Corporate Credit Booms and Heterogeneous Output Losses

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Abstract

Why do corporate credit booms cause large output losses? Bank-firm lending relationships are central to the answer. A relaxation of borrowing constraints generates an endogenous boom-bust cycle: banks compress spreads to lock in borrowers, then raise them to extract rents, triggering a contraction without a second shock. This borrower-side amplification produces cumulative output losses three to four times larger than under arm's-length credit, reaching 20 percent at high leverage. For shocks of identical size, corporate credit booms generate peak output declines and cumulative losses an order of magnitude larger than bank-driven expansions.

Keywords: Corporate Credit Booms, Heterogeneous Output Losses, Relationship Lending, Endogenous Credit Spreads, Financial Crises

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> *Credit and financial stability are intimately linked, with potentially grave consequences for macroeconomic performance. Ignoring these connections risks exposing the world to many more crises like the one just experienced. The same would have been said in the 1930s. An economist time traveler from that earlier era would alight today in an all too familiar landscape and might wonder what had happened in the meantime and if we had actually learned anything along the way.*
>
> — *Taylor (2015)*

1 Introduction

Rising corporate debt is systematically associated with subsequent financial crises and large output losses (Sever, 2023; Müller and Verner, 2024; Ivashina, Kalemli-Özcan, Laeven, and Müller, 2025). At the same time, similar-sized credit expansions often lead to materially different macroeconomic outcomes. A growing empirical literature attributes this heterogeneity to the nature of credit growth rather than its size alone. Jensen, Petrella, Ravn, and Santoro (2020) show that financially-driven expansions — those originating from relaxations of borrowing constraints — lead to deeper contractions than equally-sized non-financial expansions, establishing that the source of the expansion is a first-order determinant of the severity of the downturn. Jordà, Schularick, and Taylor (2013), using data for 14 advanced economies over 1870-2008, document that more credit-intensive expansions are systematically followed by deeper recessions, whether or not they coincide with financial crises. Importantly, they observe that "the economic costs of financial crises can vary considerably depending on the credit built up during the previous expansion phase." These findings point not only to the importance of credit growth, but also to the possibility that not all credit-intensive expansions are alike.

A central feature of corporate credit markets is the prevalence of long-term bank-firm lending relationships (Petersen and Rajan, 1994; Ongena and Smith, 2000; Kosekova, Maddaloni, Papoutsi, and Schivardi, 2025). Yet this feature is largely absent from quantitative macroeconomic models of credit booms, which typically abstract from the structure of financial intermediation or treat lending spreads as exogenous. This paper studies whether the presence of relationship-based intermediation can help account for the heterogeneity in macroeconomic outcomes across credit expansions of similar size. In particular, it asks whether lending relationships — through their implications for bank pricing behavior — can explain why some financially-driven booms are substantially more destructive than others.

To address this question, the paper develops a DSGE model with collateral-constrained firms and monopolistically competitive banks that engage in relationship lending. Borrowing capacity is governed by loan-to-value (LTV) constraints, while lending relationships are modeled using deep habits in banking (Ravn, Schmitt-Grohé, and Uribe, 2006),[1] capturing in reduced form switching costs and informational frictions that give banks pricing power over existing borrowers — consistent with empirical evidence on relationship lending (Diamond, 1984; Sharpe, 1990; Rajan, 1992; Boot, 2000; Ioannidou and Ongena, 2010; Saidi and Žaldokas, 2021; Cahn, Girotti, and Salvadè, 2024). The interaction between collateral constraints and relationship-based pricing generates endogenous dynamics in lending spreads that are central to the results.

The key mechanism is as follows. A relaxation of borrowing constraints increases firms' borrowing capacity and raises credit demand.[2] In the presence of lending relationships, banks respond by lowering lending spreads to attract and retain borrowers, reinforcing the expansion. As the effects of the initial loosening dissipate, banks optimally raise spreads above their steady-state level. This reversal reflects the intertemporal pricing incentives created by lending relationships: borrowers accumulated during the boom become partially locked in, allowing banks to extract rents during the contraction. The resulting tightening in effective credit conditions generates a downturn that arises from the same forces that drove the expansion, without requiring an additional adverse shock.

This mechanism delivers an endogenous boom-bust cycle with large and persistent output losses. A one-time relaxation of borrowing constraints generates a short-lived period of rising leverage, compressed spreads, and rapid credit growth, followed by a significantly more persistent contraction that is often comparable to or larger than the initial boom and is characterized by

[1] I do not attempt to model the endogenous formation of bank-firm credit relationships. This approach is consistent with the deep habits in banking literature that studies the implications of lending relationships and takes their existence as given (Aliaga-Díaz and Olivero, 2010; Aksoy, Basso, and Coto-Martinez, 2013; Melina and Villa, 2014, 2018; Ravn, 2016; Airaudo and Olivero, 2019; Shapiro and Olivero, 2020; Sharma, 2025, 2026). Modeling their endogenous formation would introduce additional margins that are orthogonal to the mechanism studied here.

[2] Aliber, Kindleberger, and McCauley (2023, page 19) write, "According to Minsky, events leading up to a crisis start with a displacement, some exogenous, outside shock to the macroeconomic system. The nature of this displacement varies from one speculative boom to another. It may be the outbreak or end of a war, a bumper harvest or crop failure, the widespread adoption of an invention with pervasive effects – canals, railroads, the automobile, information technology, and the internet – some political event or surprising financial success, or a debt conversion that precipitously lowers interest rates. Financial liberalization has in various places opened up the credit taps and set off a speculative boom. An unanticipated change of monetary policy might constitute such a displacement."

elevated spreads and reduced borrowing. The bust occurs without any second disturbance or exogenous reversal. The model thus links the buildup and the unwinding of credit conditions through a single underlying mechanism.

The quantitative implications are substantial. Cumulative output losses following a borrowing constraint relaxation are three to four times larger when credit is intermediated through lending relationships than in an otherwise identical economy with arm's-length credit. These losses increase further with steady-state leverage, rising from 12 percent to 20 percent of cumulative output as the steady-state LTV ratio increases from 0.75 to 0.90. The amplification arises entirely from endogenous spread dynamics, which are absent in the arm's-length benchmark.

The model also implies that the source of credit expansions matters sharply for macroeconomic outcomes. LTV shocks — originating from changes in firms' collateral constraints — generate substantially larger fluctuations than shocks to bank funding conditions (loan-to-deposit or LTD shocks) of equal size in an otherwise identical economy. The difference reflects the transmission channel. LTV shocks directly affect firms' borrowing capacity and, in the presence of lending relationships, interact with bank pricing incentives to generate a feedback loop between borrowing and spreads. LTD shocks, by contrast, operate through bank balance sheets and do not activate this interaction to the same extent. As a result, LTV shocks generate peak output contractions and cumulative output losses that are an order of magnitude larger than LTD shocks of equal size. These differences are not driven by parameterization but by the structure of transmission.

An important empirical feature of credit booms preceding financial crises is the coexistence of rising leverage and compressed credit spreads — what Krishnamurthy and Muir (2025) describe as "froth." They document that spreads compress as credit expands, and that this compression is more pronounced in episodes associated with larger subsequent downturns. Standard macro-finance models typically predict the opposite comovement, with higher leverage associated with higher spreads and risk premia (Gertler and Kiyotaki, 2010; He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014). The present framework reconciles these patterns. In the arm's-length benchmark, borrowing constraint relaxations can generate instability even with constant spreads. With relationship lending, the same expansion produces both rising leverage and compressed spreads during the boom, followed by a sharp reversal during the bust. This pattern arises from banks' optimal pricing behavior and links the depth of spread compression during the expansion to the severity of the subsequent contraction, consistent with the empirical regularities documented in Borio and Lowe (2002) and Krishnamurthy and Muir (2025).

The framework also relates to a broader literature in which crises are triggered by an exogenous reversal in borrowing conditions or through an additional adverse shock toward the end of the expansionary phase (Justiniano, Primiceri, and Tambalotti, 2015; Boissay, Collard, and Smets, 2016; Justiniano, Primiceri, and Tambalotti, 2019). By contrast, the framework developed here generates endogenous boom-bust dynamics following a one-time relaxation of corporate borrowing constraints.

Relatedly, the belief dynamics literature — Barberis, Shleifer, and Vishny (1998), Gennaioli, Shleifer, and Vishny (2012), and Bordalo, Gennaioli, and Shleifer (2022) — models crises as the consequence of shifts in beliefs, often triggered by exogenous disturbances. Gorton and Ordoñez (2023, page 147) argue that treating crises as contemporaneous large shocks obscures the forces that repeat over time and across countries. As they note, "the notion of a 'big shock' cannot be an explanation of a financial crisis without giving up on understanding forces that clearly repeat over time and across countries." The mechanism developed here instead emphasizes how the buildup of credit conditions can itself generate the subsequent contraction through the interaction of borrowing constraints and relationship-based pricing, so that by the time any external disturbance arrives — if one arrives at all — the system is already fragile in a specific and quantifiable way.

The model delivers four main implications. First, borrowing constraint relaxations generate endogenous boom-bust cycles with large and persistent output losses. Second, these losses are substantially larger under relationship lending than under arm's-length credit, due entirely to endogenous spread dynamics. Third, both the intensity and persistence of lending relationships amplify these effects, with higher steady-state leverage further increasing losses. Fourth, the source of credit expansions matters decisively — and not merely whether the expansion is financially driven and not merely its size — borrower-side shocks generate much larger fluctuations than lender-side shocks of equal size.

This paper contributes to three strands of the literature. It contributes to the literature on credit booms and financial crises by providing a structural mechanism through which a single financially-driven expansion generates boom-bust dynamics and large output losses without requiring an additional shock (Sever, 2023; Müller and Verner, 2024; Ivashina, Kalemli-Özcan, Laeven, and Müller, 2025). It contributes to the literature on collateral constraints by showing that their macroeconomic effects depend critically on the structure of financial intermediation, and that interaction with relationship lending generates amplification absent when either friction operates in isolation. It contributes to the literature on relationship lending (Petersen and Rajan, 1994; Ongena and Smith, 2000; Kosekova, Maddaloni, Papoutsi, and Schivardi, 2025) by embedding it in a quantitative macroeconomic framework and showing that it is a central determinant of the macroeconomic consequences of credit expansions. In this sense, understanding how credit and financial stability are linked through the structure of intermediation is part of what it means to have "learned anything along the way" from repeated episodes of financial instability, in the spirit of Taylor (2015).

Relationships with Literature

This paper sits at the intersection of four literatures: credit booms and output losses, collateral constraints and leverage cycles, relationship lending and deep habits in banking, and endogenous boom-bust dynamics. A common question linking these strands is why corporate credit expansions of similar size lead to substantially different macroeconomic outcomes, and what role the structure of financial intermediation plays in shaping those outcomes. Each literature addresses part of this question. However, existing frameworks do not jointly study how the source of a corporate credit expansion interacts with relationship-based bank pricing to determine the magnitude and persistence of output losses, nor how this interaction can generate a bust as the endogenous consequence of the boom. The framework developed here brings these elements together and provides a structural account of how credit expansions translate into heterogeneous macroeconomic outcomes.

Credit booms and output losses

Rapid expansions in corporate credit systematically precede financial crises and persistent output losses (Müller and Verner, 2024; Ivashina, Kalemli-Özcan, Laeven, and Müller, 2025). A central finding is that these costs vary across episodes. Jensen, Petrella, Ravn, and Santoro (2020) show that financially driven expansions – those associated with relaxations of borrowing constraints – lead to deeper contractions than equally sized non-financial expansions. Jordà, Schularick, and Taylor (2013) document that more credit-intensive expansions are systematically followed by deeper recessions across advanced economies. While these findings establish that both the source and intensity of credit growth matter, they do not provide a structural account of why outcomes differ across financially driven expansions. The present paper addresses this question by showing that, within this class of expansions, borrower-side shocks to collateral constraints generate substantially larger and more persistent output losses than lender-side shocks of comparable size, owing to a distinct interaction with the structure of financial intermediation.

Collateral constraints and leverage cycles

The theoretical literature on collateral constraints provides a natural framework for studying credit expansions driven by changes in borrowing capacity (Jensen, Ravn, and Santoro, 2018; Jensen, Petrella, Ravn, and Santoro, 2020). In these models, higher loan-to-value ratios relax borrowing constraints and amplify fluctuations through balance sheet effects. However, this literature typically abstracts from financial intermediation and treats lending spreads as exogenous, so amplification operates through quantities alone. As a result, these models do not account for the joint dynamics of credit and spreads observed in the data — such as the compression of spreads during booms and their reversal during busts documented by Krishnamurthy and Muir (2025) — nor do they capture how the structure of intermediation shapes the transmission of borrowing constraint shocks. In the present framework, borrowing constraints interact with endogenous bank pricing, generating feedback between credit quantities and spreads that is absent in arm's-length environments. This interaction materially affects the magnitude of output losses, which are substantially larger when lending relationships are present.

Relationship lending and deep habits in banking

A separate literature — based on deep habits in banking (Ravn, Schmitt-Grohé, and Uribe, 2006) — shows that lending relationships generate endogenous movements in lending spreads and time-varying markups in credit markets, with implications for the transmission of macroeconomic shocks (Aliaga-Díaz and Olivero, 2010; Aksoy, Basso, and Coto-Martinez, 2013; Melina and Villa, 2014, 2018; Ravn, 2016; Airaudo and Olivero, 2019; Shapiro and Olivero, 2020; Sharma, 2025). These models capture in reduced form the switching costs and informational frictions that give banks pricing power over their customers. Existing work shows that relationship-based pricing alters the transmission of productivity, monetary, and fiscal shocks by inducing countercyclical movements in lending spreads. The present paper extends this framework by introducing shocks to firms' borrowing capacity and studying their interaction with relationship-based pricing. When borrowing constraints relax, firms' balance sheets and credit demand respond directly, and banks' pricing incentives amplify these effects through a feedback loop — spread compression during the expansion reinforces borrowing, while subsequent spread increases tighten credit conditions during the contraction. This interaction generates amplification that is not present when either borrowing constraints or relationship lending is considered in isolation.

Endogenous boom-bust dynamics

A central issue in the literature on financial crises is whether the bust is an endogenous outcome of the boom or is triggered by an additional disturbance. Many approaches emphasize exogenous shocks or shifts in beliefs as the mechanism linking expansions to contractions (Barberis, Shleifer, and Vishny, 1998; Gennaioli, Shleifer, and Vishny, 2012; Maxted, 2024; Brianti and Cormun, 2024), while others generate crises through financial frictions but rely on additional shocks or nonlinearities to produce asymmetric dynamics (Justiniano, Primiceri, and Tambalotti, 2015; Boissay, Collard, and Smets, 2016; Justiniano, Primiceri, and Tambalotti, 2019). Recent work, such as Krishnamurthy and Li (2025), combines financial amplification with belief dynamics to match key features of crisis episodes, including the buildup of risk and the abrupt transition to downturns. The mechanism developed here is complementary to these approaches. It shows that the interaction between borrowing constraints and relationship-based pricing can generate a boom-bust cycle following a single disturbance, without requiring an additional shock. The resulting dynamics arise from the evolution of lending relationships and banks' intertemporal pricing incentives, which link the expansion and the contraction within a unified framework.

Relationship to Sharma (2026)

The paper most closely related to this work is Sharma (2026), which studies boom-bust cycles generated by shocks to banks' loan-to-deposit (LTD) ratios in an environment with relationship-based lending and endogenous spreads. While both papers employ deep habits in banking within a log-linearized framework, they address fundamentally different macro-financial questions.

Sharma (2026) studies how relationship lending amplifies disturbances originating on banks' balance sheets through changes in funding conditions and bank leverage. In contrast, the present paper studies why corporate credit booms generate heterogeneous macroeconomic outcomes and large subsequent output losses depending on how credit is intermediated. The focus here is therefore not the existence of boom-bust cycles per se, but the determinants of their severity and persistence following borrower-side credit expansions.

This distinction maps directly into the empirical literature. Recent evidence shows that credit expansions associated with relaxed corporate borrowing constraints are followed by especially severe downturns and persistent output losses (Ivashina, Kalemli-Özcan, Laeven, and Müller, 2025), while similar-sized expansions can produce markedly different outcomes depending on the nature of the expansionary phase (Jensen, Petrella, Ravn, and Santoro, 2020). The present framework provides a structural mechanism for these findings by linking the severity of downturns to the interaction between borrowing constraints and relationship-based credit markets.

The transmission mechanism also differs fundamentally across the two papers. In Sharma (2026), bank-side disturbances generate endogenous spread movements even in the absence of lending relationships, with relationship-based pricing primarily amplifying an existing channel. In contrast, borrower-side credit expansions in the present paper do not generate endogenous spread dynamics under arm's-length lending. Relationship-based pricing is instead a necessary component of the transmission mechanism itself: the interaction between borrowing constraints and lending relationships generates a feedback loop between credit quantities and lending spreads that is absent in standard credit-market environments.

These differences lead to distinct macroeconomic implications. Borrower-side credit expansions generate substantially larger and more persistent contractions than lender-side disturbances of comparable size, with cumulative output losses that are an order of magnitude larger in the model economy. More importantly, the present framework accounts for empirical episodes characterized by simultaneously rising leverage and compressed spreads — the "froth" emphasized by Krishnamurthy and Muir (2025) — while also generating endogenous boom-bust dynamics without requiring an additional adverse shock or a reversal in fundamentals. The two papers are therefore complementary: existing work explains how relationship lending propagates bank-side disturbances, while the present paper shows how the same financial structure can transform corporate credit expansions into episodes associated with large and heterogeneous macroeconomic losses.

Roadmap

The rest of this paper is organized as follows. Section 2 briefly presents motivating evidence on corporate credit booms and ensuing downturns. Section 3 presents the model. Section 4 discusses its solution and parameterization. Section 5 presents the results and its discussion.

Section 6 concludes.

2 Evidence on Corporate Credit Booms and Endogenous Financial Crises

Corporate credit booms are systematically associated with subsequent financial crises and persistent output losses (Müller and Verner, 2024; Ivashina, Kalemli-Özcan, Laeven, and Müller, 2025). At the same time, a growing empirical literature shows that similar-sized credit expansions can lead to substantially different macroeconomic outcomes depending on the nature of the expansionary phase and the underlying structure of credit markets (Jensen, Petrella, Ravn, and Santoro, 2020). These findings suggest that the severity of downturns depends not only on the size of credit growth, but also on how credit is generated and intermediated during the boom.

A central empirical feature of credit booms preceding financial crises is the coexistence of rising leverage, compressed credit spreads, and rapid credit growth – a phenomenon described by Krishnamurthy and Muir (2025) as "froth." This pattern poses a challenge for standard macro-finance frameworks. As emphasized by Krishnamurthy and Muir (2025), many leading intermediary models such as Gertler and Kiyotaki (2010), He and Krishnamurthy (2013), and Brunnermeier and Sannikov (2014) are able to account for the dynamics and aftermath of crises, but struggle to reconcile rising leverage with declining spreads during the expansionary phase. In these frameworks, increases in leverage and fragility are typically associated with rising spreads and higher risk premia. Empirically, however, crises are often preceded by unusually easy credit conditions, aggressive lending, compressed spreads, and elevated borrowing.

At the same time, a large empirical literature documents that corporate credit markets are characterized by persistent bank-firm lending relationships (Petersen and Rajan, 1994; Ongena and Smith, 2000; Boot, 2000). These relationships shape the pricing and availability of credit over the business cycle through informational frictions, switching costs, and borrower hold-up. Importantly, the consequences of these relationships become particularly pronounced during downturns and periods of financial stress. Firms dependent on relationship lenders are more exposed to contractions in credit supply, higher borrowing costs, and disruptions in refinancing conditions during crises (Chava and Purnanandam, 2011; Chodorow-Reich, 2014; Sette and Gobbi, 2015; Ricci, Soggia, and Trimarchi, 2023; Salvadè, Troege, and Taillet, 2024). This evidence suggests that the structure of credit intermediation may play an important role in determining why some credit booms culminate in substantially larger and more persistent output losses than others.

These observations point toward two unresolved questions. First, can credit booms endogenously generate their own collapse without requiring an exogenous adverse shock or a reversal in fundamentals? Second, can the interaction between borrowing constraints and relationship-based credit explain why similar credit expansions lead to dramatically different macroeconomic outcomes? These questions are particularly important because a large part of the macro-financial literature models crises as being triggered by an adverse shock toward the end of the expansionary phase. For example, Justiniano, Primiceri, and Tambalotti (2015, page 11) study a framework in which "...the collateral requirements are first loosened over several periods, and then abruptly tightened." Similarly, Boissay, Collard, and Smets (2016) write that in their framework "...the typical crisis is triggered by a moderate negative productivity shock toward the end of an unusual boom in credit." More broadly, Justiniano, Primiceri, and Tambalotti (2019) note that many approaches treat the bust as "...the result of a reversal of the same forces that had fueled the upswing," while also observing that this perspective "...treats the boom and the bust as unrelated."

The framework developed in this paper instead studies how a one-time relaxation of corporate borrowing constraints can endogenously generate a boom-bust cycle through its interaction with relationship-based lending and endogenous bank pricing. This perspective is closely related to a broader view of financial crises emphasizing that crises are not purely sudden or unpredictable events, but rather the endogenous outcome of preceding credit expansions and financial fragility. Gorton (2012, page 42), for example, describe crises as often perceived to be "sudden, unpredictable events," while Gorton and Ordoñez (2023, page 147) argue that macroeconomics must move beyond thinking of financial crises simply as contemporaneous "big shocks." They note that "the notion of a 'big shock' cannot be an explanation of a financial crisis without giving up on understanding forces that clearly repeat over time and across countries." Likewise, Borio and Lowe (2002) document that "sustained rapid credit growth combined with large increases in asset prices appears to increase the probability of an episode of financial instability."

Motivated by these empirical regularities, the analysis in this paper focuses on how the source and intermediation of credit expansions shape macroeconomic outcomes. In particular, the paper studies whether relationship-based lending amplifies borrower-side credit booms by generating endogenous movements in lending spreads that reinforce both the expansion and the subsequent contraction. As I show below, this interaction produces boom-bust cycles characterized by compressed spreads during the boom, sharp reversals in credit conditions during the downturn, and large cumulative output losses that are substantially larger than in otherwise identical economies with arm's-length credit markets.

