more" after rate hikes. This amplification mechanism is strongly supported by recent analyses of the 2022–2023 global tightening cycle. Using granular data, Coulier et al. (2024) find that euro area banks with a larger duration gap significantly "contract their lending relatively more when interest rates increase". This effect is economically meaningful and mitigated for banks that actively use interest rate derivatives to hedge their exposure. Separately, on the liability side, Drechsler et al. (2017) show that banks with market power in deposit markets also amplify tightening by widening deposit spreads, leading to deposit outflows and a contraction in lending.

In contrast, other studies find evidence of **attenuation**. English et al. (2018) found that banks with larger maturity gaps actually see profits rise from a steepening yield curve. Similarly, Gomez et al. (2021), using a US bank panel, found that banks with a positive "income gap" (assets repricing faster than liabilities) actually *reduced lending less* following a Fed tightening. This suggests that their balance sheet structure acted as a buffer.[2] This debate extends to unconventional policy; for example, during the negative interest rate policy (NIRP) era, high-deposit banks were unable to pass on negative rates, which squeezed their profits and perversely caused them to *reduce* lending (Heider et al., 2019).

Building on this foundation, our study resolves the apparent contradictions in the literature by making two contributions. First, we introduce a novel bank-level maturity gap indicator from the COREP Maturity Ladder to measure maturity transformation more precisely, using a wider sample of banks. Second, and more importantly, we demonstrate empirically that the role of this gap in transmission is highly *shock-specific*, which explains the contradictory findings in the literature. We show that the transmission of conventional policy shocks, which mainly affect short-term rates, is rather homogeneous. Using high-frequency shocks from the EA-MPD (Altavilla et al., 2019), we find that lending responses are statistically similar across all maturity gap bins. In contrast, we find that unconventional (QE/QT) shocks, which raise long-term rates, generate substantial and persistent heterogeneity, with high-maturity-gap banks cutting credit supply significantly more than low-maturity-gap banks. Our analysis relies on a novel dataset matching euro area supervisory data (FINREP/COREP) to loan-level AnaCredit from 2018 to 2025, a period uniquely spanning the entire path from negative rates to QT. This empirical design allows us to separate level (short-end) from term-premium (long-end) news and map them into heterogeneous bank supply responses.

The related literature finds that bank equity prices react asymmetrically to interest rate shocks, consistent with our *shock-specific* view. In an early contribution, Flannery and James (1984) showed that the interest rate sensitivity of bank stock returns is significantly related to the maturity composition of their nominal assets and liabilities, with banks holding longer-maturity net positions displaying greater sensitivity—an amplification result at the equity-price level. Building on this, English et al. (2018)

[2] It is important to note that the "income gap" (a short-horizon repricing gap) used in Gomez et al. (2021) is conceptually distinct from the bank's overall duration gap. Their signs need not coincide; for example, a bank can display a positive one-year repricing gap while still holding a sizeable positive duration gap. Therefore, this finding does not inherently contradict the amplification channel discussed elsewhere.

show that bank equities fall with higher expected short-rate paths and steeper curves, with the balance sheet structure explaining the cross-section. Crucially, Paul (2022) decomposes long-term yield changes into expected future short-rate and term-premium components and shows that bank equity reacts more negatively than that of non-financials to increases in expected future short-term rates, but more positively to term premia increases. In the cross-section of banks, those with a larger maturity mismatch respond more positively to a rise in term premia, consistent with our finding that the maturity gap matters primarily for long-end shocks.[3] We show that these market-price asymmetries have real consequences for the credit-quantity margin. Exploiting loan-level supply measures, we demonstrate that they translate into materially different lending paths under long-end versus short-end policy surprises.

Theoretically, recent literature has begun to connect these different findings by examining how banks actively manage maturity mismatches. While canonical DSGE models (Gertler and Kiyotaki, 2010b; Bernanke et al., 1999) often ignore this mismatch or treat it as a fixed, homogeneous parameter, newer models emphasize the dynamic role of asset duration (Wang, 2023; Varraso, 2024). For instance, Varraso (2024) shows that long periods of low interest rates push banks to "reach for yield" by buying longer-term assets, while Di Tella and Kurlat (2021) propose that banks use the maturity gap as an optimal dynamic hedging tool. Similarly, the frameworks of Gertler and Karadi (2011) and Gertler and Karadi (2013) explain how unconventional policies, such as Quantitative Easing, operate by easing constraints on banks' balance sheets. A unifying view suggests that while QE can substitute for traditional policy at the zero lower bound, reversing it (Quantitative Tightening, or QT) creates distinct challenges (Sims and Wu, 2021), highlighting the need for a theoretical framework that captures how heterogeneous maturity profiles react to different policy regimes. Relatedly, Garofalo (2024) develops a framework showing how unconventional policies rely on 'granular' intermediaries to affect the aggregate economy, a structural feature that conceptually parallels our use of segmented banking channels.

To formalize our empirical findings and bridge this empirical–theoretical gap, we

[3] This may appear in tension with our QT valuation-loss mechanism; however, the distinction lies in the nature of the long-end movement. A term-premium increase reflects a higher compensation for bearing duration risk, which raises the expected return on long-term assets and can boost bank equity valuations. In contrast, a QT-induced yield increase operates through portfolio rebalancing and mark-to-market losses on existing holdings, compressing net worth. The equity-price evidence thus complements rather than contradicts our lending-channel findings.

develop a medium-scale New Keynesian DSGE model featuring a segmented financial sector characterized by heterogeneous maturity structures. We model symmetric firms that borrow exclusively from designated financial intermediaries: one segment funded by banks with a high maturity gap, and the other by banks with a low maturity gap. This framework delivers and explains the asymmetry we find empirically: when long rates rise via unconventional (QT) shocks, high-maturity-gap banks suffer severe valuation losses that compress their net worth, leading to tighter endogenous leverage constraints and sharper credit contractions through a wider investment wedge. Conversely, when short rates rise via conventional shocks, funding costs reprice broadly, and cross-bank heterogeneity is minimal. We further show that technology and liquidity shocks have distinct implications: high-mismatch intermediaries act as a financial bottleneck during positive technology shocks but amplify liquidity squeezes, exhibiting a pattern of maturity-gap heterogeneity that qualitatively mirrors what we document empirically for *monetary policy* shocks (Section 3), suggesting that maturity mismatch is a more general amplification mechanism extending beyond the policy domain. Finally, our micro-estimated gap targets discipline the model's financial block, allowing for rigorous macro-counterfactuals regarding the conventional versus unconventional monetary policy mix.

3 Empirical Analysis

For our empirical analysis, we construct a novel panel dataset covering around 1,800 supervised euro area banks and collect information from three distinct data sources: Supervisory Reporting data and euro area credit registry (AnaCredit) data from the European Central Bank (ECB), and the Euro Area Monetary Policy Event-Study Database (EA-MPD) from Altavilla et al. (2019). The final dataset is at a monthly frequency and covers a period of six and a half years, from October 2018 to March 2025. It contains the amount of loans outstanding at the bank and counterparty sector of economic activity (NACE sector) level at the end of each month from AnaCredit, a quarterly series of banks' regulatory ratios as well as balance sheet amounts, and income statement figures from Supervisory Reporting data, a measure of maturity mismatch between banks' assets and liabilities[4], and monthly monetary policy shocks constructed from

[4]The bank balance sheet data, regulatory ratios, and the maturity gap measure are available as quarterly series. To align these with the monthly series from AnaCredit and the monetary policy

the EA-MPD. In the next two subsections, we describe in more detail the maturity mismatch measure and the monetary policy shocks that we have used in our analysis, since these are crucial variables for our identification strategy. We refer the reader to Table 6 in Appendix C for more information on the construction of the other variables, which are used as controls in the context of this study.

3.1 A maturity gap measure

To test the hypothesis that banks with different levels of maturity mismatch between their assets and liabilities transmit monetary policy shocks differently, we construct a measure that proxies for the exposure of a bank's net worth to changes in interest rates.

In finance, interest rate sensitivity is commonly captured by the Macaulay duration (Macaulay, 1938). Some studies accordingly compute a net *duration gap* to assess banks' exposure to interest rate risk (e.g., Coulier et al. (2024); Esposito et al. (2015)), while others rely on the *maturity gap* (Paul, 2023). Although the duration gap is technically a more precise measure of balance sheet sensitivity, it is mechanically affected by the level of interest rates, since risk-free rates enter the present-value calculation of asset and liability cash flows. Because our identification strategy requires lagged shock interactions, using a rate-dependent measure would introduce spurious correlation between the maturity proxy and the monetary policy shocks themselves. We therefore adopt the maturity gap indicator, following Paul (2023).

We construct the maturity gap measure for our sample of banks based on the supervisory reporting data collected within the Common Reporting (COREP) framework, specifically in template C66.01 "Maturity Ladder." In this template, banks provide the amount of inflows and outflows from their assets, liabilities, and off-balance sheet items split into 21 maturity buckets (from "Overnight" to "Above 5 years"), depending on their residual maturity. We used this information to compute the maturity-weighted sum of inflows minus the maturity-weighted sum of outflows. This value is normalized by the total assets of the bank to obtain a maturity gap. For bank i in quarter t, the

shocks, we assign the quarterly data point corresponding to the end of the previous quarter to each month within that quarter. This approach ensures that the model accounts for the maturity gap and balance sheet structure of banks prior to the occurrence of the shock, thereby mitigating potential endogeneity concerns.

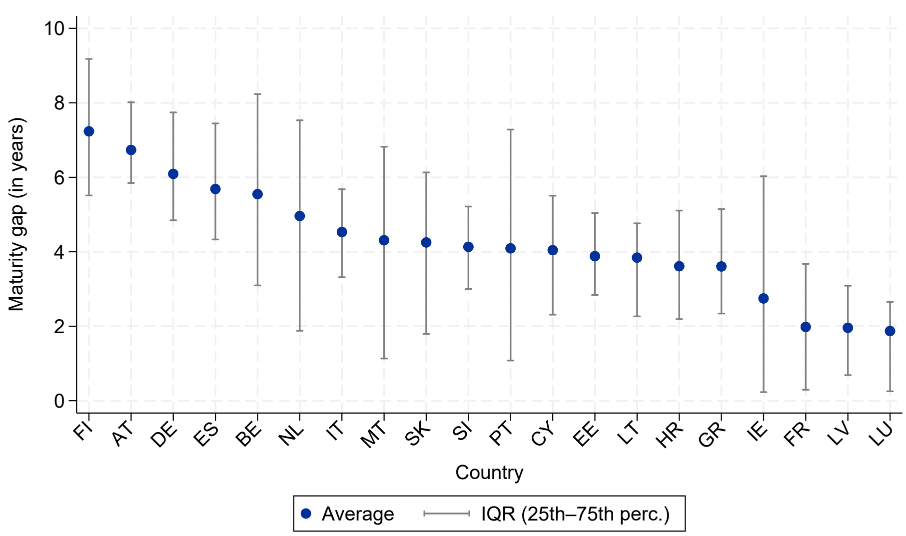
maturity gap is formally calculated as follows:

$$MatGap_{i,t} = \sum_{k=1}^{21} \frac{\tau_k(Inflows_{i,t,k} - Outflows_{i,t,k})}{TotAssets_{i,t}}$$

where τ_k is the maturity of the inflows and outflows reported in the maturity bucket k.

It is worth noting that euro area banks have different reporting requirements for the Maturity Ladder template in terms of frequency. Significant institutions are generally required to submit their reports every month, while smaller and less significant institutions must submit them every quarter. We chose to compute quarterly series of maturity gaps to cover the largest possible sample of reporting institutions and euro area countries. Figure 1 displays the average maturity gap and the interquartile range (IQR) for all euro area countries in the sample. Although the average maturity gap for ten out of the 20 countries is within the range of 3.5-4.5 years, there is a significant variance in the maturity gap across the remaining jurisdictions. Specifically, this gap ranges from below two years for the average bank in Luxembourg up to more than seven years for the average bank in Finland. Moreover, banks' maturity gaps vary substantially within each country. The largest IQR is recorded in Portugal (approximately 6 years) and among the lowest in Austria (just above 2 years).

Figure 1: Bank maturity gap distribution within and across euro area countries



This heterogeneity likely reflects underlying differences in the composition of national banking sectors along several dimensions: size (e.g., prevalence of small cooperative banks versus large universal banks), specialization (retail-focused versus corporate or investment banking models), balance-sheet strategies, and, more generally, banks' business models. Regulatory, legal, and institutional factors could also reinforce the differences observed across countries. From the perspective of our empirical analysis (presented in Section 3.3), the presence of a broad dispersion in maturity gaps is advantageous. First, it increases the statistical power to detect the relationship between the maturity gap and our variables of interest. Second, it improves external validity: results are less likely to be driven by a narrow subset of banks and more likely to generalize across different business models and institutional frameworks. From the perspective of our research question, the cross-country variance in the maturity gap reinforces, if anything, the interest in whether this interacts with monetary policy transmission (after controlling for bank-specific characteristics and balance sheet structure). If so, it may have policy implications. Because all euro area member states are subject to a common monetary policy, policymakers should account for banks' ex-ante maturity gaps when designing and assessing new policies. The pass-through in terms of pace and magnitude might be differentiated with potentially uneven effects across member states when it comes to credit supply, inflation, and broader macroeconomic outcomes.

3.2 The euro area monetary policy shocks

Monetary policy shocks in the euro area represent the key exogenous element in our identification strategy. To address our research question, we incorporate these shocks into our model specification by interacting them with the maturity-gap measure. Specifically, we use the Euro Area Monetary Policy Event-Study Database (EA-MPD), which provides comprehensive data on high-frequency financial market surprises in response to European Central Bank (ECB) monetary policy announcements. This database, developed by Altavilla et al. (2019), captures changes in asset prices within narrowly defined time windows around the ECB's press releases and press conferences of the ECB President. By focusing on these narrow windows, the dataset minimizes noise, thereby increasing the likelihood of capturing the causal relationships between policy announcements and observed asset price movements.

Altavilla et al. (2019) identify four monetary policy shocks, of which we primarily employ two: the *Target* shock and the *Quantitative Easing* (QE/QT) shock.[5] The target shock reflects unexpected changes at the short end of the risk-free curve, while the QT shock captures surprises affecting long-term yields and risk premia, which are typically associated with adjustments in market expectations regarding the ECB's non-standard monetary policy measures. As in the original paper, we extract these shocks by estimating a factor model through principal components applied to the matrix of yield changes and then rotating the factors to identify economically meaningful orthogonal policy shocks. This rotation is essential for disentangling the various dimensions of monetary policy surprises. The target shock is derived from the single significant factor identified in the press-release window, with its primary impact concentrated at the very short end of the yield curve (i.e., 1-month maturity) and diminishing at longer maturities.

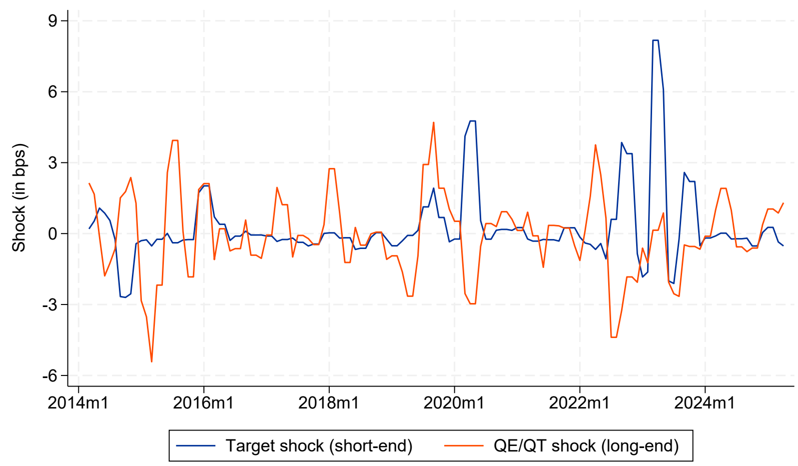
For simplicity and consistency, we define the target shock series as the high-frequency changes in the 1-month OIS rate during the press-release window, as these changes are nearly perfectly correlated with the identified factor. Meanwhile, the QT shock is associated with the third orthogonal significant factor observed in the press conference window, subject to specific restrictions. These include the shock being statistically insignificant prior to the Great Financial Crisis (before the advent of unconventional monetary policies) and the factor's loading being increasing with maturity, peaking at the long end of the yield curve (10-year maturity). The QT shock is rescaled to produce a one-unit effect on the 10-year OIS, with its sign adjusted for interpretability. The resulting monetary policy shocks, expressed in basis points, are interpreted as tightening (positive values) or easing (negative values) policy surprises. For consistency with our monthly model frequency, we extend the shocks from the ECB Governing Council meeting schedule by filling the non-meeting months with zero values.

Figure 2 illustrates the three-month moving sum of the target and QE/QT shocks since 2014. Between 2014 and 2020, QE/QT shocks were more frequent and sizeable (in absolute terms) than other types of shocks, largely reflecting the heightened focus of market participants on unconventional monetary policies as key ECB interest rates

[5] In this paper, we refer to positive QE shocks as tightening surprises related to non-standard monetary policies and negative QE shocks as easing surprises. Throughout this paper, we discuss the results of positive changes in QE shocks; thus, we mostly refer to them as *QT* shocks, that is, Quantitative Tightening shocks.

approached the effective lower bound. Conversely, from 2022 onwards, the prominence of target shocks re-emerged, driven by surprises related to the timing and pace of the ECB's tightening cycle first and easing cycle later.

Figure 2: Rotated monetary policy shocks (3-month moving sum)



In the following sections of this paper, notably in Section 4, we rely on the economic interpretation that QT shocks capture changes in market expectations concerning the ECB's unconventional monetary policies and, in particular, central bank balance sheet policies, such as the size and duration of asset purchase programs and reinvestments of the principal amounts. This is consistent with the interpretation provided by Altavilla et al. (2019) and the nature of these policies, which aim to steer rates at longer maturities. Instead, Target shocks are interpreted as surprises in market expectations concerning conventional monetary policies, that is, concerning the level of short-term yields steered by the ECB's key interest rates.

3.3 Interaction between banks' maturity gap & monetary policy transmission

Using the novel panel dataset that we constructed and enriched with monetary policy shocks and the bank-level maturity gap series, we empirically study whether banks' heterogeneity in the maturity gap matters for the transmission of monetary policy to the credit supply. The dataset we have available for this study presents the advantage of covering a time span where both a tightening and an easing cycle took place as well as multiple ECB decisions in terms of unconventional monetary policies. In addition, contrary to other studies, we have data from both significant institutions (SIs) and less significant institutions (LSIs). Thus, we can assess a broader spectrum of heterogeneous banks and ensure that all euro-area countries are effectively represented. In this regard, the results of our study are likely to have higher external validity than analyses in which the sample was composed of relatively homogeneous banks. Moreover, as we keep the borrower's economic activity level in our data, we can also control for the loan demand component.

Table 1 summarizes the dataset used in our analysis. [6] The data are at the bank-month-borrower's economic activity level, containing an unbalanced panel of 1,803 banks and a total of 802,311 observations. The firm economic sectors considered in the sample are manufacturing, construction, retail trade, transportation, accommodation, information and communication, professional, scientific and technical activities, and administrative and support service activities. Notably, financial services and public/government-related activities were excluded. Monthly loan growth rates are constructed from outstanding loans to firms as the first difference in the logarithmic value of these amounts.

[6] Minimum and maximum values are excluded from the summary statistics because in our analysis we winsorised the data to attenuate potential outlier effects. Therefore, the 1st and 99th percentiles can be respectively considered as the minimum and maximum values of our dataset.

Table 1: Summary Statistics: Loan growth, monetary policy shocks and controls

	Observations	Mean	SD	P1	P25	P75	P99
Dependent variable:							
Δlog(loans)(%)	785,737	0.7	27.1	-55.0	-2.0	2.5	66.6
Monetary policy shocks:							
QE/QT shock (bps)	802,311	-0.1	0.9	-2.9	-0.4	0.2	2.5
Target shock (bps)	802,311	0.2	1.2	-1.9	-0.2	0.0	8.0
Controls:							
Maturity gap (years)	795,006	5.9	2.5	-0.5	4.6	7.7	11.0
log(total assets)	799,550	7.6	1.7	4.4	6.6	8.4	13.2
CET1 ratio (%)	800,993	17.7	6.7	10.3	14.2	19.1	47.1
Liq. cov. ratio (%)	800,546	236.2	232.4	74.3	141.8	228.0	1626.2
Leverage ratio (%)	800,870	9.4	3.7	3.7	7.4	10.6	24.4
Return on assets (%)	797,268	0.4	0.6	-1.9	0.1	0.6	2.3
NPL ratio (%)	791,271	3.4	5.1	0.1	1.3	3.4	36.6
Loan-to-deposit ratio (%)	792,899	162.4	1063.5	24.5	72.5	104.4	1893.3
Deposit ratio (%)	792,915	68.4	17.6	2.0	64.7	78.9	88.8

To further understand the structural differences in bank balance sheets, we investigate the heterogeneity between banks with different levels of maturity transformation. Table 2 provides summary statistics split between banks with a high maturity gap and those with a low maturity gap.

There are notable differences in funding structures and liquidity positions between the two groups. High maturity gap banks appear to rely more heavily on traditional stable funding, exhibiting a significantly higher mean deposit ratio (74.1%) compared to low maturity gap banks (55.1%). Conversely, low maturity gap banks display a much higher average loan-to-deposit ratio (343.0%) compared to the high gap group (96.5%), suggesting a greater reliance on non-deposit funding sources to support their lending activities. Furthermore, low maturity gap banks maintain substantially larger liquidity buffers, with a mean liquidity coverage ratio (LCR) of 284.4%, whereas high maturity gap banks hold an average LCR of 195.3%.

