Securitization under Asymmetric Information over the Business Cycle

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Abstract

This paper studies the efficiency of financial intermediation through securitization in a model with heterogeneous investment projects and asymmetric information about the quality of securitized assets. Issuers of securitized assets can signal asset quality by retaining part of the risk. I find that signaling contributes to the variation in the degree of asymmetric information over the business cycle, which creates the documented growth asymmetry in the cycle. In particular, in the boom stage of the business cycle, signaling is inefficient and lower-quality assets accumulate on the balance sheets of financial intermediaries. This implies a deeper drop in output in a subsequent recession proportional to the length of the preceding boom.

Keywords: Asymmetric information; Securitization; Business cycles

JEL Classification: E32, E44, G01, G20.

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1 Introduction

Securitization, as well as the whole market-based system of financial intermediation, grew significantly in importance in the decades preceding the financial crisis of the late 2000s (Adrian and Shin, 2009). However, due to its role in that crisis (e.g., Bernanke, 2010), securitization has recently attracted a great deal of criticism. Most of this criticism points to various agency problems that stem from the asymmetry of information between the issuers and buyers about the quality of securitized assets. However, these problems were known well before the crisis (see e.g., Gorton and Pennacchi, 1995), and to limit them and signal asset quality, issuers of securitized assets provide recourse (guarantees) to buyers; in other words they retain some risk. This risk retention is either explicit (contractual, typically in a form of tranche retention) or implicit (non-contractual). The latter can be enforced when issuers have reputational concerns and has been popular due to its lower costs in the presence of capital requirements regulation.

The questions addressed in this paper are twofold: how does signaling by explicit or implicit risk retention affect the information asymmetry over the business cycle and what are its macroeconomic consequences. This paper suggests that risk retention reduces the asymmetry of information. However, the efficiency of this signaling, and thus the degree of information asymmetry varies over the business cycle. This creates a growth rate asymmetry in the business cycle observed in the data (decreases in output are on average larger than increases in output). Indeed skewness in annual output growth was -0.51 over the period 1953-2015 in the USA and has become more negative over time. In the last three decades (1986-2015), when securitization and market-based financial intermediation became more important, skewness was -1.56, while in the preceding three decades (1956-1985) it was -0.46.[1] In this model, signaling by risk retention is inefficient in boom stages of the business cycle, information about the quality of securitized assets remains private and low-quality assets are issued and accumulate on the balance sheets of financial intermediaries. This results in a deeper drop in output in a subsequent recession, proportional to the length of the preceding boom period. This mechanism replicates some of the securitization market outcomes observed prior to and during the late 2000s financial crisis (namely, low lending standards in the boom which contributed to the depth of the recession). To my knowledge, existing models of securitization fail to produce these results in a rational-expectations framework.

This paper contributes to the existing literature in several ways. It incorporates in a tractable manner asymmetric information and signaling problems into a business cycle model

[1] Skewness is of the first-differenced log of real gross domestic product (GDP) per capita as in Nieuwerburgh and Veldkamp (2006). At the quarterly frequency this pattern of skewness is similar: -0.46 over 1956q2-1985q4 and -1.30 over 1986q1-2015q4.

with financial intermediation, in particular into the dynamic stochastic general equilibrium (DSGE) framework by Kiyotaki and Moore (2012). Another contribution is that it studies in a business cycle model both explicit and implicit risk-retention. It also shows how asymmetric information and the signaling channel create asymmetries in the cycle and thus it contributes to the literature on asymmetric business cycles.

I motivate theoretical sections with an empirical analysis on the level of securitization deals, using data for European residential mortgage-backed securities. I study the relationship between credit enhancements (explicit recourse provided to holders of securitized assets) and the delinquency rate of the collateral (measure of the inverse of the quality of securitized assets). I find that higher lagged credit enhancement is negatively correlated with the delinquency rate in the United Kingdom (UK). This supports the signaling hypothesis of credit enhancement.[2] However, the signaling relationship disappears for the subset of deals issued in the boom. The theoretical sections endogenously produce this result for both explicit and implicit risk retention.

To study the effectiveness and macroeconomic consequences of signaling by risk retention, I develop a DSGE model of financial intermediation through securitization. To clearly demonstrate the model mechanism, I also include a simple static model version. Both models are populated by a continuum of financial firms that have access to stochastic heterogeneous investment projects. As a result, there is a need for financial intermediation. Optimally, firms would want to transfer resources to those with high-quality projects. The transfer of funds is possible through securitization, which is modeled as a sale of future cash flows from projects, but is subject to frictions. In particular, both models feature an asymmetry of information about the distribution of projects among firms.

In the boom stage of the business cycle, investing and securitizing become more profitable. As a result, under asymmetric information firms with low-quality projects are more likely to invest, and more low-quality projects are financed, which worsens the efficiency of resource allocation. To strengthen this result, the full dynamic model features the documented variation in the cross-sectional dispersion of returns from investment projects (loans). In particular, the relative cross-sectional difference in project returns is countercyclical. This variation in dispersion in the context of business loans, can be motivated by the empirical evidence in Bloom (2009) and Bloom et al. (2012), who find that the second moments of firms' total factor productivity (TFP) in the economy are countercyclical. In the context of loans to households, it can be motivated by the literature on the countercyclicality of earning risks, in particular by Guvenen et al. (2014) showing that the left-skewness of idiosyncratic income shocks is countercyclical. That means that while in recessions an average household has a

[2] See later in this Section for a list of related literature.

little lower income, a subset of households have significantly lower incomes. Loans to the latter are more prone to delinquencies such as in Nakajima and Ríos-Rull (2014), generating a countercyclical dispersion of loan returns. In this model, when booms are characterized by lower dispersion, firms with low-quality projects find investing even more attractive, which worsens further the efficiency of resource allocation in booms relative to recessions.

I investigate whether the introduction of the aforementioned risk retention tools can change the above result. I consider both explicit and implicit recourse. Explicit recourse is more expensive due to exogenous regulatory costs. Indeed, implicit recourse has been popular in reality because of regulatory arbitrage. An implicit recourse is a non-contractual support provided by issuers of securitized products to holders of these assets (see, for example, Higgins and Mason (2004) for concrete cases of implicit credit recourse or Brunnermeier (2009) for implicit liquidity recourse). This support is enforced in a reputation equilibrium, where failing to provide a recourse may be followed by punishment in the form of an inability to sell in the primary market for securitized assets in the future.[3]

I show that both explicit and implicit recourse can reduce the amount of low-quality investment and even signal the quality of securitized assets and achieve a separating equilibrium, where only high-quality projects are being financed. Recourse thus improves the efficiency of financial intermediation. However, in the boom stage of the business cycle, where it is more profitable to invest and securitize loans, sustaining a separating equilibrium would require levels of implicit recourse so high that they cannot be enforced through reputation or levels of explicit recourse that are too expensive. Therefore, the equilibrium remains pooling, i.e., both high- and low-quality projects are being financed and information about their quality remains private.

Since the efficiency of signaling varies over the cycle, signaling amplifies the time variation in asymmetric information, which especially in the presence of countercyclical dispersion in project returns causes an asymmetry in the business cycle. Indeed, investment in low-quality projects has only mild negative effects on the output as long as the economy stays in a boom, since dispersion among projects of both qualities is small. However, the effect of this accumulated stock of low-quality assets becomes more pronounced in the subsequent downturn of the economy, which is thus deeper. Indeed, the longer the boom, the larger the share of lower-quality assets on balance sheets and the deeper will be the subsequent downturn.

[3] Gorton and Souleles (2006) were among the first to show in a simple theoretical model that implicit recourse can be an equilibrium result in a repeated game due to the reputation concerns of issuers.

Related literature. The paper is related to the extensive literature on the adverse selection in asset markets and financial intermediation, including Leland and Pyle (1977) and Myers and Majluf (1984) and, more precisely in the context of securitization, Gorton and Pennacchi (1995), DeMarzo and Duffie (1999) and DeMarzo (2005), among others. In this paper, originators of securitized assets have reputational concerns similar to Chari et al. (2014) and Ordoñez (2014). Unlike in Chari et al. (2014), in this paper and in Ordoñez (2014) reputation helps firms selling high-quality assets to send a signal about the asset quality. Yet while Ordoñez (2014) focuses on the fragility of reputation-based banking in a recession, this paper shows that the signaling efficiency varies over the business cycle, finds a variation in the degree of information asymmetry over the cycle and studies its dynamic implications. Bigio (2013) also uses productivity dispersion shocks in a model with financial intermediation and asymmetric information. He finds that higher dispersion worsens the adverse selection problem and leads to a recession. In contrast, my model features signaling, which is more effective when the dispersion is larger.

One of the key results of this paper—inefficient allocation of capital in the boom—is related to the empirical evidence on the deterioration of bank lending standards during the boom stage of the business cycle (Lown and Morgan, 2006). Furthermore, this paper presents a mechanism for explaining inefficient allocation of capital in a boom that is alternative to those existing in the theoretical literature (e.g., Dell'Ariccia and Marquez, 2006, and Ruckes, 2004).

Finally, the model contributes to the literature on business cycle asymmetries. Previous papers explain growth rate asymmetries with faster learning in booms relative to recessions (Nieuwerburgh and Veldkamp, 2006) or asymmetric technology adoption costs (Jovanovic, 2006). Other papers focused on the level asymmetries (larger output deviations from trend in recessions than in booms) and put forward different mechanisms such as learning-by-doing in Acemoglu and Scott (1997), credit constraints in Kocherlakota (2000) or capacity constraints in Hansen and Prescott (2005).

The remainder of the paper is organized as follows. Section 2 presents an empirical motivation for the theoretical model. To clearly demonstrate the model mechanism and the role of frictions, I present a simple two-period model version in Section 3 and solve it analytically. Section 4 sets out the full infinite-horizon DSGE model with geometrically depreciating assets and risk-averse agents. All propositions derived in Section 3 can be reproduced analytically in the deterministic steady state of the full model. Section 5 reports the results of the full model with aggregate risk solved using global numerical methods and focuses on the dynamic effects of cyclical variation in asymmetric information. Finally, Section 6 concludes.