3 Model

The paper develops a real model that builds on the collateral constraint frameworks of Iacoviello (2005), Liu, Wang, and Zha (2013), and Justiniano, Primiceri, and Tambalotti (2015). The key departure is the introduction of a formal banking sector with lending relationships modeled through deep habits in credit markets. This extension is not merely additive. It allows corporate borrowing constraints and bank pricing to interact endogenously, which is central to the mechanism studied in this paper. In standard collateral constraint models, credit expansions operate through quantities alone, as borrowing rates do not incorporate endogenous, borrower-specific pricing adjustments, implying that amplification operates primarily through quantities rather than through a feedback between credit demand and lending spreads. By contrast, embedding deep habits in banking generates endogenous movements in lending spreads that respond to changes in borrowing behavior. Relative to the existing deep habits in banking literature, the paper introduces corporate credit booms as shocks to firms' borrowing constraints, thereby placing credit expansions — rather than traditional macroeconomic disturbances — at the center of the analysis. The interaction between borrowing capacity and relationship-based pricing is also central for understanding the behavior of lending spreads during credit booms. In particular, the model generates episodes in which increased borrowing is accompanied by declining spreads, consistent with the froth documented in the empirical literature (Krishnamurthy and Muir, 2025).

The economy consists of three types of agents: households, entrepreneurs, and banks. Patient households consume, supply labor, and deposit funds with banks, which they ultimately own. Entrepreneurs are impatient and operate firms that produce output using capital and labor. Their borrowing is constrained by the expected value of collateral, which includes both productive capital and durable land, linking credit conditions directly to asset values and investment decisions. Banks intermediate funds between households and entrepreneurs and have persistent lending relationships with borrowers. These relationships give rise to endogenous pricing power, allowing banks to adjust lending spreads in response to changes in borrowing conditions. As a result, fluctuations in borrowing constraints affect not only the quantity of credit but also its price. In what follows, I describe each agent's optimization problem.

3.1 Households

Households have the utility function of the following form:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \left(\beta^P\right)^t \left\{ \log\left(C_{i,t}^P - \gamma^P C_{i,t-1}^P\right) - \frac{N_{i,t}^{\eta}}{\eta} + \varsigma \log H_{i,t}^P \right\} \tag{1}$$

where $C_{i,t}^P$, $N_{i,t}$ and $H_{i,t}^P$ denote consumption, labor and housing respectively of the households, $\beta^P \in (0,1)$ is a discount factor, γ^P measures the degree of habit formation in consumption, η is Frisch elasticity of labor supply and ς is a weight on housing. The superscript P denotes (patient) households. The household faces the following budget constraint

$$C_{i,t}^P + Q_t^H \left(H_{i,t}^P - H_{i,t-1}^P\right) + \int_0^1 D_{ik,t} \mathrm{d}k \leq W_t N_{i,t} + \int_0^1 \Pi_{ik,t} \mathrm{d}k + R_{t-1}^D \int_0^1 D_{ik,t-1} \mathrm{d}k \tag{2}$$

where Q_t^H is the price of one unit of housing in terms of consumption goods, W_t is the real wage and R_{t-1}^D is the gross risk-free interest rate on the stock of deposits $D_{ik,t-1}$ of household i in bank k at the end of period $t-1$. I assume housing does not depreciate. Profits obtained by household i from bank k are denoted by $\Pi_{ik,t}$. After imposing symmetric equilibrium, FOCs of the households can be written as

$$\frac{1}{C_t^P - \gamma^P C_{t-1}^P} - \beta^P \mathbb{E}_t \frac{\gamma^P}{C_{t+1}^P - \gamma^P C_t^P} = \lambda_t^P \tag{3}$$

$$\beta^P \mathbb{E}_t \lambda_{t+1}^P = \frac{\lambda_t^P}{R_t^D} \tag{4}$$

$$\frac{\varsigma}{H_t^P} + \beta^P \mathbb{E}_t \left(\lambda_{t+1}^P Q_{t+1}^H\right) = \lambda_t^P Q_t^H \tag{5}$$

$$N_t^{\eta-1} = \lambda_t^P W_t \tag{6}$$

where λ_t^P is the Lagrange multiplier associated with household's budget constraint (2). One can combine household's first-order conditions with respect to consumption (3) and bank deposits (4) to obtain their Euler equation. Equation (5) describes household's Euler equation for housing and links today's housing price to the utility it provides plus the expected capital gain. Equation (6) describes household's consumption-leisure trade-off. First order conditions of the problem are derived in the Appendix C.

3.2 Entrepreneurs

Following Iacoviello (2005) and Liu, Wang, and Zha (2013), entrepreneur j maximizes the utility obtained from consuming the non-durable consumption goods

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \left(\beta^E\right)^t \log\left(C_{j,t}^E - \gamma^E C_{j,t-1}^E\right) \tag{7}$$

where β^E and γ^E are as defined before. I assume that entrepreneurs are more impatient than the (patient) households, that is, $\beta^E < \beta^P$. Entrepreneurs face a collateral constraint in the spirit of Kiyotaki and Moore (1997) that limits borrowing to a fraction of the value of pledgeable assets:

$$l_{jk,t} \leq \frac{1}{R_{k,t}^L} \theta_t a_{j,t} \tag{8}$$

Here, $l_{jk,t}$ denotes entrepreneur j's borrowing from bank k, $a_{j,t}$ is the value of the entrepreneur's collateralizable assets, and $R_{k,t}^L$ is the bank-specific lending rate. The parameter θ_t governs the tightness of the borrowing constraint and can be interpreted as a time-varying loan-to-value (LTV) ratio that determines the fraction of assets that can be pledged as collateral.

Movements in θ_t capture changes in credit conditions that affect firms' borrowing capacity independently of underlying fundamentals. An increase in θ_t relaxes the collateral constraint by raising the amount of external finance that can be obtained for a given level of assets, thereby expanding borrowing and investment. Importantly, because the constraint depends on the lending rate $R_{k,t}^L$, changes in borrowing capacity interact directly with banks' pricing decisions. This interaction — absent in standard collateral constraint models and in deep-habits frameworks without borrowing shocks — underlies the amplification mechanism developed below.

The LTV shock is assumed to follow

$$\log \theta_t = (1 - \rho_\theta) \log \theta + \rho_\theta \log \theta_{t-1} + \sigma_\theta \epsilon_{\theta,t} \tag{9}$$

where θ denotes the steady-state level of the borrowing limit and $\epsilon_{\theta,t}$ is an i.i.d. innovation. I interpret fluctuations in θ_t as capturing changes in institutional or regulatory credit conditions that affect the availability of external finance to firms. The persistence parameter ρ_θ governs the duration of credit expansions, allowing the model to distinguish between transitory and prolonged relaxations in borrowing constraints, which, as I show in Section 5, have materially different implications for the magnitude of the boom and the severity of the subsequent downturn.

Expected value of entrepreneur's assets $a_{j,t}$ is given by

$$a_{j,t} = \mathbb{E}_t \left(Q^H_{t+1} H^E_{j,t} + Q^K_{t+1} K_{j,t} \right) \tag{10}$$

In the above equation, Q^K_t denotes the value of installed capital in units of consumption goods, $K_{j,t}$ is stock of capital and $H^E_{j,t}$ stock of land or real estate.[3]

Entrepreneurs have deep habits in banking relationships and I let $x_{j,t}$ denote entrepreneur j's effective/habit-adjusted borrowing. Given the continuum of banks in the economy who compete under monopolistic competition,[4] this can be written as[5]

$$x_{j,t} = \left[\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1} \right)^{\frac{\xi-1}{\xi}} \mathrm{d}k \right]^{\frac{\xi}{\xi-1}} \tag{11}$$

where stock of habits $s_{k,t-1}$ evolves according to[6]

$$s_{k,t-1} = \rho_s s_{k,t-2} + (1-\rho_s)\, l_{k,t-1} \tag{12}$$

Here, $\gamma^L \in (0,1)$ denotes the degree of habit formation in demand for loans and $\rho_s \in (0,1)$ measures the persistence of these habits. The parameter ξ denotes the elasticity of substitution between loans from different banks and is thus a measure of the market power of each individual

[3]Real estate is a central source of collateral for firms (Chaney, Sraer, and Thesmar, 2012; Liu, Wang, and Zha, 2013). Recent evidence shows that corporate credit expansions backed by real estate collateral are strongly associated with subsequent financial crises (Müller and Verner, 2024; Ivashina, Kalemli-Özcan, Laeven, and Müller, 2025). Modeling land as collateral therefore allows the framework to capture empirically relevant credit expansions that are closely linked to severe downturns.

[4]Financial intermediation is characterized by product differentiation that makes loans from different banks imperfect substitutes from the borrower's perspective. Banks bundle lending with services such as monitoring, screening, and relationship-specific information production, which generate borrower-specific attachments (Aliaga-Díaz and Olivero, 2010). In addition, banks differentiate along observable characteristics such as balance sheet strength and reputation (Kim, Kristiansen, and Vale, 2005). This provides a microfoundation for modeling lending relationships and imperfect substitutability across banks.

[5]Notice that when $\gamma^L = 0$, Equation (11) reduces to $x_{j,t} = \left[\int_0^1 (l_{jk,t})^{\frac{\xi-1}{\xi}} \mathrm{d}k \right]^{\frac{\xi}{\xi-1}}$, meaning past borrowing plays no role in determining current-period effective borrowing.

[6]When $\rho_s = 0$, Equation (12) reduces to $s_{k,t-1} = l_{k,t-1}$, meaning that deep habit term entering Equation (11) reduces to the last period aggregate amount of loans from the bank k.

bank.[7]

Given his total financing need $x_{j,t}$, each entrepreneur chooses $l_{jk,t}$ to minimize borrowing costs

$$\min_{l_{jk,t}} \int_0^1 R^L_{k,t} l_{jk,t} \mathrm{d}k \tag{13}$$

subject to the collateral constraint (8) and the effective borrowing condition (11). The associated first-order condition yields the optimal demand for loans from bank k

$$l_{jk,t} = \left(\frac{R^L_{k,t}}{R^L_t} \right)^{-\xi} x_{j,t} + \gamma^L s_{k,t-1} \tag{14}$$

where $R^L_t \equiv \left[\int_0^1 (R^L_{k,t})^{1-\xi} \mathrm{d}k \right]^{\frac{1}{1-\xi}}$ denotes the aggregate lending rate. Equation (14) implies that loan demand is decreasing in the relative lending rate, with the elasticity governed by ξ, reflecting imperfect substitutability across banks. The presence of the relationship term $\gamma^L s_{k,t-1}$ introduces persistence in borrowing patterns, capturing switching costs and borrower-specific attachments to lenders. As a result, demand faced by each bank depends not only on current pricing but also on past lending relationships, which gives rise to endogenous pricing power. An increase in borrowing capacity — driven by movements in θ_t — raises $x_{j,t}$, which shifts demand across banks and affects equilibrium lending rates through the demand system, thereby influencing equilibrium lending spreads.

Production function of each entrepreneur is

$$Y_{j,t} = A_t \left(N_{j,t}\right)^{1-\alpha} \left\{ \left(H^E_{j,t-1}\right)^{\phi} \left(K_{j,t-1}\right)^{1-\phi} \right\}^{\alpha} \tag{15}$$

where $Y_{j,t}$ is output, $N_{i,t}$ is labor input and $\alpha, \phi \in (0,1)$ are factor shares. TFP A_t follows the process

$$\log A_t = (1-\rho_A) \log A + \rho_A \log A_{t-1} + \sigma_A \epsilon_{A,t} \tag{16}$$

with iid innovation $\epsilon_{A,t}$ following a normal process with standard deviation σ_A where $A > 0$ and

[7] Some degree of market power in lending is necessary to sustain intermediation in equilibrium. Fama (1985) shows that, absent such market power, banks would be unable to compete with alternative sources of finance with lower funding costs, such as commercial paper markets. Empirically, a large literature documents imperfect competition in loan markets; see Carletti, Leonello, and Marquez (2024) for a recent review.

$\rho_A \in (0,1)$. The evolution of capital obeys the following law of motion

$$K_{j,t} = (1-\delta)\, K_{j,t-1} + \left[1 - \frac{\Omega}{2}\left(\frac{I_{j,t}}{I_{j,t-1}} - 1\right)^2\right] I_{j,t} \tag{17}$$

where $I_{j,t}$ is firm j's investment level, $\delta \in (0,1)$ the rate of depreciation of capital stock and $\Omega > 0$ is a cost adjustment parameter. The entrepreneur faces the following budget constraint

$$C^E_{j,t} + \int_0^1 R^L_{k,t-1} l_{jk,t-1} \mathrm{d}k \leq Y_{j,t} - W_t N_{j,t} - I_{j,t} - Q^H_t \left(H^E_{j,t} - H^E_{j,t-1}\right) + x_{j,t} \tag{18}$$

After imposing symmetric equilibrium, the FOCs of the entrepreneurs are

$$\lambda^E_t = \frac{1}{C^E_t - \gamma^E C^E_{t-1}} - \beta^E \mathbb{E}_t \frac{\gamma^E}{C^E_{t+1} - \gamma^E C^E_t} \tag{19}$$

$$\lambda^E_t = \beta^E \mathbb{E}_t \lambda^E_{t+1} R^L_t + \mu^E_t R^L_t \tag{20}$$

$$W_t = (1-\alpha)\frac{Y_t}{N_t} \tag{21}$$

$$\lambda^E_t Q^H_t = \beta^E \mathbb{E}_t \left[\lambda^E_{t+1}\left(Q^H_{t+1} + \alpha\phi \frac{Y_{t+1}}{H^E_t}\right)\right] + \mu^E_t \theta_t \mathbb{E}_t Q^H_{t+1} \tag{22}$$

$$\kappa^E_t = \alpha(1-\phi)\,\beta^E \mathbb{E}_t \left(\frac{\lambda^E_{t+1} Y_{t+1}}{K_t}\right) + \beta^E (1-\delta)\, \mathbb{E}_t \kappa^E_{t+1} + \mu^E_t \theta_t \mathbb{E}_t Q^K_{t+1} \tag{23}$$

$$\lambda^E_t = \kappa^E_t \left[1 - \frac{\Omega}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \Omega \frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}} - 1\right)\right] + \beta^E \Omega \mathbb{E}_t \left[\kappa^E_{t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 \left(\frac{I_{t+1}}{I_t} - 1\right)\right] \tag{24}$$

where μ^E_t, κ^E_t and λ^E_t are Lagrange multipliers associated with the collateral constraint (8), the law of motion of capital (17), and the entrepreneur's budget constraint (18), respectively. Entrepreneur's first order conditions with respect to consumption (19) and loans (20) may be combined to derive the standard Euler equation for consumption, while Equation (21) characterizes labor demand.

Equations (22) and (23) describe the optimal accumulation of collateralizable assets. They relate current asset prices to expected future payoffs, including both their productive return and their collateral value. The presence of the multiplier μ^E_t and the borrowing limit parameter θ_t implies that these assets are valued not only for their marginal productivity but also for their ability to relax the borrowing constraint.

Changes in θ_t directly affect the tightness of the borrowing constraint and, through μ^E_t, alter the shadow value of collateral. In turn, the loan Euler equation (20) links borrowing decisions to the lending rate R_t^L, so that shifts in borrowing capacity translate into changes in credit demand faced by banks. In the presence of lending relationships, this generates an endogenous response of lending spreads. Finally, entrepreneur's Euler equation for investment is given by (24). All the derivations of first order conditions have been relegated to Appendix C.

3.3 Banking Sector

Banks accept deposits from households and extend loans to entrepreneurs. They take the deposit rate R_t^D as given and choose lending rates $R_{k,t}^L$ and loan quantities $L_{k,t}$ to maximize profits

$$\Pi_{k,t} = R_{k,t-1}^L L_{k,t-1} + \int_0^1 D_{ik,t}\mathrm{d}i - L_{k,t} - R_{t-1}^D \int_0^1 D_{ik,t-1}\mathrm{d}i \tag{25}$$

The balance sheet of bank k is given by

$$L_{k,t} = \int_0^1 D_{ik,t}\mathrm{d}i \tag{26}$$

so that deposits constitute the sole source of funding.[8]

Each bank takes the demand for its loans as given:

$$L_{k,t} = \int_0^1 l_{jk,t}\mathrm{d}j = \int_0^1 \left[\left(\frac{R_{k,t}^L}{R_t^L} \right)^{-\xi} x_t + \gamma^L s_{k,t-1} \right] \mathrm{d}j \tag{27}$$

Banks thus face a downward-sloping demand for loans, with elasticity governed by ξ, and a relationship component $\gamma^L s_{k,t-1}$ that introduces persistence and demand lock-in in borrower-bank matches. This structure implies that current lending decisions affect future demand, so that banks internalize the intertemporal consequences of lending when setting loan terms, giving rise to endogenous, dynamic pricing incentives.

Maximizing profits subject to (26) and (27), the first-order conditions under symmetry are

$$\varrho_t^E = \mathbb{E}_t q_{t,t+1} \left[\left(R_t^L - R_t^D \right) + \gamma^L (1 - \rho_s) \mathbb{E}_t \varrho_{t+1}^E \right] \tag{28}$$

and

$$\xi \varrho_t^E x_t \frac{1}{R_t^L} = \mathbb{E}_t q_{t,t+1} L_{k,t} \tag{29}$$

[8]Deposits account for the majority of bank liabilities in the data; see Doerr, Drechsel, and Lee (forthcoming) for recent evidence.

The multiplier ϱ_t^E represents the marginal value of expanding lending. Equation (28) shows that this value reflects both current profits, captured by the spread $R_t^L - R_t^D$, and the continuation value arising from lending relationships. By expanding lending today, a bank increases future demand through habit formation, which gives rise to endogenous markups over funding costs. Equation (29) characterizes optimal pricing. Banks trade off higher margins against reductions in demand, taking into account both the elasticity of substitution across lenders and the persistence of relationships.

Crucially, the scale of credit demand x_t is determined by entrepreneurs' borrowing capacity linking borrowing constraints directly to bank pricing decisions. As a result, fluctuations in θ_t shift not only the level of loan demand but also the incentives for banks to adjust lending rates, thereby inducing endogenous movements in lending spreads. Detailed derivations are provided in Appendix C.

3.4 Transmission Mechanism

Combining Equations (28) and (29), the equilibrium lending rate satisfies

$$R_t^L = \underbrace{\left[R_t^D - \gamma^L (1-\rho_s) \frac{\mathbb{E}_t q_{t,t+1} \varrho_{t+1}^E}{\mathbb{E}_t q_{t,t+1}}\right]}_{\equiv MC_t} \times \underbrace{\left[\frac{\xi \left(1 - \frac{1}{\theta_t}\Xi_t\right)}{\xi \left(1 - \frac{1}{\theta_t}\Xi_t\right) - 1}\right]}_{\equiv M_t} \tag{30}$$

where $\Xi_t \equiv \gamma^L \rho_s \frac{s_{t-2}}{a_t/R_t^L} - \gamma^L (1-\rho_s) \frac{l_{t-1}}{a_t/R_t^L}$. To simplify notation, define the continuation value of a lending relationship as

$$V_t \equiv \frac{\mathbb{E}_t q_{t,t+1} \varrho_{t+1}^E}{\mathbb{E}_t q_{t,t+1}}$$

which captures the expected discounted value of future lending to a borrower. Define also

$$\Omega_t \equiv \frac{\gamma^L \Delta_t R_t^L}{\theta_t a_t}, \qquad \text{where} \qquad \Delta_t \equiv \rho_s s_{t-2} - (1-\rho_s) l_{t-1}$$

so that Ω_t summarizes how the inherited stock of lending relationships, scaled by current borrowing capacity, affects the markup.

Equation (30) decomposes the lending rate into an effective marginal cost, MC_t, and a markup, M_t. The marginal cost equals the deposit rate R_t^D adjusted by the continuation value of lending relationships: expanding lending raises future demand through habit formation, which reflects the continuation value of lending relationships. When future lending opportunities are more valuable, this term reduces the effective marginal cost of extending credit. The markup depends on the elasticity of substitution across lenders ξ and on the ratio $\frac{1}{\theta_t}\Xi_t$, which captures the tightness of borrowing constraints relative to the inherited stock of lending relationships. Through this term, changes in θ_t affect not only the level of credit demand but also its interest-rate sensitivity, and hence banks' pricing decisions. The lending spread $\Psi_t \equiv R_t^L - R_t^D$ therefore reflects both channels.

Arm's-length benchmark

When $\gamma^L = 0$, all terms in Ξ_t vanish, so $\Xi_t = 0$ and $M_t = \frac{\xi}{\xi-1}$ is constant. Moreover, $MC_t = R_t^D$, and Equation (30) reduces to

$$R_t^L = R_t^D \cdot \frac{\xi}{\xi - 1} \tag{31}$$

The spread $\Psi_t = R_t^D \cdot \frac{1}{\xi-1}$ is therefore independent of θ_t. In partial equilibrium, LTV shocks affect quantities but not lending spreads in the absence of relationship lending.

Relationship lending

When $\gamma^L > 0$, borrowing capacity and pricing are jointly determined. Changes in θ_t affect lending rates through both the markup M_t and the continuation value embedded in MC_t. The following proposition summarizes two properties of this interaction in partial equilibrium.

Proposition 1. *Let $\hat{\Psi}_t \equiv \Psi_t - \bar{\Psi}$ and $\hat{\theta}_t \equiv \theta_t - \bar{\theta}$. Suppose $\xi > 1$, $\rho_s \in (0,1)$, and the collateral constraint binds.*

(i) If $\gamma^L = 0$, then $\frac{\partial \hat{\Psi}_t}{\partial \hat{\theta}_t} = 0$ for all t. If $\gamma^L > 0$, then $\frac{\partial \hat{\Psi}_t}{\partial \hat{\theta}_t} \neq 0$ generically (i.e., except in knife-edge cases such as $\rho_s = \frac{1}{2}$ that eliminate the inherited relationship term).

(ii) The cross-derivative satisfies

$$\left.\frac{\partial^2 \hat{\Psi}_t}{\partial \hat{\theta}_t \, \partial \gamma^L}\right|_{\gamma^L=0} = -\frac{\xi^2 (\bar{R}^D)^2 (2\rho_s - 1)\bar{l}}{(\xi - 1)^3 \, \bar{\theta}^2 \, \bar{a}} \neq 0 \quad \textit{for } \rho_s \neq \tfrac{1}{2} \tag{32}$$

A proof is provided in Appendix A.