Table 2: Summary Statistics: Low vs high maturity gap banks

	Observations	Mean	SD	P25	P75
High maturity gap banks:					
Δ log(loans)(%)	195,368	0.7	23.3	-2.0	2.4
Maturity gap (years)	198,762	8.7	0.9	8.0	9.1
log(total assets)	198,762	7.4	1.4	6.5	8.3
CET1 ratio (%)	198,738	17.5	5.0	14.5	18.7
Liq. cov. ratio (%)	198,762	195.3	145.2	136.9	199.0
Leverage ratio (%)	198,639	9.6	3.1	7.9	10.7
Return on assets (%)	198,576	0.4	0.6	0.1	0.7
NPL ratio (%)	198,456	2.2	2.2	1.1	2.7
Loan-to-deposit ratio (%)	198,395	96.5	305.9	78.3	103.2
Deposit ratio (%)	198,395	74.1	11.8	70.0	80.0
Low maturity gap banks:					
Δ log(loans)(%)	193,185	0.6	35.1	-2.1	2.5
Maturity gap (years)	198,770	2.4	1.6	1.1	3.8
log(total assets)	198,770	8.1	1.9	6.9	8.9
CET1 ratio (%)	198,724	18.6	9.5	13.8	19.5
Liq. cov. ratio (%)	198,350	284.4	288.4	149.6	282.2
Leverage ratio (%)	198,703	9.3	4.9	6.4	10.4
Return on assets (%)	196,985	0.4	0.8	0.1	0.7
NPL ratio (%)	191,361	5.3	8.2	1.4	4.7
Loan-to-deposit ratio (%)	195,491	343.0	1953.3	69.4	123.9
Deposit ratio (%)	195,507	55.1	24.6	40.0	74.5

A preliminary variance decomposition confirms that bank-level heterogeneity is the dominant dimension for explaining loan growth dynamics. We regress loan growth rates on progressively richer sets of fixed effects (Table 3). The specification that includes only firm sector-time fixed effects explains a negligible share of the variance ($R^2 = 0.43\%$, column 6), whereas bank-time fixed effects alone account for a quarter of the total variance ($R^2 = 24.99\%$, column 5). Country-time fixed effects absorb far less ($R^2 = 0.77\%$, column 8), and even country-time-sector fixed effects reach only $R^2 = 2.78\%$ (column 9), indicating that the bank-time dimension dominates country-wide dynamics.[7] Bank-firm sector ties add modestly ($R^2 = 1.43\%$, column 10). We conclude that idiosyncratic bank characteristics are the most informative dimension for understanding credit supply following shocks.

[7] We note that these R^2 comparisons should be interpreted with caution, as the bank $\times$ time specification involves a much larger number of parameters than the sector-time specification. Nevertheless, the order-of-magnitude difference in explained variance—and the fact that country $\times$ time effects absorb only a fraction of what bank $\times$ time effects do—points to the importance of bank-level heterogeneity beyond country-wide factors.

Table 3: R^2 of loan growth regressions on selected fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
R^2 (in %)	0.29	0.04	0.10	0.43	24.99	0.43	25.32	0.77	2.78	1.43
Bank FE	x			x						
Firm sector FE		x		x						
Time FE			x	x						x
Bank × Time FE					x		x			
Firm sector × Time FE						x	x			
Country × Time FE								x		
Country × Time × Firm sector FE									x	
Bank × Firm sector FE										x

Following the above result, we focus on assessing the relevance of banks' maturity mismatch, among other banks' characteristics, in the transmission of monetary policy shocks to lending. We use an econometric specification that relies on the maturity gap measure as a proxy for banks' maturity mismatch in assets and liabilities and on the exogenous target and QT shocks described in the previous subsection. Specifically, we identify the effect of these monetary policy shocks on loan growth based on local projections, as in Jordà (2005). We regress the cumulative loan growth rate on each monetary policy shock interacted with the banks' maturity gap in the quarter before the shock materialized and a set of controls for bank size, liquidity, profitability, capitalization, leverage, asset quality, and funding structure. We include country-month-firm sector fixed effects and bank fixed effects. With the former fixed effects, we control for country-specific developments that, on average, affect all banks within a country in a similar way — such as regulatory, legal, or institutional changes, country-level shifts in funding conditions, or changes in competitive pressure — and for sector-specific fluctuations in loan demand within the bank's country, including industry-level shocks that influence firms' borrowing volumes. With bank fixed effects, we instead control for any time-invariant bank characteristics that explain loan growth levels and are potentially correlated with the maturity gap. We run the local projections on a two-year horizon (i.e., 24 months). We allow for the lagged effects of monetary policy shocks on cumulative loan growth by including all interactions with lagged shocks of up to 12 months. We use standard errors two-way clustered at the bank-borrower sector and time levels.

In summary, the regression specification is as follows:

$$\begin{aligned}\Delta y_{i,s,t+h} = \alpha_i + \lambda_{c,s,t} + \gamma_h GAP_{i,t-1} + \theta_{1h} X_{i,t-1} \\ + \sum_{l=0}^{12} \delta_h^{(l)} (MP_{t-l} \times GAP_{i,t-1}) + \sum_{l=0}^{12} \theta_{2h}^{(l)} (MP_{t-l} \times X_{i,t-1}) + \varepsilon_{i,s,t+h}\end{aligned} \tag{1}$$

where,

- $\Delta y_{i,s,t+h} = \log(\text{Loans}_{i,s,t+h}) - \log(\text{Loans}_{i,s,t-1})$ is the cumulative bank-firm sector level loan growth rate from $t-1$ to $t+h$, for $h = (0, \ldots, 24)$. At $h = 0$, this reduces to the standard monthly loan growth rate.
- MP_{t-l} is the considered monetary policy shock (either target or QT) at lag $l = (0, ..., 12)$
- $GAP_{i,t-1}$ is the lagged maturity gap (measured in the quarter preceding the shock window)
- $X_{i,t-1}$ is the vector of lagged bank-level controls
- α_i are the bank fixed effects, $\lambda_{c,s,t}$ are the country-sector-time fixed effects

Three features of this specification merit clarification. First, the maturity gap entering all interaction terms is held fixed at $GAP_{i,t-1}$—the value observed in the quarter preceding the shock window—for every lag l. The same logic applies to the bank-level controls $X_{i,t-1}$. Second, the monetary policy shock series are approximately mean-zero by construction: they capture high-frequency surprises within narrow windows around ECB Governing Council announcements and are set to zero in non-meeting months (Table 1). This near-zero unconditional mean ensures that the interaction terms $MP_{t-l} \times GAP_{i,t-1}$ do not contain a spurious component proportional to $GAP_{i,t-1}$, confirming that the single main effect adequately controls for the direct influence of the gap. Third, the main effects of the lagged monetary policy shocks MP_{t-l} are not included as separate regressors because they are fully absorbed by the country-sector-time fixed effects $\lambda_{c,s,t}$, which capture all variation that is common across banks within a given country, sector, and month—including the aggregate monetary policy shock itself.

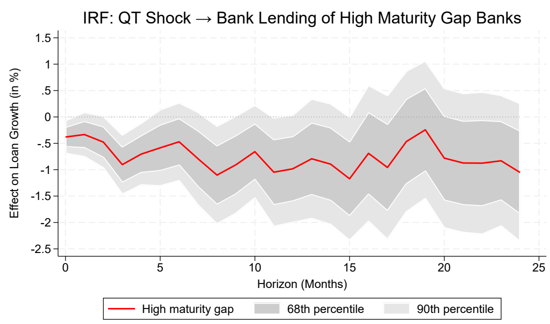
Since local projections require the h-period lead value of the loans outstanding to be in the dataset, as h increases, the number of observations in each sub-regression decreases. This can introduce a compositional effect that may produce instability in our estimates over longer horizons. We perform our baseline regressions using the full sample of observations, acknowledging this potential issue, which may produce noisier impulse responses. To ensure that our results are not driven by this compositional effect, we conduct a robustness check using a restricted sample that includes only observations for which we have a lead of loans outstanding up to the horizon $h = 24$.[8] From the specification above, we are interested in the estimated values for $\delta_h^{(0)}$. These represent the nonlinear impact of the monetary policy shock on the cumulative loan growth up to the horizon h attributable to banks' heterogeneity in their maturity gap. In terms of interpretation, a negative estimate $\hat{\delta}_h^{(0)}$ would suggest that, under a monetary policy tightening, banks with higher maturity gaps would contract their lending more than banks with lower maturity gaps and, under a monetary policy easing, banks with higher maturity gaps would expand their lending more than banks with lower maturity gaps. A positive estimate would imply the opposite interpretation.

In our baseline results using the full sample, we find a negative $\hat{\delta}_h^{(0)}$ associated with an unconventional monetary policy shock (a QT shock), as illustrated in figures 3a, 3b, and 3c. We show the implied difference in cumulative loan growth for banks at the 25th versus 75th percentile of the maturity gap distribution in our sample (between three and four years of difference in the maturity gap), following a one-basis point tightening shock from unconventional policies (QT shock). Across the 24-month horizon, the difference in the cumulative impact ranges from -0.10 to -0.47 percentage points (-0.30 on average) and is significant at the 90% confidence level until at least a year after a QT shock (except for a few noisier months). The corresponding results for a one-basis point tightening target shock are included in Appendix C (see figures 11a, 11b, and 11c) and show that the difference in loan growth responses between banks at the 25th and 75th percentiles of the maturity gap distribution is positive and significant on impact but largely insignificant and noisy on the overall horizon, especially after 9-10 months. In Appendix C, we also report the results for the restricted sample as a robustness check. Although they display - as expected - less noisy impulse responses, the outcome is broadly similar under a QT shock (see figure 12c). Conversely, the target shock in

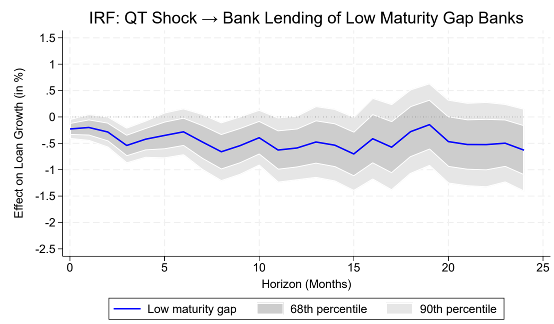
[8] The restricted sample contains 471,215 observations and ensures a constant estimation sample across all horizons. The results for this restricted sample are provided in Appendix C.

the restricted sample yields a statistically insignificant estimate for $\hat{\delta}_h^{(0)}$ (see figure 13c). We consider the empirical results under the target shock to be less robust because they are not fully consistent between the full and restricted sample. However, they are helpful in ruling out the hypothesis that banks with high maturity gaps decrease their loan supply more strongly than banks with low maturity gaps following a conventional monetary policy tightening shock.

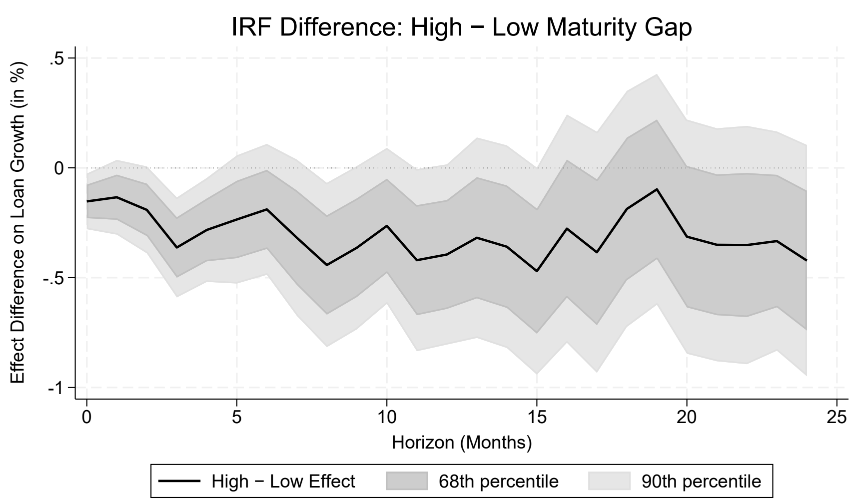
Figure 3: Analysis of bank lending responses to a QT shock, comparing high and low maturity gap banks - Full sample



(a) *Response of lending from high maturity gap banks to QT shock*



(b) *Response of lending from low maturity gap banks to QT shock*



(c) *Difference in bank lending response between banks with high vs low maturity gap under a QT shock*

Based on these findings, we can conclude that maturity gaps in banks' balance sheets *amplify* the impact of unconventional monetary policy shocks. Banks with a higher maturity gap decrease their lending more than those with a lower maturity gap after a tightening and increase their lending more compared to banks with a lower maturity gap after an easing policy. The difference is significant. In contrast, maturity gaps in banks' balance sheets do not amplify the impact of conventional monetary policy shocks, suggesting that these shocks have a rather more homogeneous effect across banks that hold different interest rate exposures.

To better understand the implications of this empirical result for real economic variables, notably inflation, economic growth, and investment, we propose a New Keynesian DSGE model with financial intermediaries. These intermediaries are characterized by heterogeneous maturity structures, which shape their exposure to valuation risk and their lending behavior. The model and impulse response functions of the calibrated conventional and unconventional monetary policy shocks are presented in the next section.

4 The Model

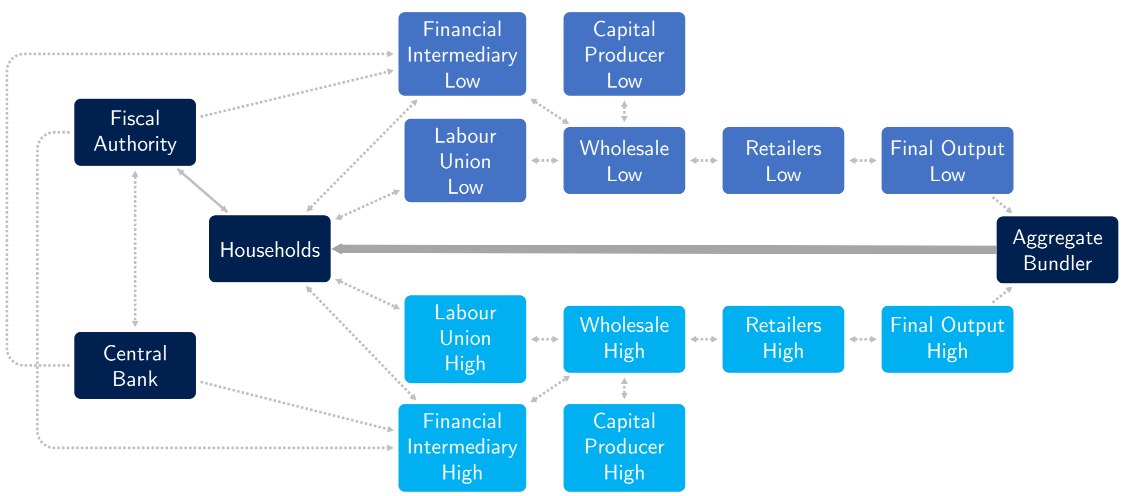


Figure 4: Stylised depiction of the model

This section outlines the core components of our model: households, labor unions, symmetric wholesale good producers, two types of segmented financial intermediaries, a fiscal authority, and a central bank. While our framework shares many similarities with canonical medium-scale DSGE models (Christiano et al., 2005; Smets and Wouters, 2007), it diverges in key ways to accommodate the segmented maturity structure of the financial sector. Below, we summarize the main features and innovative components of the framework.

Wholesale good producers (firms) use perpetual bonds with geometrically decaying coupons, following Woodford (2001), to partially finance their new capital investments. Financial intermediaries, as in Gertler and Karadi (2011) and Gertler and Karadi (2013), fund their operations using net worth and short-term debt (deposits), while holding long-term private loans, government bonds, and central bank reserves on the asset side.

A costly enforcement problem creates an endogenous leverage constraint for financial intermediaries, generating excess returns on assets. Interacting with firms' need to finance investment through long-term bonds, this constraint gives rise to an "investment wedge"—the main channel through which QE/QT affects real economic activity. Following Gertler and Karadi (2013), market segmentation prevents households from directly holding government bonds.

The central bank finances its operations by issuing interest-bearing reserves. Crucially, while financial intermediaries optimally choose their asset and liability positions subject to their constraints, their respective maturity gaps remain defined by their specific segment (low or high). A comprehensive description of the full model is provided in Appendix A.

4.1 Model Framework and Innovation

Our framework extends the New Keynesian DSGE models of Gertler and Karadi (2011, 2013); Sims and Wu (2021). Our primary innovation is to introduce a heterogeneous banking system defined by differences in maturity gaps. Instead of modeling different industrial sectors, we assume the production side is composed of symmetric firms that are identical in technology but segmented by their source of financing. Following Allen and Gale (1994) and Gertler and Kiyotaki (2010a), specific firms borrow exclusively from specific types of financial intermediaries. This creates two parallel financing channels: one served by financial intermediaries with a "High" steady-state maturity gap (36 quarters) and the other by financial intermediaries with a "Low" steady-state maturity gap (12 quarters). This setup allows us to remain agnostic about the production side itself, cleanly isolating the impact of balance sheet heterogeneity.

Production within each financing segment follows a multi-stage process. A representative wholesale goods producer (firm) combines capital and labor to produce output, which is then purchased by a continuum of retailers. These retailers repackage wholesale output and sell it to competitive final goods producers. Capital goods producers create new physical capital specific to their segment. The output from the "Low" and "High" maturity segments is then aggregated into a final consumption bundle via a CES aggregator (e.g., Ghassibe (2021)), with an elasticity of substitution $\eta_y = 1.5$ (see Table 4), which allows representative households to consume from both sources. Households supply labor to both segments, pay taxes, and save through deposits. The labor market features two layers: labor unions purchase labor from households and set wages subject to Calvo-style nominal rigidities, and a representative labor packer competitively aggregates differentiated labor for final production.

The fiscal authority consumes an exogenous, stochastic amount of final output (G_t), financed by lump-sum taxes, transfers from the central bank, and a fixed real stock of government bonds ($\bar{b}_G$), whose nominal value scales with the price level as reflected in the fiscal budget constraint (Appendix A.6). Due to the financial intermediary frictions mentioned above, Ricardian Equivalence fails, making the tax-versus-bond financing mix relevant. Following Sims and Wu (2021), the supply of government bonds is held fixed at its steady-state level $\bar{b}_G$. Lump-sum taxes adjust endogenously to ensure the government's budget constraint is satisfied in each period.

The model dynamics are driven by ten exogenous AR(1) processes, which can be categorized into three groups: (i) Aggregate policy shocks, including government spending ($\varepsilon_{G,t}$), central bank government bond holdings ($\varepsilon_{b,t}$), government bond maturity ($\varepsilon_{\kappa^b,t}$), and the monetary policy rate ($\varepsilon_{r,t}$); (ii) Segment-specific productivity shocks ($\varepsilon_{A,L,t}, \varepsilon_{A,H,t}$); and (iii) Segment-specific financial shocks, comprising liquidity constraints ($\varepsilon_{\theta,L,t}, \varepsilon_{\theta,H,t}$) and shocks to the maturity of private loans ($\varepsilon_{\kappa^f,L,t}, \varepsilon_{\kappa^f,H,t}$).

4.2 Production

Production takes place in multiple stages. Because the wholesale goods sector is the most central to our analysis, we focus on it here and relegate the remaining production layers to Appendix A. In each segment s, a representative wholesale goods producer combines capital and labor to generate intermediate output $Y_{m,s,t}$. This output is then sold to a unit continuum of retail firms indexed by $f \in [0,1]$, each of which costlessly differentiates the wholesale good so that $Y_{s,t}(f) = Y_{m,s,t}(f)$. A competitive final goods producer subsequently aggregates these differentiated retail varieties into segment-level output $Y_{s,t}$. Outputs from both segments are subsequently combined into aggregate final output Y_t via a CES technology with elasticity of substitution $\eta_y > 1$. Within each segment, a continuum of retailers differentiates wholesale output with elasticity of substitution $\epsilon_p > 1$, which pins down the demand schedule faced by each retailer. In addition, a competitive capital goods producer converts final output into new physical capital I_t.

4.2.1 Wholesale Good Producers

The representative wholesale firm in segment s produces output according to Cobb-Douglas technology:

$$Y_{m,s,t} = A_{s,t}(u_{s,t}K_{s,t-1})^{\alpha}(L_{d,s,t})^{1-\alpha} \tag{2}$$

Here $Y_{m,s,t}$ denotes flow output in segment s during period t, and $L_{d,s,t}$ is the corresponding labor input. The firm enters period t with a predetermined capital stock $K_{s,t-1}$ and selects a utilization rate $u_{s,t}$; raising utilization increases effective capital services at the cost of faster depreciation. The parameter $\alpha \in (0,1)$ governs the share of capital in production, while $A_{s,t}$ is an exogenous, segment-specific productivity shifter that obeys a stochastic process. Higher utilization accelerates depreciation through the function $\delta(u_{s,t})$, whose precise specification is given in Appendix A. The capital stock evolves according to:

$$K_{s,t} = \hat{I}_{s,t} + \Big(1 - \delta(u_{s,t})\Big)K_{s,t-1} \tag{3}$$

Following an approach similar to Carlstrom et al. (2017), we assume that wholesale producers must issue long-term bonds to finance new physical capital purchases $\hat{I}_{s,t}$. A key departure from their framework, however, is that our firm need only finance a fixed fraction $\psi \in [0,1]$ of its investment rather than the entire amount. This gives rise to a “loan-in-advance constraint”:

$$\psi P^k_{s,t}\hat{I}_{s,t} \le Q_{s,t} CF_{s,t} = Q_{s,t}(F_{s,t} - \kappa^f_{s,t} F_{s,t-1}), \tag{4}$$

where $P^k_{s,t}$ denotes the price at which the wholesale firm acquires new capital.

The wholesale producer hires labor on a competitive spot market at the nominal wage $W_{s,t}$. Its nominal dividend is given by

$$\begin{aligned} DIV_{m,s,t} =& P^m_{s,t} A_{s,t}(u_{s,t}K_{s,t-1})^{\alpha} L^{1-\alpha}_{d,s,t} - W_{s,t}L_{d,s,t} - P^k_{s,t}\hat{I}_{s,t} \\ & - F_{s,t-1} + Q_{s,t}(F_{s,t} - \kappa^f_{s,t}F_{s,t-1}) \end{aligned} \tag{5}$$

The firm seeks to maximize the present discounted value of its real dividends by choosing labor $L_{d,s,t}$, capital utilization $u_{s,t}$, next-period capital $K_{s,t}$, investment $\hat{I}_{s,t}$, and bond issuance $f_{s,t}$, where discounting relies on the household stochastic discount factor. The resulting first-order conditions are (see Appendix A for the complete Lagrangian and derivation):

$$w_{s,t} = (1-\alpha) p^m_{s,t} A_{s,t}(u_{s,t}K_{s,t-1})^{\alpha} L^{-\alpha}_{d,s,t} \tag{6}$$

$$p^k_{s,t} M_{1,s,t}\Big(\delta_{1,s} + \delta_2(u_{s,t}-1)\Big) = \alpha\, p^m_{s,t} A_{s,t}(u_{s,t}K_{s,t-1})^{\alpha-1} L^{1-\alpha}_{d,s,t} \tag{7}$$

$$\begin{aligned} p^k_{s,t} M_{1,s,t} = \mathbb{E}_t \Lambda_{t,t+1} \Big[& \alpha\, p^m_{s,t+1} A_{s,t+1} K^{\alpha-1}_{s,t} u^{\alpha}_{s,t+1} L^{1-\alpha}_{d,s,t+1} \\ & + \Big(1 - \delta(u_{s,t+1})\Big) p^k_{s,t+1} M_{1,s,t+1} \Big] \end{aligned} \tag{8}$$

$$Q_{s,t} M_{2,s,t} = \mathbb{E}_t \Lambda_{t,t+1} \Pi^{-1}_{t+1} \left[1 + \kappa^f_{s,t+1} Q_{s,t+1} M_{2,s,t+1} \right] \tag{9}$$

$$\frac{M_{1,s,t}-1}{M_{2,s,t}-1} = \psi \tag{10}$$

Here $p^k_{s,t}$ is the relative price of new capital (Tobin’s Q), $w_{s,t}$ is the real wage, and $p^m_{s,t}$ is the relative price of wholesale output in segment s. Equation (6) is the standard static labor demand condition. Equation (7) pins down the optimal utilization rate by equating the marginal cost of increased utilization—faster depreciation valued at the shadow price of capital $p^k_{s,t}M_{1,s,t}$—to the marginal product of utilization. The wedges $M_{1,s,t}$ and $M_{2,s,t}$ both arise from the loan-in-advance constraint (Equation (4)) requiring firms to issue bonds to finance investment. Equations (8) and (9) govern the optimal accumulation of capital and bonds, respectively. As shown in the Lagrangian (Equation (A.54) in the Appendix), both wedges depend on the single multiplier $\nu_{2,s,t}$ attached to the financing constraint. When the constraint is slack, $M_{1,s,t} = M_{2,s,t} = 1$ and these conditions reduce to standard asset-pricing relations. When it binds, $M_{1,s,t}$ operates as an "investment wedge" and $M_{2,s,t}$ as a "financial wedge," distorting the firm's intertemporal decisions. Fluctuations in these wedges constitute the principal channel through which unconventional monetary policies such as QE and QT transmit to the real economy.