2 Empirical motivation

This empirical exercise studies the correlation between explicit credit enhancement (credit protection provided to holders of the securitized assets by the issuer) and the delinquency rate on the collateral loans (measure of the inverse of the quality of securitized assets).

The **signaling hypothesis** implies that lagged credit enhancement should be positively (negatively) correlated with the quality of the securitized assets (delinquency rate of collateral).

The literature (see, e.g., Mandel et al., 2012) also discusses an alternative **buffer hypothesis** which suggests that credit enhancement does not serve as a quality signal but is rather provided as a buffer against observable risk. If the buffer hypothesis dominates, a positive correlation should exist between (lagged) credit enhancements and delinquency rates.

2.1 Data description

I use the Performance Data Services (PDS) database by Moody's, which contains the quarterly data for the period 1998Q2-2013Q2 on the credit enhancement backing securitized products and on the delinquency rate of collateral of those products. I have access to the part of the database covering residential mortgage backed securities (RMBS) issued in European countries.[4]

The delinquency rate is the ratio of the amount of receivables that are 90 or more days past due to the original collateral pool balance. The delinquency rate is available on the pool level.[5] The PDS database contains various types of credit enhancement on tranche level data. I use the data for overcollateralization rate which is the difference between the collateral asset principal value and the principal value of the tranches in the deal normalized by the original collateral principal value. This type of credit enhancement is by definition the same for all tranches, i.e., it is available on the deal level. By contrast, other popular forms of credit enhancement are by definition tranche-specific (subordination) or are not always available for all tranches (reserve funds), which complicates the aggregation.

I use the output gap as a measure of the business cycle obtained by applying the Hodrick-Prescott (HP) filter on the real output data from Eurostat.

[4]In Appendix E, Table E.1, I report the data summary statistics. I would like to thank the European Central Bank for providing me with access to this part of the PDS database.

[5]A deal is typically backed by a pool of loans and consists of several tranches. I drop the observations where more pools back the same deal or more deals are backed by the same pool of loans since I do not have the information needed to do a proper aggregation. Thus I obtain unique deal pool pairs and delinquency available on the deal level.

2.2 Panel regression results

Regression specification. I run the following regression on the quarterly, deal-level data with fixed effects for deals (indexed by i) and time periods (indexed by t):

$$\begin{aligned} DelinqRate_{i,t} &= \alpha_i + \alpha_t + \beta\, Overcollat^D_{i,t-1} + \gamma\, Overcollat^D_{i,t-1} \times D_i^{originated\,in\,boom} \\ &\quad + \iota\, Z_{i,t} + \varepsilon_{i,t}, \end{aligned} \tag{2.1}$$

where $DelinqRate_{i,t}$ is the delinquency rate, $Overcollat^D_{i,t-1}$ is the ratio of credit enhancement in the form of overcollateralization to the original pool balance lagged one period and controlled for its potential trend and persistence,[6] $D_i^{originated\,in\,boom}$ is the dummy variable for deals issued in a boom period of the respective country and $Z_{i,t}$ is the set of control variables.[7]

Regression results. Table 1 shows the results for the three largest European countries by securitization activity: the United Kingdom (UK), Spain (SP) and the Netherlands (NL).

For the United Kingdom the results are in line with the signaling hypothesis (coefficient of $Overcollat^D_{i,t-1}$ (β) is significantly negative). Moreover, for a subset of deals issued in the boom stage of the business cycle, the signaling hypothesis is rejected (the coefficient of $Overcollat^D_{i,t-1} \times D_i^{originated\,in\,boom}$ (γ) is significantly positive with a value comparable or exceeding the coefficient of $Overcollat^D_{i,t-1}$).[8]

Over the whole sample of countries I cannot find support for the signaling hypothesis, though I find an opposite effect for the subset of deals issued in the boom stage of the business cycle. This would correspond to the buffer hypothesis. The same findings apply for Spain.[9]

Signs of the coefficients for control variables are not surprising. They suggest that the delinquency rate is persistent. The negative coefficient of the output gap implies that the

[6] To avoid a spurious regression problem due to a potential common trend or persistence of the variables, I use lagged delinquency rate $DelinqRate_{i,t-1}$ and *Deal age* (number of quarters since the deal's closing date) as explanatory variables. Moreover, I clear *Overcollat* from potential trend and persistence in a first-stage regression prior to using it in the main regression (2.1). Details are reported in Appendix E, where I also show that the results without this first-stage regression step are qualitatively unchanged.

[7] Control variables are $DelinqRate_{i,t-1}$, interaction term of overcollateralization with dummy for boom periods $Overcollat^D_{i,t-1} \times D^{boom}_{i,t}$, *Deal age* and the output gap $Output\,gap \equiv \ln(GDP_{i,t}) - \ln\left(GDP^{HP}_{i,t}\right)$, where $GDP^{HP}_{i,t}$ is the HP filtered real Gross Domestic Product (GDP, smoothing parameter 1600).

[8] Moreover, in Appendix E, I report the regression results for the sub-sample of deals issued in the boom stage and the coefficient of $Overcollat^D_{i,t-1}$ is not significantly different from zero, rejecting the signaling hypothesis.

[9] In the case of Spain, non-existing support for the signaling hypothesis is not surprising. Contrary to other countries, the Spanish regulator treated all securitized assets as if they would have remained on the issuer's balance sheet (see Acharya and Schnabl, 2010). Therefore, securitization in Spain was not used to transfer risk, but rather for liquidity reasons (see e.g., Almazan et al., 2015), and credit enhancement did not serve as a signaling tool.

delinquency rate is lower in a boom. The negative coefficient of *Deal age* implies that the delinquency rate decreases over the lifetime of the deal. This may result from the fact that over time, as some of the loans in the deal come to their maturity, the numerator (delinquent receivables) decreases, while the denominator (the original pool) remains unchanged. In Appendix E, I show that these results are robust to various alternative specifications.

To conclude, I find support for the signaling hypothesis of explicit credit enhancement in the case of the United Kingdom, but only for loans issued outside of the boom stage of the business cycle. The theoretical sections in this paper replicate the results for the explicit recourse, but more importantly, also for the implicit recourse, for which there is limited data.

Table 1. Overcollateralization as a signal of deal quality[a,b]

	(1)	(2)	(3)	(4)
Countries[c]	UK, SP, NL	UK	SP	NL
$DelinqRate_{i,t-1}$	0.890***	0.869***	0.828***	0.897***
	(0.008)	(0.010)	(0.021)	(0.016)
$Overcoll^{D}_{i,t-1}$	0.001	-0.062**	-0.003	0.010
	(0.005)	(0.027)	(0.004)	(0.011)
$Overcoll^{D}_{i,t-1} \times D^{origin\ in\ boom}_{i}$	0.021***	0.073***	0.030**	0.017
	(0.008)	(0.028)	(0.015)	(0.015)
$Deal\ age_{i,t}$	-0.003***	-0.025***	-0.000	0.000
	(0.000)	(0.003)	(0.000)	(0.000)
$Overcoll^{D}_{i,t-1} \times D^{boom}_{i,t}$	-0.008	0.028	0.004	-0.021
	(0.007)	(0.032)	(0.008)	(0.019)
$Output\ gap_{i,t}$	-8.587***			
	(1.932)			
Observations	13,226	3,949	5,486	3,791
R-squared	0.860	0.895	0.734	0.867
Number of deals	612	190	227	195

[a] Panel data regression with $DelinqRate_{i,t}$ as the dependent variable. I do not report the fixed effects for deals and time periods.

[b] Robust standard errors are clustered by deals and reported in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

[c] Time period is 1998Q2-2013Q2 for the whole sample, 2000Q2-2013Q2 for the UK, 1998Q3-2013Q2 for Spain and 1998Q2-2013Q2 for the Netherlands.

3 Simple two-period model

3.1 Model set-up

The model is populated by a continuum of risk-neutral competitive financial firms (indexed by i) that live for two periods $t = \{1, 2\}$. At the beginning of period 1, they each receive the same endowment of perishable good n_i, but they value goods only in period 2. Therefore, they need to invest their endowment into projects with returns in period 2. Note that the model is based on a simplified framework from Kiyotaki and Moore (2012).[10]

3.1.1 Investment projects

Three types of projects are allocated to firms through an i.i.d. investment shock κ_i:

- $(1-\pi)$ share of firms (subset $\mathcal{Z}$) do not have access to any investment projects;
- $\pi\mu$ share of firms (subset $\mathcal{H}$) have access to high-quality projects with high gross returns per unit of investment r^h in period 2; and
- $\pi(1-\mu)$ share of firms (subset $\mathcal{L}$) have access to low-quality projects with low gross returns per unit of investment r^l in period 2, where $r^h > r^l$.

The realization of this shock cannot be insured by ex ante contracts. But since all firms want to invest in period 1, there is a need for financial intermediation. The focus of the paper is on the study of securitization. Therefore, for simplicity, financial intermediation is possible only through the trading of assets backed by project returns. I refer to those assets as securitized assets.

3.1.2 Frictions in financial intermediation

Two **core frictions** are present in the model:

- ***Asymmetry of information*** about the project allocation: Each firm knows its project type, but it cannot observe the allocation of projects among other firms.
- ***"Skin in the game"*** constraint (hereafter SGC): Investing firms can sell at most a θ-fraction of their project investment in the form of securitized assets.

The first friction is motivated by the opacity of securitized assets and by the aforementioned criticism of securitization. The second friction can also be observed in reality. But the main reason for having it in this otherwise simple model is that, as shown in this section, only when the SGC is binding can asymmetric information friction have an impact on the equilibrium outcome.

[10] In order to study securitization, I extend it by introducing a heterogeneous quality of investment opportunities, asymmetric information and signaling by recourse provision.