Part (i) shows that spread responses to LTV shocks are absent under arm's-length intermediation and arise only with relationship lending. Part (ii) establishes a local complementarity in the sense of increasing differences: the sensitivity of spreads to borrowing capacity rises with relationship intensity. Starting from $\gamma^L = 0$, an increase in relationship intensity generates a nonzero sensitivity of spreads to LTV shocks. For $\rho_s > \frac{1}{2}$, the cross-derivative is negative, implying that stronger relationships amplify spread compression in response to a positive LTV shock.

The proposition characterizes local properties of the pricing equation in partial equilibrium. It does not by itself determine the magnitude of the quantitative responses reported in Section 5, which reflect the interaction of this pricing channel with general equilibrium feedback over time. It does, however, identify the mechanism through which such effects can arise.

The proposition also clarifies a structural distinction between LTV and LTD shocks. LTD shocks enter the bank's balance sheet and directly shift funding conditions, appearing in marginal cost even when $\gamma^L = 0$ (see Appendix B for the corresponding pricing equation). As a result, they generate a spread response under arm's-length intermediation, with relationship lending acting only as an amplification mechanism. By contrast, LTV shocks operate exclusively through borrower-side constraints and do not enter the bank's pricing problem when $\gamma^L = 0$. In that benchmark, spreads are invariant to LTV shocks. Relationship lending is therefore not an amplifier of an existing channel but the source of the channel itself: it endogenizes a spread response that is otherwise absent. The large differences in macroeconomic outcomes between the two shocks reported in Section 5.7 reflect the propagation of this structural asymmetry through general equilibrium dynamics, rather than differences in shock size or calibration.

Dynamics

The direction of spread movements can be characterised in partial equilibrium.

On impact, lagged lending stocks s_{t-2} and l_{t-1} are predetermined at their steady-state values. A positive shock $\hat{\theta}_0 > 0$ relaxes borrowing constraints and expands credit demand. In the markup channel, the relevant state variable Ω_t — which scales the markup and is inversely related to θ_t — declines on impact, reducing M_0. In the continuation value channel, higher expected lending raises the continuation value V_t embedded in marginal cost, lowering MC_0. Both effects reduce R^L_0 relative to R^D_0, implying $\hat{\Psi}_0 < 0$.

During the contraction, θ_t returns toward its steady-state value while the inherited stock of lending relationships remains elevated. As a result, Ω_t rises above its steady-state level, increasing the markup. At the same time, declining lending reduces the continuation value, raising marginal cost. Both effects increase R_t^L relative to R_t^D, implying $\hat{\Psi}_t > 0$. The spread overshoot arises from the dynamics of predetermined state variables and does not require an additional shock.

Both channels scale with γ^L, so the magnitude of spread movements increases with relationship intensity. These dynamics are confirmed in the full general equilibrium simulations reported in Section 5.

3.5 Aggregation and Market Clearing

Aggregate resource constraint of the economy is

$$C_t^P + C_t^E + I_t = Y_t \tag{33}$$

The clearing condition for the housing market is

$$H_t^P + H_t^E = H \tag{34}$$

where H is the total fixed supply of housing.

4 Model Solution and Parameterization

The model is solved by log-linearization around steady-state using standard perturbation techniques. A period in the model refers to a quarter. Appendices D, E and F contain the list of equilibrium equations, the list of steady-state conditions and the system of log-linear equations, respectively. The calibration of parameters is rather standard and is summarized in Table 1.

I allow for a relatively significant difference between discount factors of households and entrepreneurs so that steady-state value of μ_t^E is different from zero. The degree of habit formation in consumption is chosen to be 0.6 which is in line with empirical estimates (Smets and Wouters, 2007). The Frisch elasticity of labor supply η is chosen to be 1.01 and the value of weight on housing ς is set to 0.1 (Iacoviello, 2005).

The labor income share is 0.3 which implies a steady-state capital-output ratio of 1.15, in line with US data (Liu, Wang, and Zha, 2013). The input share of land in production is close to the value estimated in Liu, Wang, and Zha (2013) and Iacoviello (2005). The investment adjustment

Table 1: Parameter values

	Value	Description	Source
β^P	0.995	Discount factor, households	Iacoviello (2005)
β^E	0.95	Discount factor, entrepreneurs	Iacoviello (2005)
γ^i, $i = \{P, E\}$	0.6	Habits in consumption, households, entrepreneurs	Smets and Wouters (2007)
η	1.01	Frisch elasticity of labor	Iacoviello (2005)
ς	0.1	Weight on utility from housing	Iacoviello (2005)
α	0.3	Non-labor share of production	Iacoviello (2005)
ϕ	0.1	Land share of non-labor input	Iacoviello (2005)
Ω	1.85	Investment adjustment cost parameter	Ravn (2016)
δ	0.0285	Capital depreciation rate	Ravn (2016)
γ^L	0.72	Deep habit formation	Aliaga-Díaz and Olivero (2010); Melina and Villa (2014, 2018); Ravn (2016); Shapiro and Olivero (2020)
ρ_s	0.93	Persistence of stock of deep habits	Aliaga-Díaz and Olivero (2010); Melina and Villa (2014, 2018); Ravn (2016); Shapiro and Olivero (2020)
ξ	230	Elasticity of substitution between banks	Aliaga-Díaz and Olivero (2010); Ravn (2016)
θ	0.75	Steady-state value of LTV ratio	Liu, Wang, and Zha (2013); Ravn (2016); Jensen, Petrella, Ravn, and Santoro (2020)
ρ_θ	0.90	Persistence of shock to credit limit	See Text
σ_θ	0.011	Standard deviation of shock to credit limit	See Text

cost parameter is given a value of 1.85 (Ravn, 2016). The literature contains estimates which range from 0 (Liu, Wang, and Zha, 2013) to above 26 (Christiano, Motto, and Rostagno, 2010). The capital depreciation rate implies a steady-state ratio of non-residential investment to output slightly above 0.13 as in Beaudry and Lahiri (2014).

For the banking sector, I draw on estimates from the deep habits in banking literature (Aliaga-Díaz and Olivero, 2010; Melina and Villa, 2014, 2018; Ravn, 2016; Shapiro and Olivero, 2020). I set the habit parameter in lending to $\gamma^L = 0.72$ and the persistence of lending relationships to $\rho_s = 0.93$, following Aliaga-Díaz and Olivero (2010) and Ravn (2016). The elasticity of substitution across loan varieties is set to $\xi = 230$, also in line with Aliaga-Díaz and Olivero

(2010) and Ravn (2016). Importantly, these parameters have distinct economic roles. The elasticity ξ governs the degree of static market power by determining the baseline markup of lending rates over funding costs. In contrast, γ^L and ρ_s shape the strength and persistence of borrower-bank relationships, introducing an intertemporal linkage in loan demand whereby current lending affects future borrowing decisions. As a result, banks internalize the dynamic demand effects of their lending choices, giving rise to a form of endogenous, intertemporal market power that is absent in standard models.

Rather than treating these parameters as auxiliary, I use them to characterize how the structure of credit markets shapes macroeconomic outcomes. Systematically varying γ^L and ρ_s generates heterogeneous boom-bust dynamics and, in particular, large differences in the magnitude and persistence of output losses following credit expansions. This exercise shows that the severity of corporate credit-driven downturns is not determined solely by the size of the initial expansion, but also by the nature of lending relationships and the extent of endogenous pricing in credit markets. In economies with stronger and more persistent lending relationships, amplification is notably higher, with larger booms, sharper reversals, and more persistent output losses. Variation in these parameters therefore provides a tractable way to map differences in financial structure into differences in macroeconomic outcomes, offering a novel link between relationship lending and the empirical evidence on credit booms and subsequent downturns.

I set the steady-state loan-to-value (LTV) ratio to $\theta = 0.75$, in line with Liu, Wang, and Zha (2013), Ravn (2016), and Jensen, Petrella, Ravn, and Santoro (2020). The LTV shock follows an AR(1) process with persistence $\rho_\theta = 0.90$ in the baseline and standard deviation $\sigma_\theta = 0.011$, implying moderate but economically meaningful fluctuations in borrowing capacity. To assess the role of shock persistence, I also consider a higher value of $\rho_\theta = 0.95$, which captures more prolonged expansions in credit conditions.

Varying the persistence of the LTV process is quantitatively important in this environment because it governs the duration over which borrowing constraints remain relaxed. In the presence of lending relationships, more persistent collateral shocks not only sustain higher borrowing by entrepreneurs but also amplify the dynamic response of lending spreads through banks' intertemporal pricing decisions. As a result, longer-lived credit expansions translate into more pronounced boom-bust cycles and substantially larger and more persistent output losses (Dell'Ariccia, Igan, Laeven, and Tong, 2016). This experiment therefore isolates how the interaction between credit conditions and relationship lending shapes the duration and severity of downturns following corporate credit booms.

5 Results and Discussion

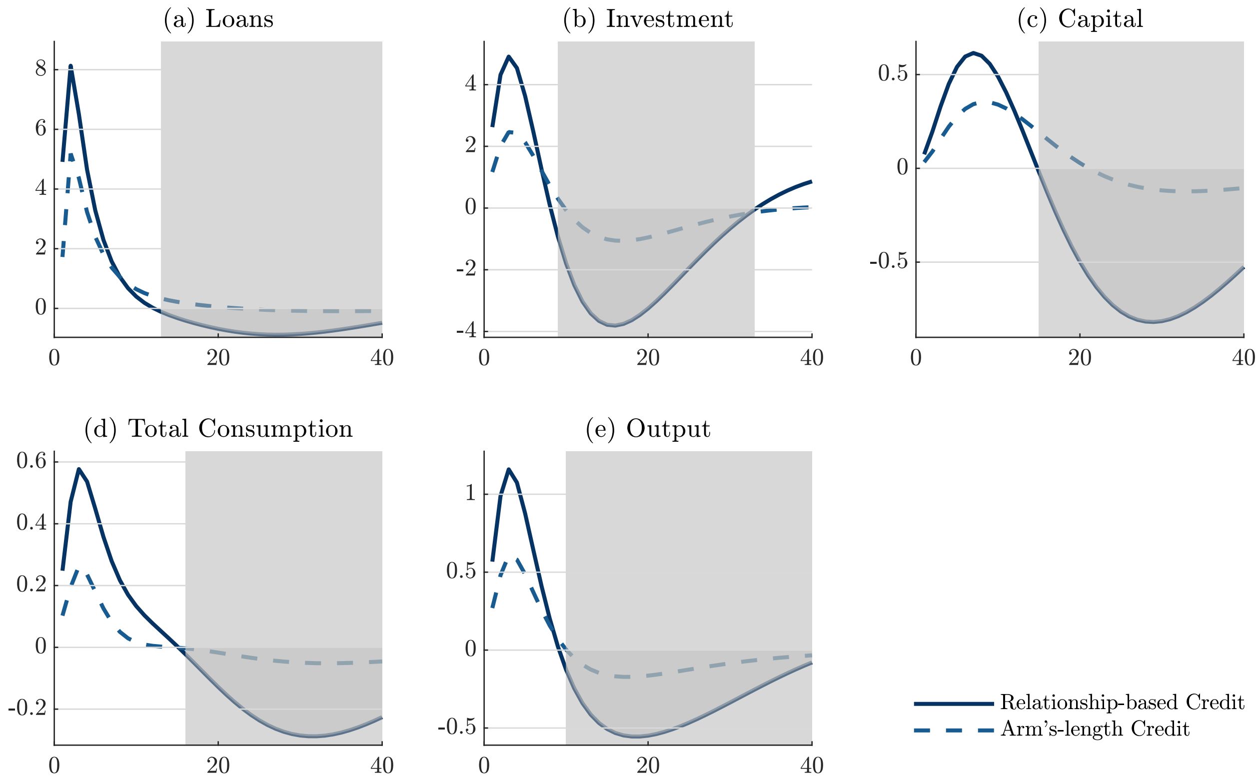
This section evaluates the mechanism established in Section 3.4 and quantifies its macroeconomic implications. Four results organize the analysis. First, a one-time relaxation of corporate borrowing constraints generates pronounced endogenous boom-bust dynamics in the presence of relationship-based lending, with a short-lived expansion followed by a significantly more persistent contraction that is often comparable to or larger than the initial boom and arises without any additional shock, belief revision, or exogenous reversal. Second, the magnitude of these dynamics depends critically on the structure of credit intermediation: cumulative output losses under relationship lending are three to four times larger than in an otherwise identical arm's-length economy, despite identical initial credit expansions. Third, these losses increase monotonically with the intensity and persistence of lending relationships and with steady-state corporate leverage, yielding sharp cross-sectional predictions. Fourth, even within financially-driven expansions, the source of the credit impulse is decisive: LTV shocks generate a peak contraction and cumulative output losses an order of magnitude larger than LTD shocks of equal size in an otherwise identical economy.

Taken together, these results identify endogenous bank pricing in relationship-based credit markets as a first-order amplification mechanism — one that is absent from standard collateral-constraint models — and show that abstracting from the structure of financial intermediation leads to a systematic underestimate of the macroeconomic costs of corporate credit booms.

5.1 Corporate Credit-Driven Endogenous Boom-Bust Cycles

Figure 1 reports the impulse responses to a one-time relaxation of the corporate borrowing constraint in economies with relationship-based and arm's-length lending. In the relationship-based economy, the shock generates a pronounced boom-bust cycle: credit and investment expand sharply on impact, with output rising by approximately 1.1 percent at its peak, followed by a contraction that is both deep and more persistent than the expansion. Output falls to roughly 0.5 percent below steady state and recovers only gradually, exhibiting the most prolonged response among macroeconomic aggregates and implying substantial medium-run losses that accumulate after the initial expansion has reversed.

Figure 1: Impact of a One-Off Corporate Credit Expansion



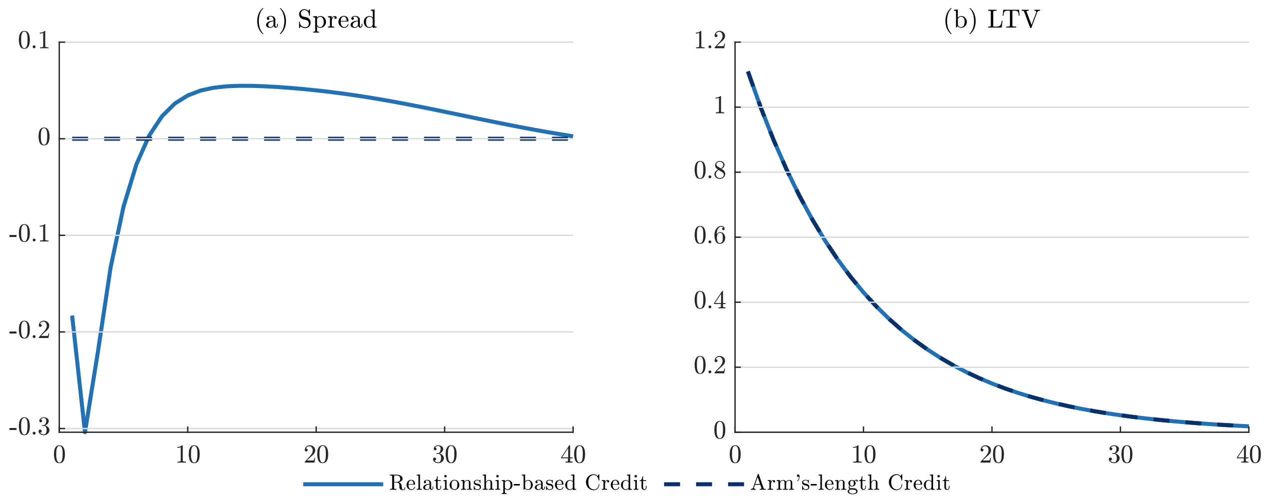
Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state. Grey area denotes where variables in relationship-based credit economy are below zero.

A central feature of these dynamics is that the contraction arises endogenously. The model is solved using standard log-linearization, and no additional disturbance — such as an exogenous tightening of financial conditions, a reversal in fundamentals, or a shift in beliefs — is required to generate the downturn. The bust is instead the consequence of the same forces that amplify the boom.

The mechanism, illustrated in Figure 2, follows directly from the interaction discussed in Section 3.4. The relaxation in the LTV ratio expands firms' borrowing capacity, increasing credit demand and raising investment and output through the collateral channel. In the presence of lending relationships, banks simultaneously adjust lending spreads to attract and retain borrowers. Both the markup and continuation-value components of bank pricing operate in the direction of spread compression on impact. This compression reinforces the initial expansion by lowering borrowing costs, amplifying the increase in credit, investment, and output beyond what the relaxation of borrowing constraints alone would generate.

As the effects of the credit loosening dissipate, the same pricing mechanism reverses. The expansion leaves the habit stock elevated above its steady-state level, strengthening banks' hold-

Figure 2: Mechanism – One-Time Corporate Credit Expansion



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state.

up position vis-à-vis their borrowers. This generates an overshoot in lending spreads during the contraction: banks raise spreads above their steady-state level to extract rents from a larger and more captive borrower base. This endogenous tightening of effective credit conditions reduces borrowing, depresses investment, and drives the contraction in output. The bust is therefore the direct consequence of the intertemporal pricing incentives that governed the boom.

The arm's-length economy provides a sharp counterfactual that isolates this mechanism. As shown in Section 3.4, when $\gamma^L = 0$, lending spreads do not respond to LTV shocks: every term in the spread equation is proportional to the habit parameter, so the price channel is identically zero regardless of the size or persistence of the shock. Consistent with this result, the same LTV relaxation in the arm's-length economy generates a significantly smaller and more symmetric response: credit and output rise modestly and return to steady state without a pronounced contraction. The comparison identifies the source of asymmetry precisely. The boom-bust pattern in the relationship-based economy is not a property of the LTV shock or of the collateral constraint in isolation, but of their interaction with endogenous bank pricing. Without relationship lending, the expansion remains dampened and largely symmetric; with it, the same expansion sets in motion a pricing reversal that generates a substantially more persistent contraction, with downturns that are often comparable to or larger than the initial boom.

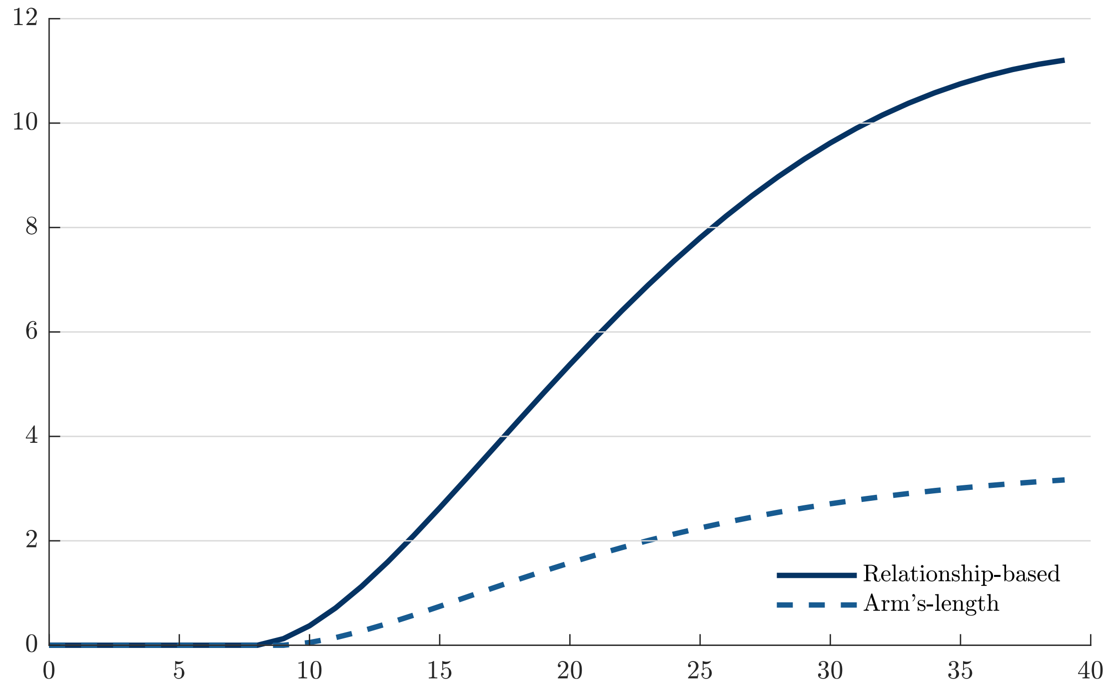
These dynamics also rationalize the joint behavior of credit and spreads observed in the data. Episodes preceding financial crises are characterized by rising leverage and compressing spreads, followed by a sharp spread reversal during the downturn, as documented by Krishnamurthy and Muir (2025). Standard macro-finance models typically predict that higher leverage is associated with rising spreads (Gertler and Kiyotaki, 2010; He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014), making this pattern difficult to reconcile. In the present framework, the arm's-length benchmark shows that borrowing-constraint relaxations can generate expansions even in the absence of spread movements. Once credit is relationship-based, however, the same expansion endogenously produces spread compression during the boom and overshooting during the bust, as a direct implication of banks' intertemporal pricing problem. The discussion in Section 3.4 links both phases of the cycle to the same underlying mechanism: incentives that favor aggressive pricing to acquire borrowers during expansions imply equally strong incentives to extract rents when conditions reverse. The model therefore provides a unified account of the observed joint dynamics of credit and spreads without relying on exogenous shifts in beliefs or additional shocks.

5.2 Cumulative Output Losses after Corporate Credit Booms

Figure 3 quantifies the medium-run output losses implied by the dynamics above over a forty-quarter horizon. In the relationship-based economy, cumulative output losses reach approximately 12 percent at the baseline leverage ratio of 0.75 — between three and four times larger than in the arm-s-length economy under an identical credit expansion. Because the two economies differ only in the presence of relationship-based pricing, this gap isolates the quantitative importance of the price-mediated feedback loop identified in Section 3.4. In the arm's-length benchmark, where lending spreads do not respond to LTV shocks, the expansion and subsequent adjustment remain relatively symmetric and generate limited cumulative losses. Under relationship lending, by contrast, the combination of spread compression during the boom and overshooting during the bust produces a considerably larger and more persistent contraction.