4.3 Financial Intermediaries

4.3.1 Bond Structure and The Heterogeneous Maturity Gap

Before turning to the intermediaries' optimization problem, we describe the structure of their balance sheets and formalize the maturity gap. Assigning distinct maturity profiles to the intermediaries in each segment $s \in \{L, H\}$ allows us to trace the resulting differences in real activity and credit supply directly to this balance-sheet heterogeneity.

4.3.2 Bond structure

Following Woodford (2001), we model long-term bonds as perpetuities whose coupon payments decay geometrically. We allow the aggregate decay rate to differ across bond types and to vary over time.

For private long-term bonds (loans) in segment s, the aggregate outstanding stock at the end of period t is $F_{s,t}$. Each period, the aggregate coupon obligation on the inherited stock decays at the current rate $\kappa^f_{s,t}$, so net new issuance is given by:

$$CF_{s,t} = F_{s,t} - \kappa^f_{s,t} F_{s,t-1}. \tag{11}$$

A bond with face value one issued in period t pays one unit in $t + 1$, and its remaining coupon stream is rolled into the aggregate stock, where it subsequently decays at whatever rate $\kappa^f_{s,t+j}$ prevails in each future period $t+j$. When $\kappa^f_{s,t}$ is constant, this reduces to the familiar geometric payment stream $1, \kappa^f, (\kappa^f)^2, \ldots$; when it is time-varying, the current $\kappa^f_{s,t}$ governs the continuation value of the entire outstanding stock, rather than being fixed at issuance. Government long-term bonds, issued by the fiscal authority, follow an identical structure with aggregate decay rate κ^b_t.

A key advantage of this perpetual-stock formulation is its tractability: one need only track the total outstanding liability $F_{s,t}$ together with the current decay rate $\kappa^f_{s,t}$. The total market value of all outstanding private bonds in segment s is then simply $Q_{s,t}F_{s,t}$. Government bonds (denoted $B_{G,t}$, with price $Q_{B,t}$) are treated analogously.

4.3.3 Long-term bond maturity

The decay parameter κ directly determines the effective maturity—or duration—of each bond. A value of κ closer to one implies slower coupon decay and hence a longer maturity. Specifically, the effective maturity of private bonds is $M^f_t = 1/(1-\kappa^f_t)$, and that of government bonds is $M^b_t = 1/(1-\kappa^b_t)$.

4.3.4 Maturity Gap

In the spirit of Paul (2023), we define the maturity gap as the difference between the value-weighted average maturity of an intermediary's assets and the maturity of its liabilities. This measure captures the extent of maturity transformation undertaken by the intermediary and serves as a proxy for its interest-rate risk exposure. Formally, for segment $s \in \{L, H\}$ at date t:

$$\text{Maturity Gap}_{s,t} = \frac{M^f_{s,t}(Q_{s,t}f_{s,t}) + M^b_t(Q_{B,t}b_{s,t}) + M^{re}re_{s,t}}{Q_{s,t}f_{s,t} + Q_{B,t}b_{s,t} + re_{s,t}} - M^d \tag{12}$$

The numerator of the first term is the value-weighted maturity of the asset side, with weights given by the market values of the bank's private loan holdings ($Q_{s,t}f_{s,t}$), government bonds ($Q_{B,t}b_{s,t}$), and central bank reserves ($re_{s,t}$); the denominator is total assets. The second term, M^d, captures the maturity of liabilities (deposits).

Among the maturity parameters, $M^f_{s,t}$ and M^b_t correspond to the long-term asset maturities derived above. For reserves and deposits we set M^{re}_t and M^d_t equal to one period ($M^{re} = M^d = 1$), consistent with the high liquidity of these instruments.[9]

[9] Within each segment, all intermediaries are identical, so the maturity gap is a segment-level object. In the empirical counterpart (Section 3), banks are heterogeneous, and the maturity gap is computed at the individual bank level.

Having established the mathematical structure of the assets and the maturity gap, we now describe the financial intermediaries' optimization problem.

4.3.5 Financial Intermediaries

Our intermediary sector builds on the frameworks of Gertler and Karadi (2011) and Gertler and Karadi (2013). The economy comprises two symmetric segments indexed by $s \in \{L, H\}$, each populated by a fixed mass of intermediaries. Intermediaries fund their operations with net worth $N_{s,i,t}$ and deposits $D_{s,i,t}$ collected from households. Each period a fraction $1 - \sigma$ of incumbents exit and transfer their accumulated net worth to households; they are immediately replaced by an equal number of entrants, each endowed with startup funds X_s from their household owners. On the asset side, intermediaries in segment s hold long-term private bonds (loans) $F_{s,i,t}$, long-term government bonds $B_{s,i,t}$, and interest-bearing reserves $RE_{s,i,t}$ at the central bank. The balance-sheet identity for a representative intermediary in segment s reads:

$$Q_{s,t}F_{s,i,t} + Q_{B,t}B_{s,i,t} + RE_{s,i,t} = D_{s,i,t} + N_{s,i,t} \tag{13}$$

Intermediaries accumulate net worth until they stochastically exit. For surviving intermediaries, net worth evolves as:

$$\begin{aligned} N_{s,i,t} =& (R^F_{s,t} - R^d_{s,t-1})Q_{s,t-1}F_{s,i,t-1} + (R^B_t - R^d_{s,t-1})Q_{B,t-1}B_{s,i,t-1} \\ &+ (R^{re}_{t-1} - R^d_{s,t-1})RE_{s,i,t-1} + R^d_{s,t-1}N_{s,i,t-1} \end{aligned} \tag{14}$$

Here R^{re}_{t-1} is the policy-determined interest rate on reserves, known at $t-1$, and $R^d_{s,t-1}$ is the market-clearing deposit rate in segment s. The first three terms capture the excess returns that the intermediary earns on its three asset classes—private bonds, government bonds, and reserves—relative to the cost of deposit funding. The final term reflects the saving from financing with equity rather than deposits. The holding-period returns on long-term private and government bonds are, respectively,

$$R^F_{s,t} = \frac{1 + \kappa^f_{s,t}Q_{s,t}}{Q_{s,t-1}} \tag{15}$$

$$R^B_t = \frac{1 + \kappa^b_t Q_{B,t}}{Q_{B,t-1}} \tag{16}$$

Each intermediary maximizes the expected discounted value of its terminal net worth, using the household discount factor $\Lambda_{t,t+1}$. Consider an intermediary in segment s that continues operating after period t. It survives to $t+1$ with probability σ and exits with probability $1-\sigma$; thus the probability of exit at horizon j is $\sigma^{j-1}(1-\sigma)$. The intermediary's objective is therefore:

$$V_{s,i,t} = \max(1-\sigma)E_t \sum_{j=1}^{\infty} \sigma^{j-1}\Lambda_{t,t+j}n_{s,i,t+j}, \tag{17}$$

where $n_{s,i,t} = N_{s,i,t}/P_t$ is the real net worth and P_t is the price of the final output.

As in Gertler and Karadi (2011) and Gertler and Karadi (2013), intermediaries are subject to a "costly enforcement problem." At the end of any period, an intermediary may choose to abscond with a portion of the assets under its management. In such an event, depositors can recover only part of their funds while the intermediary retains the remainder.

For the system to function, depositors must be willing to supply funds, which requires that the intermediary has no incentive to divert assets—an event we label "going into bankruptcy." The resulting incentive-compatibility constraint is:

$$V_{s,i,t} \geq \theta_{s,t}(Q_{s,t}f_{s,i,t} + \Delta_s Q_{B,t}b_{s,i,t}) \tag{18}$$

The left-hand side is the continuation value of operating honestly, while the right-hand side is the real value the intermediary can retain by defaulting. Upon diversion, the intermediary keeps a stochastic fraction $\theta_{s,t}$ of its private bonds but only the smaller fraction $\theta_{s,t}\Delta_s$ (with $\Delta_s \leq 1$) of government bonds, reflecting the assumption that government securities are harder to divert than private claims. Reserves are assumed to be fully recoverable by depositors and hence cannot be diverted.

The parameter $\theta_{s,t}$ is treated as stochastic and exogenous, and can be interpreted as a segment-specific "liquidity shock." A rise in $\theta_{s,t}$ means that the intermediary can divert a larger share of its assets, reducing the recovery available to depositors. The resulting reluctance to lend drives interest-rate spreads upward—a hallmark of liquidity crises.

Since all intermediaries within a given segment are identical, they share the same optimality conditions (see Appendix A for the full derivation):

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}(R_{s,t+1}^F - R_{s,t}^d)\right] = \frac{\lambda_{s,t}}{1+\lambda_{s,t}}\theta_{s,t} \tag{19}$$

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}(R_{t+1}^B - R_{s,t}^d)\right] = \frac{\lambda_{s,t}}{1+\lambda_{s,t}}\theta_{s,t}\Delta_s \tag{20}$$

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}(R_t^{re} - R_{s,t}^d)\right] = 0, \tag{21}$$

where

$$\Omega_{s,t} = 1 - \sigma + \sigma\theta_{s,t}\phi_{s,t} \tag{22}$$

$$\phi_{s,t} = \frac{1+\lambda_{s,t}}{\theta_{s,t}}E_t[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}]R_{s,t}^d \tag{23}$$

Equations (19)–(21) are the key equilibrium conditions for segment s, where $\lambda_{s,t} \geq 0$ is the multiplier on the costly enforcement constraint. Two cases arise. If the constraint does not bind, expected returns on all three asset classes equal the deposit rate to a first-order approximation. If the constraint binds, long-term private and government bonds earn positive excess returns over deposits, with $\Delta_s < 1$ ensuring that excess returns on government bonds remain below those on private bonds. The auxiliary variables $\Omega_{s,t}$ and $\phi_{s,t}$ are introduced to simplify notation. Under the maintained assumption that the intermediary's value is linear in net worth, we have:

$$V_{s,i,t} = \theta_{s,t}\phi_{s,t}n_{s,i,t} \tag{24}$$

When the constraint binds,

$$\phi_{s,t} = \frac{Q_{s,t}f_{s,i,t} + \Delta_s Q_{B,t}b_{s,i,t}}{n_{s,i,t}} \tag{25}$$

The ratio $\phi_{s,t}$ is the endogenous leverage ratio. When the enforcement constraint binds, it limits the intermediary's leverage below its unconstrained optimum, and it is this restriction that ultimately gives rise to equilibrium excess returns.

The model features two segments rather than one. Crucially, we impose financing segmentation (Allen and Gale, 1994, 2007; Gertler and Kiyotaki, 2010a): each intermediary operates exclusively within its own segment. All balance-sheet items are segment-specific; in particular, private bond holdings are confined to the corresponding segment.

4.4 Monetary Policy

4.4.1 Conventional monetary policy

Before discussing unconventional monetary policy, we must first define conventional policy. We define this as the central bank's adjustment of the short-term interest rate R_t^{tr}. This adjustment is described by an internal feedback rule, similar to the one proposed by Taylor (1993):

$$\begin{aligned} \ln R_t^{tr} &= (1-\rho_r)\ln R^{tr} + \rho_r \ln R_{t-1}^{tr} \\ &\quad + (1-\rho_r)\left[\phi_\pi(\ln \Pi_t - \ln \Pi) + \phi_y(\ln Y_t - \ln Y_{t-1})\right] + s_r\varepsilon_{r,t} \end{aligned} \tag{26}$$

In this rule, R^{tr} and Π represent the long-run "steady-state" values for the policy rate and the inflation target. The parameters $0 < \rho_r < 1$, ϕ_π, and ϕ_y are all non-negative numbers. To ensure the model has a stable solution (a "determinate equilibrium"), we only consider cases where $\phi_\pi > 1$. This rule simply means that the policy rate adjusts whenever inflation moves away from its target, or when output growth moves away from its trend (which we assume is zero in this model). We also assume that the central bank sets the interest rate on reserves the same as the main policy rate. Therefore, the segment-specific deposit rate ($R_{s,t}^d$) and the reserve rate (R_t^{re}) are both equal to R_t^{tr}:

$$R_{s,t}^d = R_t^{re} = R_t^{tr}, \qquad s \in \{L, H\} \tag{27}$$

4.4.2 Unconventional monetary policy

Quantitative easing is arguably the most significant unconventional monetary policy employed by central banks. It was first adopted by the Bank of Japan in the early 2000s. After the Great Recession, major economies such as the United States, the euro area, and the United Kingdom implemented this tool, but its use expanded to an unprecedented scale in response to the 2020 COVID-19 pandemic.

While the Federal Reserve's balance sheet reached \$4.5 trillion after its initial post-crisis programs, it surged to a peak of nearly \$9 trillion (around 36% of U.S. GDP) by early 2022. The European Central Bank's balance sheet, which stood at €4.7 trillion in late 2018, peaked at €6.89 trillion (approximately 50% of euro area GDP) by the end of 2023. The Bank of Japan's holdings, which long exceeded 100% of its GDP, grew to a high of over ¥764 trillion (approximately 130% of Japan's GDP).

This era of massive expansion has now begun to pivot. Since 2024, these central banks have entered a new phase of QT, or QN, as the ECB terms it. This shift involves discontinuing reinvestments, such as the ECB's full halt of its APP and PEPP programs by the end of 2024, and actively allowing these massive balance sheets to shrink further.

Following Gertler and Karadi (2011), Gertler and Karadi (2013), and Carlstrom et al. (2017), we define quantitative easing as a central bank's purchase of long-term government bonds. These purchases are made by creating new interest-bearing reserves held by the financial intermediaries. In our model, the central bank's balance sheet is:

$$Q_{B,t} B_{cb,t} = \mathrm{RE}_t \tag{28}$$

The central bank holds long-term government bonds ($B_{cb,t}$) as assets financed by issuing interest-bearing reserves (RE_t). Any profit (operating surplus) from these holdings is transferred to the government fiscal authority. The model's market-clearing condition requires that all bonds from the government are held by either financial intermediaries or the central bank. QE/QT policies can have real effects on the economy, but only if financial intermediaries are constrained by the costly enforcement problem. When this constraint is active (or "binds"), the central bank's bond purchases (financed by new reserves) help to ease this constraint. In this situation, the central bank's demand for bonds adds to, rather than "crowds out," the intermediaries' demand. This increases total demand for bonds, leading to higher bond prices. Higher bond prices relax the loan-in-advance constraint faced by wholesale goods producers. This ultimately results in higher investment and greater aggregate demand. However, if the intermediaries' constraint is not binding, or if wholesale firms do not need to borrow to finance investment (i.e., $\psi = 0$), then QE/QT has no economic effects. We treat QE/QT as an exogenous policy.

We assume that the central bank's bond holdings follow an external AR(1) process:

$$b_{cb,t} = (1 - \rho_b) b_{cb} + \rho_b b_{cb,t-1} + s_b \varepsilon_{b,t} \tag{29}$$

Here, b_{cb} denotes the steady-state (long-run) level of real central bank government bond holdings, ρ_b is a persistence parameter (between 0 and 1), and $\varepsilon_{b,t}$ is a stochastic shock with standard deviation s_b.

4.5 Calibration

The model is solved using a first-order linear approximation around the non-stochastic steady state and calibrated at a quarterly frequency. The values assigned to standard aggregate parameters are reported in Table 5; the segment-specific parameters are reported in Table 4.

Most aggregate parameters take on conventional values drawn from the New Keynesian DSGE literature. The discount factor is set to $\beta = 0.995$ and the steady-state depreciation rate on physical capital to $\delta_0 = 0.025$, both standard for a quarterly model. The parameter on the linear term in the utilization cost function, $\delta_{1,s}$, is chosen endogenously in each segment to be consistent with a steady-state normalization of the utilization rate to unity ($u_s = 1$). The habit formation parameter is $b = 0.70$ and the inverse Frisch labour-supply elasticity is $\eta = 1$; both are standard values. The scaling parameter on the disutility of labour, χ_s, is determined endogenously so as to normalize steady-state labour input to unity in each segment ($L_s^d = 1$). The exponent on capital services in the production function takes the conventional value $\alpha = 0.33$. The squared term in the utilization adjustment cost function is $\delta_2 = 0.01$ and the investment adjustment cost parameter is $\kappa_I = 2$, both of which are standard. The elasticities of substitution for goods and labour, ϵ_p and ϵ_w, are each set to 11, implying steady-state mark-ups of approximately ten percent. The Calvo price-rigidity parameter, ϕ_p, and the wage-rigidity parameter, ϕ_w, are each set to 0.75, implying average durations between price and wage changes of one year. No backward indexation of either prices or wages is assumed, so $\gamma_p = \gamma_w = 0$. The model is solved about a zero-inflation steady state ($\Pi = 1$). The elasticity of substitution between the two segments in the CES output aggregator is $\eta_y = 1.5$. The deposit-preference weight ω_d and the elasticity of substitution between deposits η_d are set to 0.65 and 5, respectively. The parameters of the Taylor rule—the smoothing coefficient $\rho_r = 0.80$, the inflation response $\phi_\pi = 1.50$, and the output-growth response $\phi_y = 0.00$—are standard values consistent with the euro-area literature (e.g. Smets and Wouters, 2007; Carlstrom et al., 2017). The intermediary survival probability is $\sigma = 0.95$ (common across segments) and the loan-in-advance constraint parameter is $\psi = 0.80$. Government spending as a share of output is $G/Y = 0.22$. The steady-state government-debt-to-

GDP ratio is $B/Y = 3.20$ (annualized 80%), and the central bank's government-bond holdings are $B_{cb}/Y = 0.24$ (annualized 6%). The target maturity of government bonds is 40 quarters ($\kappa^b = 1 - 1/40$).

As detailed in Table 4, the economy is composed of two segments: a dominant Low segment ($\zeta_L = 0.90$) and a smaller High segment ($\zeta_H = 0.10$). The key targets that discipline the cross-segment heterogeneity are the maturity of private loans ($M_L^f = 12$, $M_H^f = 36$ quarters), the deposit ratios ($Dep_L = 0.55$, $Dep_H = 0.75$), and the steady-state net spreads ($Sp_L^f = 200$ bps, $Sp_H^f = 400$ bps annualized). Given these targets, the model endogenously determines each segment's leverage ratio ($Lev_L = 2.22$, $Lev_H = 4.00$), divertibility parameter ($\theta_L = 0.75$, $\theta_H = 0.32$), and recoverability parameter ($\Delta_L = 0.50$, $\Delta_H = 0.25$).

It is important to distinguish the CES output weight ζ_s from the steady-state shares of other aggregates. While the CES aggregator assigns $\zeta_L = 0.90$ and $\zeta_H = 0.10$ to final-good output, all balance-sheet and real aggregates—investment, capital, net worth, deposits, and loans—are obtained by simple summation across segments (e.g., $I_t = I_{L,t} + I_{H,t}$). Because each segment is endowed with a separate labor market and an independent production technology, their steady-state capital stocks are of comparable magnitude: the investment shares are $I_L/I = 0.52$ and $I_H/I = 0.48$. The financial side is even more tilted toward the High segment: since longer-maturity bonds command higher market prices ($Q_H \gg Q_L$) and the High segment operates at higher leverage, loans by market value split $fM_L/fM = 0.26$ versus $fM_H/fM = 0.74$.[10] When verifying that aggregate IRFs are consistent with their segment-level components, the appropriate weights are these steady-state shares, not the CES output parameter ζ_s. Concretely, when the liquidity shock originates in the High segment, the approximately 0.8% decline in High-segment investment translates into a sizable aggregate effect because the High segment accounts for roughly 48% of total steady-state investment. In addition, general equilibrium spillovers—operating through the common deposit market, the shared Taylor rule, and the CES output aggregator—transmit part of the High-segment contraction to the Low segment, further amplifying the aggregate response. The same logic applies to the technology shock analysis in Section **??**.

All segment-specific shocks (productivity, liquidity, private-loan maturity) and ag-

[10]Net worth shares are $n_L/n = 0.63$ and $n_H/n = 0.37$, reflecting the lower leverage of the Low segment.

gregate shocks (government spending, central-bank bond holdings, government-bond duration) follow AR(1) processes. Their persistence and volatility parameters are reported in Tables 4 and 5.