Kiyotaki and Moore (2012) consider an additional friction (a resaleability constraint)[11] and study the effect of shock to this friction.[12] For simplicity, parameter capturing financing constraint in this model (θ) is exogenous in the body of the paper. In Appendix A.5 this friction is endogenized by the existence of a moral hazard problem and the qualitative results of the paper remain unchanged.[13]

3.1.3 Firms' problem

Each firm (indexed by i) chooses the level of investment x_i in period 1 in high- or low-quality projects subject to their availability (realization of κ_i).[14] Firms which decide to invest are referred to as "investing firms" (subset $\mathcal{I}$) and the remaining ones are "saving firms" (subset $\mathcal{S}$). When an investment is undertaken, securitized assets in the quantities x_i are originated. These assets are backed by project returns in period 2 and have market value q_i. An investing firm decides to keep $a_{i,i}$ of them on its balance sheet and sell the rest in the market $x_i - a_{i,i} \equiv s_i x_i$, where s_i is the fraction of investment sold in the market. Each firm can also buy securitized assets issued by other firms (indexed by j): $\{a_{i,j}\} \forall j \neq i$ for prices $\{q_j\}$.

If a firm sells part of its investment in the form of securitized assets, it can provide recourse to asset buyers in the form of a guaranteed minimum gross return r_i^G in period 2. This means that the firm promises to pay to any asset buyer any positive difference between the guaranteed return r_i^G and the project return $r_i \in \left\{r^h, r^l\right\}$, resulting in a promised payment: $g_i^G \equiv \max\left\{r_i^G - r_i, 0\right\}$ per unit of asset. The recourse can be either explicit r_i^{EG} or implicit r_i^{IG}.[15] In contrast to the explicit recourse, there is no contractual obligation to repay the implicit recourse, so an investing firm can default on it in period 2. The choice of default is represented by $\chi_i \in \{0, 1\}$.[16] I assume that explicit recourse is more costly than implicit. In particular, firms have to pay additional costs $\tau > 0$ per unit of provided explicit

[11] An extension of this model in Kuncl (2016) endogenizes this friction.

[12] One of the drawbacks of studying those exogenous shocks in isolation is that they produce a counterfactual asset price increases in recessions (Shi, 2015), therefore to fit the asset price data one need to consider them in combination with productivity shocks.

[13] Note that if recessions in the dynamic business cycle model are characterized by lower θ_t, which put an upward pressure on asset prices and on securitization profitability, the model mechanism may be weakened. But a sufficient condition for maintaining all the qualitative results in this paper is that asset prices do not increase in recessions, which is in line with the data.

[14] Following Gertler and Kiyotaki (2010), I sometimes refer to the investment in projects as loans. I also calibrate the full model using the performance of mortgage-backed securities. The underlying idea is that project owners, which are not modeled here, are able to offer perfectly state-contingent debt, and financial firms (banks) have all the bargaining power and extract the entire profit from project owners.

[15] When recourse is not provided, $r_i^{EG} = 0, r_i^{IG} = 0$. Explicit recourse in the model is analogous to explicit "vertical risk retention" which is typically implemented in reality by an issuer retaining the first-loss tranche.

[16] χ_i takes the value of 1 in the case of no default and 0 in the case of default.

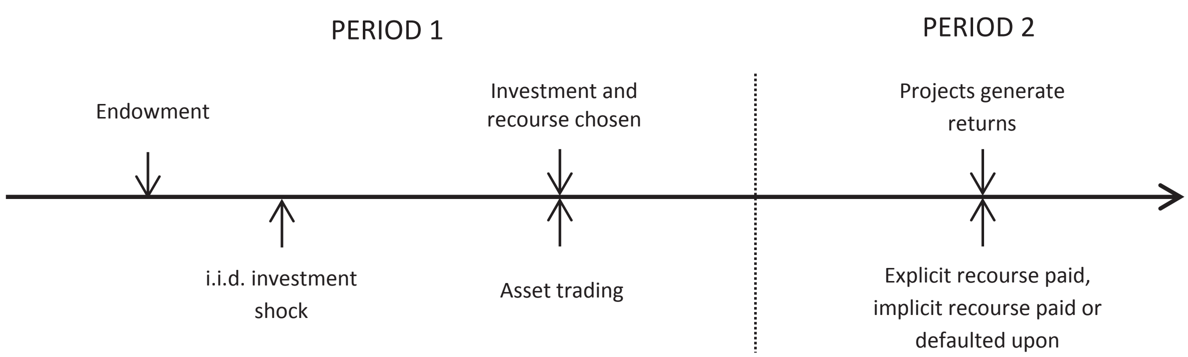
recourse in period 2.[17] In reality these additional costs are typically regulatory, but for the sake of simplicity they are exogenous here. The asset holder receives a return augmented by the recourse: $\hat{r}_i = \max\{r_i, r_i^{EG}, \chi_i r_i^{IG}\}$. Total recourse costs per unit of sold asset g_i^T to the asset seller are given by:

$$g_i^T = \max\left\{g_i^{EG}, \chi_i g_i^{IG}\right\} + \tau g_i^{EG}.$$

Asset buyers update their beliefs about the underlying project quality based on observable control variables of the selling firm. Each firm observes the following controls of each seller j: $b_{j,1} = \{r_j^{EG}, r_j^{IG}, s_j\}\ \forall j \in \mathcal{I}$ in period 1, and $b_{j,2} = \{\hat{r}_j\}\ \forall j \in \mathcal{I}$ in period 2. $\varphi_j(b_{j,1}) \in [0,1]$ denotes the posterior buyers' belief in period 1 that the asset sold by firm j is of high quality.[18]

Finally, firms obtain a continuation value $V(w_i)$, which increases in wealth at the end of period 2, w_i. To maintain the risk-neutrality of firms, I assume that the value function is linear in wealth: $V(w_i) = \nu w_i$.[19]

Figure 3.1. Timing of shocks and the choice of a firm's controls within each period



The timing of shocks and the choice of a firm's controls in both periods are shown in Figure 3.1. Given the above description of firms' options, their problem can be formalized. Each financial firm maximizes its expected value function

$$\max EV(w_i) = E\nu w_i$$

[17]Timing of additional costs is not relevant for the main results of the paper. For simplicity these costs do not depend on a buyer's beliefs about project type φ_i (see later definition).

[18]Note that the belief has no i index for the firm holding it, because all buyers have the same priors and the same information set.

[19]Note that the multiplicative functional form allows for easy comparison with analytic solutions in the full model with log utility.

subject to the SGC $s_i \leq \theta$ and budget constraints. In period 1, the budget constraint is:

$$x_i + \sum_{\substack{j \in \mathcal{I} \\ j \neq i}} a_{i,j} q_j = n_i + s_i x_i q_i. \tag{3.1}$$

This constraint shows that a firm's endowment n_i together with the market value of sold assets $s_i x_i q_i$ must equal the costs of investment $x_i = s_i x_i + a_{i,i}$ (marginal investment costs are normalized to 1) and the value of securitized assets bought from other firms $\sum_{\substack{j \in \mathcal{I} \\ j \neq i}} a_{i,j,t} q_j$. The period 2 budget constraint states that a firm's wealth at the end of period 2 w_i is comprised of asset returns augmented by the recourse received from other firms after deducting the costs of recourse provided by the firm g_i^T:

$$w_i = \sum_{j \neq i} a_{i,j} \hat{r}_j + a_{i,i} r_i - g_i^T s_i x_i. \tag{3.2}$$

3.1.4 Clearing of goods and assets markets

The model features a market for perishable goods and for securitized assets.

The goods market clears in period 1 when all endowment N is invested[20]

$$X^h + X^l = N, \tag{3.3}$$

and in period 2 when all project output constitutes the aggregate wealth of firms:

$$W_t = X^h r^h + X^l r^l. \tag{3.4}$$

Asset markets are cleared by a vector of prices which equalize expected returns from traded assets and make buyers indifferent among them:

$$E\left(\hat{r}_i / q_i\right) = E\left(\hat{r}_j / q_j\right) \; \forall i, j. \tag{3.5}$$

3.1.5 Equilibrium definitions and refinement

Formally, firms' actions and objectives define an extensive-form game of incomplete information which may have multiple perfect Bayesian equilibria (PBE).

Definition 1. A competitive PBE consists of prices $\{q_i\}$ $\forall i$ and individual strategies $\{x_i$, $\{a_{i,j}\}$, r_i^{EG}, r_i^{IG}, $\chi_i\}$ $\forall i, \forall j \in \mathcal{I}$ such that: (i) individual strategies solve firms' problems and

[20]The capital letters denote the aggregate quantities for the whole economy: $N = \sum_i n_i$, $X^h = \sum_i x_i \; \forall i \in \mathcal{H}$, $X^l = \sum_i x_i \; \forall i \in \mathcal{L}$ and $W = \sum_i w_i$.

are sequentially rational given firms' beliefs about quality of projects sold by other firms $\varphi_j(b_{j,1})$ $\forall j \in \mathcal{I}$ taking prices as given; (ii) both assets and goods markets clear; and (iii) firms update their beliefs using Bayes' rule on the equilibrium path.

Any equilibrium is either pooling or separating. In a pooling equilibrium, firms with high-quality projects and at least some firms with low-quality projects optimally choose the same level of controls that are observed by all other firms $b_{i,1}$ $\forall i \in \mathcal{I}$, where $\mathcal{I} \cap \mathcal{L} \neq \emptyset$. Therefore, assets backed by both high- and low- quality projects are sold in the market and buyers cannot distinguish between them. In a separating equilibrium, firms with high- and low-quality projects optimally select different observable controls, and therefore, buyers can exactly identify each asset's underlying project quality.

I use the "intuitive criterion" (Cho and Kreps, 1987) as a refinement to eliminate the dominated equilibria with unreasonable out-of-equilibrium beliefs. Consider an equilibrium in which investing firms have value functions V^{h*} and V^{l*} if they sell high- and low-quality assets, respectively. This equilibrium satisfies the intuitive criterion, if there does not exist a choice of a firm's observable control variables b_i' such that: (a) $V_i \mid_{\varphi_i=1,b_i=b_i'} > V^{h*}$ $\forall i \in \mathcal{H}$ and (b) $V_i \mid_{\varphi_i=1,b_i=b_i'} < V^{l*}$ $\forall i \in \mathcal{L}$. If such an observable control b_i' exists, then uninformed buyers should believe that only firms selling high-quality assets would choose such an observable control, which by (a) would represent a profitable deviation for firms selling high-quality assets and cause this equilibrium (with value functions V^{h*} and V^{l*}) to fail the intuitive criterion.