Figure 4 further characterizes the nature of these losses. While the depth of the contraction is substantially greater under relationship lending, the recovery half-life — the number of quarters required for output to recover half of its peak decline — is similar across the two economies. The amplification therefore operates primarily through the severity of the downturn rather than its duration. Output falls much further below trend, but does not take proportionately longer to recover, implying that the additional losses generated by relationship lending are concentrated

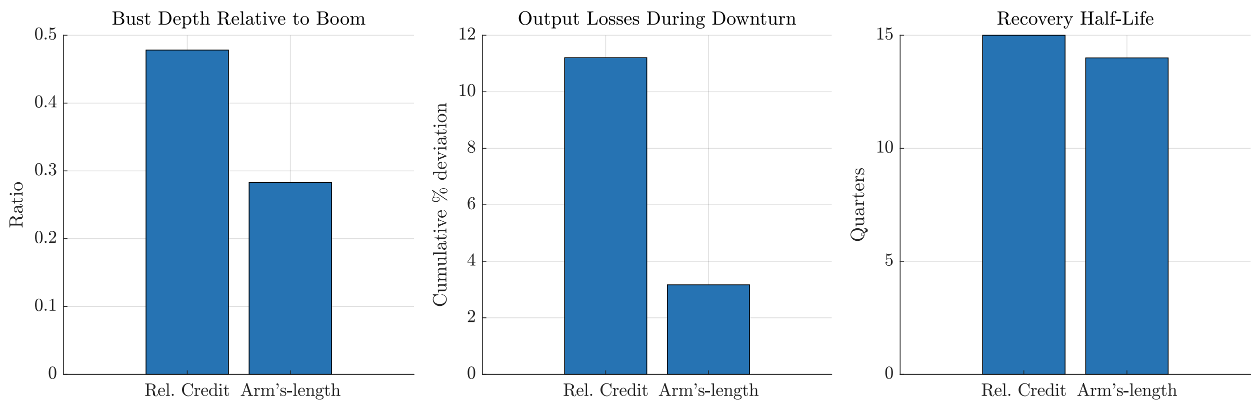
Figure 3: Cumulative Output Losses



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show cumulative output losses in percentage.

around the trough of the cycle. This pattern is consistent with the empirical characterization of financial crises as sharp and severe output events rather than prolonged gradual deteriorations.

Figure 4: Output Asymmetry



The magnitudes implied by the model are broadly consistent with the empirical evidence on the macroeconomic costs of corporate credit booms. Ivashina, Kalemli-Özcan, Laeven, and Müller (2025) document that real GDP is approximately 15 percent lower five years after large pre-crisis increases in corporate credit. The results here are generated by a one-standard-deviation relaxation in borrowing constraints; given the log-linear structure of the model, larger shocks scale proportionally, implying that the model can match the empirical magnitudes at higher shock realizations or leverage levels. The baseline results should therefore be interpreted as a conservative benchmark for the output losses associated with corporate credit expansions.

The framework also provides a structural interpretation of the cross-country evidence documented by Jordà, Schularick, and Taylor (2013), who show that more credit-intensive expansions are systematically followed by deeper recessions. In the model, the same mechanism that amplifies the boom — endogenous spread compression that attracts additional borrowing — also amplifies the bust through spread overshooting that tightens credit conditions without any additional disturbance. If the intensity of relationship lending varies across economies, as suggested by evidence on bank-firm linkages, the model predicts that the association between credit growth and subsequent output losses should be stronger in economies with more prevalent relationship-based intermediation, holding the size of the expansion fixed. This provides a testable cross-sectional implication linking financial structure to macroeconomic outcomes.

The mechanism underlying these aggregate losses is consistent with a broader body of microeconomic evidence on the role of bank-firm relationships during downturns. Empirical studies show that bank-dependent borrowers face higher borrowing costs and reduced credit supply during recessions and financial crises, and that disruptions to lending relationships are associated with declines in investment and employment (Chava and Purnanandam, 2011; Chodorow-Reich, 2014; Sette and Gobbi, 2015; Ricci, Soggia, and Trimarchi, 2023; Salvadè, Troege, and Taillet, 2024). Moreover, firms experiencing relationship disruptions are often unable to fully substitute toward alternative sources of financing, reinforcing the persistence of the contraction. The model abstracts from explicit relationship severance (Carvalho, Ferreira, and Matos, 2015; Li, Lu, and Srinivasan, 2019), yet still generates substantial output losses through endogenous pricing alone. This suggests that the quantitative magnitudes reported here are likely conservative relative to the full general equilibrium effects operating in economies where relationship disruption further constrains access to credit.

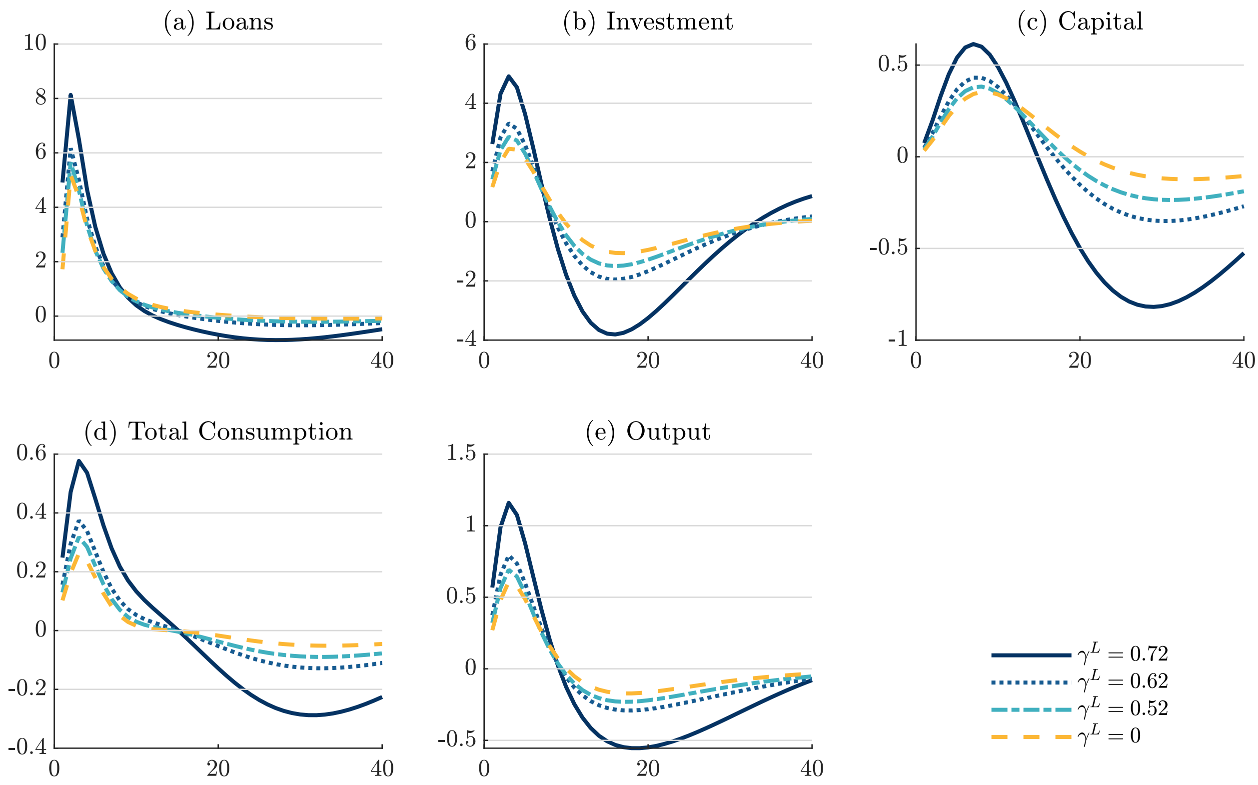
Taken together, these results show that the structure of credit intermediation is a central determinant not only of the dynamics of the boom-bust cycle but also of the magnitude and distribution of output losses over time. Relationship-based lending amplifies the depth of the contraction without proportionately extending its duration, generating large cumulative losses through endogenous movements in lending spreads that are absent in arm's-length environments.

5.3 Role of Relationship-Based Credit

Section 3.4 delivers a clear comparative static: stronger lending relationships — captured by a higher habit parameter γ^L — amplify both the expansion and the subsequent contraction. This result follows from the fact that the marginal amplification generated by relationship lending is increasing in the intensity of lending ties.

Figure 5 confirms this prediction across four values of γ^L (0.72 in the baseline, 0.62, 0.52, and 0 corresponding to the arm's-length case). The amplification is monotone at all horizons and becomes more pronounced over time as the effects of dynamic pricing accumulate. Moving from the arm's-length benchmark to the baseline level of relationship intensity generates a large increase in the volatility of credit, investment, and output, with the strongest differences emerging during the contraction phase.

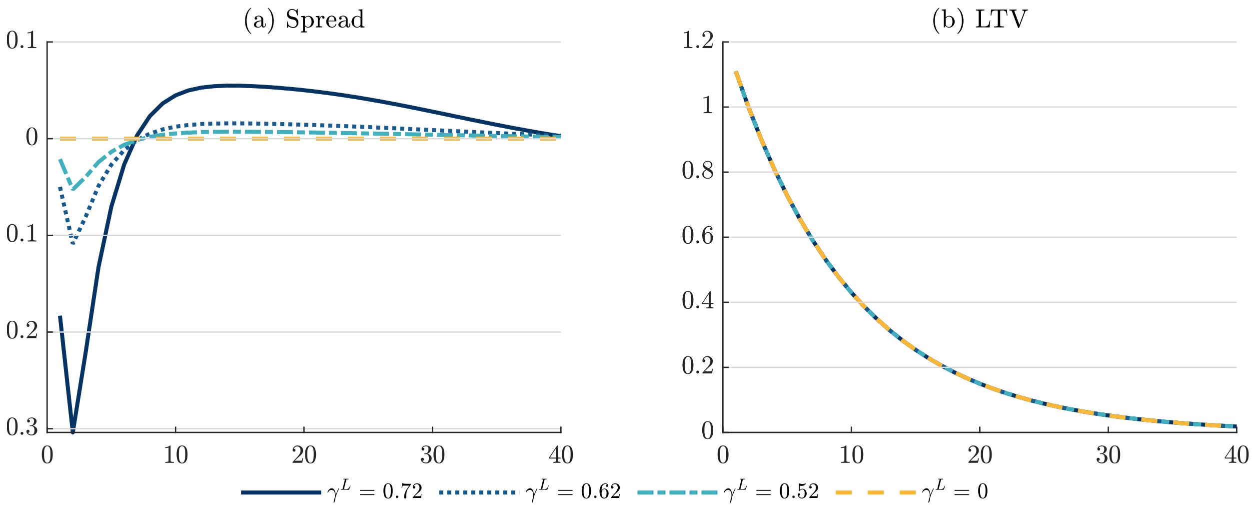
Figure 5: One-Time Corporate Credit Expansion and Intensity of Relationship-Based Credit



Note: Except intensity of relationship-based lending parameter γ^L, all other parameters held fixed at their baseline value in Table 1. Numbers on the horizontal axis represent quarters since the shock. Numbers on the vertical axis show percentage deviation from the steady state.

The mechanism (Figure 6) follows directly from the interaction between borrower lock-in and banks' intertemporal pricing incentives. A higher γ^L strengthens the hold-up effect: banks retain a larger share of their borrower base over time, increasing the present value of future rents from each relationship. This raises the incentive to compete for borrowers during the expansion. Banks therefore compress spreads more aggressively, lowering borrowing costs and reinforcing the increase in credit demand generated by the relaxation of borrowing constraints. The resulting expansion in credit, investment, and output is correspondingly larger.

Figure 6: Mechanism – One-Time Corporate Credit Expansion and Intensity of Relationship-Based Credit



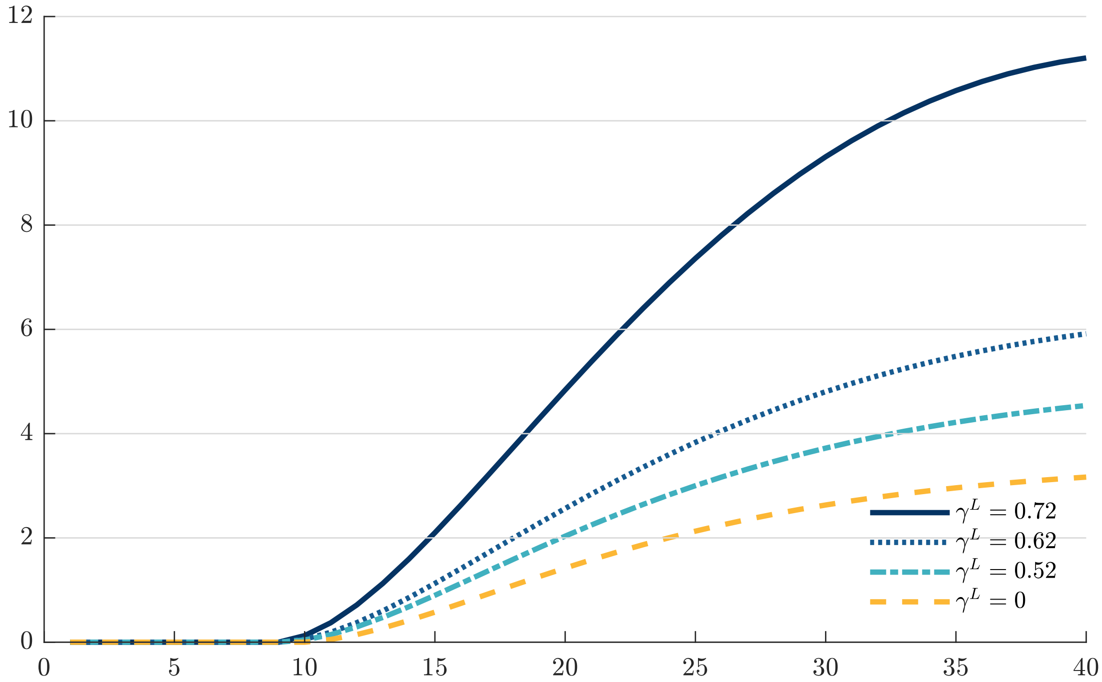
Note: Except intensity of relationship-based lending parameter γ^L, all other parameters held fixed at their baseline value in Table 1. Numbers on the horizontal axis represent quarters since the shock. Numbers on the vertical axis show percentage deviation from the steady state.

When the expansion reverses, the same force operates in the opposite direction. A stronger hold-up position allows banks to extract greater rents from a larger and more captive borrower base. Spreads therefore overshoot by more, tightening effective credit conditions and generating a sharper contraction in borrowing, investment, and output. The amplification of the bust is thus the direct counterpart of the amplification of the boom: both arise from the same underlying pricing incentives.

Figure 7 shows that these dynamics translate into substantial differences in medium-run outcomes. Cumulative output losses increase monotonically with γ^L, with the transition from arm's-length lending to the baseline level of relationship intensity accounting for a three-to-four-fold increase in losses. The increase is nonlinear, but not uniformly so across the parameter space. As shown in Section 3.4, this channel is absent in the arm's-length economy and becomes operative only once lending relationships introduce endogenous spread dynamics.

These results underscore that the structure of financial intermediation is not a second-order feature of the model but a primary determinant of macroeconomic outcomes. Models that abstract from relationship-based lending — thereby shutting down the price-mediated feedback

Figure 7: Cumulative Output Losses at Different Degrees of Intensity of Relationship-Based Credit



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show cumulative output losses in percentage.

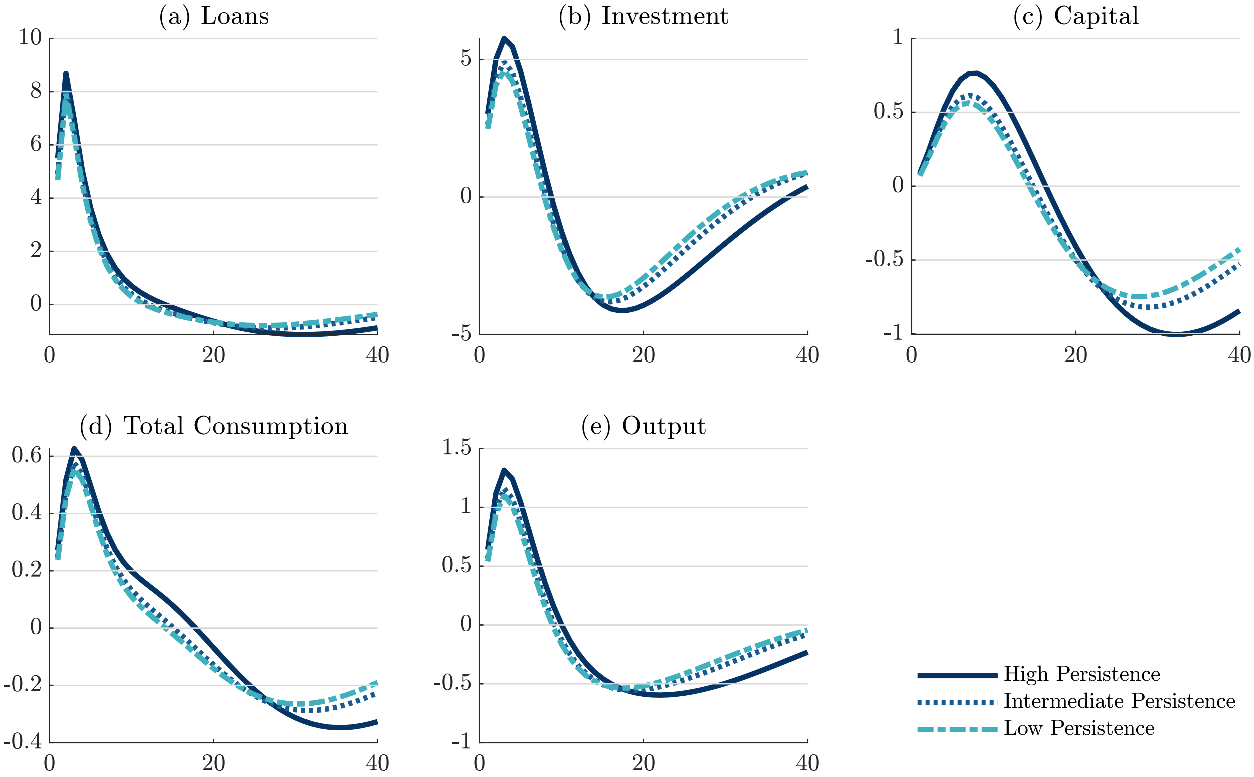
between borrowing constraints and lending spreads — cannot capture this amplification mechanism, regardless of their calibration. In this sense, variation in γ^L provides a direct quantitative mapping from the intensity of bank-firm relationships to the severity of boom-bust cycles and the magnitude of the associated output losses.

5.4 Persistence of Relationship-Based Credit

I now vary the persistence of the habit stock, holding the intensity of lending relationships fixed at its baseline level. Figure 8 reports impulse responses for three values of persistence, corresponding to cases in which approximately 10 percent, 5 percent, and 2.5 percent of the habit stock remains after a decade. Increasing persistence amplifies both the expansion and the subsequent contraction, consistent with the discussion in Section 3.4, but through a mechanism distinct from the variation in relationship intensity considered above.

Higher persistence extends the horizon over which banks can extract rents from their borrower base. Anticipating a longer period of future rent extraction, banks have a stronger incentive to acquire and retain borrowers during the expansion. As a result, they compress lending spreads more aggressively on impact, reinforcing the increase in credit demand generated by the

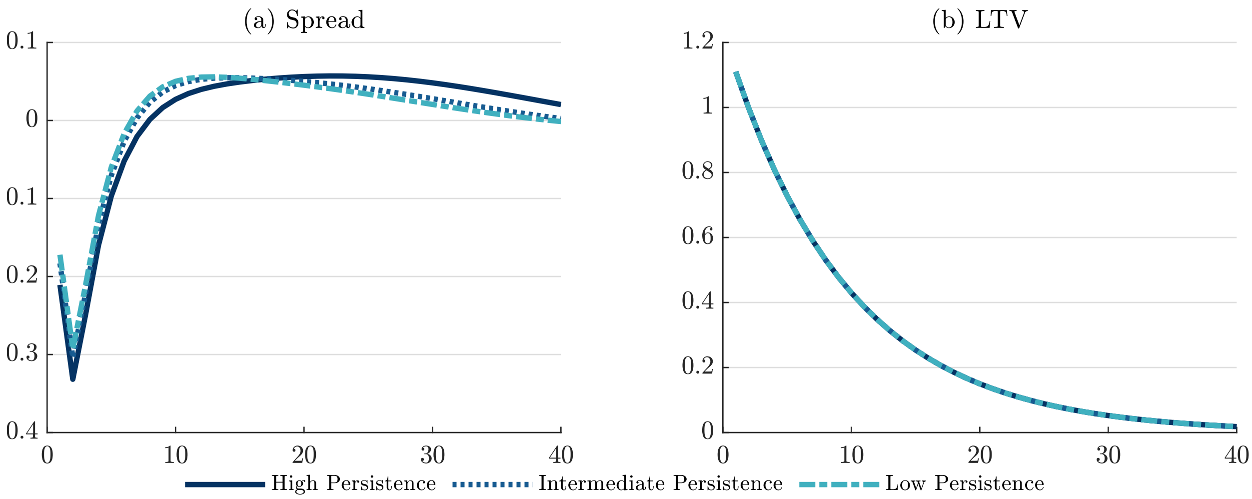
Figure 8: One-Time Corporate Credit Expansion and Persistence of Relationship-Based Credit



Note: Except persistence of relationship-based lending parameter ρ_s, all other parameters held fixed at their baseline value in Table 1. Numbers on the horizontal axis represent quarters since the shock. Numbers on the vertical axis show percentage deviation from the steady state.

relaxation of borrowing constraints (Figure 9). The expansion in credit, investment, and output is therefore larger when relationships are more persistent.