Table 4: Calibrated Parameters: Segment-Specific (Low vs. High)

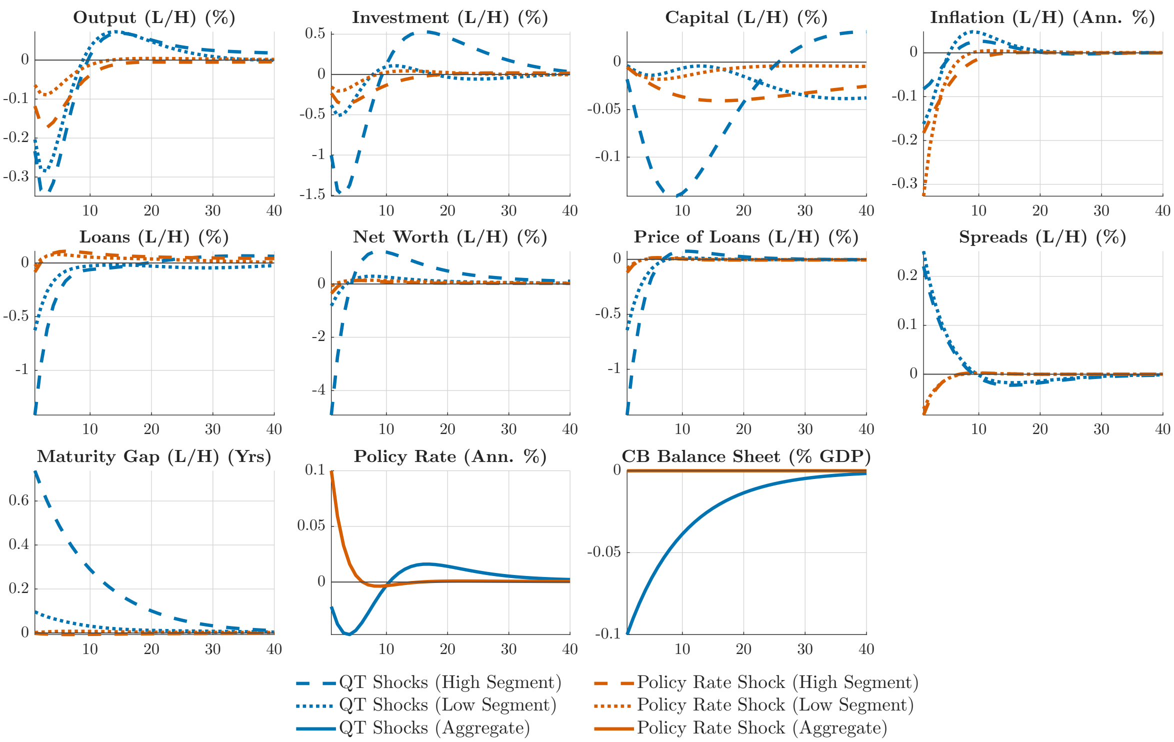
		Segment Value	
Param.	**Description**	**Low** (L)	**High** (H)
Financial Frictions & Balance Sheet			
ζ_s	Share of the segment	0.90	0.10
Lev_s	Leverage ratio	2.22	4.00
θ_s	Divertibility parameter	0.75	0.32
Dep_s	Target deposit ratio	0.55	0.75
Δ_s	Recoverability parameter	0.50	0.25
Sp_s^f	Steady-state net spread	200 bps	400 bps
Maturity Structure			
M_s^f	Target loan maturity (Qtrs)	12	36
M^b	Target government bond maturity (Qtrs)	40	40
M^{re}	Target reserve maturity (Qtrs)	1	1
M^d	Target deposit maturity (Qtrs)	1	1
Segment-Specific Shocks			
ρ_A, s_A	Productivity shock	0.95, 0.01	
ρ_θ, s_θ	Liquidity shock	0.95, 0.01	
$\rho_{\kappa^f}, s_{\kappa^f}$	Duration of private loans shock	0.95, 0.01	

Note: Parameters with a single value are calibrated symmetrically across segments. Spreads are expressed in annualized basis points (bps). Shock volatilities set to zero indicate that the corresponding shock is inactive in the baseline calibration.

5 Discussion

In this section, we compare the effects of exogenous shocks on both conventional and unconventional policy tools. We compare two types of shocks: (i) a conventional monetary policy tightening shock (i.e., an unexpected increase in the desired policy rate, $\varepsilon_{r,t}$), and (ii) a QT shock (i.e., an unexpected contraction in the central bank's government bond holdings, $\varepsilon_{b,t}$). Subsequently, we examine the effects of liquidity and technology shocks.

Figure 5: Responses of High vs. Low Maturity Gap Segments to Policy Rate and QT Shocks

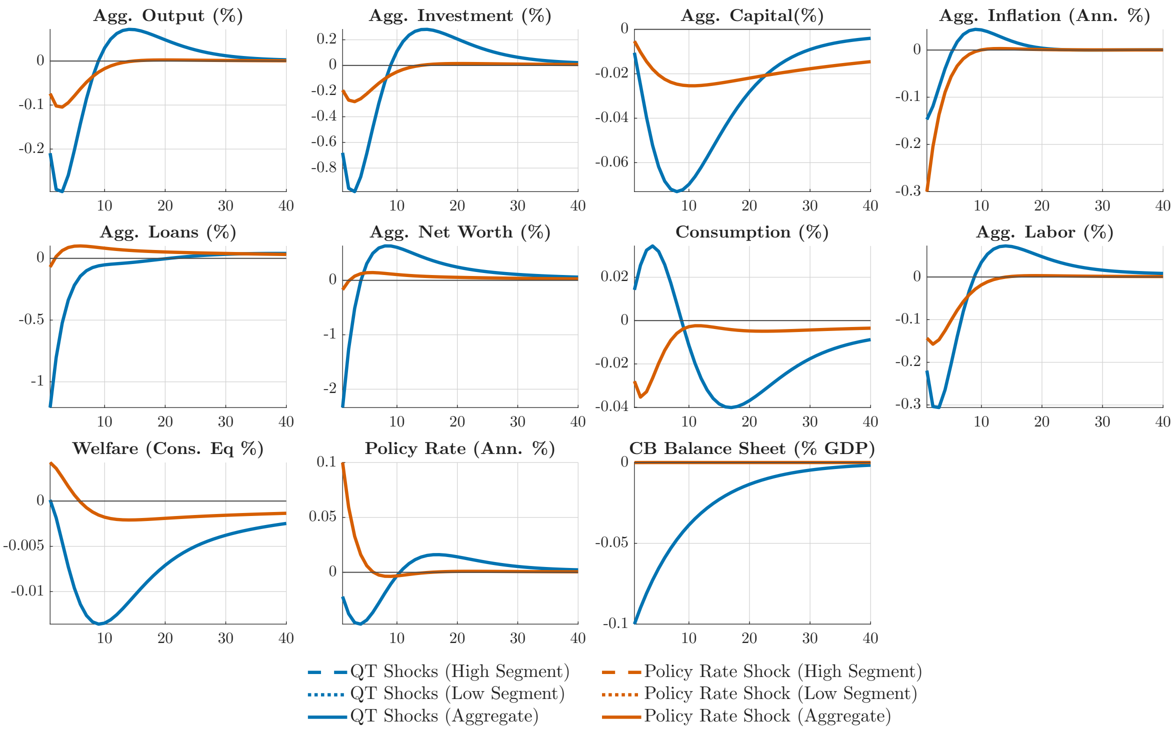


5.1 Conventional (Policy Rate) and Unconventional (QT) Shocks

Figure 5 isolates the impact of bank heterogeneity by plotting the segment-level responses to conventional (policy rate) and unconventional (QT) shocks. This differential analysis provides a visual test of how the financial structure—specifically the maturity mismatch—mediates different policy tools.

The transmission mechanisms of these shocks are fundamentally different, which explains the varied outcomes observed in Figure 5. The conventional policy rate hike (orange lines) operates primarily through the intertemporal substitution channel and by raising the short-term funding cost for banks. As the central bank raises its policy rate, deposit rates rise uniformly. This squeezes net interest margins similarly across all banks, regardless of their asset duration. Consequently, the segment-level responses display substantially less heterogeneity than under the QT shock. While the orange High- and Low-segment lines do not perfectly overlap—the High segment's contraction is visibly larger in some panels, reflecting residual differences in leverage and spreads—the gap between them is economically small compared to the pronounced

Figure 6: Aggregate Responses to Policy Rate and QT Shocks



divergence observed under QT, confirming that the maturity gap plays a limited role in the transmission of conventional policy.

In sharp contrast, the unconventional QT shock (blue lines) operates directly through the bank balance sheet channel, which is highly sensitive to maturity mismatches. QT involves the central bank reducing its government bond holdings, which drains reserves and increases the supply of long-term assets in the market. Banks holding long-duration assets funded by short-duration liabilities suffer mark-to-market valuation losses due to the resulting spike in yields.

This mechanism is clearly visible in the Net Worth and Price of Loans panels of Figure 5. Under the QT shock, High-segment (H) banks suffer a severe capital hit—net worth drops by approximately 4%—creating a large divergence compared to the Low segment (L), where the decline is roughly half as large. The corresponding fall in the price of loans reaches around 1% in the High segment. This drop in net worth causes the leverage constraint to bind more tightly. To restore their capital ratios, High-segment banks are forced to deleverage aggressively. The Spreads panel shows a sharp widening of the credit spread—by roughly 0.2 percentage points in the High segment—reflecting the scarcity of bank capital. This "financial wedge" forces a contraction in credit supply, visible in the Loans panel, where the High segment experiences a decline in lending of approximately 1%, compared to a much smaller decline in the Low segment. The Maturity Gap panel reveals that the QT shock widens the effective maturity gap by approximately 0.6 years in the High segment, further illustrating how this shock interacts directly with the duration structure of bank balance sheets.

Figure 6 demonstrates how this heterogeneity translates into aggregate macroeconomic outcomes. Both policy actions successfully trigger a contraction, causing aggregate output, investment, and consumption to fall. However, the unconventional QT shock is substantially more powerful, and its effects are far more persistent. Under the QT shock, aggregate output drops by about 0.3%—roughly three times the decline caused by the conventional policy rate shock—while aggregate investment contracts by approximately 1%. While the QT shock produces a deflationary impulse of around 0.15 percentage points, the conventional policy rate shock generates an even larger decline of roughly 0.30 percentage points in annualized inflation. This deflationary effect arises because the severe credit contraction depresses aggregate demand by more than the rate hike alone.

The Aggregate Investment panel highlights the amplification through the balance sheet channel. Under the QT scenario, the credit crunch described above starves firms of capital. Investment contracts by roughly twice the amount observed under the conventional policy shock. Aggregate net worth falls by approximately 2%, driving a sustained credit contraction (aggregate loans decline by approximately 1%) that produces a deeper and longer-lasting fall in aggregate output.

Crucially, the Welfare panel summarizes the asymmetric costs of these policies. The QT shock induces a welfare loss of approximately 0.015% in consumption-equivalent terms—substantially larger and more persistent than the welfare cost of the conventional rate shock.

Interestingly, the Policy Rate panel reveals a further asymmetry. While the conventional policy rate shock directly raises the short-term rate and then allows it to revert, the QT shock triggers an endogenous decrease in the policy rate—reaching approximately 0.1 percentage points (annualized)—as the Taylor rule responds to the macroeconomic fallout. This means that, in practice, the contractionary effects of QT prompt an endogenous monetary easing. Rather than compounding the initial balance sheet shock, this automatic policy response partially offsets it, dampening the overall rise in funding costs and buffering the real economy.

This analysis confirms that maturity mismatch functions as a potent systemic amplifier for unconventional shocks. While conventional rate changes act as a broad tool affecting intertemporal decisions uniformly across the banking system, QT operates directly through the bank balance sheet channel, where it is amplified by maturity mismatches. When the banking sector is characterized by high maturity transformation, QT triggers a severe credit contraction that extends well beyond the initial portfolio adjustment.

5.2 Responses to Real and Financial Shocks

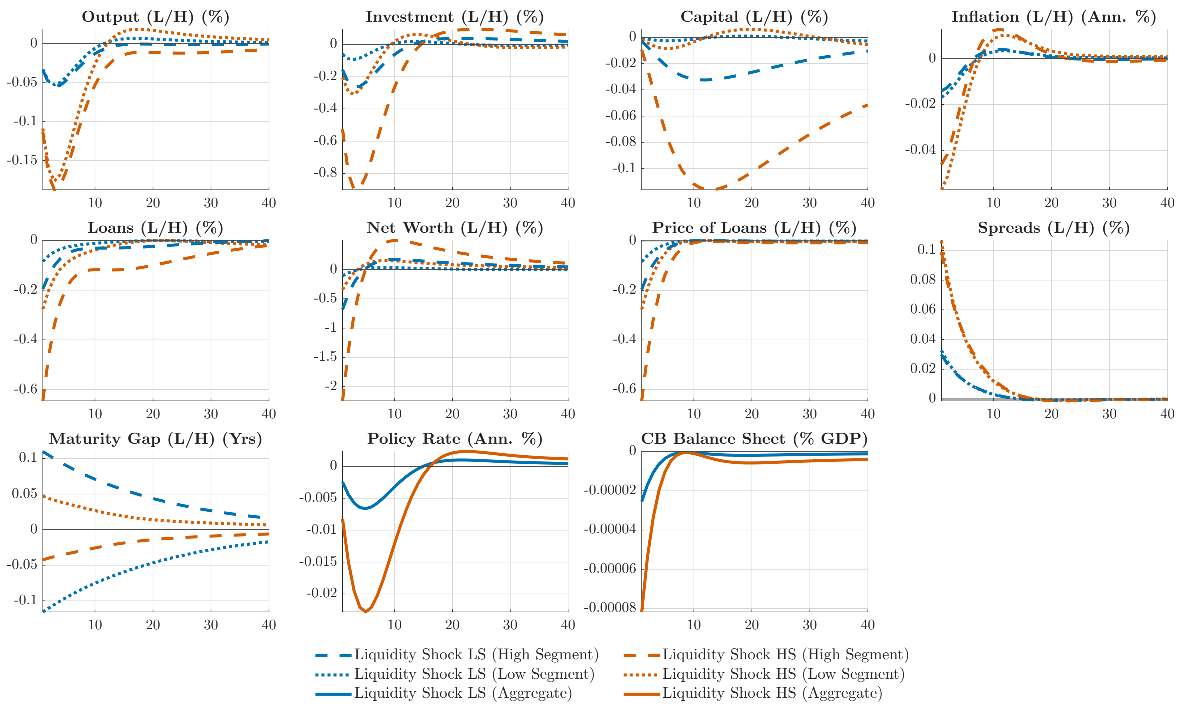
Having established that bank maturity mismatch is a critical determinant for the transmission of unconventional monetary policy but not conventional policy, we now broaden the analysis. We examine two non-policy shocks to understand the wider implications of this financial structure for the economy. First, we introduce a liquidity shock (a pure financial friction shock) to test whether the high-maturity-gap structure serves as a more general source of systemic fragility, amplifying crises that originate within the financial system itself, independent of any policy action. Second, we introduce a positive technology shock (a real, supply-side shock) to test whether the banking system's maturity gap also mediates the economy's ability to capitalize on positive opportunities or whether it acts as a structural drag on growth.

5.2.1 Impulse Response to Liquidity Shock

Figures 7 and 8 illustrate the economy's response to a tightening of bank constraints, modeled as a sudden exogenous positive shock to $\theta_{s,t}$ (a "liquidity shock"). We analyze two distinct scenarios based on the segment from which this financial disturbance originates: a shock originating in the Low segment (L), characterized by a low maturity mismatch, versus a shock originating in the High segment (H), characterized by a high maturity mismatch.

This shock acts as a sudden tightening of funding conditions, generating a clear macroeconomic contraction. The aggregate results (Figure 8) demonstrate that financial frictions can drive a real-sector downturn: aggregate output, investment, and consumption all decline. The transmission mechanism works through the banking sector's

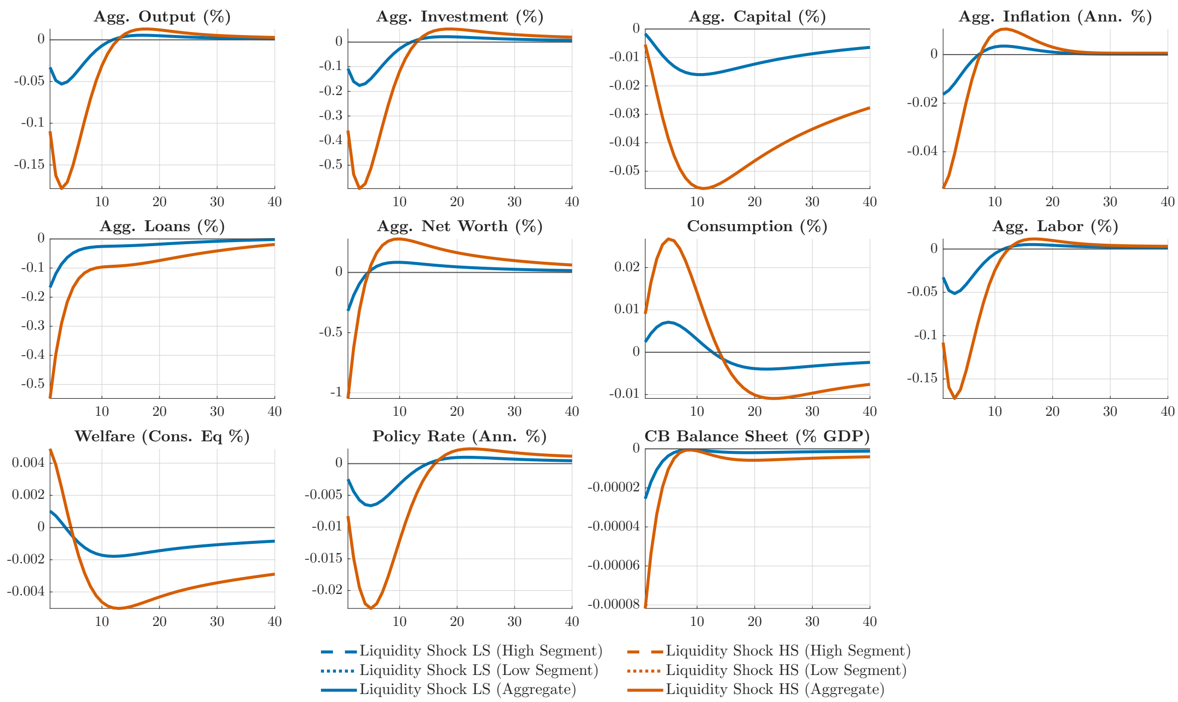
Figure 7: Segment-Level Impulse Responses to Liquidity Shock



balance sheet. The shock forces banks to deleverage to satisfy the tighter constraint. This is visible in the contraction of aggregate loans, which creates a credit crunch. Because firms rely on these loans for working capital (via the loan-in-advance constraint) and capital accumulation, the reduction in credit availability directly affects the real economy. Investment contracts sharply, and the economy enters a recession. In response to the resulting deflationary pressure, the central bank cuts the policy rate to stimulate demand.

However, the quantitative impact depends heavily on the segment from which the shock originates. A shock hitting the High segment triggers a far more severe crisis than one hitting the Low segment. When the liquidity shock originates in the High segment, the contraction is amplified substantially. As shown in Figure 8, aggregate output falls by approximately 0.15%, and aggregate investment declines by approximately 0.5%—impacts that are several times larger than those observed in the Low-segment scenario. Aggregate net worth falls by approximately 1%, driving a corresponding contraction in aggregate loans of approximately 0.5%. This deeper recession is driven by the structural vulnerability inherent in the High segment's balance sheet. Due to

Figure 8: Aggregate Impulse Responses to Liquidity Shock



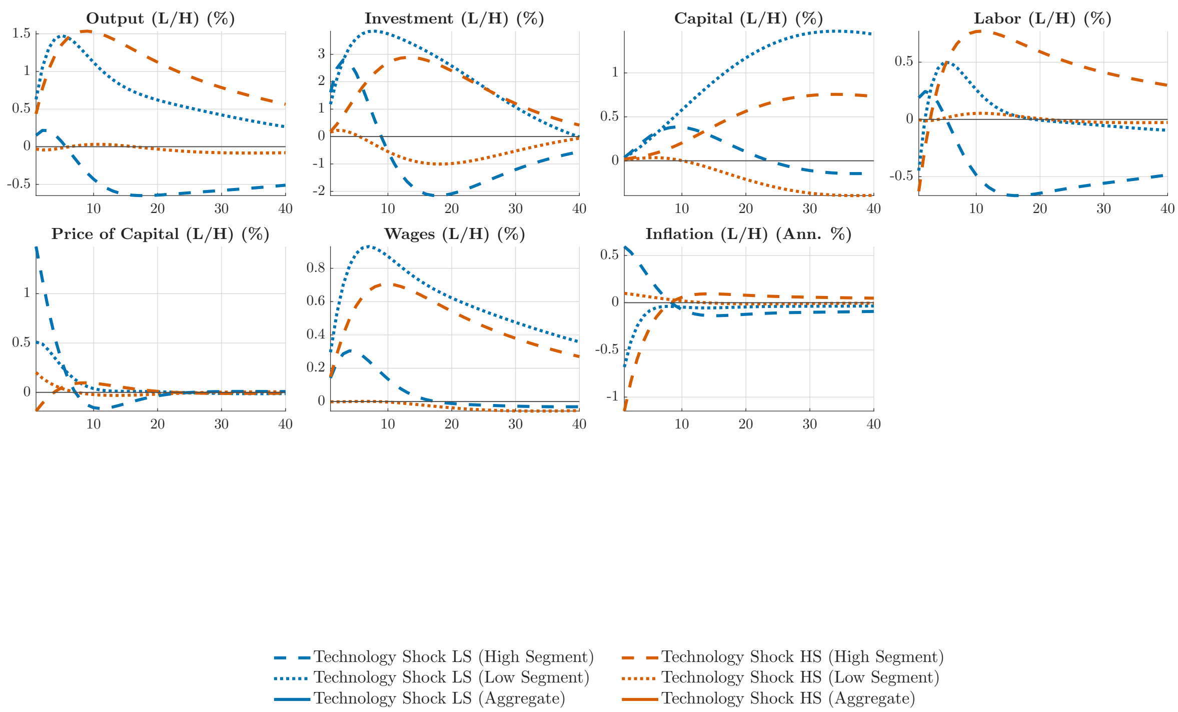
its high degree of maturity transformation, the High segment is heavily dependent on rolling over short-term funding to finance long-term assets. Consequently, when funding conditions tighten, the shock forces aggressive deleveraging.

Figure 7 highlights the heterogeneity driving this divergence. At the segment level, the High-segment shock produces markedly larger responses than the Low-segment shock across all financial variables. The Price of Loans panel shows a decline of approximately 0.6% in the High segment, while the Spreads panel indicates a rise of approximately 0.1 percentage points—both substantially larger than the corresponding Low-segment responses. This relative tightening of credit conditions implies that the financial wedge widens significantly more when the shock originates in the High segment. The Investment panel further confirms this, showing that segment-level investment drops by approximately 0.8% in the High segment under the HS shock—roughly four times larger than under the LS shock. The Net Worth panel reveals the underlying driver: High-segment net worth declines by approximately 1.5–2%, reflecting the acute vulnerability of maturity-mismatched balance sheets to funding shocks.

In summary, the High segment's financial structure acts as a magnifier for financial shocks. Because of its reliance on maturity transformation, a liquidity squeeze in this segment translates into a sharp spike in funding costs and a contraction in lending, rendering the central bank's accommodative policy less effective. The intended stimulus from the rate cut is overwhelmed by the widening credit spreads, leading to deeper welfare losses and economic contraction.