The implicit recourse can be enforced in a reputation equilibrium, where originating firms want to keep their reputation of honoring promises. In such an equilibrium, losing this reputation by defaulting on the implicit recourse must lower the firm's continuation value: $\nu \mid_{\chi_i=1} \equiv \nu^{ND} > \nu \mid_{\chi_i=0} \equiv \nu^{D}$. In the full infinite-horizon model in Section 4, I endogenize the effect of default on the firm's value function by assuming that default triggers a punishment in the form of an inability to sell assets in the market. In the same spirit, I assume in this simpler model that the negative effect of defaults is an increasing function in the firm's profits from asset sale and is zero when these profits are zero: $\nu^{ND} - \nu^{D} = f(\pi_{sale})$, $f'(\cdot) > 0$ and $f(0) = 0$, where $\pi_{sale} = w_i - w_i \mid_{s_i=0}$.

I call an implicit recourse exceeding a project return credible, if the originating firm i honors the recourse, i.e., when the following non-default condition is satisfied:

$$EV_i \mid_{\chi_i=1} \geq EV_i \mid_{\chi_i=0} . \tag{3.6}$$

Definition 2. A reputation equilibrium is one in which firms provide and honor an implicit recourse exceeding their project return.

Note that when the recourse is provided and honored ($\hat{r}_i > r_i$), asset holders do not observe project returns $r_i \ \forall i$.[21] Therefore, in a pooling equilibrium the asset quality never becomes public information and, unlike in the case of default which is observable, the continuation value of firms which sell low-quality asset is not negatively affected by the fact that they are "lying" about project quality.

3.2 Model solution

To demonstrate the effects of frictions in financial intermediation, I first show the model solution without frictions, and then successively introduce asymmetric information and a binding SGC.

3.2.1 Cases without binding SGC: first-best

No financial frictions. If neither of the two frictions is present, only firms with high-quality projects invest in equilibrium ($\mathcal{I} = \mathcal{H}$). As a result, all assets in the economy are of high quality.

Because of competition among firms with high-quality projects, the price of high-quality assets equals marginal investment costs: $q_i \equiv q^h = 1 \ \forall i \in \mathcal{H}$. Thanks to frictionless financial intermediation, all of the endowment is invested in period 1 into high-quality projects. As a result, the wealth of each firm ($w_i = n_i r^h \ \forall i$) as well as the aggregate wealth in period 2 ($W = N r^h$) is at the highest achievable level; therefore, the model solution is first-best. The following claim characterizes the choice of recourse and implies that since securitization brings zero profits for the investing firm (revenue from asset sale $q_i = 1$ equals the investment costs), therefore no recourse is provided in equilibrium (see proof in Appendix A.1).

Claim 1. *Under symmetric information, due to competition, recourse is provided if asset sale revenue exceeds the costs of recourse provision; in particular:*

- *explicit recourse is provided if* $q^h > 1 + \tau$,
- *credible implicit recourse is provided if* $q^h > 1$ *and if the non-default condition* (3.6) *is satisfied (the latter condition is more restrictive).*

Introducing asymmetric information Asymmetric information allows firms with low-quality projects to mimic firms with high-quality projects. In a pooling equilibrium, they

[21] This assumption can be mainly justified in the case of implicit recourse, which is used in reality as a means of regulatory arbitrage. Therefore, issuers prefer to provide recourse in ways that are hard to detect by the regulator, so they would hide the project return r_i.

can sell low-quality assets at a market price $q_i \equiv q \; \forall i \in \mathcal{I}$ which reflects the average quality of invested projects and exceeds the value of low-quality assets. The separating equilibrium exists only if firms with low-quality projects prefer buying high-quality assets to mimicking firms with high-quality assets:

$$V_i \left|_{buying\, high-quality\, assets} \quad > \quad V_i \right|_{mimicking} \; \forall i \in \mathcal{L}, \tag{3.7}$$

where mimicking requires a firm to invest, securitize and sell securitized assets with the same observable controls (b_i) as those chosen by firms with high-quality projects. Again because of competition, $q^h = 1$, securitization is not profitable; therefore no recourse is provided, and condition 3.7 can be written as $\nu n_i r^h > \nu n_i r^l$, which collapses to $r^h > r^l$ and is always satisfied by assumption. This leads to the following proposition.

Proposition 1. *When the SGC is not binding, asymmetric information friction has no effect on the model solution and the outcome is first-best.*

3.2.2 Cases with binding SGC

The SGC is binding when it restricts investment of firms with high-quality projects.[22] In this case, they sell a θ-share of their investment $s_i = \theta \; \forall i \in \mathcal{H}$ and use all their resources to fund a $(1-\theta)$ share of their investment $a_{i,i} = (1-\theta)\, x_i \; \forall i \in \mathcal{H}$. In other words, they do not buy assets issued by other firms ($\sum_{\substack{j \in \mathcal{I} \\ j \neq i}} a_{i,j} q_j = 0 \; \forall i \in \mathcal{H}$). Therefore, their period 1 budget constraint (3.1) can be rewritten as

$$x_i = \frac{n_i}{(1-\theta q_i)} \; \forall i \in \mathcal{H}. \tag{3.8}$$

I guess and verify that all firms with high-quality projects behave symmetrically, and as a result assets issued by them are priced equally: $q_i = q \; \forall i \in \mathcal{H}$. Since the individual investment function (3.8) is linear in endowment and the investment shock is i.i.d., I can aggregate them to obtain $X^h = \pi \mu N / \left(1 - \theta q\right)$, which in combination with the goods market clearing condition (3.3) for the separating equilibrium $X^h = N$ gives an expression for the equilibrium price:

$$q = \frac{1 - \pi\mu}{\theta}. \tag{3.9}$$

This leads to the next proposition.

[22] These firms are the only ones to invest when the SGC is not binding.

Proposition 2. *If the "skin in the game" is sufficiently large to satisfy*

$$1-\theta > \pi\mu, \tag{3.10}$$

then the price of high-quality assets exceeds investment costs, $q > 1$.

This implies that if the share of assets that need to remain on balance sheets of firms with high-quality projects, $1-\theta$, exceeds their share of endowment $\pi\mu$, the asset supply is restricted. To clear the market, the price must exceed the marginal investment costs. This makes securitization profitable and recourse can be provided in equilibrium.

For the sake of exposition, I first show the model solution when default on an implicit recourse does not affect firms' continuation values $\nu(\chi_i) = \nu \ \forall\chi_i, \forall i$. In this case, firms always default on implicit recourse in period 2, which renders such recourse not credible. Then I show cases in a reputation equilibrium where credible implicit is provided.

Model solution without implicit recourse

Claim 2. *Suppose condition* (3.10) *in Proposition 2 is satisfied and explicit recourse is not provided because of high costs ($\tau > \bar{\tau}$). Then the equilibrium is separating only if the return dispersion satisfies:*

$$\frac{r^h}{r^l} > \frac{(1-\theta)q^h}{1-\theta q^h} = \frac{(1-\theta)(1-\pi\mu)}{\pi\mu\theta}. \tag{3.11}$$

q^h is the price of a high-quality asset without recourse. Since condition (3.10) is satisfied, the right-hand side (RHS) of (3.11) exceeds one, and therefore a pooling equilibrium exists for small productivity dispersions. Appendix A.2 presents the proof of Claim 2 and a complete equilibrium characterization. The non-mimicking condition (3.11) shows that the return dispersion has to be higher for tighter financial intermediation frictions (low θ, μ and π). These frictions restrict the asset supply and increase the equilibrium market price, making mimicking more attractive. Particularly interesting is the effect of the maximum fraction of project for sale θ, which can be decomposed into a direct and an indirect general equilibrium effect. The direct effect of larger θ increases the RHS of (3.11) and makes separating equilibrium less likely, because the skin in the game, which is more costly for firms with low-quality investment, is reduced. The indirect effect of larger θ is lower equilibrium price, lower RHS of (3.11) and higher likelihood of a separating equilibrium. This is because lower price makes securitization less profitable. The indirect general equilibrium effect dominates:

$$d\left(\frac{(1-\theta)q^h}{1-\theta q^h}\right)/d\theta = \frac{1}{(1-\theta q^h)^2}\Big(\overbrace{q^h(q^h-1)}^{\text{direct effect }(+)} + \overbrace{(1-\theta)\frac{dq^h}{d\theta}}^{\text{indirect effect (-)}}\Big) < 0. \tag{3.12}$$

This result also implies that firms with high-quality assets cannot deviate from the pooling equilibrium to a separating equilibrium by keeping higher than the minimum required skin in the game in the investment (selling lower than maximum investment share $s_i < \theta$).[23] In a partial equilibrium a lower s_i might signal project quality, because it is more costly for firms with low-quality projects, but in a general equilibrium the indirect effect dominates.

Claim 3. *Lowering the skin in the game (increasing s_i) cannot signal project type in equilibrium.*

The threshold costs for providing explicit recourse is given by $\bar{\tau} = \frac{1}{\theta}\left(\frac{1-\theta}{\pi\mu} - 1\right)$ (see Appendix A.2). In other words, $\bar{\tau}$ increases with tighter frictions (low θ, μ and π). When these frictions are tight enough, $\tau < \bar{\tau}$ and explicit recourse is provided in equilibrium.

Claim 4. *Suppose condition* (3.10) *in Proposition 2 is satisfied and explicit recourse is provided* ($0 < \tau < \bar{\tau}$)*. Then the equilibrium is separating only if the return dispersion satisfies:*

$$\frac{r^h}{r^l} > \frac{1+\tau}{1+\tau-\pi\mu\tau}. \tag{3.13}$$

Given that $\tau > 0$, the RHS of condition (3.13) exceeds one, and therefore a pooling equilibrium exists for small productivity dispersions. The explicit recourse provision increases the costs of mimicking for firms with low-quality projects, whose recourse-related costs (proportional to $r^{EG} - r^l$) exceed those of firms with high-quality projects (proportional to $r^{EG} - r^h$). Moreover, the competitive equilibrium price for which guaranteed assets are sold, $q_i \equiv q^G \; \forall i \in \mathcal{H}$, depends only on the parameters that restrict the asset supply $q^G = (1-\pi\mu)/\theta$ in a separating equilibrium (see 3.9). Therefore, higher recourse does not increase the equilibrium price; it only increases securitization costs, which erodes the returns of price-taking firms and further disincentivizes mimicking by firms with low-quality projects. Note also that the RHS of (3.13) increases in τ, which implies that increasing the regulatory costs of explicit recourse increases the probability of a pooling equilibrium and as a result worsens the resource allocation. This leads us to the following proposition (formal proof in Appendix A.2).