Figure 9: Mechanism – One-Time Corporate Credit Expansion and Persistence of Relationship-Based Credit

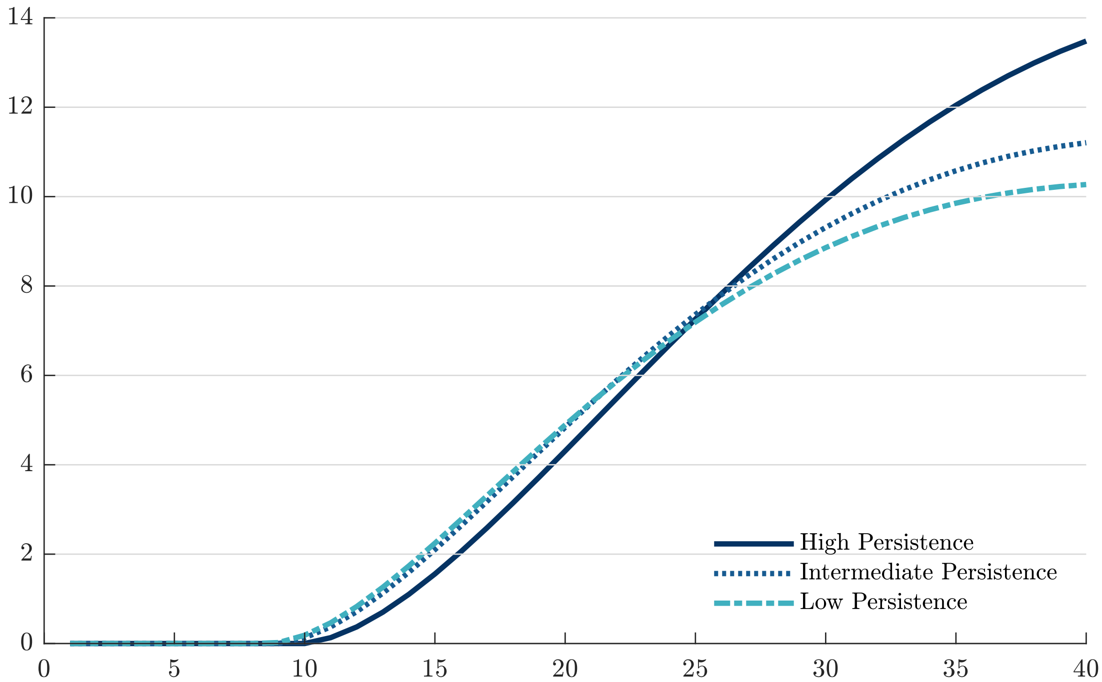


Note: Except persistence of relationship-based lending parameter ρ_s, all other parameters held fixed at their baseline value in Table 1. Numbers on the horizontal axis represent quarters since the shock. Numbers on the vertical axis show percentage deviation from the steady state.

As the effects of the credit loosening dissipate, the same logic operates in reverse. The longer expected duration of borrower lock-in increases the value of rent extraction during the contraction, leading banks to raise spreads more aggressively once the expansion ends. This generates a sharper tightening of effective credit conditions and a correspondingly deeper contraction in borrowing, investment, and output. The amplification of the cycle thus reflects the intertemporal nature of bank pricing: persistence increases the value of both acquiring borrowers during the boom and extracting rents during the bust.

Figure 10 shows that these dynamics translate into larger cumulative output losses as persistence increases. The relationship is monotone, confirming that both the intensity and the persistence of lending relationships independently amplify the boom-bust cycle. At the same time, the gradient with respect to persistence is noticeably smaller than the gradient with respect to intensity documented in the previous subsection. This asymmetry is informative. It implies that the strength of the hold-up effect in any given period — captured by relationship intensity — plays a larger role in determining macroeconomic outcomes than the duration over which that effect persists.

FIGURE 10: CUMULATIVE OUTPUT LOSSES AND PERSISTENCE OF RELATIONSHIP-BASED CREDIT



NOTE: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show cumulative output losses in percentage.

This ranking yields a natural cross-sectional implication. Differences in the intensity of bank-firm relationships across economies should be a more important determinant of heterogeneity in output losses following corporate credit booms than differences in the typical duration of those relationships. This prediction is consistent with evidence that economies characterized by concentrated banking sectors and strong bilateral lending ties exhibit more pronounced credit cycle dynamics than those with more arm's-length financial systems. More broadly, the results highlight that different dimensions of financial structure — intensity versus persistence — have distinct quantitative implications for macroeconomic stability, even when they operate through the same underlying pricing mechanism.

5.5 Longer-Running Corporate Credit Booms

I next examine the persistence of the LTV shock itself, which governs the duration of the credit expansion rather than the persistence of lending relationships. This distinction is central for interpreting the empirical evidence that longer and more credit-intensive booms are followed by deeper recessions, as documented by Dell'Ariccia, Igan, Laeven, and Tong (2016). The model provides a structural mechanism for this regularity.

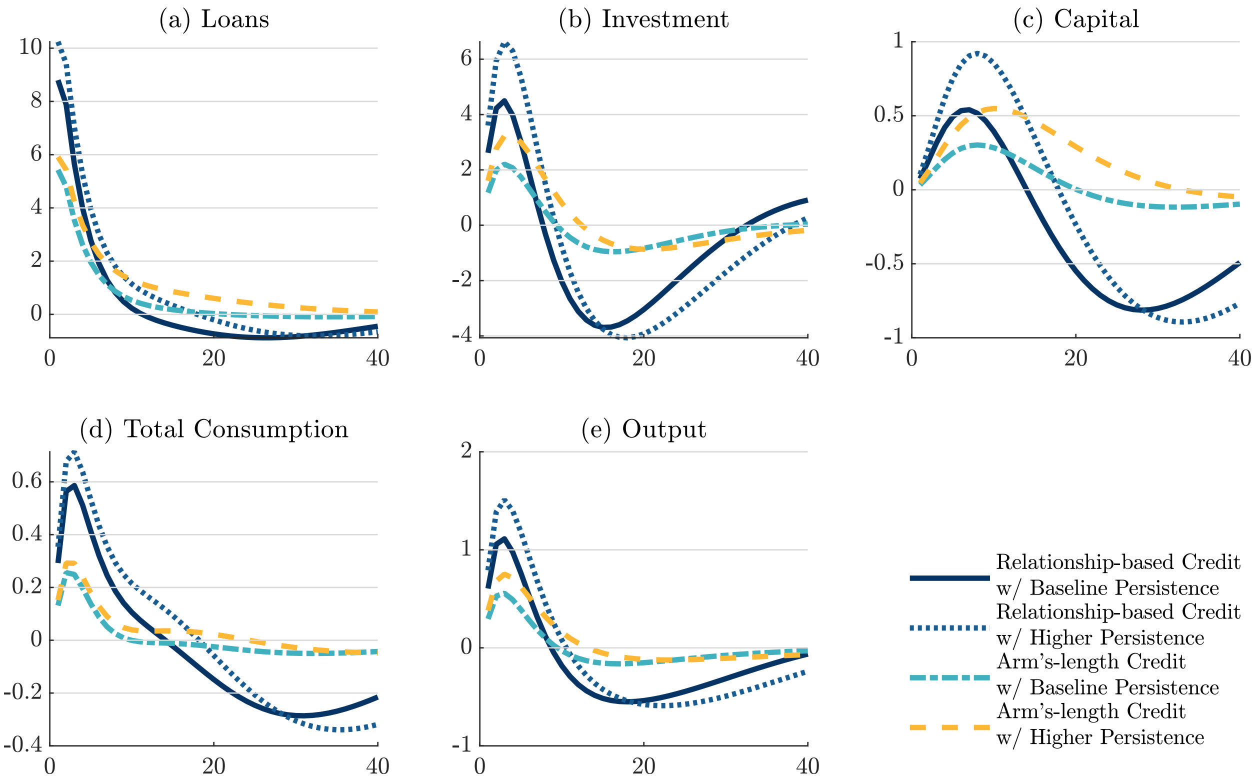
Figure 11 compares the baseline specification with a more persistent relaxation of borrowing constraints. A more persistent shock extends the period over which firms can expand borrowing against collateral, increasing both the scale and duration of the credit expansion. At the same time, it raises the value of borrower relationships to banks: a longer expansion implies a larger stock of borrowers to lock in and a longer horizon over which future rents can be extracted.

This change in incentives operates immediately through banks' intertemporal pricing decisions. Anticipating a longer period of relationship rents, banks compress spreads more aggressively during the expansion (Figure 12). This is not a passive consequence of higher credit demand but an active equilibrium response: the expected duration of the boom increases the return to acquiring borrowers today, leading to stronger competition and deeper spread compression. The result is a larger amplification of the credit expansion than would arise from the borrowing constraint relaxation alone.

When the shock dissipates, the same mechanism operates in reverse. The deeper initial compression implies a larger subsequent overshoot in spreads, tightening effective credit conditions more sharply. The contraction is therefore not only larger but also more abrupt, as banks transition from borrower acquisition to rent extraction. Figure 13 shows that these dynamics translate into substantially larger cumulative output losses under more persistent credit expansions.

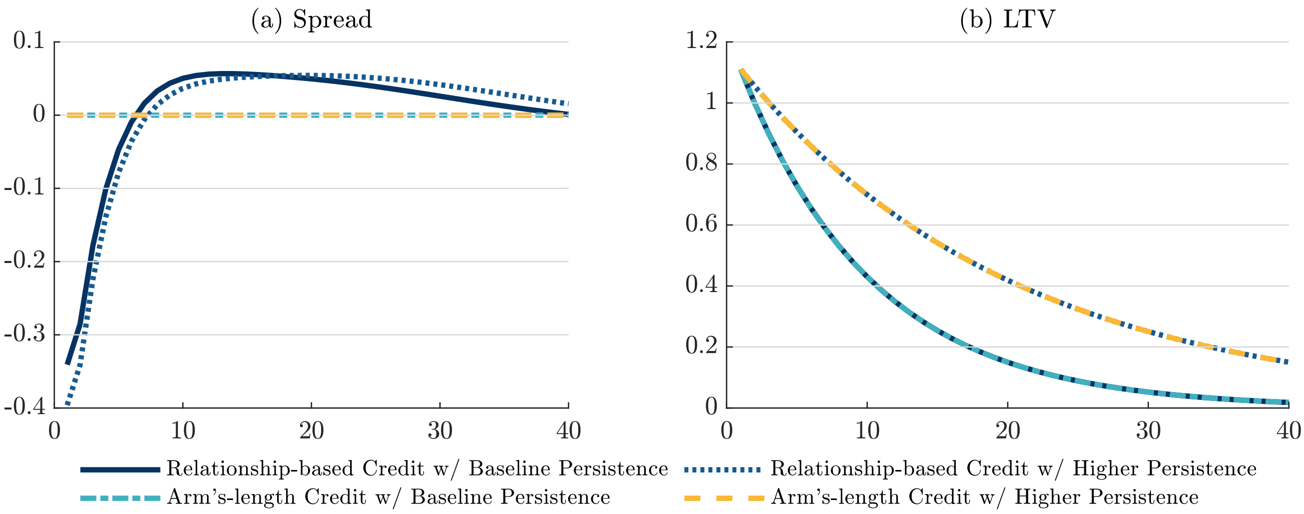
The key point is that duration amplifies the cycle through pricing incentives, not just quan-

Figure 11: Impact of a Longer-Running Corporate Credit Expansion



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state.

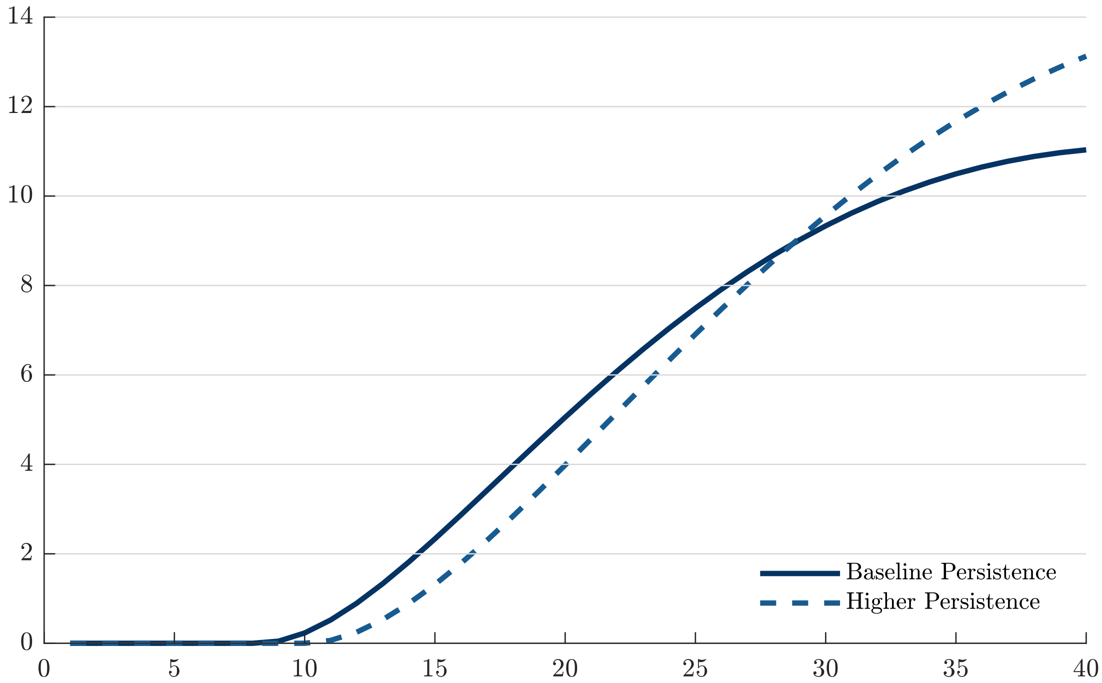
Figure 12: Mechanism – Longer-Running Corporate Credit Expansion



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state.

tities. A longer-running boom does not merely accumulate more borrowing; it changes the intertemporal trade-off faced by banks, strengthening both phases of the cycle — more aggressive competition during the boom and more severe tightening during the bust. This interaction

Figure 13: Cumulative Output Losses when Corporate Credit Expansion Runs Longer



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show cumulative output losses in percentage.

between the persistence of credit expansions and relationship-based pricing is absent from models with arm's-length intermediation, which cannot capture how the expected duration of a boom feeds back into current pricing behavior.

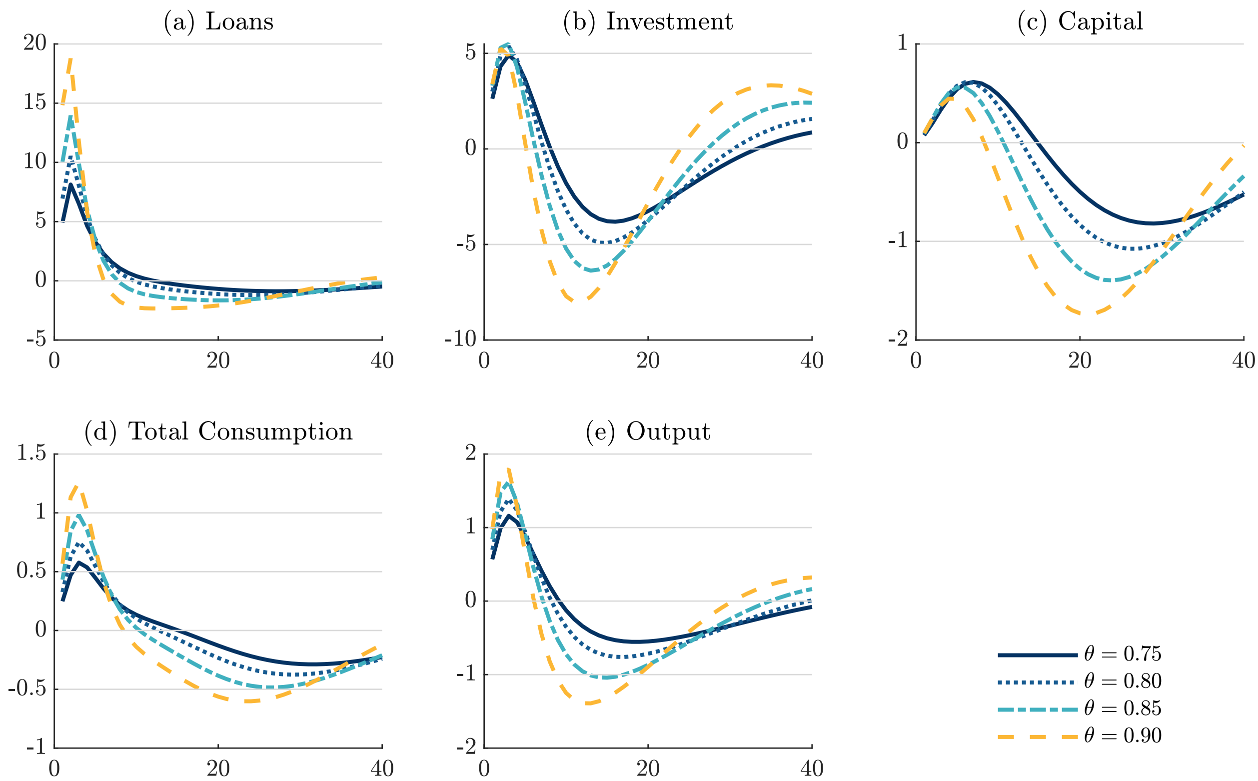
The model therefore provides a structural interpretation of Dell'Ariccia, Igan, Laeven, and Tong (2016)'s result who document that "The larger and the longer is a boom, the more likely that it ends up badly." The amplification arises not because longer booms mechanically build larger imbalances, but because they alter the incentives of financial intermediaries in a way that endogenously intensifies both the expansion and its reversal.

5.6 Steady-State Corporate Leverage

I next examine how steady-state leverage — captured by the steady-state LTV ratio — shapes the economy's response to a credit expansion. This dimension is central for connecting the model to the secular rise in corporate leverage documented in the data (Jensen, Ravn, and Santoro, 2018) and for assessing whether higher leverage mechanically scales outcomes or instead alters the underlying transmission mechanism.

Figure 14 reports impulse responses for four steady-state LTV ratios. Higher leverage amplifies both the boom and the bust monotonically, but the amplification is not a simple scaling effect. The mechanism operates through the interaction between firms' collateral positions and banks' pricing incentives. At higher steady-state leverage, a given proportional relaxation of borrowing constraints translates into a larger increase in borrowing in absolute terms, raising the value of each borrower relationship to the bank. This strengthens banks' incentive to compete for borrowers during the expansion, leading to deeper spread compression, and to extract rents during the contraction, leading to a larger overshoot in spreads (Figure 15).

Figure 14: Impact of a One-Time Corporate Credit Expansion at Different LTV Ratios

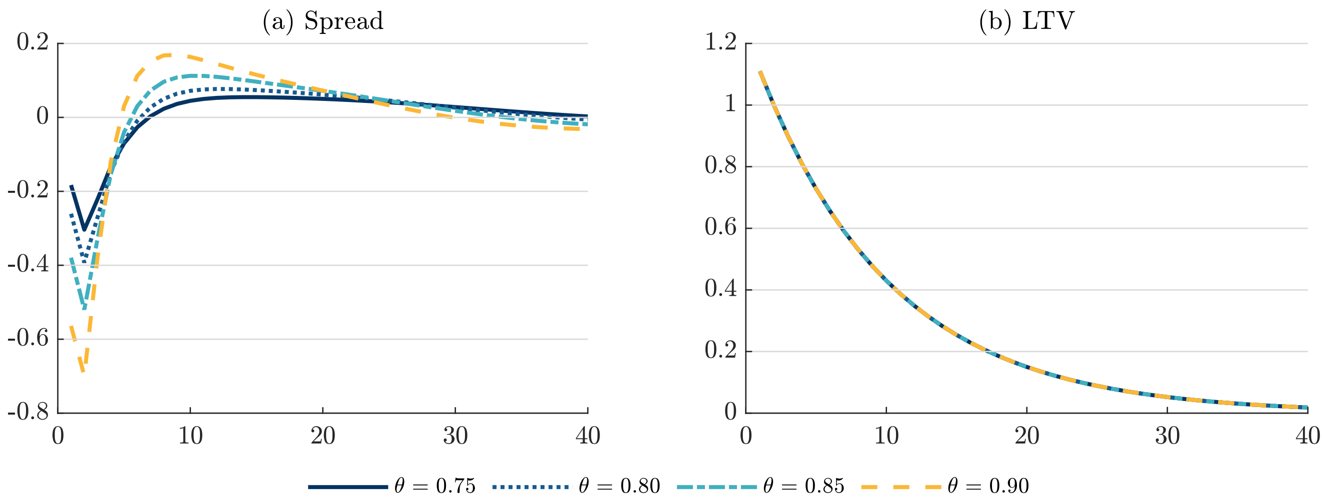


Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state.

These pricing responses reinforce the quantity channel at every stage of the cycle. During the boom, stronger spread compression amplifies the increase in credit, investment, and output beyond what the collateral channel alone would generate. During the bust, the larger spread overshoot tightens effective credit conditions more sharply, producing a deeper contraction and prolonging the decline in economic activity through its effects on investment and capital accumulation.