5.2.2 Impulse Response to Technology Shock

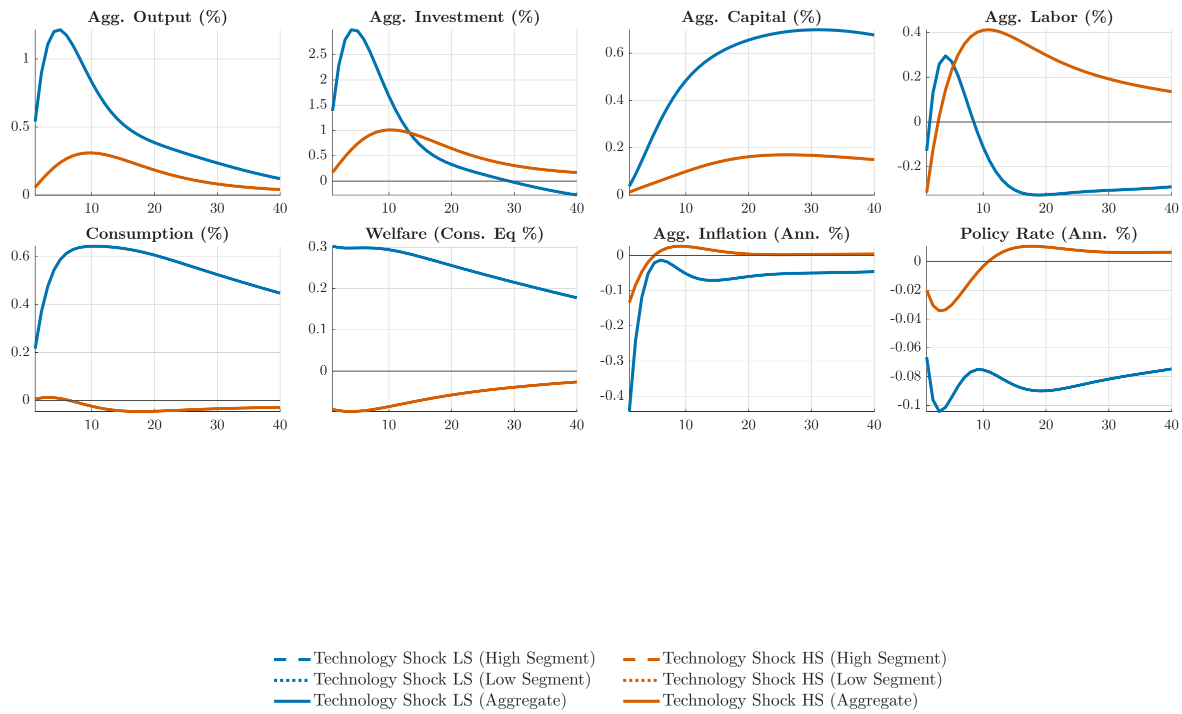
Figure 9: Segment-Level Impulse Responses to Technology Shock



Figures 9 and 10 analyze the economy's response to a positive technology shock. We distinguish between two scenarios based on the segment in which the productivity gain originates: a shock in the Low segment (L), characterized by a low maturity mismatch, versus a shock in the High segment (H), characterized by a high maturity mismatch.

The aggregate results (Figure 10) align with standard macroeconomic theory: both shocks lead to a persistent expansion, with aggregate output, investment, and consumption all rising. As the economy's productive capacity expands and outpaces aggregate demand, downward pressure on prices causes inflation to decrease—by approximately

Figure 10: Aggregate Impulse Responses to Technology Shock



0.4 percentage points (annualized) in the Low-segment scenario and approximately 0.2 percentage points in the High-segment scenario. This benign disinflationary environment gives the central bank (via the Taylor rule) clear justification to adopt an accommodative stance, as seen in the decline of the policy rate to approximately -0.1% (annualized) in the Low-segment scenario.

However, the quantitative differences between the two scenarios highlight that the banking system's structure plays a critical role in mediating this positive shock. The Low-segment shock triggers a significantly stronger economic expansion compared to the High-segment shock. As shown in Figure 10, aggregate investment in the Low-segment scenario surges to a peak of approximately 2.5%, more than double the response observed when the shock hits the High segment (approximately 1%). Aggregate output rises by approximately 1% under the Low-segment shock, compared to approximately 0.5% under the High-segment shock. Consequently, the Low-segment shock leads to a higher trajectory for consumption (peaking at approximately 0.6% versus 0.3%) and a more significant improvement in welfare (approximately 0.3% versus 0.15% in consumption-equivalent terms).

The muted response in the High segment is explained by the structural friction inherent in its balance sheet. While the technology shock increases profitable investment opportunities, the High segment's reliance on maturity transformation creates a bottleneck. Figure 9 illustrates this mechanism at the segment level. The Investment panel shows that the Low-segment shock generates a pronounced investment response, with Low-segment investment surging by approximately 3%, while the High-segment shock generates a response of approximately 1%. The Capital and Price of Capital panels confirm that this investment differential translates into a substantial divergence in capital accumulation and asset prices: under the Low-segment shock, the price of capital rises by approximately 1%, whereas the High-segment shock produces a notably weaker response.

Crucially, the Wages panel reveals that the Low-segment shock generates a sharp, immediate spike in the relative wage of approximately 0.8%, which, through the household's intratemporal labor-supply conditions (A.8), induces an increase in labor supplied to the Low segment. The Labor panel corroborates this, showing a corresponding rise in Low-segment employment. In contrast, the High-segment shock fails to generate this strong market signal. Because the High-segment banks are constrained by their maturity mismatch, they cannot expand credit as efficiently to fund the new investment opportunities. This financial friction acts as a structural drag, dampening the pass-through of the accommodative policy rate and limiting the economy's capacity to capitalize on the productivity gains.

In summary, this analysis demonstrates that the banking system's maturity structure is not just a vulnerability that amplifies negative shocks (as seen in the liquidity crisis); it is also a limiting factor during positive expansions. A less flexible, high-maturity-gap banking segment acts as a brake on growth, impeding the efficient allocation of new capital even in the face of positive fundamental shocks.

6 Concluding Remarks

This study demonstrates that the financial system's structure—specifically, the degree of maturity transformation within the banking sector—is a critical determinant of macroeconomic outcomes and the propagation of various shocks. This conclusion is most evident when comparing the effects of different monetary policy tools.

We find a *shock-specific* asymmetry between conventional (policy rate) and unconventional (QT) policies. Conventional policy rate hikes operate broadly through intertemporal substitution and rising funding costs, and their effects are largely indifferent to banks' maturity gaps. In contrast, unconventional policy (QT) operates directly through the bank balance sheet channel. By inflicting valuation losses on long-duration assets, QT severely tightens the leverage constraints of banks with high maturity gaps. Thus, this financial structure functions as a potent amplifier of unconventional policies, leading to a deeper and more persistent economic downturn and significantly larger welfare losses.

The effects of banking structure extend beyond monetary policy. We find that a high-maturity-gap structure not only amplifies negative shocks but also dampens positive ones. Such a structure renders the banking segment substantially more vulnerable to negative financial shocks. Conversely, in response to positive technology shocks, the high-maturity-gap banking segment acts as a bottleneck. By failing to fully channel credit toward productive opportunities, it constrains credit expansion and mutes the potential economic boom.

By connecting detailed supervisory data with a structural model of banking behavior, this study highlights *the central role of maturity transformation* in monetary transmission and in overall financial and economic stability. Our combined theoretical and empirical findings have significant policy implications. First, they suggest that the choice between policy tools (e.g., rate hikes vs. QE/QT) is *not neutral* and must account for the prevailing financial structure and potential welfare costs. Second, the results provide a strong justification for macroprudential policies aimed at limiting excessive maturity transformation. Thus, monitoring and managing maturity mismatches is essential not only for prudential oversight but also for enhancing macroeconomic resilience, reducing systemic risk, and understanding how different policy tools and macroeconomic disturbances propagate through the banking system and the broader economy.

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Appendix A Full Model and Derivations

A.1 Households

The economy is populated by a continuum of identical households of unit measure, so we can focus on the problem of a single representative household. The framework builds on Gertler and Karadi (2013). Each household is composed of two categories of members: workers and financial intermediaries, with their relative shares remaining constant over time. The intermediary sector is divided into two segments indexed by $s \in \{L, H\}$, corresponding to low and high maturity-gap intermediaries, respectively. In each period, a type-s intermediary continues operating in the subsequent period with probability σ (common across segments); with the complementary probability $1-\sigma$, it ceases operation and is replaced by a worker who transitions into a new type-s intermediary, receiving initial net worth X_s.

The representative household maximizes the following expected lifetime utility:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left(\ln(C_{t+j} - bC_{t+j-1}) - \left[\chi_L \frac{L_{L,t+j}^{1+\eta}}{1+\eta} + \chi_H \frac{L_{H,t+j}^{1+\eta}}{1+\eta} \right] \right), \tag{A.1}$$

where $\beta \in (0,1)$ denotes the discount factor, $b \in [0,1)$ governs internal habit persistence, $\chi_s > 0$ is a scaling parameter for the disutility of work in segment s, and $\eta > 0$ represents the inverse of the Frisch labor supply elasticity. The household provides labor services to both segments, $(L_{L,t}, L_{H,t})$, and chooses consumption of a composite final good C_t.

The household is subject to the following nominal budget constraint:

$$\begin{aligned} P_t C_t + \sum_{s\in\{L,H\}} D_{s,t} - \sum_{s\in\{L,H\}} D_{s,t-1} \leq\ & MRS_{L,t} L_{L,t} + MRS_{H,t} L_{H,t} + DIV_t \\ & - P_t(X_L + X_H) - P_t T_t + \sum_{s\in\{L,H\}} (R^d_{s,t-1} - 1) D_{s,t-1} \end{aligned} \tag{A.2}$$

where P_t is the aggregate price of final output, and $D_{s,t}$ denotes deposits placed with type-s intermediaries earning a gross return $R^d_{s,t}$, with D_t representing the deposit composite defined below. The term $MRS_{s,t}$ is the nominal remuneration that households receive for supplying labor in segment s (paid via labor unions), and $mrs_{s,t} \equiv MRS_{s,t}/P_t$ is its real counterpart. The variable DIV_t captures all dividend income accruing to the household, including profits from non-financial firms and the net worth of exiting intermediaries. The quantities X_s are real startup transfers to newly entering intermediaries, and T_t represents lump-sum taxes.

Deposit aggregation. Households allocate deposits across the two intermediary segments. In real terms, letting $d_{s,t} \equiv D_{s,t}/P_t$ and $d_t \equiv D_t/P_t$, the deposit composite is aggregated via a CES technology:

$$d_t = \left[\omega_d \, d_{L,t}^{\frac{\eta_d - 1}{\eta_d}} + (1 - \omega_d) \, d_{H,t}^{\frac{\eta_d - 1}{\eta_d}} \right]^{\frac{\eta_d}{\eta_d - 1}}, \tag{A.3}$$

where $\eta_d > 0$ governs the elasticity of substitution between the two deposit types and $\omega_d \in (0, 1)$ is the relative weight on low-segment deposits. The corresponding dual gross deposit rate index satisfies:

$$(R_t^d)^{1-\eta_d} = \omega_d (R_{L,t}^d)^{1-\eta_d} + (1 - \omega_d)(R_{H,t}^d)^{1-\eta_d}. \tag{A.4}$$

The household's optimal allocation of deposits across the two segments yields:

$$\frac{d_{L,t}}{d_{H,t}} = \left(\frac{\omega_d}{1 - \omega_d} \right)^{\eta_d} \left(\frac{R_{L,t}^d}{R_{H,t}^d} \right)^{\eta_d}. \tag{A.5}$$

Note that deposits represent household savings rather than expenditures: a higher deposit rate $R_{s,t}^d$ attracts more funds to segment s, so the substitution elasticity in (A.5) carries a positive sign—in contrast to standard CES demand systems where higher input prices reduce demand. Equation (A.4) defines the composite return R_t^d as the CES dual of (A.3); it satisfies the accounting identity $R_t^d d_t = \omega_d R_{L,t}^d d_{L,t} + (1 - \omega_d) R_{H,t}^d d_{H,t}$ only at the symmetric steady state, and more generally serves as the unit-return function associated with the deposit aggregator.

First-order conditions. The household chooses $\{C_t, L_{L,t}, L_{H,t}, d_t\}$ to maximize (A.1) subject to (A.2). The resulting optimality conditions are:

$$\mu_t = \frac{1}{C_t - bC_{t-1}} - b\beta\mathbb{E}_t \frac{1}{C_{t+1} - bC_t}, \tag{A.6}$$

$$\Lambda_{t,t+1} = \beta \frac{\mu_{t+1}}{\mu_t}, \tag{A.7}$$

$$\chi_s L_{s,t}^{\eta} = \mu_t \, mrs_{s,t}, \qquad s \in \{L, H\}, \tag{A.8}$$

$$1 = R_t^d \, \mathbb{E}_t \left[\Lambda_{t,t+1} \Pi_{t+1}^{-1} \right], \tag{A.9}$$

where $\Pi_t \equiv P_t/P_{t-1}$ denotes gross inflation. Expression (A.6) characterizes the marginal utility of consumption μ_t under habit formation. Equation (A.7) gives the household's stochastic discount factor $\Lambda_{t,t+1}$. Condition (A.8) is the segment-specific intratemporal optimality condition equating the marginal rate of substitution between consumption and leisure to the real payment for labor. Equation (A.9) is the intertemporal Euler equation for the deposit composite, with R_t^d defined by (A.4).

A.2 Financial Intermediaries

This subsection provides the step-by-step derivation of the intermediary's optimality conditions and the expressions for the auxiliary variables reported in the main text.

Real net worth. Dividing both sides of the nominal net worth equation by the aggregate price level P_t, and recalling that gross inflation is $\Pi_t \equiv P_t/P_{t-1}$, the real net worth accumulation equation is:

$$\begin{aligned} \Pi_t n_{s,i,t} = {} & \left(R_{s,t}^F - R_{s,t-1}^d\right) Q_{s,t-1} f_{s,i,t-1} + \left(R_t^B - R_{s,t-1}^d\right) Q_{B,t-1} b_{s,i,t-1} \\ & + \left(R_{t-1}^{re} - R_{s,t-1}^d\right) re_{s,i,t-1} + R_{s,t-1}^d n_{s,i,t-1} \end{aligned} \tag{A.10}$$

Multiplying through by $\Lambda_{t,t+1}\Omega_{s,t+1}$ and advancing one period yields:

$$
\begin{aligned}
\Lambda_{t,t+1}\Omega_{s,t+1}n_{s,i,t+1} = \Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}\Big[&\left(R^F_{s,t+1} - R^d_{s,t}\right) Q_{s,t} f_{s,i,t} \\
&+ \left(R^B_{t+1} - R^d_{s,t}\right) Q_{B,t} b_{s,i,t} + \left(R^{re}_t - R^d_{s,t}\right) re_{s,i,t} \\
&+ R^d_{s,t} n_{s,i,t}\Big]
\end{aligned} \tag{A.11}
$$

Value function. Using the recursive structure, the intermediary's value function can be expanded as:

$$
\begin{aligned}
V_{s,i,t} &= \max(1-\sigma)\mathbb{E}_t\Lambda_{t,t+1}n_{s,i,t+1} + \sigma\mathbb{E}_t\Lambda_{t,t+1}V_{s,i,t+1} \\
&= \max(1-\sigma)\mathbb{E}_t\Bigg[\Lambda_{t,t+1}\Bigg(\frac{R^F_{s,t+1} - R^d_{s,t}}{\Pi_{t+1}} Q_{s,t} f_{s,i,t} \\
&\qquad + \frac{R^B_{t+1} - R^d_{s,t}}{\Pi_{t+1}} Q_{B,t} b_{s,i,t} \\
&\qquad + \frac{R^{re}_t - R^d_{s,t}}{\Pi_{t+1}} re_{s,i,t} \\
&\qquad + \frac{R^d_{s,t}}{\Pi_{t+1}} n_{s,i,t}\Bigg)\Bigg] \\
&\quad + \sigma\mathbb{E}_t\Lambda_{t,t+1}V_{s,i,t+1}
\end{aligned} \tag{A.12}
$$

Lagrangian. Incorporating the costly enforcement constraint with multiplier $\lambda_{s,t}$, the intermediary's Lagrangian becomes:

$$
\begin{aligned}
\mathcal{L}_{s,i,t} = \max(1+\lambda_{s,t})\mathbb{E}_t\Bigg[(1-\sigma)\Lambda_{t,t+1}\Bigg(&\frac{R^F_{s,t+1} - R^d_{s,t}}{\Pi_{t+1}} Q_{s,t} f_{s,i,t} + \frac{R^B_{t+1} - R^d_{s,t}}{\Pi_{t+1}} Q_{B,t} b_{s,i,t} \\
&+ \frac{R^{re}_t - R^d_{s,t}}{\Pi_{t+1}} re_{s,i,t} + \frac{R^d_{s,t}}{\Pi_{t+1}} n_{s,i,t}\Bigg) + \sigma\Lambda_{t,t+1}V_{s,i,t+1}\Bigg] \\
- \lambda_{s,t}\theta_{s,t}(Q_{s,t} f_{s,i,t} + \Delta_s Q_{B,t} b_{s,i,t})&
\end{aligned} \tag{A.13}
$$

Here $\lambda_{s,t}$ is the Lagrange multiplier on the enforcement constraint for segment s. Taking first-order conditions with respect to $f_{s,i,t}$, $b_{s,i,t}$, and $re_{s,i,t}$ delivers Equations (19)–(21) in the main text.

Derivation of auxiliary variables. We now derive closed-form expressions for the auxiliary variables $\Omega_{s,t}$ and $\phi_{s,t}$ appearing in Equations (22) and (23). The starting point is the maintained assumption that the value function is linear in net worth. Combining this linearity with the binding enforcement constraint and the first-order conditions, and exploiting the proportionality of expected excess returns implied by Equations (19) and (20),

$$\mathbb{E}_t[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}(R_{t+1}^B - R_{s,t}^d)] = \Delta_s\,\mathbb{E}_t[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}(R_{s,t+1}^F - R_{s,t}^d)]$$

allows us to consolidate the two risky asset positions $f_{s,i,t}$ and $b_{s,i,t}$. The result is:

$$\begin{aligned} &\mathbb{E}_t[\Lambda_{t,t+1}\Omega_{s,t+1}n_{s,i,t+1}] \\ =&\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}(R_{s,t+1}^F - R_{s,t}^d)\right](Q_{s,t}f_{s,i,t} + \Delta_s Q_{B,t}b_{s,i,t}) \\ &+\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}\right]R_{s,t}^d n_{s,i,t} \\ &= \frac{\lambda_{s,t}}{1+\lambda_{s,t}}\theta_{s,t}\phi_{s,t}n_{s,i,t} + \mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}\right]R_{s,t}^d n_{s,i,t} \end{aligned}$$

Substituting the linear value function (Equation (24)) and the definition of $\Omega_{s,t}$ (Equation (22)) into Equation (A.12) gives:

$$\theta_{s,t}\phi_{s,t}n_{s,i,t} = \max\mathbb{E}_t[\Lambda_{t,t+1}n_{s,i,t+1}\Omega_{s,t+1}] = \frac{\lambda_{s,t}}{1+\lambda_{s,t}}\theta_{s,t}\phi_{s,t}n_{s,i,t} + \mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}\right]R_{s,t}^d n_{s,i,t}$$

Dividing through by $n_{s,i,t}$ yields:

$$\theta_{s,t}\phi_{s,t} = \frac{\lambda_{s,t}}{1+\lambda_{s,t}}\theta_{s,t}\phi_{s,t} + \mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}\right]R_{s,t}^d$$

Rearranging,

$$\theta_{s,t}\phi_{s,t} = (1+\lambda_{s,t})\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{s,t+1}\Pi_{t+1}^{-1}\right]R_{s,t}^d \tag{A.14}$$

which verifies Equation (23) in the main text.

A.3 Labor Market

Within each intermediary segment $s \in \{L, H\}$, the labor market operates in two stages. In the first stage, a unit continuum of labor unions indexed by $h \in [0,1]$ purchases labor from households at the competitive payment $MRS_{s,t}$ and resells it to a segment-specific labor packer. Each union h purchases and sells the same quantity, so $L_{d,s,t}(h) = L_{s,t}(h)$. In the second stage, the packer in segment s combines the differentiated labor services into an aggregate labor input $L_{d,s,t}$ using a CES aggregation technology with elasticity of substitution $\epsilon_w > 1$. The downward-sloping demand schedule confronting each union is:

$$L_{d,s,t}(h) = \left(\frac{W_{s,t}(h)}{W_{s,t}}\right)^{-\epsilon_w} L_{d,s,t}, \tag{A.15}$$

and the aggregate wage index in segment s is:

$$W_{s,t}^{1-\epsilon_w} = \int_0^1 W_{s,t}(h)^{1-\epsilon_w}\, dh. \tag{A.16}$$

Labor union problem. The nominal profit of a representative labor union in segment s is:

$$DIV_{L,s,t}(h) = W_{s,t}(h) L_{d,s,t}(h) - MRS_{s,t} L_{s,t}(h). \tag{A.17}$$

Substituting the demand curve (A.15) and imposing $L_{s,t}(h) = L_{d,s,t}(h)$, union profits can be expressed as:

$$DIV_{L,s,t}(h) = W_{s,t}(h)^{1-\epsilon_w} W_{s,t}^{\epsilon_w} L_{d,s,t} - MRS_{s,t}\, W_{s,t}(h)^{-\epsilon_w} W_{s,t}^{\epsilon_w} L_{d,s,t}. \tag{A.18}$$

Wages exhibit nominal rigidity à la Calvo: each period, a union in segment s may reset its wage with probability $1 - \phi_w$; otherwise, it indexes to lagged inflation in segment s at rate $\gamma_w \in [0,1]$. Let $\Pi_{s,t} \equiv P_{s,t}/P_{s,t-1}$ be gross inflation in segment s. A wage chosen at date t that has not been re-optimized by date $t+j$ evolves according to:

$$W_{s,t+j}(h) = W_{s,t}(h) \left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{\gamma_w}. \tag{A.19}$$

A union in segment s that is given the opportunity to reset at date t selects $W_{s,t}(h)$ to maximize the expected present discounted value of nominal profits, discounted by the household's nominal stochastic discount factor $\Lambda_{t,t+j}/P_{t+j}$, taking into account the probability ϕ_w^j that the chosen wage will remain in effect at horizon $t+j$. Since

P_{t+j} does not depend on the union's choice variable $W_{s,t}(h)$, it cancels from the first-order condition. The resulting asymmetry in powers of $P_{s,t+j}$—$P_{s,t+j}^{\epsilon_w-1}$ in the revenue term versus $P_{s,t+j}^{\epsilon_w}$ in the cost term—arises because $mrs_{s,t+j} \equiv MRS_{s,t+j}/P_{t+j}$ absorbs one power of the price level relative to the purely nominal revenue expression. The transition to segment-s real units is carried out in the *real terms* paragraph below:

$$\max_{W_{s,t}(h)} \mathbb{E}_t \sum_{j=0}^{\infty} \phi_w^j \Lambda_{t,t+j} \Bigg[\left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{(1-\epsilon_w)\gamma_w} W_{s,t}(h)^{1-\epsilon_w} P_{s,t+j}^{\epsilon_w-1} w_{s,t+j}^{\epsilon_w} L_{d,s,t+j} - mrs_{s,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{-\epsilon_w\gamma_w} W_{s,t}(h)^{-\epsilon_w} P_{s,t+j}^{\epsilon_w} w_{s,t+j}^{\epsilon_w} L_{d,s,t+j} \Bigg]. \tag{A.20}$$