Proposition 3. *Provision of an explicit recourse increases the parameter space where separating equilibrium takes place, and thereby improves aggregate resource allocation. However, as long as $\tau > 0$ it does not eliminate all the friction-related inefficiencies as pooling equilibria still exist. Increasing τ worsens the resource allocation.*

[23] In reality such behavior is sometimes reffed to as "vertical risk retention."

Note that since firms cannot default on the explicit recourse, prices of the assets with explicit recourse do not depend on the underlying project type.

Model solution with implicit recourse

In a reputation equilibrium, a credible implicit recourse can under asymmetric information serve as a signal of asset quality. Unlike in the case of the explicit recourse, firms can default on the implicit recourse, and since firms with low-quality projects have higher incentives to default, the beliefs of buyers about the project quality $\varphi_i \; \forall i$ matter. The update of beliefs and the intuitive criterion refinement will determine the model equilibrium. For the sake of clarity let us focus on the case where an explicit recourse is not provided because the additional costs τ are sufficiently large to discourage it ($\tau > \tilde{\tau}$).

Claim 5. *Suppose condition* (3.10) *in Proposition 2 is satisfied and explicit recourse is not provided ($\tau > \tilde{\tau}$). Then the equilibrium is separating only if the return dispersion satisfies:*

$$\frac{r^h}{r^l} > \frac{(1-\theta P)\, q^h}{1-\theta P q^h} = \frac{(1-\theta P)\,(1-\pi\mu)}{P\pi\mu\theta}, \tag{3.14}$$

where $P \equiv r_i^{IG}/r^h \; \forall i \in \mathcal{H}$ is the price premium for the recourse and $q^h = q^G/P$ is the price of an asset returning r^h. This equilibrium is the only PBE that satisfies the intuitive criterion.

See Appendix A.4 for the proof of Claim 5 and complete equilibrium characterization. The credible implicit recourse exceeds the project return ($r^{IG} > r^h$) if the default is costly, $\nu^{ND} > \nu^D$, which takes place only when the asset sale is profitable:[24]

$$\pi_{sale} = w_i \mid_{s_i=\theta} - w_i \mid_{s_i=0} = \left(\frac{r^h - \theta r^{IG}}{1-\theta q^G} - r^h \right) n_i = r^h n_i \theta P \frac{q^h - 1}{\pi\mu} > 0 \; \forall i \in \mathcal{H},$$

which collapses to $q^h > 1$. This implies that the RHS of (3.14) exceeds one; therefore a pooling equilibrium exists for small productivity dispersions not satisfying (3.14).

Comparing the conditions for the existence of separating equilibria both with an implicit recourse (condition 3.14 in Claim 5) and without (condition 3.11 in Claim 2), I find that provision of the implicit recourse increases the parameter subspace where a separating equilibrium takes place. The intuition for this is the same as in the case of explicit recourse.

Proposition 4. *Provision of an implicit recourse increases the parameter subspace where a separating equilibrium takes place, and thereby improves aggregate resource allocation. However, it does not eliminate all the friction-related inefficiencies as pooling equilibria still exist.*

[24]Recall that the effect of profit from asset sale on the difference in continuation values is endogenized in the full model, where default on implicit recourse triggers a punishment preventing the defaulting firm from selling issued assets in the future.

In this section, I have shown that despite the provision of an explicit or implicit recourse, the equilibrium remains pooling for low dispersion of project returns. The full model in the next two sections features aggregate productivity shocks and a countercyclical dispersion of returns, which both result in the switching between a pooling equilibrium in booms and a separating equilibrium in recessions. Dynamic implications of this variation in asymmetric information are analyzed.

4 Full infinite-horizon model

4.1 Model set-up

The full model is populated by a continuum of risk averse, infinitely-lived firms. Every period, firms consume part of the endowment and invest the rest into geometrically depreciating projects. I show that the main results derived in the two-period model hold in this more general model by re-deriving analytically the main propositions of the previous section for the model's deterministic steady state. The full stochastic model is solved using global numerical solution methods and its dynamic properties are shown in Section 5.

4.1.1 Investment projects

Similar to the two-period model, firms are allocated to heterogeneous investment projects through an i.i.d. shock κ_t: $(1-\pi)$ fraction of firms (subset $\mathcal{Z}_t$) do not have access to projects, $\pi\mu$ fraction of firms (subset $\mathcal{H}_t$) have access to high-quality projects with a high gross profit per unit of capital $r_t^h = A_t^h K_t^{\alpha-1}$, and $\pi(1-\mu)$ share of firms (subset $\mathcal{L}_t$) have access to low-quality projects with a low gross profit per unit of capital $r_t^l = A_t^l K_t^{\alpha-1}$. K is the aggregate holdings of capital consisting of high- and low-quality capital, H_t and L_t, respectively: $K_t = H_t + L_t$. Economy output Y_t is given by $Y_t = r_t^h H_t + r_t^l L_t = \left(A_t^h \frac{H_t}{K_t} + A_t^l \frac{L_t}{K_t}\right) K_t^\alpha$. Note that there are decreasing returns to scale in investment on the aggregate level. But, similar to Kiyotaki and Moore (2012), financial firms are small and face constant returns to scale, i.e., they take r_t^h and r_t^l as given.[25]

Countercyclical dispersion. The relative difference in gross profits from high- and low-quality projects is countercyclical:

$$\frac{\partial}{\partial A_t}\frac{A_t^h - A_t^l}{A_t^l} < 0, \tag{4.1}$$

[25]Kiyotaki and Moore (2012) obtain this result endogenously by including labor in the production function and requiring a competitive wage to be paid to workers.

where A_t is the aggregate component of TFP.[26] In other words, a dispersion shock is negatively correlated with the productivity shock. In the context of business loans this assumption is inspired by the empirical evidence in Bloom (2009) and Bloom et al. (2012) on countercyclical cross-sectional variance in the TFP of U.S. firms.[27] In the context of household credit, this assumption is inspired by the countercyclical income risk literature, in particular by the evidence in Guvenen et al. (2014) that left-skewness of income shocks is strongly countercyclical. This means that while in recessions an average household has a little lower income, a subset of households have significantly lower incomes. Loans to the latter households would be more prone to delinquencies, which would also imply a countercyclical loan return dispersion. For simplicity I do not model loan defaults and collateral to explicitly micro-found this assumption, rather following Gertler and Kiyotaki (2010) I assume that the project owners (borrowers) are able to offer a perfectly state contingent debt and financial firms have all the bargaining power and extract the entire profit/income from borrowers.

4.1.2 Firms' problem

Each firm (indexed by i) maximizes its utility from consumption.[28] A firm's wealth at the beginning of period $w_{i,t}$ consists of asset returns and the market value of the non-depreciated fraction λ of assets, reduced by the costs of explicit and implicit recourse promised in the preceding period. This wealth is used to consume $c_{i,t}$, to invest $x_{i,t}$, to keep non-depreciated assets and to acquire new assets. When a project investment is undertaken, assets backed by project returns are created. The investing firm sells $s_{i,t}x_{i,t}$ of these assets for the market price $q^P_{i,t}$ and promises explicit and implicit recourse, $r^{EG}_{i,t+1}$ and $r^{IG}_{i,t+1}$, respectively.[29] Explicit recourse carries additional costs τ. The firm may default on the implicit recourse ($\chi_{i,t+1} = 0$). Asset holders receive a return augmented by the recourse: $\hat{r}_{i,t+1} = \max\{r_{i,t+1}, r^{EG}_{i,t+1}, \chi_{i,t+1}r^{IG}_{i,t+1}\}$. Each firm can observe only the following seller j controls $b_{j,t} = \{r^{EG}_{j,u+1}, r^{IG}_{j,u+1}, s_{j,u}, \hat{r}_{j,u}\}$ $\forall u \leq t$, based on which they update beliefs about the quality of assets sold by the seller $\varphi_{j,t}(b_{j,t})$. Total recourse costs per unit of sold asset $g^T_{i,t+1}$

[26]Projects' TFP has an aggregate component, A_t, and a type-specific component, Δ^h_t and Δ^l_t: $A^h_t = A_t\Delta^h_t$ and $A^l_t = A_t\Delta^l_t$.

[27]Motivated by the empirical evidence, Bloom (2009) and Bloom et al. (2012) construct models that assume time-varying second moments of idiosyncratic TFP shocks and show that a higher variance can cause a recession. This can be reinterpreted in a simpler setting as a negative correlation between productivity and dispersion shocks.

[28]Except for assets and their prices, the notation remains the same as in the two-period model (Section 3).

[29]This implies a promised payment to asset buyers of $q^{EG} = \max\{r^{EG}_{i,t+1} - r_{i,t+1}, 0\}$ or $q^{IG} = \max\{r^{IG}_{i,t+1} - r_{i,t+1}, 0\}$, respectively.

to the asset seller are given by:

$$g^T_{i,t+1} = \max\left\{g^{EG}_{i,t+1}, \chi_{i,t+1} g^{IG}_{i,t+1}\right\} + \tau g^{EG}_{i,t+1}.$$

To keep the model tractable, the information about the issuer of a particular asset is available only for one period after asset issuance.[30] This implies that explicit and credible implicit recourse can be provided only for one period, because no recourse exceeding the project return will be provided when asset holders cannot identify the issuer. As a result of this assumption, there are three types of assets in every period t:

- Assets issued in the current period t: $a^P_{i,j,t}$ traded for $q^P_{j,t}$,
- Assets issued in the previous period $t-1$: $a^S_{i,j,t}$ traded for $q^S_{j,t}$,
- "Old" assets issued in periods prior to $t-1$, which have informative cash-flows due to the absence of recourse, and therefore, collapse into "old" high- and "old" low-quality assets: $h^O_{i,t}$ and $l^O_{i,t}$ traded for q^h_t and q^l_t, respectively.