Figure 16 shows that both peak output declines and cumulative output losses increase with leverage. Cumulative losses rise from approximately 12 percent at the baseline to roughly 20 percent at the highest leverage level considered. These magnitudes are consistent with the empirical

Figure 15: Mechanism – One-Time Corporate Credit Expansion at Different LTV Ratios



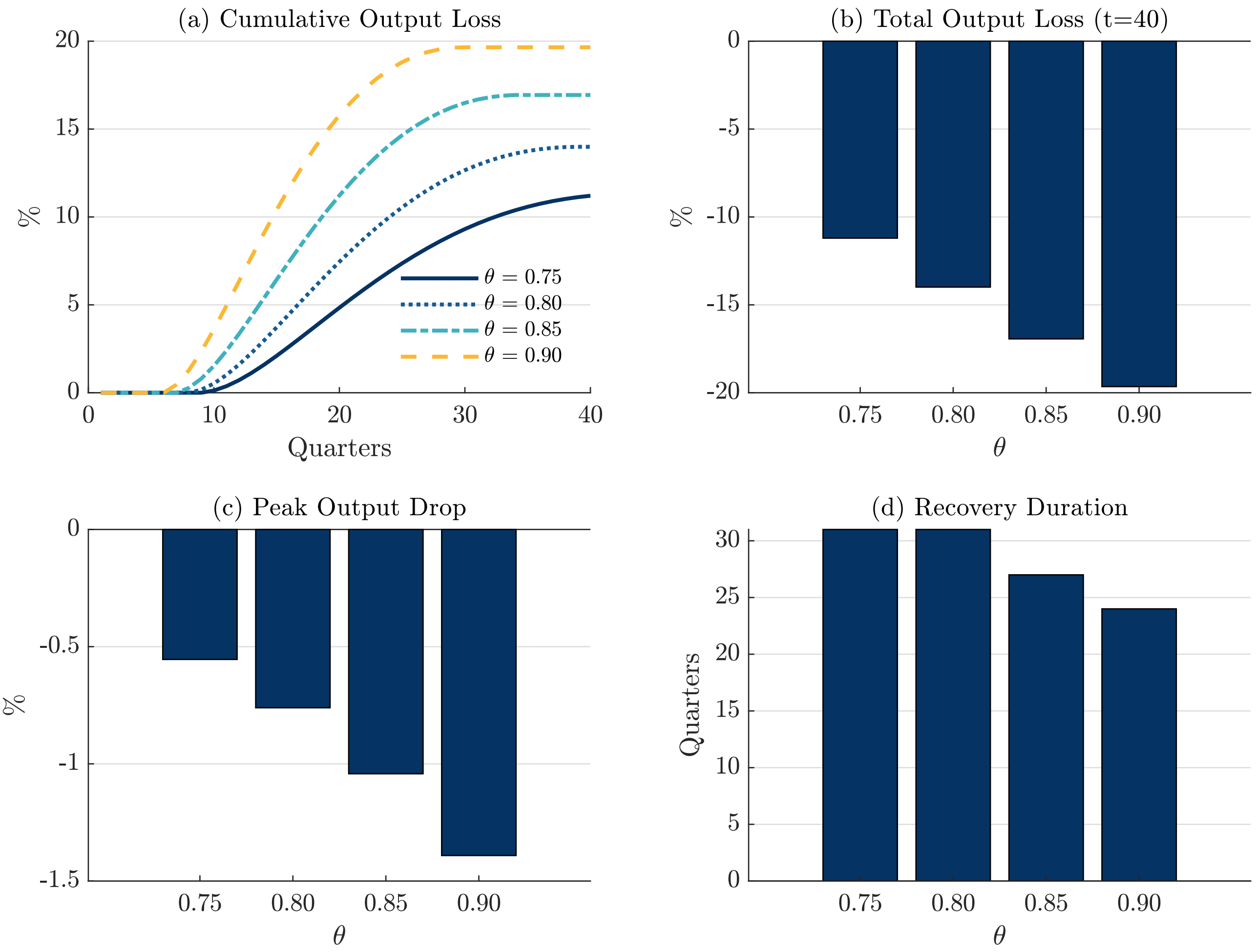
Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state.

evidence on the macroeconomic costs of credit booms documented by Ivashina, Kalemli-Özcan, Laeven, and Müller (2025). Importantly, they are generated by a single one-standard-deviation shock in a log-linearized framework, without relying on occasionally binding constraints, regime switches, or multiple disturbances.

The mechanism implies that higher steady-state leverage increases not only the scale of borrowing but the strength of amplification. Economies with higher leverage are therefore structurally more fragile: the same credit loosening generates disproportionately larger boom-bust cycles because it operates through a pricing channel that becomes more powerful as the value of borrower relationships rises. This is a distinct prediction relative to standard collateral-constraint models, where leverage primarily scales the quantity response but does not alter the nature of transmission.

This result has direct implications for the secular increase in corporate leverage documented by Jensen, Ravn, and Santoro (2018). As steady-state LTV ratios rise, the interaction with relationship-based lending implies that identical credit expansions generate increasingly severe output losses (Jordà, Schularick, and Taylor, 2017). Models that abstract from the structure of financial intermediation would not detect this increase in fragility, because the amplification operates through endogenous pricing responses that are absent when lending is arm's-length.

Figure 16: One-Time Corporate Credit Expansion and Output Losses at Different LTV Ratios



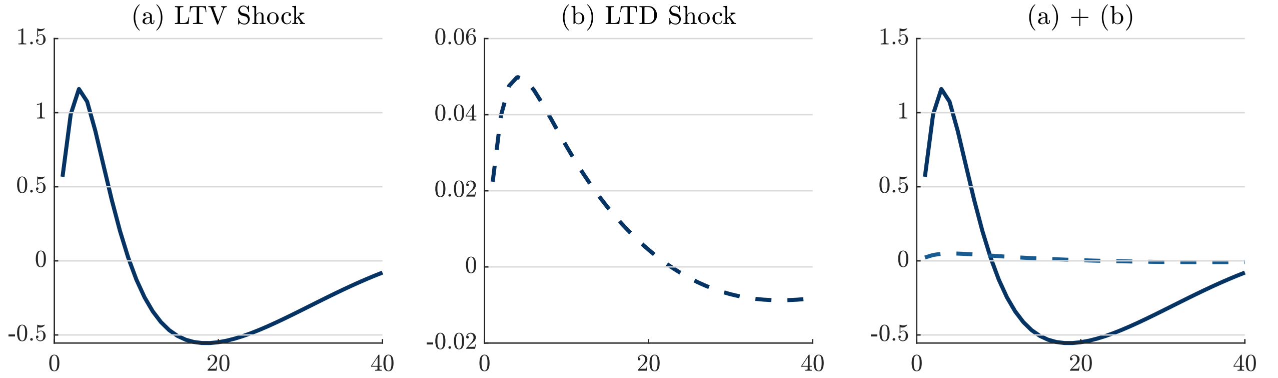
5.7 The Source of Credit Expansion: LTV Versus LTD Shocks

The preceding results establish how relationship-based lending amplifies fluctuations given a borrowing-constraint shock. The central question, however, is whether the source of a credit expansion is itself a first-order determinant of macroeconomic outcomes. This subsection answers that question by comparing borrower-side (LTV) and lender-side (LTD) shocks within an identical environment.

The comparison is deliberately controlled: both shocks are implemented in the same model, with identical parameters, persistence, and one-standard-deviation size. The only difference is where the credit impulse originates. The LTV shock relaxes firms' borrowing constraints and operates through collateral values and borrowing capacity. The LTD shock originates on banks' balance sheets and operates through funding conditions, as in Sharma (2026). This design isolates the transmission mechanism from all other features of the model.

The quantitative differences are immediate and large. As shown in Figure 17, LTV shocks generate output responses that are roughly an order of magnitude larger than those generated by LTD shocks at every horizon. These gaps arise on impact, before any dynamic amplification has time to operate. They therefore reflect a difference in the nature of the transmission mechanism, not the accumulation of small differences over time.

Figure 17: Output Dynamics During Corporate Credit Expansion Versus Bank-Side Expansion



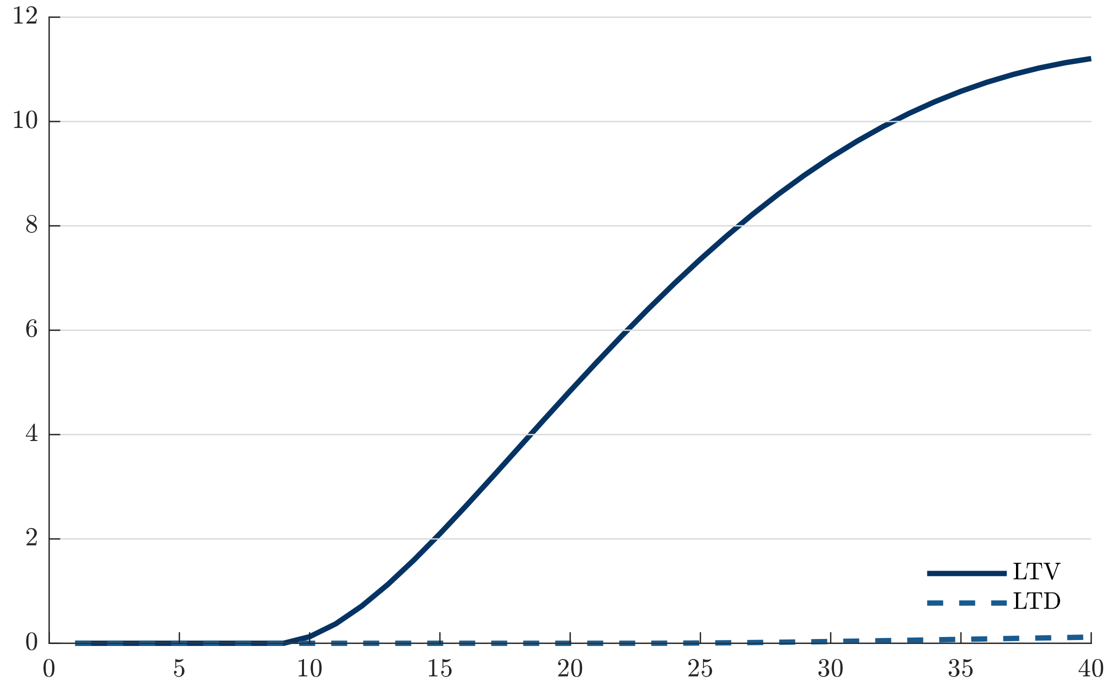
Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show percentage deviation from steady state.

The divergence persists in cumulative terms. Figure 18 shows that LTV shocks generate large and persistent output losses, while LTD shocks produce losses that remain close to zero at all horizons. The reason is a categorical difference in how the two shocks interact with relationship-based pricing. LTD shocks affect the marginal cost of lending and transmit from banks to borrowers through the supply price of credit. They do not directly affect firms' collateral positions, borrowing capacity, or the value of individual lending relationships. The transmission is therefore one-directional: bank balance sheets influence lending terms, which in turn affect borrowing and activity.

LTV shocks operate through a fundamentally different channel. By relaxing borrowing constraints, they simultaneously increase firms' demand for credit and raise the value of each borrower relationship to the bank. This activates a bidirectional feedback loop: stronger borrower balance sheets increase banks' incentives to compete for borrowers, leading to deeper spread compression, which further expands credit. When conditions reverse, the same interaction generates spread overshooting and a sharp contraction. As discussed in Section 3.4 this channel is exactly zero in the absence of lending relationships ($\gamma^L = 0$), implying that it is entirely driven by the interaction between borrowing constraints and relationship-based pricing.

This distinction is decisive. LTD shocks engage an existing price channel; relationship lending amplifies it only modestly. LTV shocks create a new channel in which quantities affect prices

Figure 18: Corporate Credit Expansion Versus Bank-Side Expansion



Note: Numbers on the horizontal axis are quarters since the shock. Numbers on the vertical axis show cumulative output losses in percentage.

and feed back into quantities. Because this feedback operates in both directions — during the boom and the bust — it generates large peak declines and substantial cumulative losses. The near-zero losses under LTD shocks therefore reflect the absence of this amplification mechanism, not a weaker realization of the same mechanism.

The model is therefore not comparing two calibrations of the same mechanism, but two distinct transmission structures. The large quantitative differences follow directly from this difference in economic structure.

This result maps directly to the empirical literature. Evidence shows that credit expansions associated with borrowing-constraint relaxations generate the largest output losses, and that corporate credit booms are followed by substantial medium-run declines in output, as shown by Ivashina, Kalemli-Özcan, Laeven, and Müller (2025). The model provides a structural explanation: borrower-side shocks activate a feedback mechanism that lender-side shocks do not. Within financially driven expansions, the source of the credit impulse is therefore a first-order determinant of outcomes.

This comparison also clarifies the relationship to the LTD-based framework. That framework shows that endogenous boom-bust dynamics can arise under relationship lending when shocks originate on banks' balance sheets. The present results show that such shocks do not generate large output losses because they do not activate the borrower-side amplification channel. The contribution here is therefore not to introduce a different shock within the same mechanism, but to show that the mechanism itself changes when the source of credit expansion shifts from lenders to borrowers. Under LTD shocks, relationship lending amplifies an existing price channel; under LTV shocks, it creates a new feedback loop between quantities and prices that is absent otherwise. In this sense, the results provide a structural counterpart to the observation by Krishnamurthy and Li (2025) that "credit growth in banks, firms, and households matters differently for crisis outcomes" – and show that this difference operates through the interaction between borrower balance sheets and intermediary pricing.

The implication is that distinguishing between borrower-side and lender-side credit expansions is essential for understanding macroeconomic outcomes. This conclusion sharpens the empirical evidence in Jensen, Petrella, Ravn, and Santoro (2020) that the nature of the expansionary phase matters for downturn severity.[9] While that literature establishes that financially driven expansions are more costly than non-financial ones, the model shows that even within financial expansions, the source of the credit impulse — borrower-side versus lender-side — is a first-order determinant of macroeconomic outcomes.

6 Conclusion

This paper shows that the interaction between corporate borrowing constraints and relationship-based bank pricing is a central amplification mechanism in credit booms. In the model, a one-time relaxation of corporate loan-to-value (LTV) constraints generates an endogenous boom-bust cycle with heterogeneous output losses. When credit is intermediated through lending relationships, banks compress spreads during the expansion to attract and retain borrowers and raise them above steady state during the contraction, reflecting the pricing power associated with locked-in customers. The resulting tightening in credit conditions produces a deep and prolonged downturn without requiring an additional adverse shock. In this sense, the bust arises as the endogenous consequence of the boom, driven by the dynamics of relationship-based pricing set in motion during the expansion.

A central implication of the analysis is that this amplification mechanism depends on the

[9] Jensen, Petrella, Ravn, and Santoro (2020, page 278) note that "The nature of the expansionary phase, as much as its size, is an important determinant of the ensuing downturn, and policymakers should pay close attention to the sources of a buildup of credit during expansions in macroeconomic activity."

interaction of the two frictions. In the arm's-length benchmark, borrowing constraint relaxations do not generate endogenous spread dynamics, so the amplification documented here is absent. The results therefore highlight that it is the combination of collateral constraints and relationship-based intermediation — not either friction in isolation — that gives rise to the pronounced boom-bust dynamics. Models that abstract from this interaction do not capture this channel and therefore understate the macroeconomic consequences of credit expansions.

The quantitative implications are substantial. Cumulative output losses following an LTV relaxation are three to four times larger under relationship lending than in an otherwise identical economy with arm's-length credit, and increase from 12 to 20 percent of cumulative output as steady-state leverage rises from 0.75 to 0.90. These magnitudes are broadly consistent with the empirical evidence in Ivashina, Kalemli-Özcan, Laeven, and Müller (2025) on the output costs of corporate credit booms. The model also implies that the source of credit expansions matters sharply for macroeconomic outcomes. Borrower-side shocks to collateral constraints generate peak output contractions and cumulative output losses an order of magnitude larger than lender-side shocks of equal size in an otherwise identical economy. This difference reflects the transmission channel — LTV shocks activate a feedback loop between firms' borrowing capacity and banks' pricing incentives that is not engaged by shocks originating on bank balance sheets. In this way, the analysis refines the empirical findings of Jensen, Petrella, Ravn, and Santoro (2020) by showing that, within financially driven expansions, the origin of the credit impulse is itself a first-order determinant of macroeconomic outcomes.

Several additional implications connect the mechanism to empirical regularities. Both the intensity and persistence of lending relationships amplify the boom-bust cycle, with intensity playing the larger role. This suggests that cross-country differences in the strength of bank-firm relationships may contribute to the heterogeneity in output losses following credit booms documented by Jordà, Schularick, and Taylor (2013). The model also provides a structural interpretation of the empirical association between credit intensity and subsequent downturn severity: relationship-based pricing both compresses spreads during the expansion and generates overshooting during the contraction, linking the depth of the boom to the severity of the bust. Similarly, the coexistence of rising leverage and compressed spreads prior to crises — what Krishnamurthy and Muir (2025) describe as "froth" — emerges here as an equilibrium outcome of bank pricing behavior rather than an exogenous feature of the pre-crisis environment.

The analysis also implies that rising steady-state leverage increases macroeconomic vulnerability. As leverage increases, the profitability of lending relationships rises, strengthening banks' incentives to adjust spreads intertemporally and amplifying both the expansion and the contraction. This channel is absent in models without relationship-based pricing, and therefore highlights a mechanism through which secular increases in corporate leverage can lead to progressively larger boom-bust cycles.

These findings have implications for both theory and policy. For theory, they identify a channel through which the structure of financial intermediation shapes macroeconomic stability. The interaction between borrowing constraints and relationship-based pricing generates a form of amplification that is not present when either friction is studied in isolation, and suggests that models abstracting from this interaction may understate the persistence and magnitude of output losses associated with credit booms. For policy, the results indicate that borrower-side credit expansions are particularly consequential for macroeconomic outcomes, and that the effects of macroprudential tools targeting borrowing constraints depend on the structure of financial intermediation. In economies with more prevalent or more intense relationship lending, adjustments to borrowing constraints have larger effects on both the buildup and the unwinding of credit conditions.

More broadly, the framework provides a mechanism through which the bust emerges endogenously from the boom. While other approaches emphasize exogenous shocks or shifts in beliefs to generate crises, the present analysis shows how the interaction of borrowing constraints and relationship-based pricing can generate a reversal in credit conditions without an external trigger. This does not preclude a role for belief dynamics or other nonlinear mechanisms, but highlights a parsimonious channel through which substantial amplification can arise in a tractable setting.

The analysis abstracts from several features that may further amplify these dynamics, including the rise in non-performing loans during downturns, the potential breakdown of lending relationships in crises, and firm heterogeneity in credit access. Incorporating these elements is a promising direction for future research and may help account for even larger output losses observed in the data.

Returning to the question posed by Taylor (2015), the analysis highlights a specific way in which credit and financial stability are linked through the structure of intermediation. Empirical work has established that the source and intensity of credit expansions matter for macroeconomic outcomes, and recent theoretical work has emphasized the role of financial amplification and expectations. The contribution of this paper is to show that relationship-based lending — an important feature of corporate credit markets — provides an additional channel through which these forces are amplified, and that this channel can generate large and persistent fluctuations without requiring an external trigger. Incorporating this mechanism into models used to assess financial stability may therefore improve our understanding of why credit booms so often give rise to costly downturns, and in doing so bring the analysis closer to the recurring patterns emphasized in Taylor (2015).

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Appendix (For Online Publication)

Corporate Credit Booms and Heterogeneous Output Losses

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Contents

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A Proof of Proposition 1

This appendix provides the complete proof of Proposition 1. The analysis is conducted in partial equilibrium, taking R_t^D, a_t, s_{t-2}, l_{t-1}, and the continuation value $V_t \equiv \mathbb{E}_t q_{t,t+1} \varrho^E_{t+1} / \mathbb{E}_t q_{t,t+1}$ as given. This isolates the direct pricing mechanism from general equilibrium feedback and is the appropriate object for characterising the properties of the bank's optimality conditions. Define the lending spread deviation $\hat{\Psi}_t \equiv \Psi_t - \bar{\Psi}$ and the borrowing constraint perturbation $\hat{\theta}_t \equiv \theta_t - \bar{\theta}$. At the deterministic steady state, the habit stock law of motion implies $\bar{s} = \bar{l} = \bar{L}$, so $\bar{\Delta} = (2\rho_s - 1)\bar{L}$ and $\bar{\Omega} = \gamma^L(2\rho_s - 1)/\bar{\theta}$.

Part (i): Necessity

When $\gamma^L = 0$. When $\gamma^L = 0$, every term in Ξ_t contains γ^L as an explicit multiplicative factor:

$$\Xi_t = \gamma^L \rho_s \frac{s_{t-2}}{a_t / R_t^L} - \gamma^L (1 - \rho_s) \frac{l_{t-1}}{a_t / R_t^L}$$

Therefore $\Xi_t = 0$ identically, $\Omega_t \equiv \gamma^L \Delta_t R_t^L / (\theta_t a_t) = 0$ identically, and the markup reduces to

$$M_t = \frac{\xi(1-0)}{\xi(1-0) - 1} = \frac{\xi}{\xi - 1}$$

a constant independent of θ_t. Simultaneously, $MC_t = R_t^D - \gamma^L(1-\rho_s)V_t = R_t^D$ when $\gamma^L = 0$. Therefore:

$$R_t^L = R_t^D \cdot \frac{\xi}{\xi - 1} \qquad \Longrightarrow \qquad \Psi_t = R_t^D \cdot \frac{1}{\xi - 1}$$

Since R_t^D is determined by the household Euler equation independently of θ_t, we have $\partial R_t^D / \partial \theta_t = 0$ in partial equilibrium, and therefore:

$$\frac{\partial \hat{\Psi}_t}{\partial \hat{\theta}_t} = \frac{\partial \Psi_t}{\partial \theta_t} = \frac{1}{\xi - 1} \cdot \frac{\partial R_t^D}{\partial \theta_t} = 0$$

exactly, for all t, all shock sizes, all LTV ratios, and all admissible parameter values. This completes the first part of part (i).

When $\gamma^L > 0$. When $\gamma^L > 0$, θ_t enters M_t through $\Omega_t = \gamma^L \Delta_t R_t^L / (\theta_t a_t)$ and enters MC_t through the continuation value V_t. For $\theta_t \neq \bar{\theta}$, $\Omega_t \neq \bar{\Omega}$ generically (since Δ_t need not be zero unless $\rho_s = 1/2$ exactly and $s_{t-2} = l_{t-1}$), so $M_t \neq \bar{M}$. Simultaneously, V_t responds to changes in the expected future loan portfolio as θ_t varies. Both channels therefore generate a nonzero response of Ψ_t to θ_t generically, establishing $\partial\hat{\Psi}_t/\partial\hat{\theta}_t \neq 0$.

For the necessity of the relationship friction: at steady state with $\hat{\theta}_t = 0$, $\hat{\Psi}_t = 0$ trivially regardless of γ^L, so $\partial\hat{\Psi}_t/\partial\gamma^L\big|_{\hat{\theta}_t=0} = 0$. Combined with $\partial\hat{\Psi}_t/\partial\hat{\theta}_t\big|_{\gamma^L=0} = 0$ from above, both frictions individually generate zero spread-mediated amplification of LTV shocks near the steady state. □

Part (ii): Superadditivity

The equilibrium lending rate satisfies

$$F(R_t^L;\, \theta_t, \gamma^L) \;\equiv\; R_t^L - MC_t(\gamma^L)\cdot M_t(\Omega_t) \;=\; 0$$

where $\Omega_t \equiv \gamma^L \Delta_t R_t^L/(\theta_t a_t)$, $\Delta_t \equiv \rho_s s_{t-2} - (1-\rho_s)l_{t-1}$, and $h(\Omega) \equiv \frac{\xi(1-\Omega)}{\xi(1-\Omega)-1}$ so that $M_t = h(\Omega_t)$. Note that $h'(\Omega) = \frac{\xi}{(\xi(1-\Omega)-1)^2} > 0$ for $\xi(1-\Omega) > 1$, which holds in a neighbourhood of the steady state for $\xi > 1$.