First-order condition. Differentiating (A.20) with respect to $W_{s,t}(h)$ and equating to zero gives:

$$(\epsilon_w - 1) W_{s,t}(h)^{-\epsilon_w} \mathbb{E}_t \sum_{j=0}^{\infty} \phi_w^j \Lambda_{t,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{(1-\epsilon_w)\gamma_w} P_{s,t+j}^{\epsilon_w-1} w_{s,t+j}^{\epsilon_w} L_{d,s,t+j} = \epsilon_w W_{s,t}(h)^{-\epsilon_w-1} \mathbb{E}_t \sum_{j=0}^{\infty} \phi_w^j \Lambda_{t,t+j}\, mrs_{s,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{-\epsilon_w\gamma_w} P_{s,t+j}^{\epsilon_w} w_{s,t+j}^{\epsilon_w} L_{d,s,t+j}. \tag{A.21}$$

Since all resetting unions within a given segment choose an identical wage, we may drop the index h. Define the nominal auxiliary variables:

$$F_{1,s,t} = \mathbb{E}_t \sum_{j=0}^{\infty} \phi_w^j \Lambda_{t,t+j}\, mrs_{s,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{-\epsilon_w\gamma_w} P_{s,t+j}^{\epsilon_w} w_{s,t+j}^{\epsilon_w} L_{d,s,t+j}, \tag{A.22}$$

$$F_{2,s,t} = \mathbb{E}_t \sum_{j=0}^{\infty} \phi_w^j \Lambda_{t,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}}\right)^{(1-\epsilon_w)\gamma_w} P_{s,t+j}^{\epsilon_w-1} w_{s,t+j}^{\epsilon_w} L_{d,s,t+j}. \tag{A.23}$$

Using these definitions, the optimal reset nominal wage in segment s can be written compactly as:

$$W_{s,t}^* = \frac{\epsilon_w}{\epsilon_w - 1} \frac{F_{1,s,t}}{F_{2,s,t}}. \tag{A.24}$$

The infinite sums $F_{1,s,t}$ and $F_{2,s,t}$ admit the following recursive representations:

$$F_{1,s,t} = mrs_{s,t} P_{s,t}^{\epsilon_w} w_{s,t}^{\epsilon_w} L_{d,s,t} + \phi_w \mathbb{E}_t\big[\Lambda_{t,t+1} \Pi_{s,t}^{-\epsilon_w\gamma_w} F_{1,s,t+1}\big], \tag{A.25}$$

$$F_{2,s,t} = P_{s,t}^{\epsilon_w - 1}\, w_{s,t}^{\epsilon_w}\, L_{d,s,t} + \phi_w\, \mathbb{E}_t \Big[\Lambda_{t,t+1}\, \Pi_{s,t}^{(1-\epsilon_w)\gamma_w}\, F_{2,s,t+1} \Big]. \tag{A.26}$$

Real terms. Define the real reset wage as $w_{s,t}^* \equiv W_{s,t}^*/P_{s,t}$ and the real auxiliary variables $f_{1,s,t} \equiv F_{1,s,t}/P_{s,t}^{\epsilon_w}$ and $f_{2,s,t} \equiv F_{2,s,t}/P_{s,t}^{\epsilon_w - 1}$. Dividing (A.24) by $P_{s,t}$ and (A.25)–(A.26) by $P_{s,t}^{\epsilon_w}$ and $P_{s,t}^{\epsilon_w-1}$, respectively, yields:

$$w_{s,t}^* = \frac{\epsilon_w}{\epsilon_w - 1} \frac{f_{1,s,t}}{f_{2,s,t}}, \tag{A.27}$$

$$f_{1,s,t} = mrs_{s,t}\, w_{s,t}^{\epsilon_w} L_{d,s,t} + \phi_w\, \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{\Pi_{s,t+1}}{\Pi_{s,t}^{\gamma_w}} \right)^{\epsilon_w} f_{1,s,t+1} \right], \tag{A.28}$$

$$f_{2,s,t} = w_{s,t}^{\epsilon_w} L_{d,s,t} + \phi_w\, \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{\Pi_{s,t+1}}{\Pi_{s,t}^{\gamma_w}} \right)^{\epsilon_w - 1} f_{2,s,t+1} \right], \tag{A.29}$$

for $s \in \{L, H\}$. Here $f_{1,s,t}$ captures the discounted marginal cost of labor, while $f_{2,s,t}$ captures the discounted marginal revenue, both weighted by the likelihood that the reset wage persists.

Aggregation. Integrating the demand schedule (A.15) over all unions in each segment and using $L_{s,t}(h) = L_{d,s,t}(h)$ gives:

$$L_{s,t} = L_{d,s,t}\, v_{s,t}^w, \tag{A.30}$$

where $v_{s,t}^w \geq 1$ is a measure of wage dispersion within segment s. Its law of motion is:

$$v_{s,t}^w = (1 - \phi_w) \left(\frac{w_{s,t}^*}{w_{s,t}} \right)^{-\epsilon_w} + \phi_w \left(\frac{\Pi_{s,t}}{\Pi_{s,t-1}^{\gamma_w}} \right)^{\epsilon_w} \left(\frac{w_{s,t}}{w_{s,t-1}} \right)^{\epsilon_w} v_{s,t-1}^w. \tag{A.31}$$

The aggregate real wage in segment s evolves as:

$$w_{s,t}^{1-\epsilon_w} = (1 - \phi_w)(w_{s,t}^*)^{1-\epsilon_w} + \phi_w \Pi_{s,t-1}^{\gamma_w(1-\epsilon_w)} \Pi_{s,t}^{\epsilon_w - 1} w_{s,t-1}^{1-\epsilon_w}. \tag{A.32}$$

Total labor supply across both segments is:

$$L_t = L_{L,t} + L_{H,t}. \tag{A.33}$$

A.4 Production

The production side of the economy features multiple layers within each segment $s \in \{L, H\}$. A representative wholesale firm in segment s converts capital and labor into intermediate output $Y_{m,s,t}$. Wholesale output is then sold to a continuum of retail firms indexed by $f \in [0, 1]$. These retailers differentiate the wholesale good, set prices subject to nominal rigidities, and sell their output to a competitive final goods firm. New physical capital $\hat{I}_{s,t}$ is produced by a competitive capital goods producer. The final output Y_t is a CES composite across segments.

A.4.1 Retailers

The retail layer in each segment $s \in \{L, H\}$ consists of a continuum of monopolistically competitive firms indexed by $f \in [0, 1]$. Each retailer f purchases wholesale output at the nominal price $P^m_{s,t}$, differentiates it costlessly, and sells it at an individual price $P_{s,t}(f)$. Retail output is aggregated into segment-s final output $Y_{s,t}$ by a competitive final goods firm using a CES technology with elasticity $\epsilon_p > 1$. The demand function faced by each retailer is therefore:

$$Y_{s,t}(f) = \left(\frac{P_{s,t}(f)}{P_{s,t}}\right)^{-\epsilon_p} Y_{s,t}, \qquad \epsilon_p > 1, \tag{A.34}$$

and the segment-s price index satisfies:

$$P_{s,t}^{1-\epsilon_p} = \int_0^1 P_{s,t}(f)^{1-\epsilon_p}\, df. \tag{A.35}$$

The nominal profit of retailer f in segment s is:

$$\text{DIV}^R_{s,t}(f) = P_{s,t}(f) Y_{s,t}(f) - P^m_{s,t} Y_{m,s,t}(f). \tag{A.36}$$

Substituting the demand curve (A.34) and using $Y_{m,s,t}(f) = Y_{s,t}(f)$, this becomes:

$$\text{DIV}^R_{s,t}(f) = P_{s,t}(f)^{1-\epsilon_p}\, P^{\epsilon_p}_{s,t}\, Y_{s,t} - P^m_{s,t}\, P_{s,t}(f)^{-\epsilon_p}\, P^{\epsilon_p}_{s,t}\, Y_{s,t}. \tag{A.37}$$

Price setting. Prices are set subject to Calvo-style nominal frictions: in any given period, a fraction $1-\phi_p$ of segment-s retailers are randomly selected to re-optimize their price, while the remaining fraction ϕ_p index their price to lagged inflation in segment s at rate $\gamma_p \in [0,1]$. Accordingly, a price set at date t that has not been re-optimized by $t+j$ evolves as:

$$P_{s,t+j}(f) = P_{s,t}(f) \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{\gamma_p}. \tag{A.38}$$

The probability that the price chosen at t is still effective at $t+j$ is ϕ_p^j.

A retailer in segment s that receives the opportunity to re-optimize at date t selects $P_{s,t}(f)$ to maximize the expected present discounted value of nominal profits, discounted by the household's stochastic discount factor $\Lambda_{t,t+j}$ augmented by the probability of non-adjustment. Since $P_{s,t}(f)$ does not appear in the discount factor or any other term, it enters the first-order condition only through the revenue and cost components of nominal profit. The asymmetry in powers of $P_{s,t+j}$ across the two terms—$P_{s,t+j}^{\epsilon_p-1}$ in revenue versus $P_{s,t+j}^{\epsilon_p}$ in cost—reflects the additional factor of the nominal wholesale price $P^m_{s,t+j}$ in the cost term. This asymmetry resolves when the nominal auxiliary sums are converted to segment-s real units in the *real terms* paragraph below:

$$\begin{aligned} \max_{P_{s,t}(f)} \mathbb{E}_t \sum_{j\geq 0} \phi_p^j \Lambda_{t,t+j} \Bigg[& P_{s,t}(f)^{1-\epsilon_p} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{(1-\epsilon_p)\gamma_p} P_{s,t+j}^{\epsilon_p-1} Y_{s,t+j} \\ & - P^m_{s,t+j} P_{s,t}(f)^{-\epsilon_p} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{-\epsilon_p\gamma_p} P_{s,t+j}^{\epsilon_p} Y_{s,t+j} \Bigg]. \end{aligned} \tag{A.39}$$

First-order condition. Differentiating (A.39) with respect to $P_{s,t}(f)$ and equating to zero gives:

$$\begin{aligned} (\epsilon_p - 1) P_{s,t}(f)^{-\epsilon_p} \mathbb{E}_t \sum_{j\geq 0} \phi_p^j \Lambda_{t,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{(1-\epsilon_p)\gamma_p} P_{s,t+j}^{\epsilon_p-1} Y_{s,t+j} = \\ \epsilon_p P_{s,t}(f)^{-\epsilon_p-1} \mathbb{E}_t \sum_{j\geq 0} \phi_p^j \Lambda_{t,t+j} P^m_{s,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{-\epsilon_p\gamma_p} P_{s,t+j}^{\epsilon_p} Y_{s,t+j}. \end{aligned} \tag{A.40}$$

Since all re-optimizing retailers within a given segment choose an identical price, we may drop f. Define the nominal auxiliary variables:

$$X_{1,s,t} = \mathbb{E}_t \sum_{j=0}^{\infty} \phi_p^j \Lambda_{t,t+j} P^m_{s,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{-\epsilon_p\gamma_p} P_{s,t+j}^{\epsilon_p} Y_{s,t+j}, \tag{A.41}$$

$$X_{2,s,t} = \mathbb{E}_t \sum_{j=0}^{\infty} \phi_p^j \Lambda_{t,t+j} \left(\frac{P_{s,t+j-1}}{P_{s,t-1}} \right)^{(1-\epsilon_p)\gamma_p} P_{s,t+j}^{\epsilon_p - 1} Y_{s,t+j}. \tag{A.42}$$

Using these definitions, the optimal reset nominal price in segment s can be expressed compactly as:

$$P_{s,t}^* = \frac{\epsilon_p}{\epsilon_p - 1} \frac{X_{1,s,t}}{X_{2,s,t}}. \tag{A.43}$$

The infinite sums $X_{1,s,t}$ and $X_{2,s,t}$ admit the following recursive representations:

$$X_{1,s,t} = P_{s,t}^m P_{s,t}^{\epsilon_p} Y_{s,t} + \phi_p \mathbb{E}_t \left[\Lambda_{t,t+1} \Pi_{s,t}^{-\epsilon_p \gamma_p} X_{1,s,t+1} \right], \tag{A.44}$$

$$X_{2,s,t} = P_{s,t}^{\epsilon_p - 1} Y_{s,t} + \phi_p \mathbb{E}_t \left[\Lambda_{t,t+1} \Pi_{s,t}^{(1-\epsilon_p)\gamma_p} X_{2,s,t+1} \right]. \tag{A.45}$$

Real terms. Define the relative reset price as $p_{s,t}^* \equiv P_{s,t}^* / P_{s,t}$ and the real auxiliary variables $x_{1,s,t} \equiv X_{1,s,t} / P_{s,t}^{\epsilon_p}$ and $x_{2,s,t} \equiv X_{2,s,t} / P_{s,t}^{\epsilon_p - 1}$. Dividing (A.43) by $P_{s,t}$ and (A.44)–(A.45) by $P_{s,t}^{\epsilon_p}$ and $P_{s,t}^{\epsilon_p - 1}$, respectively, yields:

$$p_{s,t}^* = \frac{\epsilon_p}{\epsilon_p - 1} \frac{x_{1,s,t}}{x_{2,s,t}}, \tag{A.46}$$

$$x_{1,s,t} = p_{s,t}^m Y_{s,t} + \phi_p \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{\Pi_{s,t+1}}{\Pi_{s,t}^{\gamma_p}} \right)^{\epsilon_p} x_{1,s,t+1} \right], \tag{A.47}$$

$$x_{2,s,t} = Y_{s,t} + \phi_p \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{\Pi_{s,t+1}}{\Pi_{s,t}^{\gamma_p}} \right)^{\epsilon_p - 1} x_{2,s,t+1} \right], \tag{A.48}$$

for $s \in \{L, H\}$. Here $p_{s,t}^m \equiv P_{s,t}^m / P_{s,t}$ is the relative price of wholesale output in segment s. The variable $x_{1,s,t}$ captures the present value of marginal costs, while $x_{2,s,t}$ captures the present value of marginal revenues, both conditional on the current reset price remaining in effect.

Aggregation. Integrating the demand for retail output (A.34) over all firms and noting that $Y_{m,s,t}(f) = Y_{s,t}(f)$, we obtain the relationship between aggregate wholesale output and final output in segment s:

$$Y_{m,s,t} = Y_{s,t} \, v_{s,t}^p, \tag{A.49}$$

where $v^p_{s,t} \geq 1$ captures price dispersion within segment s. Its recursive law of motion is:

$$v^p_{s,t} = (1-\phi_p)(p^*_{s,t})^{-\epsilon_p} + \phi_p \left(\frac{\Pi_{s,t}}{\Pi^{\gamma_p}_{s,t-1}}\right)^{\epsilon_p} v^p_{s,t-1}. \tag{A.50}$$

The price index in segment s evolves according to:

$$1 = (1-\phi_p)(p^*_{s,t})^{1-\epsilon_p} + \phi_p \, \Pi^{\gamma_p(1-\epsilon_p)}_{s,t-1} \Pi^{\epsilon_p - 1}_{s,t}, \tag{A.51}$$

for $s \in \{L, H\}$.

A.5 Wholesale Good Producers

This subsection provides the complete specification and derivation of the wholesale firm's optimization problem, the key results of which are reported in the main text.

Depreciation. The depreciation rate is modeled as an increasing and convex function of utilization:

$$\delta(u_{s,t}) = \delta_{0,s} + \delta_{1,s}(u_{s,t} - 1) + \frac{\delta_2}{2}(u_{s,t} - 1)^2, \tag{A.52}$$

where $\delta_{0,s}$ is the steady-state depreciation rate (evaluated at $u = 1$), and the parameters $\delta_{1,s}$ and δ_2 control the sensitivity of depreciation to utilization.

Real dividend. Deflating by the aggregate price level, the firm's real dividend can be written as

$$\begin{aligned} div_{m,s,t} =& p^m_{s,t} A_{s,t} (u_{s,t} K_{s,t-1})^{\alpha} L^{1-\alpha}_{d,s,t} - w_{s,t} L_{d,s,t} - p^k_{s,t} \hat{I}_{s,t} \\ &+ Q_{s,t}\left(\frac{F_{s,t}}{P_t} - \kappa^f_{s,t} \frac{F_{s,t-1}}{P_{t-1}} \Pi^{-1}_t\right) - \frac{F_{s,t-1}}{P_{t-1}} \Pi^{-1}_t \end{aligned} \tag{A.53}$$

Lagrangian. The firm maximizes the present discounted value of real dividends, using the household stochastic discount factor $\Lambda_{t,t+j}$ for discounting. Attaching multiplier $\nu_{1,s,t}$ to the capital accumulation equation and $\nu_{2,s,t}$ to the loan-in-advance constraint, the Lagrangian is:

$$\mathcal{L}_{m,s,t} = \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \Bigg\{ p^m_{s,t+j} A_{s,t+j} (u_{s,t+j} K_{s,t+j-1})^{\alpha} L^{1-\alpha}_{d,s,t+j} - w_{s,t+j} L_{d,s,t+j} - p^k_{s,t+j} \hat{I}_{s,t+j}$$
$$+ Q_{s,t+j} \left(\frac{F_{s,t+j}}{P_{t+j}} - \kappa^f_{s,t+j} \frac{F_{s,t+j-1}}{P_{t+j-1}} \Pi^{-1}_{t+j} \right) - \frac{F_{s,t+j-1}}{P_{t+j-1}} \Pi^{-1}_{t+j}$$
$$+ \nu_{1,s,t+j} \Big(\hat{I}_{s,t+j} + \big(1 - \delta(u_{s,t+j})\big) K_{s,t+j-1} - K_{s,t+j} \Big)$$
$$+ \nu_{2,s,t+j} \left(Q_{s,t+j} \left(\frac{F_{s,t+j}}{P_{t+j}} - \kappa^f_{s,t+j} \frac{F_{s,t+j-1}}{P_{t+j-1}} \Pi^{-1}_{t+j} \right) - \psi p^k_{s,t+j} \hat{I}_{s,t+j} \right) \Bigg\} \tag{A.54}$$

Differentiating this Lagrangian with respect to the five choice variables—$L_{d,s,t}$, $u_{s,t}$, $\hat{I}_{s,t}$, $K_{s,t}$, and $f_{s,t}$—and setting each derivative equal to zero delivers the following first-order conditions:

$$w_{s,t} = (1-\alpha) p^m_{s,t} A_{s,t} (u_{s,t} K_{s,t-1})^{\alpha} L^{-\alpha}_{d,s,t} \tag{A.55}$$

$$\nu_{1,s,t} \Big(\delta_{1,s} + \delta_2 (u_{s,t} - 1) \Big) = \alpha\, p^m_{s,t} A_{s,t} (u_{s,t} K_{s,t-1})^{\alpha-1} L^{1-\alpha}_{d,s,t} \tag{A.56}$$

$$p^k_{s,t} + \psi \nu_{2,s,t} p^k_{s,t} = \nu_{1,s,t} \tag{A.57}$$

$$\nu_{1,s,t} = \mathbb{E}_t \Lambda_{t,t+1} \Big[\alpha\, p^m_{s,t+1} A_{s,t+1} K^{\alpha-1}_{s,t} u^{\alpha}_{s,t+1} L^{1-\alpha}_{d,s,t+1} + \Big(1 - \delta(u_{s,t+1})\Big) \nu_{1,s,t+1} \Big] \tag{A.58}$$

$$Q_{s,t}(1 + \nu_{2,s,t}) = \mathbb{E}_t \Lambda_{t,t+1} \Pi^{-1}_{t+1} \Big[1 + \kappa^f_{s,t+1} Q_{s,t+1} (1 + \nu_{2,s,t+1}) \Big] \tag{A.59}$$

Definitions of $M_{1,s,t}$ and $M_{2,s,t}$. We define the investment and financial wedges in terms of the Lagrange multiplier $\nu_{2,s,t}$ on the loan-in-advance constraint:

$$M_{1,s,t} \equiv 1 + \psi \nu_{2,s,t} \tag{A.60}$$

$$M_{2,s,t} \equiv 1 + \nu_{2,s,t} \tag{A.61}$$

These definitions immediately imply:

$$\frac{M_{1,s,t}-1}{M_{2,s,t}-1}=\frac{\psi\nu_{2,s,t}}{\nu_{2,s,t}}=\psi \tag{A.62}$$

From the investment condition (A.57), we obtain $\nu_{1,s,t} = p^k_{s,t}M_{1,s,t}$. Substituting this relationship into (A.56) and (A.58), and replacing $1+\nu_{2,s,t}$ with $M_{2,s,t}$ in (A.59), yields the compact first-order conditions (6)–(10) presented in the main text. When the loan-in-advance constraint is slack ($\nu_{2,s,t}=0$), both wedges collapse to unity ($M_{1,s,t} = M_{2,s,t} = 1$) and these conditions reduce to standard frictionless asset-pricing relations. When the constraint binds ($\nu_{2,s,t} > 0$), $M_{1,s,t}$ acts as an investment wedge that raises the effective cost of capital, while $M_{2,s,t}$ operates as a financial wedge that depresses bond prices below their frictionless level. Because both wedges are driven by the single multiplier $\nu_{2,s,t}$, their ratio is pinned down by the financing parameter ψ.

A.5.1 Capital Good Producers

In each segment $s \in \{L, H\}$, a representative competitive capital goods producer transforms final output (investment) into new installed capital. The capital producer purchases $I_{s,t}$ units of the final good and converts them into $\hat{I}_{s,t}$ units of effective new capital according to:

$$\hat{I}_{s,t} \;=\; \Big[1-S_s\big(I_{s,t}/I_{s,t-1}\big)\Big]I_{s,t}, \qquad S_s(x)=\frac{\kappa_{I,s}}{2}(x-1)^2, \tag{A.63}$$

where the function $S_s(\cdot)$ represents a convex adjustment cost that penalizes deviations of investment growth from its steady-state rate.

The capital stock in segment s accumulates according to:

$$K_{s,t}=\big(1-\delta_s(u_{s,t})\big)K_{s,t-1}+\hat{I}_{s,t}, \tag{A.64}$$

where $\delta_s(u_{s,t})$ is the depreciation rate, which depends on the utilization rate $u_{s,t}$ chosen by wholesale firms.

Let $p^k_{s,t}$ denote the real price of installed capital in segment s (Tobin's q). The capital producer earns real dividends equal to:

$$div_{k,s,t}=p^k_{s,t}\Big[1-S_s\big(I_{s,t}/I_{s,t-1}\big)\Big]I_{s,t}-I_{s,t}. \tag{A.65}$$

The capital producer selects $\{I_{s,t}\}$ to maximize the expected present discounted value of dividends, discounted at the household's stochastic discount factor:

$$\max_{\{I_{s,t}\}} \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left\{ p^k_{s,t+j} \left[1 - S_s\Big(\frac{I_{s,t+j}}{I_{s,t+j-1}}\Big)\right] I_{s,t+j} - I_{s,t+j} \right\}. \tag{A.66}$$

The first-order condition with respect to $I_{s,t}$ is:

$$\begin{aligned} 1 \ &= p^k_{s,t} \left[1 - \frac{\kappa_{I,s}}{2}\Big(\frac{I_{s,t}}{I_{s,t-1}} - 1\Big)^2 - \kappa_{I,s}\Big(\frac{I_{s,t}}{I_{s,t-1}} - 1\Big)\Big(\frac{I_{s,t}}{I_{s,t-1}}\Big)\right] \\ &\quad + \mathbb{E}_t\left[\Lambda_{t,t+1}\, p^k_{s,t+1}\, \kappa_{I,s}\Big(\frac{I_{s,t+1}}{I_{s,t}} - 1\Big)\Big(\frac{I_{s,t+1}}{I_{s,t}}\Big)^2\right], \end{aligned} \tag{A.67}$$

for $s \in \{L, H\}$. The left-hand side represents the marginal cost of one unit of investment (the price of the final good, normalized to unity). The right-hand side captures the marginal benefit: the current-period value of new capital net of the adjustment cost, plus the expected future saving in adjustment costs that results from raising today's investment.