Assets issued in periods t and $t-1$ have known issuers but, due to the asymmetry of information, their quality is not known unless revealed in equilibrium.

Figure 4.1 shows the timing of shocks and indicates that within each period firms make decision at two points in time (early and late). First, early in the period after the aggregate productivity shock is realized, firms that have not defaulted previously choose $\chi_{i,t}$ to maximize

$$\chi_{i,t} E^e_t V^{ND}\left(\bar{\mathbf{s}}_{i,t}\mid_{\chi_{i,t}=1}; \bar{\mathbf{S}}_t\right) + (1-\chi_{i,t}) E^e_t V^D\left(\bar{\mathbf{s}}_{i,t}\mid_{\chi_{i,t}=0}; \bar{\mathbf{S}}_t\right),$$

where E^e_t denotes expectations early in the period before the realization of the investment shock, $\bar{\mathbf{s}}_{i,t} = \{x_{i,t-1},\ \{a^P_{i,j,t-1}\},\ \{a^S_{i,j,t-1}\},\ h^O_{i,t-1},\ l^O_{i,t},\ r^{EG}_{i,t},\ r^{IG}_{i,t},\ \sigma_{i,t-1},\ \kappa_{i,t},\ \chi_{i,t}\}\ \forall j$ is the vector of individual state variables and $\bar{\mathbf{S}}_t = \{K_t, \omega_t, A_t, \Sigma_t\}$ is the vector of aggregate state variables.[31] V^{ND} and V^D are the value functions of firms that have never defaulted and firms that have defaulted previously, respectively. Those value functions are maximized late in the period. After the realization of the investment shock, firms choose $c_{i,t}$, $x_{i,t}$, $\{a^P_{i,j,t}\}\ \forall j \in \mathcal{I}_t$, $\{a^S_{i,j,t}\}\ \forall j \in \mathcal{I}_{t-1}$, $h^O_{i,t}$, $l^O_{i,t}$, $r^{EG}_{i,t+1}$ and $r^{IG}_{i,t+1}$ to maximize:

[30] In a related paper, Kuncl (2016) relaxes this assumption, features infinite-horizon implicit recourse and replicates the main qualitative results of this paper.

[31] $\kappa_{i,t}$ is the individual realization of the investment shock and $\sigma_{i,t}$ is the variable keeping track of firm's i default history, whose law of motion is $\sigma_{i,t} = \sigma_{i,t-1} + (1-\chi_{i,t})$. If the firm has never defaulted on the implicit recourse, then $\sigma_{i,t} = 0$. Σ_t is the distribution of wealth across firms.

$$
\begin{aligned}
V^{ND}\left(\bar{\mathbf{s}}_{i,t};\bar{\mathbf{S}}_t\right) &= \max[\log\left(c_{i,t}\right)+\beta E_t[\chi_{i,t+1}V^{ND}\left(\bar{\mathbf{s}}_{i,t+1}\,|_{\chi_{i,t+1}=1};\bar{\mathbf{S}}_{t+1}\right) \\
&\quad +\left(1-\chi_{i,t+1}\right)V^{D}\left(\bar{\mathbf{s}}_{i,t+1}\,|_{\chi_{i,t+1}=0};\bar{\mathbf{S}}_{t+1}\right)]] \\
V^{D}\left(\bar{\mathbf{s}}_{i,t};\bar{\mathbf{S}}_t\right) &= \max\left[\log\left(c_{i,t}\right)+\beta E_t V^{D}\left(\bar{\mathbf{s}}_{i,t+1};\bar{\mathbf{S}}_{t+1}\right)\right],
\end{aligned}
$$

subject to the SGC $s_{i,t} \leq \theta$ and budget constraints

$$
c_{i,t}+x_{i,t}+\sum_{\substack{j\in\mathcal{I}_t\\ j\neq i}} a^P_{i,j,t}q^P_{j,t}+\sum_{j\in\mathcal{I}_{t-1}} a^S_{i,j,t}q^S_{j,t}+h^O_{i,t}q^h_t+l^O_{i,t}q^l_t = w_{i,t}+s_{i,t}x_{i,t}q^P_{i,t}\;\forall i,\forall t. \tag{4.2}
$$

A firm's wealth at the beginning of the period t is determined by:

$$
\begin{aligned}
w_{i,t} &= \sum_{j\in\mathcal{I}_{t-1}} a^P_{i,j,t-1}\left(\hat{r}_{j,t}+\lambda q^S_{j,t}\right)+\left(h^O_{i,t-1}+\sum_{j\in\mathcal{I}_{t-2}\cap\mathcal{H}_{t-2}} a^S_{i,j,t-1}\right)\left(r^h_t+\lambda q^h_t\right) \\
&\quad +\left(l^O_{i,t-1}+\sum_{j\in\mathcal{I}_{t-2}\cap\mathcal{L}_{t-2}} a^S_{i,j,t-1}\right)\left(r^l_t+\lambda q^l_t\right)-g^T_{i,t}s_{i,t+1}x_{i,t+1}.
\end{aligned} \tag{4.3}
$$

Finally, firms which lost reputation due to default on implicit recourse in period $\bar{t}$ suffer a punishment in the form of an additional constraint: $s_{i,t}=0\;\forall t\geq\bar{t}$.

Following the identification of asset types, I can derive their aggregate laws of motion. First, all non-depreciated assets issued in period $t-1$ become in period t assets "issued in previous period":

$$
\sum_i\sum_{j\in\mathcal{I}_{t-1}} a^S_{i,j,t}=\sum_i\sum_{j\in\mathcal{I}_{t-1}}\lambda a^P_{i,j,t-1}
$$

Second, assets with status "issued in previous period" in period $t-1$ will be added in period t to the stock of non-depreciated high- or low-quality "old" assets of known quality:

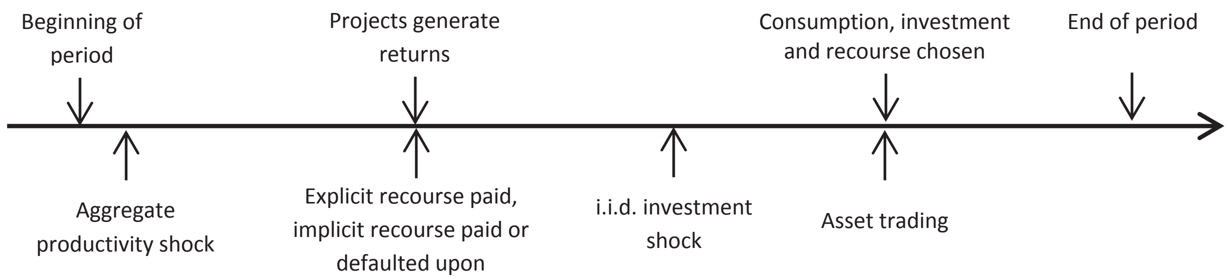
$$
\begin{aligned}
H^O_{t+1} &= \sum_i h^O_{i,t+1}=\sum_i\sum_{j\in\mathcal{H}_{t-2}}\lambda a^S_{i,j,t-1}+\sum_i\lambda h^O_{i,t-1}, \\
L^O_{t+1} &= \sum_i l^O_{i,t+1}=\sum_i\sum_{j\in\mathcal{L}_{t-2}}\lambda a^S_{i,j,t-1}+\sum_i\lambda l^O_{i,t-1}.
\end{aligned}
$$

Appendix B states the equilibrium definition and derives all the optimality conditions.

4.1.3 Goods and asset markets' clearing

The goods market clears when all current output Y_t is consumed or invested: $Y_t=C_t+X_t$. Markets for assets of different vintages and issued by different issuers clear when saving firms are indifferent about holding different assets (see their first-order conditions (FOC) in

Figure 4.1. Timing of shocks and the choice of a firm's controls within each period



Appendix B).

Recall that all assets depreciate over time, so the law of motion for capital (stock of projects) is $K_{t+1} = \lambda K_t + X_t$.[32]

4.2 Model solution in the deterministic steady state

Under constant aggregate productivity, the full model can be solved analytically and propositions in Section 3 can be re-derived for the full model. In this section, I reiterate the main results regarding the role of frictions (see Appendix C for proofs).

When the SGC constraint is not binding, only high quality projects are financed; their price equals investment costs $q^h = 1$; and the amount of investment, output and consumption is the first-best. The current period gross profit per unit of invested capital plus the value of non-depreciated assets is equal to the time preference rate $r^h + \lambda = \frac{1}{\beta}$.

The SGC constraint becomes binding when

$$1 - \theta > \frac{\pi\mu}{1-\lambda}. \tag{4.4}$$

This is a more general expression for the condition (3.10) in Proposition 2.[33]

The asymmetric information friction only has an effect on the equilibrium if the SGC is binding. When condition (4.4) is satisfied but the implicit recourse is ruled out by assumption, the equilibrium is separating when productivity dispersions are large enough to satisfy:

$$\frac{A^h}{A^l} > \frac{(1-\theta)q^h}{1-\theta q^h} = \frac{(1-\theta)(1-\pi\mu)(1-\lambda)}{\pi\mu(\theta+\lambda(1-\theta))} \tag{4.5}$$

[32] Similar laws hold for both types of capital (high- and low-quality): $H_{t+1} = \lambda H_t + X_t^h$, $L_{t+1} = \lambda L_t + X_t^l$. As in Kiyotaki and Moore (2012), I assume that the subjective discount factor exceeds the share of capital left after depreciation: $\beta > \lambda$.