By the implicit function theorem:

$$\frac{\partial R_t^L}{\partial \theta_t} = -\frac{F_\theta}{F_{R^L}}$$

where

$$F_{R^L} = 1 - MC_t \cdot h'(\Omega_t)\cdot \frac{\partial \Omega_t}{\partial R_t^L} = 1 - MC_t\cdot h'(\Omega_t)\cdot \frac{\gamma^L\Delta_t}{\theta_t a_t} \tag{A.1}$$

$$F_\theta = -MC_t\cdot h'(\Omega_t)\cdot\frac{\partial\Omega_t}{\partial\theta_t} = MC_t\cdot h'(\Omega_t)\cdot\frac{\gamma^L\Delta_t R_t^L}{\theta_t^2 a_t} \tag{A.2}$$

Evaluating at $\gamma^L = 0$. At $\gamma^L = 0$: $\Omega_t = 0$, $h'(0) = \xi/(\xi-1)^2$, $MC_t = R_t^D$, and every term containing γ^L vanishes, giving:

$$F_{R^L}\big|_{\gamma^L=0} = 1, \qquad F_\theta\big|_{\gamma^L=0} = 0, \qquad \left.\frac{\partial R_t^L}{\partial\theta_t}\right|_{\gamma^L=0} = 0$$

reproducing part (i).

Computing the cross-derivative. Differentiating $\partial R_t^L/\partial\theta_t = -F_\theta/F_{R^L}$ with respect to γ^L and evaluating at $\gamma^L = 0$, using $F_\theta|_{\gamma^L=0} = 0$ and $F_{R^L}|_{\gamma^L=0} = 1$:

$$\left.\frac{\partial^2 R_t^L}{\partial\theta_t\,\partial\gamma^L}\right|_{\gamma^L=0} = -\frac{\partial F_\theta/\partial\gamma^L\big|_{\gamma^L=0}}{F_{R^L}|_{\gamma^L=0}} = -F_{\theta\gamma^L}\big|_{\gamma^L=0}$$

To compute $F_{\theta\gamma^L}|_{\gamma^L=0}$, differentiate $F_\theta = MC_t \cdot h'(\Omega_t) \cdot \gamma^L \Delta_t R_t^L/(\theta_t^2 a_t)$ with respect to γ^L:

$$\frac{\partial F_\theta}{\partial\gamma^L} = \underbrace{\frac{\partial MC_t}{\partial\gamma^L} \cdot h'(\Omega_t) \cdot \frac{\gamma^L\Delta_t R_t^L}{\theta_t^2 a_t}}_{\text{Term A: contains } \gamma^L\to 0} + \underbrace{MC_t \cdot h''(\Omega_t) \cdot \frac{\partial\Omega_t}{\partial\gamma^L} \cdot \frac{\gamma^L\Delta_t R_t^L}{\theta_t^2 a_t}}_{\text{Term B: contains } \gamma^L\to 0}$$
$$+ \underbrace{MC_t \cdot h'(\Omega_t) \cdot \frac{\Delta_t R_t^L}{\theta_t^2 a_t}}_{\text{Term C: survives at } \gamma^L=0} \tag{A.3}$$

Terms A and B each contain γ^L as an explicit factor and therefore vanish at $\gamma^L = 0$. Term C survives. Evaluating Term C at steady-state values — $\bar{MC} = \bar{R}^D$, $h'(0) = \xi/(\xi-1)^2$, $\bar{R}^L = \bar{R}^D\xi/(\xi-1)$, $\bar{\Delta} = (2\rho_s - 1)\bar{l}$ — yields:

$$F_{\theta\gamma^L}\big|_{\gamma^L=0} = \bar{R}^D \cdot \frac{\xi}{(\xi-1)^2} \cdot \frac{(2\rho_s-1)\bar{l}\cdot\bar{R}^D\xi/(\xi-1)}{\bar{\theta}^2\,\bar{a}} = \frac{\xi^2(\bar{R}^D)^2(2\rho_s-1)\bar{l}}{(\xi-1)^3\,\bar{\theta}^2\,\bar{a}}$$

Therefore:

$$\left.\frac{\partial^2\hat{\Psi}_t}{\partial\hat{\theta}_t\,\partial\gamma^L}\right|_{\gamma^L=0} = \left.\frac{\partial^2 R_t^L}{\partial\theta_t\,\partial\gamma^L}\right|_{\gamma^L=0} = -\frac{\xi^2(\bar{R}^D)^2(2\rho_s-1)\bar{l}}{(\xi-1)^3\,\bar{\theta}^2\,\bar{a}}$$

which is nonzero for $\rho_s \neq \frac{1}{2}$.

Superadditivity. By part (i), $\partial\hat{\Psi}_t/\partial\hat{\theta}_t\big|_{\gamma^L=0} = 0$ and $\partial\hat{\Psi}_t/\partial\gamma^L\big|_{\hat{\theta}_t=0} = 0$. The sum of the individual contributions is therefore zero. The cross-derivative established above is nonzero, so the joint effect of the two frictions strictly exceeds this sum. This is the superadditivity claim. □

Sign of the cross-derivative and economic interpretation

For $\rho_s > \frac{1}{2}$ — the empirically relevant case, as the persistence of the habit stock is calibrated to satisfy this condition in Table 1 — the factor $(2\rho_s - 1) > 0$, so the cross-derivative is negative:

$$\left.\frac{\partial^2\hat{\Psi}_t}{\partial\hat{\theta}_t\,\partial\gamma^L}\right|_{\gamma^L=0} < 0.$$

A marginal increase in γ^L causes the spread to *fall* in response to a positive LTV shock. This is the spread compression: banks with stronger lending relationships have a greater incentive to lower spreads during the expansion to attract and retain borrowers, because the present value of the future rents they can extract from locked-in customers is larger. The magnitude of the cross-derivative is proportional to $\xi^2/(\xi-1)^3$, which is increasing in ξ: higher substitutability across lenders intensifies competition during the boom, amplifying the pricing response. It is also proportional to $(2\rho_s-1)\bar{l}/(\bar{\theta}^2\bar{a})$, which increases in the persistence of the habit stock ρ_s and in the steady-state volume of lending $\bar{l}$, and decreases in the square of the steady-state LTV ratio $\bar{\theta}$. The last comparative static — that the cross-derivative falls in $\bar{\theta}$ — reflects the fact that at higher steady-state leverage, the same increase in γ^L generates less incremental spread sensitivity per unit of borrowing capacity, because the baseline profitability of each relationship is already higher. The general equilibrium interaction of these forces with the full model dynamics is quantified in Section 5.

B Lending rate under LTD shocks (Sharma, 2026)

In Sharma (2026), combining the bank's optimality conditions yields the lending rate. In the absence of lending relationships ($\gamma^L=0$), the pricing equation reduces to

$$R_t^L = \left[\frac{1}{\psi_t}\left(R_t^D - \frac{1}{\mathbb{E}_t q_{t,t+1}}\right) + \frac{1}{\mathbb{E}_t q_{t,t+1}}\right]\frac{\xi}{\xi-1} \tag{B.1}$$

Equation (B.1) shows that the credit shock ψ_t enters directly into the pricing equation through the term R_t^D/ψ_t, and hence affects the effective marginal cost of lending even when $\gamma^L=0$. As a result, LTD shocks generate a nonzero spread response under arm's-length intermediation.

This contrasts with LTV shocks in the present paper, which do not enter the pricing equation when $\gamma^L=0$ and therefore leave lending spreads invariant in that benchmark. Relationship lending thus amplifies an existing pricing channel for LTD shocks, but creates the pricing channel for LTV shocks.

C Derivation of FOCs

C.1 Households

The Lagrangian of the household is

$$\mathcal{L}_t = \mathbb{E}_t \left\{ \sum_{t=0}^{\infty} \left(\beta^P\right)^t \left[\begin{array}{c} \log\left(C_{i,t}^P - \gamma^P C_{i,t-1}^P\right) - \frac{N_{i,t}^{\eta}}{\eta} + \varsigma \log H_{i,t}^P \\ -\lambda_{i,t}^P \left[\begin{array}{c} C_{i,t}^P + Q_t^H\left(H_{i,t}^P - H_{i,t-1}^P\right) + \int_0^1 D_{ik,t}\mathrm{d}k \\ -W_t N_{i,t} - \int_0^1 \Pi_{ik,t}\mathrm{d}k - R_{t-1}^D \int_0^1 D_{ik,t-1}\mathrm{d}k \end{array} \right] \end{array} \right] \right\} \tag{C.1}$$

The problem yields the following first order conditions (here, I ignore all the i's denoting individual households):

$$\frac{\partial \mathcal{L}}{\partial C_t^P} : \frac{1}{C_t^P - \gamma^P C_{t-1}^P} - \beta^P \mathbb{E}_P \frac{\gamma^P}{C_{t+1}^P - \gamma^P C_t^P} = \lambda_t^P \tag{C.2}$$

$$\frac{\partial \mathcal{L}}{\partial D_t} : \beta^P \mathbb{E}_t \lambda_{t+1}^P = \frac{\lambda_t^P}{R_t^D} \tag{C.3}$$

$$\frac{\partial \mathcal{L}}{\partial H_t^P} : \frac{\varsigma}{H_t^P} + \beta^P \mathbb{E}_t\left(\lambda_{t+1}^P Q_{t+1}^H\right) = \lambda_t^P Q_t^H \tag{C.4}$$

$$\frac{\partial \mathcal{L}}{\partial N_t} : N_t^{\eta-1} = \lambda_t^P W_t \tag{C.5}$$

C.2 Entrepreneurs

Entrepreneur's optimization problem features two parts. The first part consists of choosing how much to borrow from each individual bank, $l_{jk,t}$ to minimize his total interest rate expenditure. This problem can be framed as

$$\min_{l_{jk,t}} \left[\int_0^1 R_{k,t}^L l_{jk,t}\mathrm{d}k\right] - \chi_t^E \left[x_{j,t} - \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{\xi}{\xi-1}}\right] \tag{C.6}$$

The first order condition for this problem is

$$R_{k,t}^L = -\frac{\xi}{\xi-1}\chi_t^E \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{1}{\xi-1}} \frac{\xi-1}{\xi}\left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{-\frac{1}{\xi}} \tag{C.7}$$

This can be rewritten as

$$\begin{aligned}
R^L_{k,t} &= -\chi^E_t \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{1}{\xi-1}} \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{-\frac{1}{\xi}} \\
R^L_{k,t}\left(l_{jk,t} - \gamma^L s_{k,t-1}\right) &= -\chi^E_t \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{1}{\xi-1}} \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \\
\int_0^1 R^L_{k,t}\left(l_{jk,t} - \gamma^L s_{k,t-1}\right) \mathrm{d}k &= -\chi^E_t \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{1}{\xi-1}} \int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k \\
\int_0^1 R^L_{k,t}\left(l_{jk,t} - \gamma^L s_{k,t-1}\right) \mathrm{d}k &= -\chi^E_t \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{\xi}{\xi-1}} \qquad \text{(C.8)}
\end{aligned}$$

Now, using $\left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{\xi}{\xi-1}} = x_{j,t}$, the previous equation can be written as

$$x_{j,t} = -\frac{1}{\chi^E_t}\left[\int_0^1 R^L_{k,t}\left(l_{jk,t} - \gamma^L s_{k,t-1}\right) \mathrm{d}k\right] \qquad \ddagger$$

Define the aggregate lending rate as $R^L_t \equiv \left[\int_0^1 \left(R^L_{k,t}\right)^{1-\xi}\right]^{\frac{1}{1-\xi}}$ and note that at the optimum, the following condition must hold

$$R^L_t x_{j,t} = \int_0^1 R^L_{k,t}\left(l_{jk,t} - \gamma^L s_{k,t-1}\right) \mathrm{d}k$$

Now, ‡ can be rewritten as

$$\begin{aligned}
x_{j,t} &= -\frac{1}{\chi^E_t}\left[R^L_t x_{j,t}\right] \\
-\chi^E_t &= R^L_t
\end{aligned}$$

Inserting this in first order condition (C.8)

$$\begin{aligned}
R^L_{k,t} &= -\frac{\xi}{\xi-1}\chi^E_t \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}} \mathrm{d}k\right)^{\frac{1}{\xi-1}} \frac{\xi-1}{\xi}\left(l_{j,t} - \gamma^L s_{k,t-1}\right)^{-\frac{1}{\xi}} \\
R^L_{k,t} &= R^L_t \left(\int_0^1 \left(l_{jk,t} - \gamma^L s_{k,t-1}\right) \mathrm{d}k\right)^{\frac{1}{\xi-1}} \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{-\frac{1}{\xi}} \\
R^L_{k,t} &= R^L_t \left(x_t\right)^{\frac{1}{\xi}} \left(l_{jk,t} - \gamma^L s_{k,t-1}\right)^{-\frac{1}{\xi}}
\end{aligned}$$

Rearranging the above expression

$$
\begin{aligned}
\left(l_{jk,t}-\gamma^{L}s_{k,t-1}\right)^{\frac{1}{\xi}} &= \left(x_t\right)^{\frac{1}{\xi}}\frac{R_t^L}{R_{k,t}^L}\\
l_{jk,t} &= \left(\frac{R_t^L}{R_{k,t}^L}\right)^{\xi}x_t+\gamma^L s_{k,t-1}\\
l_{jk,t} &= \left(\frac{R_{k,t}^L}{R_t^L}\right)^{-\xi}x_t+\gamma^L s_{k,t-1}
\end{aligned}
$$

The second part of entrepreneur's optimization problem can be written as

$$
\mathscr{L}_t=\mathbb{E}_t\left\{\sum_{t=0}^{\infty}\left(\beta^E\right)^t\left[\begin{array}{c}\log\left(C_{j,t}^E-\gamma^E C_{j,t-1}^E\right)\\ -\lambda_{j,t}^E\left[\begin{array}{c}C_{j,t}^E+R_{k,t-1}^L\int_0^1 l_{jk,t-1}\mathrm{d}k-Y_{j,t}+W_tN_{j,t}+I_{j,t}\\ +Q_t^H\left(H_{j,t}^E-H_{j,t-1}^E\right)-x_{j,t}\end{array}\right]\\ -\mu_{j,t}^E\left[R_{k,t}^L\int_0^1 l_{jk,t}\mathrm{d}k-\int_0^1\theta_t\mathrm{d}k\mathbb{E}_t\left(Q_{t+1}^H H_{j,t}^E+Q_{t+1}^K K_{j,t}\right)\right]\\ -\kappa_{j,t}^E\left[K_{j,t}-\left(1-\delta\right)K_{j,t-1}-\left\{1-\frac{\Omega}{2}\left(\frac{I_{j,t}}{I_{j,t-1}}-1\right)^2\right\}I_{j,t}\right]\\ -\epsilon_{j,t}^E\left[x_{j,t}-\left\{\int_0^1\left(l_{jk,t}-\gamma^L s_{k,t-1}\right)^{\frac{\xi-1}{\xi}}\mathrm{d}k\right\}^{\frac{\xi}{\xi-1}}\right]\end{array}\right]\right\} \tag{C.9}
$$

where $Y_{j,t}=A_t\left(N_{j,t}\right)^{1-\alpha}\left\{\left(H_{j,t-1}^E\right)^{\phi}\left(K_{j,t-1}\right)^{1-\phi}\right\}^{\alpha}$ may be inserted for $Y_{j,t}$ in the budget constraint. Solving entrepreneur's optimization problem, the first order conditions are (I ignore all j's here):

$$
\frac{\partial\mathscr{L}}{\partial C_t^E}:\frac{1}{C_t^E-\gamma^E C_{t-1}^E}-\beta^E\mathbb{E}_t\frac{\gamma^E}{C_{t+1}^E-\gamma^E C_t^E}=\lambda_t^E \tag{C.10}
$$

$$
\frac{\partial\mathscr{L}}{\partial x_t}:\lambda_t^E=\epsilon_t^E \tag{C.11}
$$

$$
\frac{\partial\mathscr{L}}{\partial l_t}:\epsilon_t^E=\beta^E\mathbb{E}_t\lambda_{t+1}^E R_t^L+\mu_t^E R_t^L \tag{C.12}
$$

$$
\frac{\partial\mathscr{L}}{\partial N_t}:W_t=\left(1-\alpha\right)\frac{Y_t}{N_t} \tag{C.13}
$$

$$
\frac{\partial\mathscr{L}}{\partial H_t^E}:\lambda_t^E Q_t^H=\beta^E\mathbb{E}_t\left\{\lambda_{t+1}^E\left(Q_{t+1}^H+\alpha\phi\frac{Y_{t+1}}{H_t^E}\right)\right\}+\mu_t^E\theta_t\mathbb{E}_tQ_{t+1}^H \tag{C.14}
$$

$$
\frac{\partial\mathscr{L}}{\partial K_t}:\kappa_t^E=\alpha\left(1-\phi\right)\beta^E\mathbb{E}_t\left(\frac{\lambda_{t+1}^E Y_{t+1}}{K_t}\right)+\beta^E\left(1-\delta\right)\mathbb{E}_t\kappa_{t+1}^E+\mu_t^E\theta_t\mathbb{E}_tQ_{t+1}^K \tag{C.15}
$$

$$
\frac{\partial\mathscr{L}}{\partial I_t}:\lambda_t^E=\kappa_t^E\left\{1-\frac{\Omega}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2-\Omega\frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}}-1\right)\right\}+\beta^E\Omega\mathbb{E}_t\left\{\kappa_{t+1}^E\left(\frac{I_{t+1}}{I_t}\right)^2\left(\frac{I_{t+1}}{I_t}-1\right)\right\} \tag{C.16}
$$

Using $\lambda_t^E = \epsilon_t^E$ from (C.11), (C.12) becomes

$$\beta^E \mathbb{E}_t \left(\lambda_{t+1}^E R_t^L \right) + \mu_t^E R_t^L = \lambda_t^E \tag{C.17}$$

C.3 Banks

The problem of banks is to choose their lending rate and the total amount of lending. The bank considers deep habits in loan demand. The bank solves the following problem

$$\max_{L_{k,t}, R_{k,t}^L} \Pi_t = R_{k,t-1}^L L_{k,t-1} - R_{t-1}^D L_{k,t-1} + \varrho_t^E \left(\int_0^1 \left[\left(\frac{R_t^L}{R_{k,t}^L} \right)^{\xi} x_t + \gamma^L s_{k,t-1} \right] \mathrm{d}j - L_{k,t} \right)$$

The first order condition for $L_{k,t}$ is

$$\mathbb{E}_t q_{t,t+1} R_{k,t}^L - \mathbb{E}_t q_{t,t+1} R_t^D + \gamma^L (1-\rho_s) \mathbb{E}_t \Big(q_{t,t+1} \varrho_{t+1}^E \Big) - \varrho_t^E = 0$$

Rearranging terms

$$\varrho_t^E = \mathbb{E}_t q_{t,t+1} \Big[\left(R_{k,t}^L - R_t^D \right) + \gamma^L (1-\rho_s) \mathbb{E}_t \varrho_{t+1}^E \Big] \tag{C.18}$$

The first order condition for $R_{k,t}^L$ is

$$\mathbb{E}_t q_{t,t+1} L_{k,t}^E + \xi \varrho_t^E \left(\frac{R_t^L}{R_{k,t}^L} \right)^{\xi-1} x_t \left(\frac{-R_t^L}{\left(R_{k,t}^L\right)^2} \right) = 0$$

Moving terms around

$$\mathbb{E}_t q_{t,t+1} L_{k,t}^E = \xi \varrho_t^E x_t \left(\frac{R_t^L}{R_{k,t}^L} \right)^{\xi-1} \left(\frac{R_t^L}{\left(R_{k,t}^L\right)^2} \right) \tag{C.19}$$

In a symmetric equilibrium all banks have the same lending rate $R_{k,t}^L = R_t^L, \forall k$ and consequently lend the same amount $L_{k,t} = L_t, \forall k$. Bank's first order condition in this case can be rewritten as

$$\varrho_t^E = \mathbb{E}_t q_{t,t+1} \Big[\left(R_t^L - R_t^D \right) + \gamma^L (1-\rho_s) \mathbb{E}_t \varrho_{t+1}^E \Big] \tag{C.20}$$

$$\frac{\xi \varrho_t^E x_t}{R_t^L} = \mathbb{E}_t q_{t,t+1} L_t \tag{C.21}$$

where I have imposed $L_t = l_t$ in a symmetric equilibrium.