Aggregate investment across both segments is:

$$I_t = I_{L,t} + I_{H,t}. \tag{A.68}$$

A.6 Fiscal Authority

The government purchases an exogenous and stochastic quantity of final goods G_t each period. It finances this expenditure through a combination of lump-sum taxes T_t, remittances from the central bank $T_{cb,t}$, and the issuance of long-term nominal government bonds, maintained at a fixed real stock $\bar{b}_G$. Let $Q_{B,t}$ denote the market price of a government perpetuity with geometrically decaying coupons at rate $\kappa^b_t \in [0, 1]$, and let $\bar{b}_G$ be the fixed real stock of government bonds outstanding in every period. The government's flow budget constraint in real terms is:

$$G_t + \Pi_t^{-1}\bar{b}_G = T_t + T_{cb,t} + Q_{B,t}\bar{b}_G \left(1 - \kappa^b_t\, \Pi_t^{-1}\right). \tag{A.69}$$

The left-hand side records expenditures on goods plus the face value of maturing bonds. The right-hand side captures tax revenue, central bank remittances, and the proceeds from newly issued bonds net of the rolled-over portion of the existing stock. The transfer $T_{cb,t}$ is determined endogenously by the central bank's balance sheet and remittance rule described in the monetary authority block.

A.7 Aggregation and Exogenous Processes

Exogenous processes. The model features both segment-specific and aggregate exogenous driving forces. For each segment $s \in \{L, H\}$, productivity and the financial tightness parameter evolve as AR(1) processes in logs:

$$\ln A_{s,t} = \rho_{A,s} \ln A_{s,t-1} + s_{A,s}\varepsilon_{A,s,t}, \tag{A.70}$$

$$\ln \theta_{s,t} = (1-\rho_\theta)\ln \bar{\theta}_s + \rho_\theta \ln \theta_{s,t-1} + s_{\theta,s}\varepsilon_{\theta,s,t}. \tag{A.71}$$

Aggregate government spending obeys:

$$\ln G_t = (1-\rho_G)\ln \bar{G} + \rho_G \ln G_{t-1} + s_G \varepsilon_{G,t}. \tag{A.72}$$

The supply of government bonds is strictly fixed at the parameter $\bar{b}_G$.

The maturity parameters for private and public bonds follow segment-specific and aggregate AR(1) processes in logs, respectively. For $s \in \{L, H\}$:

$$\ln M^f_{s,t} = (1-\rho_{kf})\ln \bar{M}^f_s + \rho_{kf} \ln M^f_{s,t-1} + s_{kf,s}\varepsilon_{kf,s,t}, \tag{A.73}$$

$$\ln M^b_t = (1-\rho_{kb})\ln \bar{M}^b + \rho_{kb} \ln M^b_{t-1} + s_{kb}\varepsilon_{kb,t}. \tag{A.74}$$

The coupon decay rates on long-term private and public bonds are derived from the corresponding maturities:

$$\kappa^f_{s,t} = 1 - \frac{1}{M^f_{s,t}} \quad \text{and} \quad \kappa^b_t = 1 - \frac{1}{M^b_t}. \tag{A.75}$$

All innovations $\varepsilon_{\cdot,t}$ are drawn from standard normal distributions, with the corresponding $s_\cdot$ parameters scaling the standard deviations of the shocks. Autoregressive coefficients are restricted to the interval $[0, 1)$.

Final output aggregation. Outputs from both segments are combined into final output via a CES aggregator with segment weights (ζ_L, ζ_H) and substitution elasticity

η_y:

$$Y_t = \left[\zeta_L^{\frac{1}{\eta_y}} Y_{L,t}^{\frac{\eta_y - 1}{\eta_y}} + \zeta_H^{\frac{1}{\eta_y}} Y_{H,t}^{\frac{\eta_y - 1}{\eta_y}} \right]^{\frac{\eta_y}{\eta_y - 1}}. \tag{A.76}$$

We normalize the steady-state aggregate price level to unity ($P_t = 1$), which imposes the following restriction on relative segment prices $p_{s,t} \equiv P_{s,t}/P_t$:

$$1 = \zeta_L \, p_{L,t}^{1-\eta_y} + \zeta_H \, p_{H,t}^{1-\eta_y}. \tag{A.77}$$

The demand allocation across segments (the expenditure share) satisfies:

$$Y_{s,t} = \zeta_s \, Y_t \, p_{s,t}^{-\eta_y}, \qquad s \in \{L, H\}. \tag{A.78}$$

Market clearing. Bond markets clear for government bonds:

$$\bar{b}_G = b_{L,t} + b_{H,t} + b_t^{cb}, \tag{A.79}$$

where aggregate government bond holdings by intermediaries are $b_t = b_{L,t} + b_{H,t}$.

Intermediary balance sheets. Each type-s intermediary's balance sheet (expressed in real terms) satisfies:

$$Q_{s,t} f_{s,t} + Q_{B,t} b_{s,t} + re_{s,t} = d_{s,t} + n_{s,t}, \qquad s \in \{L, H\}. \tag{A.80}$$

The evolution of aggregate net worth in each segment is:

$$\begin{aligned} n_{s,t} = \sigma \Pi_t^{-1} \Big[&(R_{s,t}^F - R_{s,t-1}^d) Q_{s,t-1} f_{s,t-1} + (R_t^B - R_{s,t-1}^d) Q_{B,t-1} b_{s,t-1} \\ &+ (R_{t-1}^{re} - R_{s,t-1}^d) re_{s,t-1} + R_{s,t-1}^d n_{s,t-1} \Big] + X_s, \qquad s \in \{L, H\}. \end{aligned} \tag{A.81}$$

The leverage constraint (which binds in equilibrium) restricts the total risk-weighted assets of each intermediary type:

$$Q_{s,t} f_{s,t} + \Delta_s \, Q_{B,t} b_{s,t} = \phi_{s,t} \, n_{s,t}, \qquad s \in \{L, H\}. \tag{A.82}$$

Aggregate reserves, net worth, and deposits are the sums across segments:

$$re_t = re_{L,t} + re_{H,t}, \tag{A.83}$$

$$n_t = n_{L,t} + n_{H,t}, \tag{A.84}$$

$$d_t = d_{L,t} + d_{H,t}. \tag{A.85}$$

Resource constraint. The economy's aggregate resource constraint is:

$$Y_t = C_t + I_t + G_t, \tag{A.86}$$

where total investment is $I_t = I_{L,t} + I_{H,t}$.

Appendix B Equilibrium Conditions

Notation. The economy has two segments, Low vs. High maturity gap, indexed by $s \in \{L, H\}$. Expectations are $\mathbb{E}_t[\cdot]$.

Households

$$\mu_t = \frac{1}{C_t - b\,C_{t-1}} - \beta b\,\mathbb{E}_t\left[\frac{1}{C_{t+1} - b\,C_t}\right]. \tag{B.1}$$

$$\chi_s\,L_{s,t}^{\eta} = \mu_t\,mrs_{s,t}, \qquad s \in \{L, H\}. \tag{B.2}$$

$$R_t^d\,\mathbb{E}_t\big[\Lambda_{t,t+1}\,\Pi_{t+1}^{-1}\big] = 1. \tag{B.3}$$

$$\frac{d_{L,t}}{d_{H,t}} = \left(\frac{\omega_d}{1-\omega_d}\right)^{\eta_d}\left(\frac{R_{L,t}^d}{R_{H,t}^d}\right)^{\eta_d}. \tag{B.4}$$

$$\left(R_t^d\right)^{1-\eta_d} = \omega_d\left(R_{L,t}^d\right)^{1-\eta_d} + (1-\omega_d)\left(R_{H,t}^d\right)^{1-\eta_d}. \tag{B.5}$$

$$\Lambda_{t,t+1} = \beta\,\frac{\mu_{t+1}}{\mu_t}. \tag{B.6}$$

Financial Intermediaries

$$R_{s,t}^F = \frac{1 + \kappa_{s,t}^f\,Q_{s,t}}{Q_{s,t-1}}, \qquad s \in \{L, H\}. \tag{B.7}$$

$$R_t^B = \frac{1 + \kappa_t^b\,Q_{B,t}}{Q_{B,t-1}}. \tag{B.8}$$

$$\Omega_{s,t} = 1 - \sigma + \sigma\,\theta_{s,t}\,\phi_{s,t}, \qquad s \in \{L, H\}. \tag{B.9}$$

$$\mathbb{E}_t\big[\Lambda_{t,t+1}\,\Omega_{s,t+1}\,\Pi_{t+1}^{-1}\left(R_{s,t+1}^F - R_{s,t}^d\right)\big] = \frac{\lambda_{s,t}}{1+\lambda_{s,t}}\,\theta_{s,t}, \qquad s \in \{L, H\}. \tag{B.10}$$

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\,\Omega_{s,t+1}\,\Pi_{t+1}^{-1}\left(R_{t+1}^{B}-R_{s,t}^{d}\right)\right]=\frac{\lambda_{s,t}}{1+\lambda_{s,t}}\,\theta_{s,t}\,\Delta_s,\qquad s\in\{L,H\}. \tag{B.11}$$

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\,\Omega_{s,t+1}\,\Pi_{t+1}^{-1}\left(R_{t}^{re}-R_{s,t}^{d}\right)\right]=0,\qquad s\in\{L,H\}. \tag{B.12}$$

$$\theta_{s,t}\,\phi_{s,t}=(1+\lambda_{s,t})\,\mathbb{E}_t\left[\Lambda_{t,t+1}\,\Omega_{s,t+1}\,\Pi_{t+1}^{-1}\,R_{s,t}^{d}\right],\qquad s\in\{L,H\}. \tag{B.13}$$

Labor Market

Labor Unions

$$w_{s,t}^{*}=\frac{\epsilon_w}{\epsilon_w-1}\frac{f_{1,s,t}}{f_{2,s,t}},\qquad s\in\{L,H\}. \tag{B.14}$$

$$f_{1,s,t}=mrs_{s,t}\,w_{s,t}^{\epsilon_w}\,L_{s,t}^{d}+\phi_w\,\mathbb{E}_t\left[\Lambda_{t,t+1}\,\Pi_{s,t+1}^{\epsilon_w}\,\Pi_{s,t}^{-\epsilon_w\gamma_w}\,f_{1,s,t+1}\right],\qquad s\in\{L,H\}. \tag{B.15}$$

$$f_{2,s,t}=w_{s,t}^{\epsilon_w}\,L_{s,t}^{d}+\phi_w\,\mathbb{E}_t\left[\Lambda_{t,t+1}\,\Pi_{s,t+1}^{\epsilon_w-1}\,\Pi_{s,t}^{(1-\epsilon_w)\gamma_w}\,f_{2,s,t+1}\right],\qquad s\in\{L,H\}. \tag{B.16}$$

Aggregation

$$L_{s,t}=L_{s,t}^{d}\,v_{s,t}^{w},\qquad s\in\{L,H\}. \tag{B.17}$$

$$L_t=L_{L,t}+L_{H,t}. \tag{B.18}$$

$$v_{s,t}^{w}=(1-\phi_w)\left(\frac{w_{s,t}^{*}}{w_{s,t}}\right)^{-\epsilon_w}+\phi_w\,\Pi_{s,t}^{\epsilon_w}\,\Pi_{s,t-1}^{-\gamma_w\epsilon_w}\,w_{s,t}^{\epsilon_w}\,w_{s,t-1}^{-\epsilon_w}\,v_{s,t-1}^{w},\qquad s\in\{L,H\}. \tag{B.19}$$

$$w_{s,t}^{1-\epsilon_w}=(1-\phi_w)\left(w_{s,t}^{*}\right)^{1-\epsilon_w}+\phi_w\,\Pi_{s,t-1}^{\gamma_w(1-\epsilon_w)}\,\Pi_{s,t}^{\epsilon_w-1}\,w_{s,t-1}^{1-\epsilon_w},\qquad s\in\{L,H\}. \tag{B.20}$$

Production

Retail Firms

$$p^*_{s,t} = \frac{\epsilon_p}{\epsilon_p - 1}\frac{x_{1,s,t}}{x_{2,s,t}}, \qquad s \in \{L, H\}. \tag{B.21}$$

$$x_{1,s,t} = p^m_{s,t}\, Y_{s,t} + \phi_p\, \mathbb{E}_t\Big[\Lambda_{t,t+1}\, \Pi^{\epsilon_p}_{s,t+1}\, \Pi^{-\epsilon_p \gamma_p}_{s,t}\, x_{1,s,t+1}\Big], \qquad s \in \{L, H\}. \tag{B.22}$$

$$x_{2,s,t} = Y_{s,t} + \phi_p\, \mathbb{E}_t\Big[\Lambda_{t,t+1}\, \Pi^{\epsilon_p - 1}_{s,t+1}\, \Pi^{(1-\epsilon_p)\gamma_p}_{s,t}\, x_{2,s,t+1}\Big], \qquad s \in \{L, H\}. \tag{B.23}$$

Wholesale Firms

$$Y^m_{s,t} = A_{s,t}\,(u_{s,t} K_{s,t-1})^{\alpha}\,(L^d_{s,t})^{1-\alpha}, \qquad s \in \{L, H\}. \tag{B.24}$$

$$w_{s,t} = p^m_{s,t}(1-\alpha)\, A_{s,t}\,(u_{s,t} K_{s,t-1})^{\alpha}\,(L^d_{s,t})^{-\alpha}, \qquad s \in \{L, H\}. \tag{B.25}$$

$$p^k_{s,t} M_{1,s,t}\Big(\delta_{1,s} + \delta_2(u_{s,t} - 1)\Big) = \alpha\, p^m_{s,t}\, A_{s,t}\,(u_{s,t} K_{s,t-1})^{\alpha-1}\,(L^d_{s,t})^{1-\alpha}, \qquad s \in \{L, H\}. \tag{B.26}$$

$$\begin{aligned} p^k_{s,t} M_{1,s,t} = \mathbb{E}_t\Bigg[\Lambda_{t,t+1}\Big(&\alpha\, p^m_{s,t+1} A_{s,t+1}\, K^{\alpha-1}_{s,t}\, u^{\alpha}_{s,t+1}\,(L^d_{s,t+1})^{1-\alpha} \\ &+ \Big(1 - \delta_{0,s} - \delta_{1,s}(u_{s,t+1} - 1) - \frac{\delta_2}{2}(u_{s,t+1} - 1)^2\Big)\, p^k_{s,t+1} M_{1,s,t+1}\Big)\Bigg], \end{aligned} \qquad s \in \{L, H\}. \tag{B.27}$$

$$Q_{s,t} M_{2,s,t} = \mathbb{E}_t\Big[\Lambda_{t,t+1}\, \Pi^{-1}_{t+1}\Big(1 + \kappa^f_{s,t+1}\, Q_{s,t+1} M_{2,s,t+1}\Big)\Big], \qquad s \in \{L, H\}. \tag{B.28}$$

$$\frac{M_{1,s,t} - 1}{M_{2,s,t} - 1} = \psi, \qquad s \in \{L, H\}. \tag{B.29}$$

$$\psi\, p^k_{s,t}\, \hat{I}_{s,t} = Q_{s,t}\Big(f_{s,t} - \kappa^f_{s,t}\, f_{s,t-1}\, \Pi_t^{-1}\Big), \qquad s \in \{L, H\}. \tag{B.30}$$

$$K_{s,t} = \hat{I}_{s,t} + \Big(1 - \delta_{0,s} - \delta_{1,s}(u_{s,t} - 1) - \frac{\delta_2}{2}(u_{s,t} - 1)^2\Big)K_{s,t-1}, \qquad s \in \{L, H\}. \tag{B.31}$$

$$K_t = K_{L,t} + K_{H,t}. \tag{B.32}$$

Capital Producers

$$\hat{I}_{s,t} = \left(1 - \frac{\kappa_{I,s}}{2}\left(\frac{I_{s,t}}{I_{s,t-1}} - 1\right)^2\right) I_{s,t}, \qquad s \in \{L, H\}. \tag{B.33}$$

$$\begin{aligned} 1 = p^k_{s,t} &\left(1 - \frac{\kappa_{I,s}}{2}\left(\frac{I_{s,t}}{I_{s,t-1}} - 1\right)^2 - \kappa_{I,s}\left(\frac{I_{s,t}}{I_{s,t-1}} - 1\right)\left(\frac{I_{s,t}}{I_{s,t-1}}\right)\right) \\ &+ \mathbb{E}_t\left[\Lambda_{t,t+1}\, p^k_{s,t+1}\kappa_{I,s}\left(\frac{I_{s,t+1}}{I_{s,t}} - 1\right)\left(\frac{I_{s,t+1}}{I_{s,t}}\right)^2\right], \qquad s \in \{L, H\}. \end{aligned} \tag{B.34}$$

$$I_t = I_{L,t} + I_{H,t}. \tag{B.35}$$

Government

$$G_t + \Pi_t^{-1}\bar{b}_G = T_t + T_{cb,t} + Q_{B,t}\bar{b}_G\Big(1 - \kappa^b_t\, \Pi_t^{-1}\Big). \tag{B.36}$$

Central Bank and Monetary Policy

$$Q_{B,t} b_{cb,t} = re_t. \tag{B.37}$$

$$T_{cb,t} = (1 + \kappa^b_t Q_{B,t})\, \Pi_t^{-1} b_{cb,t-1} - R^{re}_{t-1}\, \Pi_t^{-1} re_{t-1}. \tag{B.38}$$

$$\ln R_t^{tr} = (1-\rho_r)\ln R^{tr} + \rho_r \ln R_{t-1}^{tr} + (1-\rho_r)\Big[\phi_\pi(\ln \Pi_t - \ln \Pi) + \phi_y(\ln Y_t - \ln Y_{t-1})\Big] + s_r \varepsilon_{r,t}. \tag{B.39}$$

$$R_t^{re} = R_t^{tr}. \tag{B.40}$$ [11]

Aggregation, Price System, and Market Clearing

$$Y_{s,t} = \zeta_s \, Y_t \, p_{s,t}^{-\eta_y}, \qquad s \in \{L, H\}. \tag{B.41}$$

$$Y_{s,t}^m = Y_{s,t} \, v_{s,t}^p, \qquad s \in \{L, H\}. \tag{B.42}$$

$$v_{s,t}^p = (1-\phi_p)(p_{s,t}^*)^{-\epsilon_p} + \phi_p \, \Pi_{s,t}^{\epsilon_p} \, \Pi_{s,t-1}^{-\gamma_p \epsilon_p} \, v_{s,t-1}^p, \qquad s \in \{L, H\}. \tag{B.43}$$

$$1 = (1-\phi_p)(p_{s,t}^*)^{1-\epsilon_p} + \phi_p \, \Pi_{s,t}^{\epsilon_p - 1} \, \Pi_{s,t-1}^{\gamma_p(1-\epsilon_p)}, \qquad s \in \{L, H\}. \tag{B.44}$$

$$\Pi_{s,t} = \Pi_t \left(\frac{p_{s,t}}{p_{s,t-1}} \right), \qquad s \in \{L, H\}. \tag{B.45}$$

$$Y_t = \left[\zeta_L^{\frac{1}{\eta_y}} \, Y_{L,t}^{\frac{\eta_y - 1}{\eta_y}} + \zeta_H^{\frac{1}{\eta_y}} \, Y_{H,t}^{\frac{\eta_y - 1}{\eta_y}} \right]^{\frac{\eta_y}{\eta_y - 1}}. \tag{B.46}$$

$$Q_{s,t} f_{s,t} + Q_{B,t} b_{s,t} + re_{s,t} = d_{s,t} + n_{s,t}, \qquad s \in \{L, H\}. \tag{B.47}$$

$$Q_{s,t} f_{s,t} + \Delta_s \, Q_{B,t} b_{s,t} = \phi_{s,t} n_{s,t}, \qquad s \in \{L, H\}. \tag{B.48}$$

$$n_{s,t} = \sigma \, \Pi_t^{-1} \Big((R_{s,t}^F - R_{s,t-1}^d) \, Q_{s,t-1} f_{s,t-1} + (R_t^B - R_{s,t-1}^d) \, Q_{B,t-1} b_{s,t-1} + (R_{t-1}^{re} - R_{s,t-1}^d) \, re_{s,t-1} + R_{s,t-1}^d \, n_{s,t-1} \Big) + X_s, \qquad s \in \{L, H\}. \tag{B.49}$$

[11] Combined with (B.12), this implies $R_{s,t}^d = R_t^{re} = R_t^{tr}$ for $s \in \{L, H\}$, as stated in the main text.

$$\bar{b}_G = b_t + b_{cb,t}. \tag{B.50}$$

$$b_t = b_{L,t} + b_{H,t}. \tag{B.51}$$

$$f_t = f_{L,t} + f_{H,t}. \tag{B.52}$$

$$d_t = d_{L,t} + d_{H,t}. \tag{B.53}$$

$$n_t = n_{L,t} + n_{H,t}. \tag{B.54}$$

$$Y_t = C_t + I_t + G_t. \tag{B.55}$$

$$re_t = re_{L,t} + re_{H,t}. \tag{B.56}$$

$$R_{s,t}^{L,F} = \kappa_{s,t}^{f} + Q_{s,t}^{-1}, \qquad s \in \{L, H\}. \tag{B.57}$$

$$R_t^{L,B} = \kappa_t^{b} + Q_{B,t}^{-1}. \tag{B.58}$$

Exogenous Processes (Shocks)

$$\ln A_{s,t} = \rho_{A,s} \ln A_{s,t-1} + s_{A,s}\, \varepsilon_{A,s,t}, \qquad s \in \{L, H\}. \tag{B.59}$$

$$\ln G_t = (1 - \rho_G) \ln G + \rho_G \ln G_{t-1} + s_G\, \varepsilon_{G,t}. \tag{B.60}$$

$$\ln \theta_{s,t} = (1 - \rho_\theta) \ln \bar{\theta}_s + \rho_\theta \ln \theta_{s,t-1} + s_{\theta,s}\, \varepsilon_{\theta,s,t}, \qquad s \in \{L, H\}. \tag{B.61}$$

$$b_{cb,t} = (1 - \rho_b) b_{cb} + \rho_b b_{cb,t-1} + s_b\, \varepsilon_{b,t}. \tag{B.62}$$

Returns and Spreads

$$return^f_{s,t} = \ln R^F_{s,t} - \ln R^d_{s,t-1}, \qquad s \in \{L, H\}. \tag{B.63}$$

$$return^b_{s,t} = \ln R^B_t - \ln R^d_{s,t-1}, \qquad s \in \{L, H\}. \tag{B.64}$$

$$Spread^f_{s,t} = \ln R^{L,F}_{s,t} - \ln R^d_{s,t}, \qquad s \in \{L, H\}. \tag{B.65}$$

$$Spread^b_{s,t} = \ln R^{L,B}_t - \ln R^d_{s,t}, \qquad s \in \{L, H\}. \tag{B.66}$$

$$return^{fb}_{s,t} = \ln R^F_{s,t} - \ln R^B_t, \qquad s \in \{L, H\}. \tag{B.67}$$

Real Rates

$$f^r_{s,t} = \ln R^{L,F}_{s,t} - \ln \Pi_{t+1}, \qquad s \in \{L, H\}. \tag{B.68}$$

$$b^r_t = \ln R^{L,B}_t - \ln \Pi_{t+1}. \tag{B.69}$$

Welfare

$$W_t = \ln(C_t - b\,C_{t-1}) - \chi_L \frac{L^{1+\eta}_{L,t}}{1+\eta} - \chi_H \frac{L^{1+\eta}_{H,t}}{1+\eta} + \beta\,\mathbb{E}_t[W_{t+1}]. \tag{B.70}$$

Maturity Gap and Market Values

$$\ln M^f_{s,t} = (1-\rho_{kf}) \ln \bar{M}^f_s + \rho_{kf} \ln M^f_{s,t-1} + s_{kf,s}\,\varepsilon_{kf,s,t}, \qquad s \in \{L, H\}. \tag{B.71}$$

$$\ln M^b_t = (1-\rho_{kb}) \ln \bar{M}^b + \rho_{kb} \ln M^b_{t-1} + s_{kb}\,\varepsilon_{kb,t}. \tag{B.72}$$

$$\kappa^f_{s,t} = 1 - \frac{1}{M^f_{s,t}}, \qquad s \in \{L, H\}. \tag{B.73}$$

$$\kappa^b_t = 1 - \frac{1}{M^b_t}. \tag{B.74}$$

$$mgap_{s,t} = \left(\frac{M^f_{s,t}\, f_{s,t}\, Q_{s,t} + M^b_t\, b_{s,t}\, Q_{B,t} + M^{re}_s\, re_{s,t}}{f_{s,t}\, Q_{s,t} + b_{s,t}\, Q_{B,t} + re_{s,t}} \right) - M^d_s, \qquad s \in \{L, H\}. \quad \text{(B.75)}$$

$$MV^f_{s,t} = Q_{s,t}\, f_{s,t}, \qquad s \in \{L, H\}. \quad \text{(B.76)}$$

$$MV^f_t = MV^f_{L,t} + MV^f_{H,t}. \quad \text{(B.77)}$$

$$MV^b_{s,t} = Q_{B,t}\, b_{s,t}, \qquad s \in \{L, H\}. \quad \text{(B.78)}$$

$$MV^b_t = MV^b_{L,t} + MV^b_{H,t}. \quad \text{(B.79)}$$

The full set of equilibrium conditions consists of **127 equations for 127 endogenous variables**. All equations indexed by $s \in \{L, H\}$ represent **two** segments (Low and High).