[33] Intuitively a smaller depreciation rate $1-\lambda$ makes the SGC less likely to be binding, because more assets issued in preceding periods remain on balance sheets, which reduces demand for newly issued assets.

in the case where explicit recourse is too costly to be provided ($\tau > \bar{\tau}^F$); and

$$\frac{A^h}{A^l} > \frac{(1+\tau)(1-\lambda\rho_A)}{(1+\tau)(1-\lambda\rho_A) - \pi\mu\tau(1+\lambda\rho_B)} \tag{4.6}$$

when the explicit recourse is provided in equilibrium ($0 < \tau < \bar{\tau}^F$). ρ_A and ρ_B are positive constants defined in Appendix C. Conditions (4.5) and (4.6) are generalized version of conditions (3.11) and (3.13) in the simple model, respectively. When implicit recourse is provided (but explicit recourse is too costly ($\tau > \tilde{\tau}^F$), then the PBE which satisfies the intuitive criterion is separating if productivity dispersions are large enough to satisfy:

$$\frac{A^h}{A^l} > \frac{(1-\theta P)q^h}{1-\theta P q^h} = \frac{(1-\theta P)(1-\pi\mu)(1-\lambda)}{P\pi\mu(\theta+\lambda(1-\theta))}, \tag{4.7}$$

where $P > 1$ is the price premium for the implicit recourse. This condition is equivalent to condition (3.14) in Claim 5.

Similar to the simple model, comparison of the separating condition without recourse (4.5) with separating conditions with explicit (4.6) and implicit recourse (4.7), shows that the latter are satisfied on a larger parameter subspace. This implies that the provision of recourse improves the allocation of resources. But the RHS of all conditions (4.5), (4.6) and (4.5) exceed one. Therefore, similar to the simple model version, despite the provision of explicit or implicit recourse, pooling equilibria exist for the small productivity dispersions. Recourse does not eliminate all inefficiencies which are due to the existence of the binding SGC and asymmetric information.

Conditions for the existence of a separating equilibrium requires the productivity dispersion to be sufficiently high. Since the full model features aggregate productivity shocks and a countercyclical dispersion, asymmetric information varies over the cycle. The following section explores dynamic implications of this variation.

5 Dynamics

In this section, I show the solution of the full model with aggregate shocks. First, I find that financial frictions and asymmetric information lower output and increase its volatility. Second, I find that introducing signaling, increases output, lowers its volatility and makes output growth significantly negatively skewed, i.e., decreases in output when entering recessions are larger than output increases when entering expansions.

Calibration of parameters: The model is calibrated at an annual frequency. The aggregate productivity follows a two-state Markov chain $A_t \in \left(A^H, A^L\right)$[34] with a transition matrix $\mathcal{P} = [p, 1-p; 1-p, p]$. The persistence parameter for the productivity process is $p = 0.9$.[35] The ratio of aggregate productivities $A^H/A^L = 1.0277$ is chosen to match the annual standard deviation of GDP in the USA, which is 2.09% over 1953-2015. Ratio of idiosyncratic productivities in booms $\Delta^l\left(A^H\right)/\Delta^h\left(A^H\right) = 0.941$ is chosen to match the skewness of output growth in the USA, which is -1.56 in the last three decades (1986-2015), during which market-based financial intermediation including securitization became more widespread. Analogue ratio of productivities in recession $\Delta^l\left(A^L\right)/\Delta^h\left(A^L\right) = 0.745$ is set to reflect the delinquency rate of subprime mortgages after 12 months for loans issued in 2007, just prior to the financial crisis (25.5%). μ is set to match an increase of delinquencies on single-family residential mortgages from an average of 1.89% in the period between recessions of 2001 and of 2008-09 to 6.6% in 2008Q4 (one year after the onset of the 2008-09 recession). The annual asset persistence $\lambda = 0.78$ is chosen to replicate the weighted average life (WAL) for RMBS of 54.5 months (Centorelli and Peristiani, 2012). I use some parameterization from Del Negro et al. (2017), which is also refereed to for calibration by Kiyotaki and Moore (2012): $\alpha = 0.34$, $\beta = 0.96$ (annualized), and $\theta = 0.792$. The rate of availability of investment opportunities is set to $\pi = 0.04$ in order to allow for the switching between pooling and separating equilibria over the business cycle, supported by the empirical analysis in Section 2.[36] Finally, for simplicity I assume that additional costs of explicit recourse are large enough so that only implicit recourse is provided in equilibrium.

Solution method: The model with aggregate shocks is solved using a global numerical approximation method.[37] In particular, I find price and value functions by iterating them on a grid of state variables until convergence (see Appendix D).

Results: Table 1 compares standard deviation of output and skewness of output growth in different model versions. We can see that compared to the first-best case, the introduction of frictions increases output volatility and makes skewness of output growth slightly negative. Allowing signaling by recourse in the constrained case reduces output volatility compared to

[34]I will refer to periods with high (low) productivity as booms (recessions). Note that capital superscripts H, L refer to the aggregate state of the economy and not to the type of investment opportunity.

[35]This corresponds to an autocorrelation of quarterly TFP shocks of 0.95.

[36]This is lower (tighter) than in Del Negro et al. (2017), but this additional tightness compensates for the absence of other frictions in this model that are present in Del Negro et al. (2017) and which also restrict credit supply.

[37]See e.g. Judd (1998) for the description of global numerical methods and their distinction from local numerical methods.

the constrained case without signaling, but moves skewness of output growth much further into the negative territory.

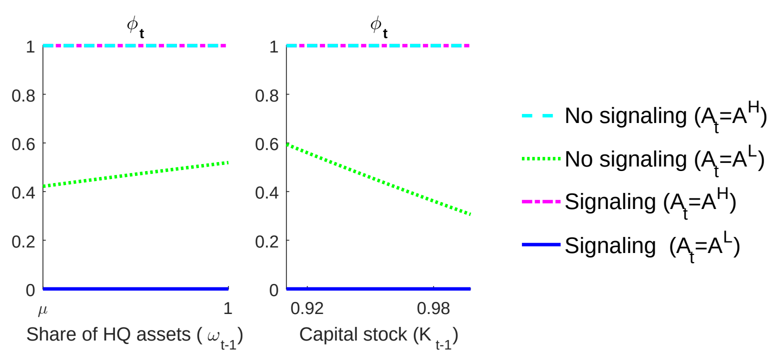
To understand the mechanism behind these effects, I plot selected policy functions and impulse responses in Figures 5.1-5.3. Figure 5.1 shows the equilibrium share of firms with low-quality projects that decide to invest as a function of state variables: $\phi_t(A_t, \omega_{t-1}, K_{t-1})$.[38] We can see that in the boom ($A_t = A^H$) irrespective of the signaling, the equilibrium is pure pooling, i.e., all firms with low-quality projects invest ($\phi_t = 1$). Investment is so profitable, that even signaling does not separate any firms with low-quality projects. In a recession, the share of firms with low-quality projects that decide to invest drops in both cases, but by much more in the case with signaling. In this calibration signaling leads to a complete separation in recessions ($\phi_t = 0$).

Table 1. Output statistics[a]

	Standard deviation	Skewness
Data	2.09	-1.56
First-best case	1.68	0.12
Constrained case without signaling	3.31	-0.29
Constrained case with signaling	2.09	-1.56

[a] Statistics for real annual GDP per capita: Standard deviation computed for percentage deviations from Hodrick-Prescott trend (1952-2015). Skewness is of the first-differenced log of GDP per capita (1986-2015). Model statistics (20,000 simulated observations): Standard deviation computed for percentage output deviation from mean and skewness is of the first-differenced output.

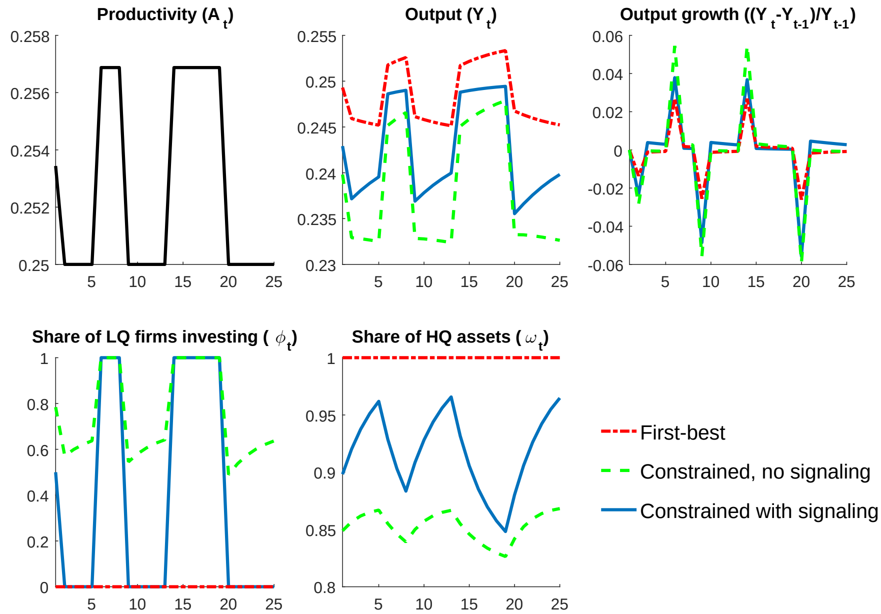
Figure 5.1. In recessions signaling reduces the share of LQ firms investing (ϕ_t)



Note: Left panel shows ϕ_t as a function of ω_{t-1} while K_{t-1} is fixed at 0.96. Right panel shows ϕ_t as a function of K_{t-1}, while ω_{t-1} is fixed at 0.91. Both panels show ϕ_t functions separately for A^H and A^L.

[38] In a separating equilibrium $\phi_t = 0$, in a pure pooling equilibrium, where all firms with low-quality assets invest $\phi_t = 1$, and in a mixing pooling equilibrium, where firms with low-quality assets are indifferent about investing $\phi_t \in (0, 1)$.