D List of Equations

D.1 Households

$$\frac{1}{C_t^P - \gamma^P C_{t-1}^P} - \beta^P \mathbb{E}_t \frac{\gamma^P}{C_{t+1}^P - \gamma^P C_t^P} = \lambda_t^P \tag{D.1}$$

$$\beta^P \mathbb{E}_t \lambda_{t+1}^P = \frac{\lambda_t^P}{R_t^D} \tag{D.2}$$

$$\frac{\varsigma}{H_t^P} + \beta^P \mathbb{E}_t \left(\lambda_{t+1}^P Q_{t+1}^H\right) = \lambda_t^P Q_t^H \tag{D.3}$$

$$N_t^{\eta-1} = \lambda_t^P W_t \tag{D.4}$$

D.2 Entrepreneurs

$$\frac{1}{C_t^E - \gamma^E C_{t-1}^E} - \beta^E \mathbb{E}_t \frac{\gamma^E}{C_{t+1}^E - \gamma^E C_t^E} = \lambda_t^E \tag{D.5}$$

$$\beta^E \mathbb{E}_t \left(\lambda_{t+1}^E R_t^L\right) + \mu_t^E R_t^L = \lambda_t^E \tag{D.6}$$

$$W_t = (1-\alpha) \frac{Y_t}{N_t} \tag{D.7}$$

$$\lambda_t^E Q_t^H = \beta^E \mathbb{E}_t \left\{ \lambda_{t+1}^E \left(Q_{t+1}^H + \alpha\phi \frac{Y_{t+1}}{H_t^E} \right) \right\} + \mu_t^E \theta_t \mathbb{E}_t Q_{t+1}^H \tag{D.8}$$

$$\kappa_t^E = \alpha (1-\phi) \beta^E \mathbb{E}_t \left(\frac{\lambda_{t+1}^E Y_{t+1}}{K_t} \right) + \beta^E (1-\delta) \mathbb{E}_t \kappa_{t+1}^E + \mu_t^E \theta_t \mathbb{E}_t Q_{t+1}^K \tag{D.9}$$

$$\lambda_t^E = \kappa_t^E \left\{ 1 - \frac{\Omega}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 - \Omega \frac{I_t}{I_{t-1}} \left(\frac{I_t}{I_{t-1}} - 1 \right) \right\} + \beta^E \Omega \mathbb{E}_t \left\{ \kappa_{t+1}^E \left(\frac{I_{t+1}}{I_t} \right)^2 \left(\frac{I_{t+1}}{I_t} - 1 \right) \right\} \tag{D.10}$$

$$s_t = \rho_s s_{t-1} + (1-\rho_s) l_t \tag{D.11}$$

$$x_t = \left(l_t - \gamma^L s_{t-1} \right) \tag{D.12}$$

$$L_t = l_t \tag{D.13}$$

$$C_t^E + R_{t-1}^L l_{t-1} = Y_t - W_t N_t - I_t - Q_t \left(H_t^E - H_{t-1}^E \right) + x_t \tag{D.14}$$

$$l_t = \frac{\theta_t a_t}{R_t^L} \tag{D.15}$$

$$a_t = \mathbb{E}_t \left(Q^H_{t+1} H^E_t + Q^K_{t+1} K_t \right) \tag{D.16}$$

$$\kappa^E_t = \lambda^E_t Q^K_t \tag{D.17}$$

D.3 Banks

$$\varrho^E_t = \mathbb{E}_t q_{t,t+1} \Big[\left(R^L_t - R^D_t \right) + \gamma^L \left(1 - \rho_s\right) \mathbb{E}_t \varrho^E_{t+1} \Big] \tag{D.18}$$

$$\xi \varrho^E_t x_t \frac{1}{R^L_t} = \mathbb{E}_t q_{t,t+1} L_t \tag{D.19}$$

$$\Pi_t = R^L_{t-1} L_{t-1} + D_t - L_t - R^D_{t-1} D_{t-1} \tag{D.20}$$

$$L_t = D_t \tag{D.21}$$

$$q_{t,t+1} = \beta^P \mathbb{E}_t \frac{\lambda^P_{t+1}}{\lambda^P_t} \tag{D.22}$$

D.4 Market Clearing and Resource Constraints

$$C^P_t + C^E_t + I_t = Y_t \tag{D.23}$$

$$H^P_t + H^E_t = H \tag{D.24}$$

$$Y_t = A_t \left(N_t\right)^{1-\alpha} \left\{ \left(H^E_{t-1}\right)^{\phi} \left(K_{t-1}\right)^{1-\phi} \right\}^{\alpha} \tag{D.25}$$

$$K_t = \left(1 - \delta\right) K_{t-1} + \left\{ 1 - \frac{\Omega}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right\} I_t \tag{D.26}$$

E Steady State Conditions

All $i's$, $j's$ and $k's$ denoting individual household, entrepreneur and bank respectively are ignored. From household's FOC with respect to consumption (D.1) and labor (D.4), I have

$$\frac{1 - \beta^P \gamma^P}{\left(1 - \gamma^P\right) C^P} = \lambda^P \tag{E.1}$$

and

$$N^{\eta - 1} = \lambda^P W \tag{E.2}$$

respectively. Household's FOC with respect to deposit (D.2) yields the steady-state gross interest rate

$$R^D = \frac{1}{\beta^P} \tag{E.3}$$

underscoring that the time preference of most patient individual determines the steady-state rate of interest. From (D.3), I obtain

$$\begin{aligned} \frac{\varsigma}{H^P} + \beta^P \lambda^P Q^H &= \lambda^P Q^H \\ \Rightarrow Q^H H^P &= \frac{\varsigma}{\lambda^P \left(1 - \beta^P\right)} \\ \Rightarrow H^P &= \frac{\varsigma}{Q^H \lambda^P \left(1 - \beta^P\right)} \end{aligned} \tag{E.4}$$

I next turn to entrepreneurs. Their consumption FOC (D.5) yields

$$\frac{1 - \beta^E \gamma^E}{\left(1 - \gamma^E\right) C^E} = \lambda^E \tag{E.5}$$

Entrepreneur's FOC with respect to loans (D.6) gives

$$\begin{aligned} \beta^E \lambda^E R^L + \mu^E R^L &= \lambda^E \\ \Rightarrow \mu^E &= \frac{\lambda^E \left(1 - \beta^E R^L\right)}{R^L} \end{aligned} \tag{E.6}$$

The borrowing constraint for entrepreneurs binds only if μ^E is positive. This implies that β^E must be less than R^L. In the baseline calibration, β^E is set to 0.95 whereas the steady state value of R^L is 1.0219 which implies that β^E must be less than 0.9786 which is indeed the case. The production function is

$$Y = A \left(N\right)^{1-\alpha} \left[\left(H^E\right)^{\phi} \left(K\right)^{1-\phi}\right]^{\alpha} \tag{E.7}$$

From firm's labor choice for households (D.7),

$$W = \left(1 - \alpha\right) \frac{Y}{N} \tag{E.8}$$

From entrepreneur's FOC with respect to housing (D.8), I have

$$\lambda^E Q^H = \beta^E \lambda^E \left(Q^H + \alpha\phi \frac{Y}{H^E} \right) + \mu^E \theta Q^H$$
$$\Rightarrow \frac{Q^H H^E}{Y} = \frac{\beta^E \alpha\phi R^L}{\left(1-\beta^E\right) R^L - \theta \left(1-\beta^E R^L\right)} \tag{E.9}$$

From aggregate law of motion for capital (D.26)

$$K = (1-\delta) K + \left[1 - \frac{\Omega}{2}\left(\frac{I}{I} - 1\right)\right] I$$
$$\Rightarrow I = \delta K \tag{E.10}$$

I have the following steady-state resource constraints

$$Y = C^P + C^E + I \tag{E.11}$$

$$H = H^P + H^E \tag{E.12}$$

$$L = D \tag{E.13}$$

Also, I have the following steady-state version of agents' budget constraints (one of them is redundant because of Walras' Law)

$$C^P = WN - (R^D - 1)D + \Pi \tag{E.14}$$

$$C^E = Y - R^L l - WN - I - x \tag{E.15}$$

So the steady state is characterized by the vector

$$\left[Y, C^P, C^E, I, H^P, H^E, K, N, L, D, Q^H, Q^K, R^D, R^L, W, \lambda^P, \lambda^E, \mu^E\right]$$

From entrepreneur's optimal choice of capital (D.9), I have

$$\kappa_t^E = \alpha\left(1-\alpha\right)\beta^E \mathbb{E}_t \left(\frac{\lambda_{t+1}^E Y_{t+1}}{K_t}\right) + \beta^E \left(1-\delta\right) \mathbb{E}_t \kappa_{t+1}^E + \mu_t^E \theta_t \mathbb{E}_t Q_{t+1}^K$$
$$\Rightarrow \frac{\kappa^E}{\lambda^E}\left(1 - \left(1-\delta\right)\beta^E\right) = \alpha\left(1-\phi\right)\beta^E \frac{Y}{K} + \frac{\left(1-\beta^E R^L\right)}{R^L} \theta Q^K \tag{E.16}$$

Entrepreneur's optimal choice of investment (D.10) yields

$$\lambda_t^E(j) = \kappa_t^E(j)\left[1 - \frac{\Omega}{2}\left(\frac{I_t(j)}{I_t(j-1)} - 1\right)^2 - \Omega\frac{I_t(j)}{I_t(j-1)}\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)\right]$$
$$+ \beta^E\Omega\mathbb{E}_t\left[\kappa_{t+1}^E(j)\left(\frac{I_{t+1}(j)}{I_t(j)}\right)^2\left(\frac{I_{t+1}(j)}{I_t(j)} - 1\right)\right]$$
$$\Rightarrow \lambda^E = \kappa^E \tag{E.17}$$

Combining this with steady state version of

$$\kappa^E = \lambda^E Q^K \tag{E.18}$$

I obtain $Q^K = 1$ in the steady state. Plugging this into (E.16), I obtain the expression for capital-to-output ratio

$$\frac{\kappa^E}{\lambda^E}\left(1 - (1-\delta)\beta^E\right) = \alpha(1-\phi)\beta^E\frac{Y}{K} + \frac{\left(1 - \beta^E R^L\right)}{R^L}\theta Q^K$$
$$\Rightarrow \frac{K}{Y} = \frac{\alpha(1-\phi)R^L\beta^E}{R^L\left(1-(1-\delta)\beta^E\right) - \theta\left(1-\beta^E R^L\right)} \tag{E.19}$$

Next, combining (D.15) and (D.16) yields

$$l = \frac{\theta}{R^L}\left[Q^H H^E + Q^K K\right] \tag{E.20}$$

Dividing by Y, the above expression becomes

$$\frac{l}{Y} = \frac{\theta}{R^L}\left[\frac{Q^H H^E}{Y} + \frac{Q^K K}{Y}\right]$$

Plugging in the values of $\frac{Q^H H^E}{Y}$ and $\frac{K}{Y}$ and using that $Q^K = 1$, I have

$$\frac{l}{Y} = \alpha\theta\beta^E\left[\frac{\phi}{R^L\left(1-\beta^E\right) - \theta\left(1-\beta^E R^L\right)} + \frac{(1-\phi)}{R^L\left(1-(1-\delta)\beta^E\right) - \theta\left(1-\beta^E R^L\right)}\right] \tag{E.21}$$

From entrepreneur's budget constraint (D.14)

$$C^E + R^L l = Y - WN - I + x \tag{E.22}$$

Rewriting this in ratios to output

$$\begin{aligned}\frac{C^E}{Y}+\frac{R^L l}{Y}&=1-\frac{WN}{Y}-\frac{I}{Y}+\frac{x}{Y}\\ \Rightarrow \frac{C^E}{Y}&=\alpha-\delta\frac{K}{Y}+\left(1-\gamma^L-R^L\right)\frac{l}{Y}\end{aligned}\tag{E.23}$$

Dividing (E.4) by Y and then dividing it again by (E.9) gives

$$\begin{aligned}\frac{\frac{Q^H H^P}{Y}}{\frac{Q^H H^E}{Y}}&=\frac{\frac{\varsigma}{Y\lambda^P\left(1-\beta^P\right)}}{\frac{\beta^E\alpha\phi R^L}{\left(1-\beta^P\right)R^L-\theta\left(1-\beta^E R^L\right)}}\\ \Rightarrow \frac{H^P}{H^E}&=\frac{\varsigma}{Y\frac{1-\beta^P\gamma^P}{\left(1-\gamma^P\right)C^P}\left(1-\beta^P\right)}\frac{\left(1-\beta^E\right)R^L-\theta\left(1-\beta^E R^L\right)}{\beta^E\alpha\phi R^L}\\ \Rightarrow \frac{H^P}{H-H^P}&=\frac{\varsigma\left(1-\gamma^P\right)}{\left(1-\beta^P\right)\left(1-\beta^P\gamma^P\right)}\frac{\left(1-\beta^P\right)R^L-\theta\left(1-\beta^E R^L\right)}{\beta^E\alpha\phi R^L}\frac{C^P}{Y}\end{aligned}\tag{E.24}$$

From entrepreneur's stock of habits for loans (D.11)

$$\begin{aligned}s_t&=\rho_s s_{t-1}+\left(1-\rho_s\right)l_t\\ s&=l\end{aligned}\tag{E.25}$$

Entrepreneur's effective demand for loans (D.12) gives

$$\begin{aligned}x_t&=\left(l_t-\gamma^L s_{t-1}\right)\\ \Rightarrow x&=\left(1-\gamma^L\right)l\end{aligned}\tag{E.26}$$

Total loans of entrepreneurs (D.13)

$$L=l\tag{E.27}$$

From bank's balance sheet condition (D.21), total deposits must equal total loans

$$D=L\tag{E.28}$$

Steady state version of stochastic discount factor (D.22) reads

$$q=\beta^P\tag{E.29}$$

The steady-state version of bank's first order condition (D.18) with respect to loans reads

$$\varrho^E = \beta^P \left[R^L - R^D + \gamma^L (1-\rho_s) \varrho^E\right]$$

which can be simplified to yield

$$\varrho^E = \beta^P \frac{R^L - R^D}{1 - \beta^P \gamma^L (1-\rho_s)} \tag{E.30}$$

The steady-state version of bank's second first order condition with respect to lending rate (D.19) writes

$$\xi \varrho^E x \frac{1}{R^L} = \beta^P L$$

Steady-state version of aggregate resource constraint (D.23) is

$$\begin{aligned} C^P + C^E + I &= Y \\ \Rightarrow \frac{C^P}{Y} &= 1 - \frac{C^E}{Y} - \delta \frac{K}{Y} \end{aligned} \tag{E.31}$$

Combining (E.1), (E.2) and (E.8) gives steady-state equilibrium condition for households

$$\begin{aligned} N^{\eta-1} &= \lambda^P W \\ \Rightarrow N^{\eta-1} &= \frac{1-\beta^P\gamma^P}{(1-\gamma^P) C^P} (1-\alpha) \frac{Y}{N} \\ \Rightarrow N &= \left[\frac{\left(1-\beta^P\gamma^P\right)(1-\alpha)}{(1-\gamma^P)} \left(\frac{C^P}{Y}\right)^{-1}\right]^{\frac{1}{\eta}} \end{aligned} \tag{E.32}$$

From (D.25), steady state output is

$$\begin{aligned} Y &= A (N)^{1-\alpha} \left[\left(H^E\right)^{\phi} (K)^{1-\phi}\right]^{\alpha} \\ Y^{1-\alpha} &= A (N)^{1-\alpha} \left[\left(\frac{H^E}{Y}\right)^{\phi} \left(\frac{K}{Y}\right)^{1-\phi}\right]^{\alpha} \\ Y^{1-\alpha} &= A (N)^{1-\alpha} \left[\left(\frac{H^E}{Y}\right)^{\phi} \left(\frac{\alpha (1-\phi) R^L \beta^E}{R^L \left(1-(1-\delta)\beta^E\right) - \theta \left(1-\beta^E R^L\right)}\right)^{1-\phi}\right]^{\alpha} \end{aligned} \tag{E.33}$$

From (E.4)

$$Q^H = \frac{\varsigma}{H^P \lambda^P (1-\beta^P)} \tag{E.34}$$

F System of Loglinear Equations

The system of equations log-linearized around their steady state is as below:

F.1 Optimality Conditions of Households

Equations (D.1), (D.2) and (D.3) become

$$\beta^P \gamma^P \mathbb{E}_t \widehat{C}^P_{t+1} - \left(1 + \left(\gamma^P\right)^2 \beta^P\right) \widehat{C}^P_t + \gamma^P \widehat{C}^P_{t-1} = \left(1 - \beta^P \gamma^P\right) \left(1 - \gamma^P\right) \widehat{\lambda}^P \tag{F.1}$$

$$\mathbb{E}_t \widehat{\lambda}^P_{t+1} = \widehat{\lambda}^P_t - \widehat{R}^D_t \tag{F.2}$$

$$\beta^P \mathbb{E}_t \left[\widehat{\lambda}^P_{t+1} + \widehat{Q}^H_{t+1} + \widehat{H}^P_t\right] = \widehat{\lambda}^P_t + \widehat{Q}^H_t + \widehat{H}^P_t \tag{F.3}$$

Log-linearization of (D.4) gives

$$(\eta - 1) \widehat{N}_t = \widehat{\lambda}^P_t + \widehat{W}_t \tag{F.4}$$

F.2 Optimality Conditions of Entrepreneurs

From (D.5) and (D.6), I have

$$\beta^E \gamma^E \mathbb{E}_t \widehat{C}^E_{t+1} - \left(1 + \left(\gamma^E\right)^2 \beta^E\right) \widehat{C}^E_t + \gamma^E \widehat{C}^E_{t-1} = \left(1 - \beta^E \gamma^E\right) \left(1 - \gamma^E\right) \widehat{\lambda}^E_t \tag{F.5}$$

and

$$\widehat{\lambda}^E_t = \widehat{R}^L_t + \beta^E R^L \mathbb{E}_t \widehat{\lambda}^E_{t+1} + \left(1 - \beta^E R^L\right) \widehat{\mu}^E_t \tag{F.6}$$

(D.7) yields

$$\widehat{W}_t = \widehat{Y}_t - \widehat{N}_t \tag{F.7}$$

From Equation (D.8), I derive

$$\begin{aligned}\left(\widehat{\lambda}^E_t + \widehat{Q}^H_t\right) = \beta^E \mathbb{E}_t \big(\widehat{\lambda}^E_{t+1} + \widehat{Q}^H_{t+1}\big) + \left(\frac{1}{R^L} - \beta^E\right) \theta \mathbb{E}_t \big(\widehat{\mu}^E_t + \widehat{\theta}_t + \widehat{Q}^H_{t+1}\big) \\ + \left[\left(1 - \beta^E\right) - \theta \left(\frac{1}{R^L} - \beta^E\right)\right] \mathbb{E}_t \big[\widehat{\lambda}^E_{t+1} + \widehat{Y}_{t+1} - \widehat{H}^E_t\big]\end{aligned} \tag{F.8}$$

Equation (D.9) becomes

$$\widehat{Q}_t^K = \left[1 - \beta^E(1-\delta) - \theta\left(\frac{1}{R^L} - \beta^E\right)\right]\mathbb{E}_t\left[\widehat{\lambda}_{t+1}^E - \widehat{\lambda}_t^E + \widehat{Y}_{t+1} - \widehat{K}_t\right]$$
$$+ \beta^E(1-\delta)\mathbb{E}_t\left(\widehat{Q}_{t+1}^K + \widehat{\lambda}_{t+1}^E - \widehat{\lambda}_t^E\right) + \left(1 - \beta^E R^L\right)\frac{1}{R^L}\theta\mathbb{E}_t\left[\widehat{\mu}_t^E - \widehat{\lambda}_t^E + \widehat{\theta}_t + \widehat{Q}_{t+1}^K\right] \quad \text{(F.9)}$$

(D.10) is approximated as

$$\widehat{Q}_t^K = \left(1 + \beta^E\right)\Omega\widehat{I}_t - \beta^E\Omega\mathbb{E}_t\widehat{I}_{t+1} - \Omega\widehat{I}_{t-1} \quad \text{(F.10)}$$

From (D.11) and (D.12), I get

$$\widehat{s}_t = \rho_s\widehat{s}_{t-1} + (1-\rho_s)\,\widehat{l}_t \quad \text{(F.11)}$$

and

$$\widehat{x}_t = \frac{\widehat{l}_t}{1-\gamma^L} - \frac{\gamma^L\widehat{s}_{t-1}}{1-\gamma^L} \quad \text{(F.12)}$$

From (D.13), I obtain

$$\widehat{L}_t = \widehat{l}_t \quad \text{(F.13)}$$

Equation (D.14) becomes

$$C^E\widehat{C}_t^E + R^L l\left(\widehat{R}_{t-1}^L + \widehat{l}_{t-1}\right) = Y\widehat{Y}_t - WN\left(\widehat{W}_t + \widehat{N}_t\right) - I\widehat{I}_t - Q^H H^E\left(\widehat{H}_t^E - \widehat{H}_{t-1}^E\right) + x\widehat{x}_t \quad \text{(F.14)}$$

(D.15) gives

$$\widehat{l}_t = \widehat{\theta}_t + \widehat{a}_t - \widehat{R}_t^L \quad \text{(F.15)}$$

Equation (D.16) yields

$$\widehat{a}_t = \frac{Q^H H^E}{Q^H H^E + Q^K K}\mathbb{E}_t\left(\widehat{Q}_{t+1}^H + \widehat{H}_t^E\right) + \frac{Q^K K}{Q^H H^E + Q^K K}\mathbb{E}_t\left(\widehat{Q}_{t+1}^K + \widehat{K}_t\right) \quad \text{(F.16)}$$

Linearized version of (D.17) is

$$\widehat{\kappa}_t^E = \widehat{\lambda}_t^E + \widehat{Q}_t^K \quad \text{(F.17)}$$

F.3 Optimality Conditions of Banks

From (D.18), I obtain

$$\frac{\varrho^E}{\beta^P}\widehat{\varrho}_t^E - \varrho^E\gamma^L(1-\rho_s)\mathbb{E}_t\widehat{\varrho}_{t+1}^E = \left[R^L - R^D + \varrho^E\gamma^L(1-\rho_s)\right]\mathbb{E}_t\widehat{q}_{t,t+1} + R^L\widehat{R}_t^L - R^D\widehat{R}_t^D \quad \text{(F.18)}$$

Log-linearization of (D.19) yields

$$\xi\varrho^E x\left(\widehat{\varrho}_t^E + \widehat{x}_t\right) = \beta^P R^L L\left(\widehat{R}_t^L + \widehat{L}_t + \mathbb{E}_t\widehat{q}_{t,t+1}\right) \quad \text{(F.19)}$$

From (D.21), I get

$$\widehat{L}_t = \widehat{D}_t \quad \text{(F.20)}$$

Linearized version of Equation (D.22) is

$$\widehat{q}_{t,t+1} = \widehat{\lambda}_{t+1}^P - \widehat{\lambda}_t^P \quad \text{(F.21)}$$

F.4 Market Clearing and Resource Constraints

Equations (D.23) and (D.24) yield

$$\widehat{Y}_t = \frac{C^P}{Y}\widehat{C}_t^P + \frac{C^E}{Y}\widehat{C}_t^E + \frac{I}{Y}\widehat{I}_t \quad \text{(F.22)}$$

and

$$H^P\widehat{H}_t^P + H^E\widehat{H}_t^E = 0 \quad \text{(F.23)}$$

From (D.25), I have

$$\widehat{Y}_t = \widehat{A}_t + (1-\alpha)\widehat{N}_t + \alpha\phi\widehat{H}_{t-1}^E + \alpha(1-\phi)\widehat{K}_{t-1} \quad \text{(F.24)}$$

Equation (D.26) gives

$$\widehat{K}_t = (1-\delta)\widehat{K}_{t-1} + \delta\widehat{I}_t \quad \text{(F.25)}$$