- **Households**: marginal utility, labor FOCs (s), deposit Euler + aggregation, SDF.
- **Financial Intermediaries**: returns, $\Omega_{s,t}$, portfolio FOCs (s), multiplier link (s).
- **Labor Market**: wage setting (s), wage dispersion and wage evolution (s), employment aggregation.
- **Production**: retail pricing (s), wholesale block (s), capital producer block (s).
- **Government and Central Bank**: fiscal constraint, CB balance sheet, remittances, Taylor rule, rate setting.
- **Aggregation and Market Clearing**: output/price system, intermediary constraints, bond clearing, resource constraint, reserves, long yields.
- **Exogenous Processes**: segment-specific and aggregate AR(1) shocks (productivity, liquidity, government spending, CB government bond holdings, private loan maturity, government bond maturity, monetary policy).

- **Definitions**: spreads/returns, real rates, reporting variables, maturity gap and market values.

- **Welfare**: recursive welfare.

These comprise 127 equations for the 127 endogenous variables:

$$\{C_t, L_t, L_{L,t}, L_{H,t}, mrs_{L,t}, mrs_{H,t}, R^d_{L,t}, R^d_{H,t}, R^d_t, \Lambda_{t,t+1}, \Pi_t, \Pi_{L,t}, \Pi_{H,t}, Y_t, G_t,$$
$$Q_{L,t}, Q_{H,t}, Q_{B,t}, f_{L,t}, f_{H,t}, f_t, b_{L,t}, b_{H,t}, b_t, d_t, d_{L,t}, d_{H,t}, n_t, n_{L,t}, n_{H,t}, R^F_{L,t}, R^F_{H,t}, R^B_t, R^{re}_t, R^{tr}_t,$$
$$\phi_{L,t}, \phi_{H,t}, MV^f_t, MV^f_{L,t}, MV^f_{H,t}, MV^b_t, MV^b_{L,t}, MV^b_{H,t}, w^*_{L,t}, w^*_{H,t}, w_{L,t}, w_{H,t}, L^d_{L,t}, L^d_{H,t},$$
$$p^*_{L,t}, p^*_{H,t}, Y^m_{L,t}, Y^m_{H,t}, A_{L,t}, A_{H,t}, K_t, K_{L,t}, K_{H,t}, u_{L,t}, u_{H,t}, p^k_{L,t}, p^k_{H,t}, M_{1,L,t}, M_{1,H,t}, M_{2,L,t}, M_{2,H,t},$$
$$\hat{I}_{L,t}, \hat{I}_{H,t}, I_{L,t}, I_{H,t}, I_t, \theta_{L,t}, \theta_{H,t}, R^{L,B}_t, R^{L,F}_{L,t}, R^{L,F}_{H,t}, re_{L,t}, re_{H,t}, re_t,$$
$$\mu_t, \Omega_{L,t}, \Omega_{H,t}, p^m_{L,t}, p^m_{H,t}, \lambda_{L,t}, \lambda_{H,t}, f_{1,L,t}, f_{1,H,t}, f_{2,L,t}, f_{2,H,t}, v^w_{L,t}, v^w_{H,t}, x_{1,L,t}, x_{1,H,t}, x_{2,L,t}, x_{2,H,t},$$
$$v^p_{L,t}, v^p_{H,t}, \kappa^f_{L,t}, \kappa^f_{H,t}, \kappa^b_t, M^f_{L,t}, M^f_{H,t}, M^b_t, mgap_{L,t}, mgap_{H,t}, T_t, T_{cb,t}, W_t, b_{cb,t}, f^r_{L,t}, f^r_{H,t},$$
$$b^r_t, return^f_{L,t}, return^f_{H,t}, return^b_{L,t}, return^b_{H,t}, return^{fb}_{L,t}, return^{fb}_{H,t}, Spread^b_{L,t}, Spread^b_{H,t},$$
$$Spread^f_{L,t}, Spread^f_{H,t}, Y_{L,t}, Y_{H,t}, p_{L,t}, p_{H,t}\}$$

Table 5: Calibrated Parameters: Standard and Aggregate

Param.	**Value/Target**	**Description**
Household & Technology		
β	0.995	Discount factor
b	0.70	Habit formation
η	1	Inverse Frisch elasticity
α	0.33	Capital share in production
δ_0	0.025	Steady-state depreciation rate
$\delta_{1,s}$	(endogenous)	Linear utilization cost; pinned by $u_s = 1$ in SS
δ_2	0.01	Utilization adjustment cost
ϵ_p, ϵ_w	11	Elasticity of substitution (goods & labor)
ϕ_w	0.75	Wage rigidity (Calvo)
ϕ_p	0.75	Price Stickiness (Calvo)
σ	0.95	Intermediary survival prob.
ψ	0.80	Loan-in-advance constraint
κ_I	2.00	Investment adjustment cost
χ_s	(endogenous)	Labor disutility scaling; pinned by $L_s^d = 1$ in SS
γ_p, γ_w	0	Price and wage indexation
Π	1	Steady-state (gross) inflation
η_d	5	Elasticity of substitution (between deposits)
ω_d	0.65	Deposit preference weight
η_y	1.5	CES elasticity of substitution (between segments)
Fiscal & Central Bank		
G/Y	0.22	Government spending share
B/Y	3.20	Steady-state debt-to-GDP (4×0.80)
B_{cb}/Y	0.24	CB government bond holdings (4×0.06)
M^b	40	Target maturity: government bonds (quarters)
κ^b	$1 - 1/40$	Decay rate: government bonds
Monetary Policy		
ρ_r	0.80	Interest rate smoothing
ϕ_π	1.50	Response to inflation
ϕ_y	0.00	Response to output growth
s_r	0.10	Monetary policy shock volatility
Aggregate Shock Processes		
ρ_G, s_G	0.95, 0.01	Government spending
ρ_b, s_b	0.90, 0.10	CB government bond holdings
$\rho_{\kappa^b}, s_{\kappa^b}$	0.95, 0.01	Gov. bond duration shock

Note: Parameters marked "(endogenous)" are calibrated according to steady-state normalizations ($u_s = 1$ for $\delta_{1,s}$; $L_s^d = 1$ for χ_s).

Appendix C Empirical analysis

Table 6: Description of the variables

Variable	**Unit and Frequency**	**Data Source**	**Description**
Dependent and core variables			
Loan growth	Percentages, monthly	AnaCredit	Computed from the (recognized) outstanding loans reported in *AnaCredit*, where the counterparty is a euro area non-financial corporation. Aggregations are done at the bank–month–economic activity of the counterparty (NACE sector) level.
Maturity gap	Years, quarterly	ECB Supervisory Reporting data	The maturity gap proxy is calculated based on the future cash flows, both inflows and outflows, reported by euro area banks in template COREP C66.01 – *Maturity Ladder*. Cash flows are reported in 21 maturity buckets. The maturity of inflows and outflows in each bucket is proxied by the bucket's midpoint (for example, 1.5 years for flows in "Greater than 12 months and up to 2 years"). A maturity of 15 years is assigned to cash flows allocated to "Greater than 5 years"[1]. The maturity-weighted difference between inflows and outflows is scaled by the bank's total assets (from the FINREP template F01).
Monetary policy shocks: Target and QT	Basis points, monthly	EA-MPD (Altavilla et al. (2019))	Conventional and unconventional monetary policy shocks refer to the "Target" and "QT" shocks, respectively, as defined by Altavilla et al. (2019). These are computed as the rotated factors explaining high-frequency changes in Overnight Index Swap (OIS) rates around monetary policy events (i.e., between the press release of the ECB monetary policy decision and the end of the ECB President's press conference). The Target shock is scaled to yield a unit effect on the one-month OIS rate. The QT shock is scaled to yield a unit effect on the ten-year OIS yield.

[1] Unfortunately, the Maturity Ladder does not provide a further breakdown of cash flows that settle beyond five years. Therefore, we had to assign a default maturity value of 15 years to the "Greater than 5 years" bucket, an approach consistent with previous studies (e.g., Coulier et al. (2024)). This assumption is a limitation of our maturity gap measure, as it might cause inaccuracies in the gap distribution across banks. In the worst case, this could misclassify banks with high maturity gaps as having low maturity gaps, and vice versa. However, we are reassured by two key factors. First, the results do not change significantly when we modify the default value (testing for 5, 10, 20, or 30 years). Second, the banks at the tails of our maturity gap distribution (those with the highest or lowest gaps) do indeed have business models that imply a large imbalance between very short-term and long-term cash flows. Hence, we believe our measure still captures valuable information on the cross-sectional differences among banks regarding their exposure to long-term yields.

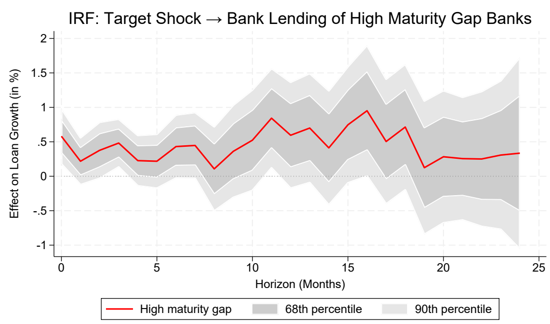
Table 7: Description of control variables

Variable	**Unit and Frequency**	**Data Source**	**Description**
Controls			
Bank size	No unit (log), quarterly	ECB Supervisory Reporting data	Defined as log(Total Assets). Total Assets are the carrying amounts sourced from template F01 of FINREP.
Non-performing loan (NPL) ratio	Percentages, quarterly	ECB Supervisory Reporting data	Defined as non-performing loans over total loans. Only loans granted to the non-financial private sector (i.e., non-financial corporations and households) are considered in both the numerator and the denominator. The carrying amounts are sourced from the FINREP template F18.
Liquidity coverage ratio (LCR)	Percentages, quarterly	ECB Supervisory Reporting data	The liquidity coverage ratio is sourced from the COREP template C76. Banks report this value in line with the definition outlined in Article 4(1) of the Delegated Regulation (EU) 2015/61.
Profitability: Return on assets	Percentages, quarterly	ECB Supervisory Reporting data	Defined as Total Profit/Loss over Total Assets. The numerator is sourced from the FINREP template F02 and adjusted such that it represents the four-quarter trailing sum of profits (i.e., a year-on-year measure). The denominator is sourced from FINREP template F01.
Capital: Common Equity Tier 1 (CET1) ratio	Percentages, quarterly	ECB Supervisory Reporting data	Defined as the CET1 capital over the total risk exposure amount (i.e., risk-weighted assets). This value is reported in COREP template C03, in accordance with point (a) of Article 92(2) of the CRR.
Leverage ratio	Percentages, quarterly	ECB Supervisory Reporting data	Defined by the regulator as the Tier 1 capital amount over the total leverage ratio exposure measure. We use the fully phased-in definition. The denominator includes on-balance sheet assets, securities financing transactions, derivatives exposures, and other off-balance sheet items, net of exemptions (e.g., intragroup exposures, promotional loans,...). The leverage ratio is sourced from the COREP template C47.

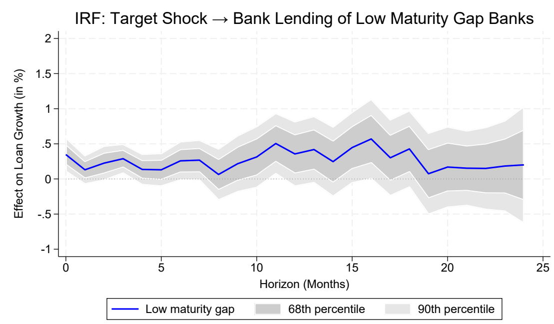
Table 8: Description of additional control variables

Variable	Unit and Frequency	Data Source	Description
Controls			
Loan-to-deposit ratio	Percentages, quarterly	ECB Supervisory Reporting data	Defined as the total loans to the non-financial private sector (i.e., non-financial corporations and households) divided by the total deposits from the non-financial private sector. The carrying amount of loans is sourced from the FINREP template F18, summing the amounts reported under the different accounting rules (i.e., at fair value and amortized cost). The carrying amount of deposits is sourced from the FINREP template F8, which sums the amounts reported under the different accounting rules.
Deposit ratio	Percentages, quarterly	ECB Supervisory Reporting data	Defined as the total deposits from the non-financial private sector (i.e., non-financial corporations and households) divided by total assets. The carrying amount of deposits is sourced from the FINREP template F8, summing the amounts reported under the different accounting rules. Total Assets are carrying amounts sourced from template F01 of FINREP.

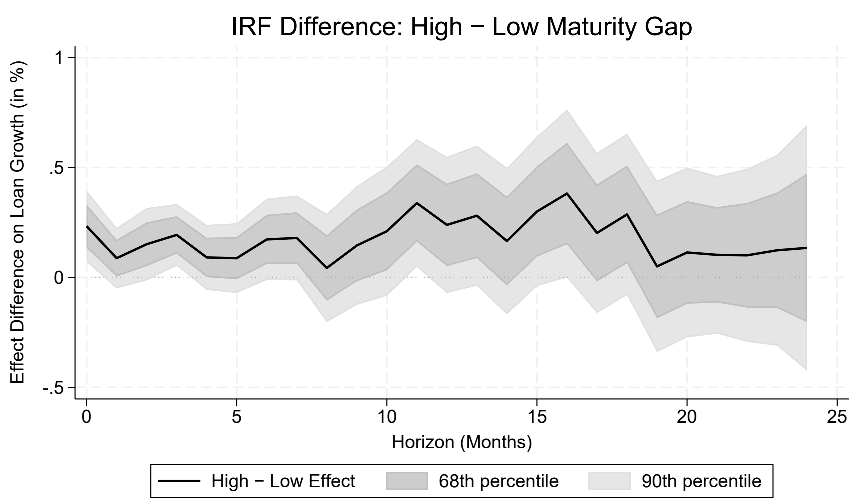
Figure 11: Analysis of bank lending responses to a target shock, comparing high and low maturity gap banks - Full sample



(a) *Response of lending from high maturity gap banks to target shock*

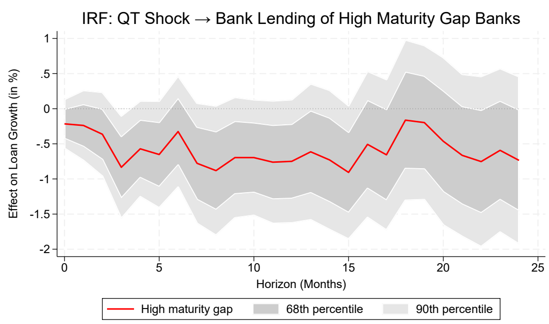


(b) *Response of lending from low maturity gap banks to target shock*

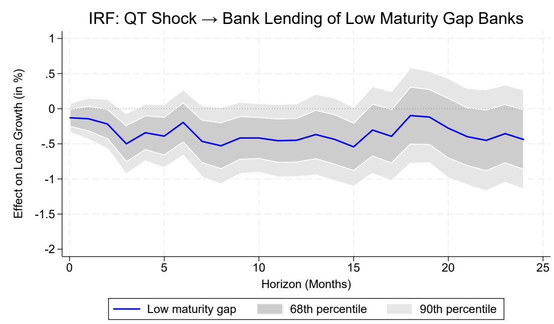


(c) *Difference in bank lending response between banks with high vs low maturity gap under a target shock*

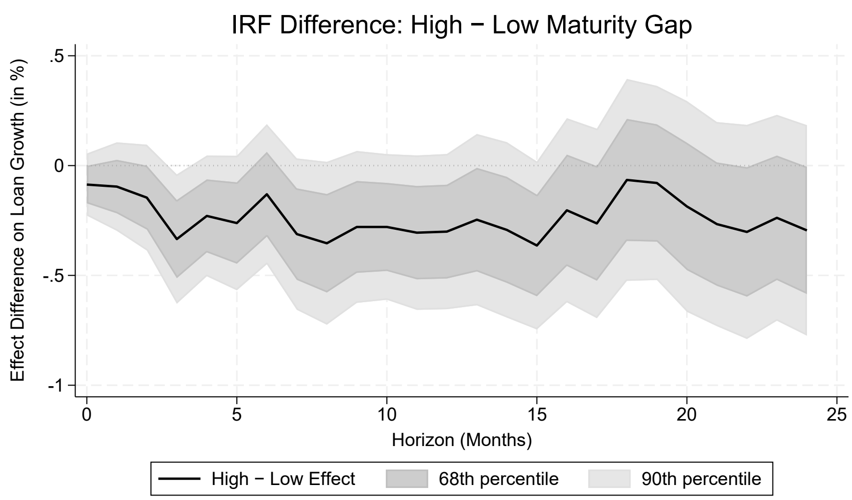
Figure 12: Analysis of bank lending responses to a QT shock, comparing high and low maturity gap banks - Restricted sample



(a) *Response of lending from high maturity gap banks to QT shock*

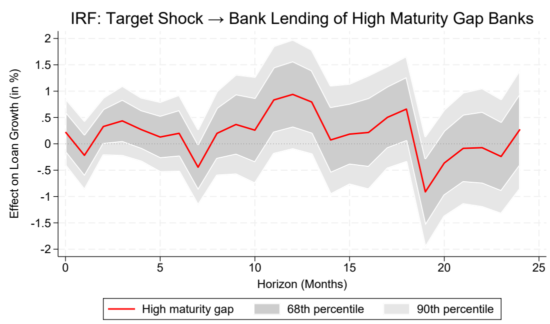


(b) *Response of lending from low maturity gap banks to QT shock*

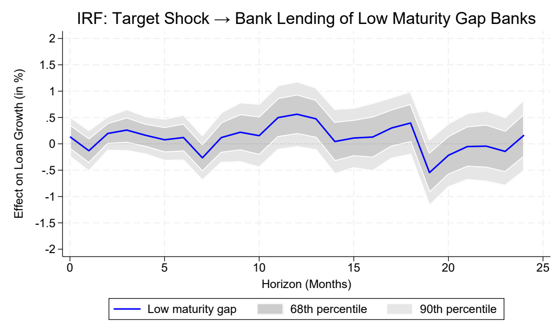


(c) *Difference in bank lending response between banks with high vs low maturity gap under a QT shock*

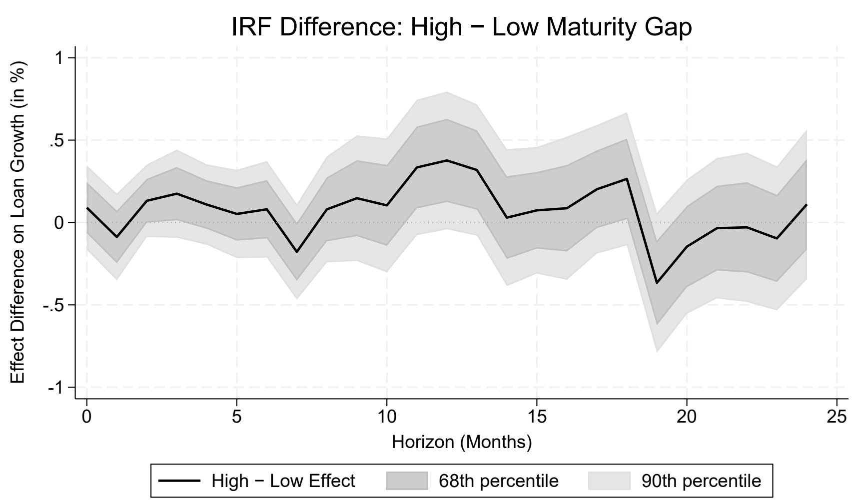
Figure 13: Analysis of bank lending responses to a target shock, comparing high and low maturity gap banks - Restricted sample



(a) *Response of lending from high maturity gap banks to target shock*



(b) *Response of lending from low maturity gap banks to target shock*



(c) *Difference in bank lending response between banks with high vs low maturity gap under a target shock*