Figure 5.2. Impulse responses to productivity shocks



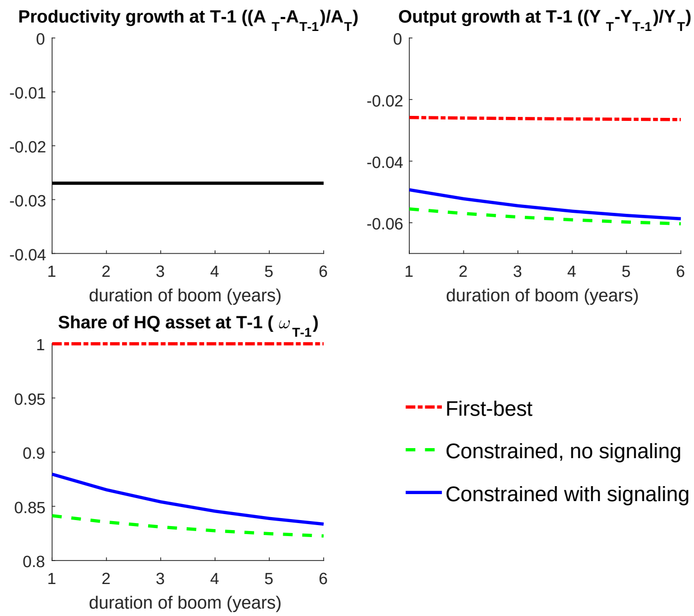
Note: All variables are expressed in levels and start in their respective stochastic steady states.

Figure 5.2 shows how the variation in ϕ_t over the cycle translates to output. It compares the response of selected variables to a series of exogenous productivity shocks. All variables start from their respective stochastic steady states[39] and are expressed in levels rather than deviations from steady states. We can see that output is lower and more volatile in the constrained cases than in the first-best case. Due to asymmetric information and the SGC, the allocation of firms' investment is inefficient. Indeed, as can be seen on lower panels of Figure 5.2, many low-quality projects are undertaken (ϕ_t is positive especially in a boom), which lowers the balance of outstanding high-quality assets in the economy (ω_t). Since return of low-quality projects is more volatile over the cycle, volatility of output increases in the constrained cases.

Figure 5.2 shows us also the effect of signaling. We already know from Figure 5.1 that $\phi = 1$ varies more over the cycle in the presence of signaling. This implies that the share of high-quality assets on firms balance sheets (ω_t) is also more volatile with signaling which causes larger asymmetry in output growth (negative skewness of output growth). Indeed, signaling cleans up balance sheets of firms from low-quality assets during recessions, so the output recovers slowly already in the low-productivity state. When the economy moves to a high-productivity state, the output increase is lower than in the absence of signaling, where

[39]Productivity in a steady state is kept at the zero-probability mean of the ergodic distribution across (A^H, A^L) with expectations that in the next period each state is equally likely. The impulse responses of endogenous variables start from a steady state to which they converge after many periods of this average productivity.

Figure 5.3. The longer the boom stage, the deeper the subsequent recession



Note: Recession starts in period T. Figure shows that while the drop of productivity in period T is independent of the duration of a preceding boom, output drop is sensitive in constrained cases, especially when signaling is present, because low-quality assets accumulate on balance sheets during boom.

a larger quantity of low quality assets start to perform significantly better. Analogously, in a boom low-quality projects are financed and the composition of firms' balance sheets worsens relatively faster in the case with signaling (ω_t drops relatively faster). Therefore, at the end of the boom, there is a larger fraction of low-quality assets that amplify the output drop when the economy switches to a recession.

Figure 5.3 shows that in the constrained cases, the longer is the boom period preceding the recession, the smaller is the fraction of high-quality assets on firms balance sheets when entering the recession (ω_{T-1}), and the more negative the change in output at the entry to the recession ($(Y_T - Y_{T-1})/Y_T$). This feature is significant mainly in the presence of signaling.

6 Conclusion

Motivated by the recent harsh criticism of securitization practices, I investigate the efficiency of financial intermediation through securitization in a DSGE model. In particular, I study how signaling with explicit and implicit risk retention by issuers of securitized assets affect the information asymmetry over the business cycle and what are its macroeconomic consequences.

Empirical analysis suggests that the explicit recourse (credit enhancement) may in some countries signal the quality of the loan. However, I also find that the signaling relationship disappears for the subset of securitization deals issued in the boom stage of the business cycle. In theoretical sections I endogenously replicate this result for both costly explicit recourse and for implicit recourse, for which detailed data is not available. Indeed signaling reduces the problem of asymmetric information in recessions. However, the higher costs of explicit recourse and credibility limits of implicit recourse make this signaling inefficient in the boom stages of business cycles, characterized by high productivity and low return dispersion. Due to this mechanism, low-quality projects are undertaken in boom and accumulate on balance sheets of financial intermediaries, which then amplify a subsequent downturn of the economy. This variation in asymmetric information over the business cycle ultimately results in a growth asymmetry in business cycles observed in the data.

The mechanism presented in this paper contributes to the understanding of the recent financial crisis, since it describes the experience of securitization markets prior to and during the crisis. In the preceding period, many inefficient investments of unknown quality were undertaken. While this was not problematic as long as the economy was performing well, the large amount of low-quality loans in the economy ultimately contributed to the depth of the financial crisis. The results are relevant for regulation of securitization since they suggest that self-regulation by risk-retention is inefficient in the boom.

References

Acemoglu, D., Scott, A., 1997. Asymmetric business cycles: Theory and time-series evidence. Journal of Monetary Economics 40, 501–533.

Acharya, V. V., Schnabl, P., 2010. Do global banks spread global imbalances? asset-backed commercial paper during the financial crisis of 2007-09. IMF Economic Review 58 (1), 37–73.

Adrian, T., Shin, H., 2009. Money, liquidity, and monetary policy. American Economic Review: Papers and Proceedings 99 (2), 600–605.

Almazan, A., Martín-Oliver, A., Saurina, J., 2015. Securitization and banks' capital structure.

Bernanke, B., 2010. Economic challenges: Past, present and future. A speech at the Dallas Regional Chamber, Dallas, Texas, April 7, 2010.
URL http://www.federalreserve.gov/newsevents/speech/20100407a.htm

Bigio, S., 2013. Endogenous liquidity and the business cycle. American Economic Review 105 (6), 1883–1927.

Bloom, N., 2009. The impact of uncertainty shocks. Econometrica 77 (3), 623–685.

Bloom, N., Floetotto, M., Jaimovich, N., Sapora-Eksten, I., Terry, S., 2012. Really uncertain business cycles. NBER Working Papers (18245).

Brunnermeier, M., 2009. Deciphering the liquidity and credit crunch 2007-2008. Journal of Economic Perspectives 23 (1), 77–100.

Centorelli, N., Peristiani, S., 2012. The role of banks in asset securitization. FRBNY Economic Policy Review 18 (2), 47–63.

Chari, V. V., Shourideh, A., Zetlin-Jones, A., 2014. Reputation and persistence of adverse selection in secondary loan markets. American Economic Review 104, 4027–70.

Cho, I.-K., Kreps, D. M., 1987. Signaling games and stable equilibria. The Quarterly Journal of Economics 102 (2), 179–222.

Del Negro, M., Eggertsson, G., Ferrero, A., Kiyotaki, N., March 2017. The great escape? a quantitative evaluation of the fed's liquidity facilities. American Economic Review 107 (3), 824–57.

Dell'Ariccia, G., Marquez, R., 2006. Lending booms and lending standards. The Journal of Finance 61 (5), 2511–2546.

DeMarzo, P., 2005. The pooling and tranching of securities: A model of informed intermediation. The Review of Financial Studies 18 (1), 1–35.

DeMarzo, P., Duffie, D., 1999. A liquidity-based model of security design. Econometrica 67 (1), 65–99.

Gertler, M., Kiyotaki, N., 2010. Financial intermediation and credit policy in business cycle analysis, 1st Edition. Vol. 3. In: Friedman, B. and Woodford, M. (Eds.), Handbook of Monetary Economics. Elsevier, Ch. 11, pp. 547–599.

Gorton, G., Pennacchi, G., 1995. Banks and loan sales: Marketing nonmarketable assets. Journal of Monetary Economics 35 (3), 389–411.

Gorton, G., Souleles, N., 2006. Special purpose vehicles and securitization. In: Carey, M. and Stulz, R. (Eds.), The risks of financial institutions. University of Chicago Press, Chicago, pp. 549–602.

Guvenen, F., Ozkan, S., Song, J., 2014. The nature of countercyclical income risk. Journal of Political Economy 122 (3), 621–660.

Hansen, G. D., Prescott, E. C., 2005. Capacity constraints, asymmetries, and the business cycle. Review of Economic Dynamics 8, 850–865.

Higgins, E., Mason, J., 2004. What is the value of recourse to asset-backed securities? A clinical study of credit card banks. Journal of Banking and Finance 28 (4), 875–899.

Jovanovic, B., 2006. Asymmetric cycles. The Review of Economic Studies 73 (1), 145–162.

Judd, K. L., 1998. Numerical methods in economics. MIT press.

Kiyotaki, N., Moore, J., 2012. Liquidity, business cycles and monetary policy. NBER Working Papers (17934).

Kocherlakota, N. R., 2000. Creating business cycles through credit constraints. Federal Reserve Bank of Minneapolis Quarterly Review 24 (4), 2–10.

Kuncl, M., 2016. Fragility of resale markets for securitized assets and policy of asset purchases. Bank of Canada Staff Working Paper (46).

Leland, H. E., Pyle, D. H., 1977. Informational asymmetries, financial structure, and financial intermediation. The Journal of Finance 32 (2), 371–387.

Lown, C., Morgan, D., 2006. The credit cycle and the business cycle: New findings using the loan officer opinion surveys. Journal of Money, Credit and Banking 38 (6), 1575–1597.

Mandel, B. H., Morgan, D., Wei, C., 2012. The role of bank credit enhancements in securitization. FRBNY Economic Policy Review 18 (2), 35–46.

Myers, S. C., Majluf, N. S., 1984. Informational asymmetries, financial structure, and financial intermediation. Journal of Financial Economics 13 (2), 187–221.

Nakajima, M., Ríos-Rull, J.-V., 2014. Credit, bankruptcy, and aggregate fluctuations. NBER Working Paper 20617.

Nieuwerburgh, S. V., Veldkamp, L., 2006. Learning asymmetries in real business cycles. Journal of Monetary Economics 53 (4), 753 – 772.

Ordoñez, G., 2014. Confidence banking and strategic default. Mimeo. University of Pennsylvania and NBER.

Ruckes, M., 2004. Bank competition and credit standards. The Review of Financial Studies 17 (4), 1073–1102.

Shi, S., 2015. Liquidity, assets and business cycles. Journal of Monetary Economics 70, 116–132.