Received: 11 August 2017 | Revised: 2 February 2018 | Accepted: 31 December 2018

DOI: 10.1002/ijfe.1721

RESEARCH ARTICLE

WILEY

Securitization as a response to monetary policy

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Funding information
China Europe International Business School Faculty Research Grant

JEL Classification: D82; G21; E52

Abstract

This paper studies how monetary easing provides incentives for banks to take risk and issue mortgage-backed securities (MBS) and, because MBS have the "lemon" property, why MBS buyers are willing to purchase high-risk securities at high prices. Banks need equity to attract deposits. Monetary easing reduces this need, and banks leverage up and reduce their monitoring efforts. The internal need for liquidity and risk sharing motivates banks to issue MBS. Security buyers understand the moral hazard problem that banks face but are willing to purchase bank securities at high prices because monetary easing would also reduce their cost of funds.

KEYWORDS

monetary policy, mortgage-backed securities, risk taking

1 | INTRODUCTION

On what caused the financial crisis of 2008, there are two schools of thought. One, represented by the chairman of the Federal Reserve, Ben Bernanke, holds financial deregulation and the consequent outburst of exotic financial innovation such as mortgage-backed securities (MBS) the primary cause (Bernanke, 2010). The other, advanced by John Taylor (2008, 2012) and others, holds monetary policy as the primary factor contributing to the unprecedented U.S. housing boom that eventually led to the crisis.

Although some researchers blame MBS for providing banks with additional liquidity and incentives to take excessive risk (Dokko et al., 2009), we conjecture that monetary easing policies induced banks first to take risk and then to sell MBS as a rational response to meet capital constraints or to transfer risk away. Indeed, Figure 1 shows that the issuance of MBS did not lead to explosive growth until 2002. The timing coincides with the onset of a low interest rate period. Furthermore, Figure 2 shows an almost one-to-one correspondence between the subprime MBS market value and subprime mortgages from 2003 to 2006. A divergence is seen in 2007, when the MBS market suffered a major correction. Thus, a couple of questions naturally arise: Could monetary policy be a driving force behind the surge in subprime mortgages? Would banks have then hedged against the increased risk of their loan portfolio by selling more MBS? If both questions can be answered in the affirmative, monetary policy and financial innovations cannot be treated as parallel and equally responsible for the housing bubble. Rather, the former may be considered the definitive cause and the latter a consequence.

In a previous study, Xu and Zhang (2017) show that if the central bank cuts its benchmark interest rate, commercial banks will lower their lending standards by

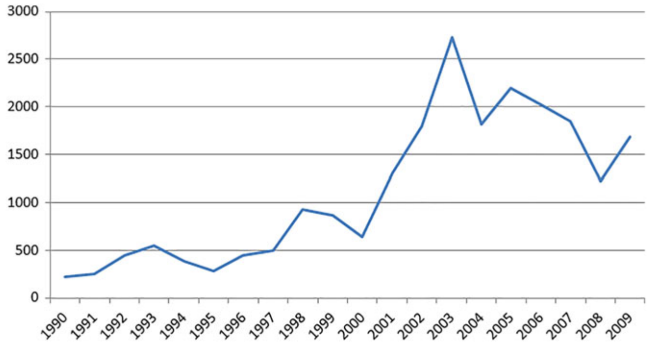

FIGURE 1 Total mortgage-backed securities issuance in the United States (billions of dollars; source: sifma.org report) [Colour figure can be viewed at wileyonlinelibrary.com]

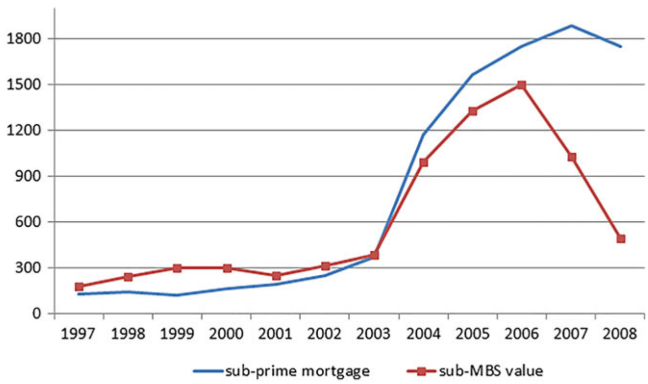

FIGURE 2 Subprime mortgage and subprime mortgage-backed securities (MBS) in the United States (billions of dollars; source: sifma.org report) [Colour figure can be viewed at wileyonlinelibrary.com]

allowing their clients to borrow more against the *same* collateral. We know that a higher loan-to-value ratio is one feature of subprime mortgages. However, when gauging the relative importance of monetary policy and MBS in generating the housing bubble, Xu and Zhang (2017) do not discuss why and to what extent banks would use MBS but set the MBS values exogenously.

In this study, we build a partial equilibrium model and examine how banks adjust their asset portfolio, particularly by using MBS, in response to changes in monetary policy. The literature identifies two motivations for banks to securitize loans: relaxation of capital constraints (also known as demand for liquidity, Altunbas, Gambacorta, & Marques, 2009; Berger & Udell, 1993; Carlstrom & Samolyk, 1995; Cerasi & Rochet, 2014; DeMarzo & Duffie, 1999) and transferring portfolio risks to third parties in the financial market (Dahiya, Puri, & Saunders, 2003; Dell'Ariccia, Igan, & Laeven, 2012; Marsh, 2006). These two motivations are considered as benefits of issuing MBS, which we model explicitly. We show that lower interest rate induces risk taking of banks, and therefore, their demand for liquidity and risk sharing increases.

Issuing MBS also incurs costs, due to asymmetric information and adverse selection problem in the MBS market. As widely acknowledged by the literature, the MBS market is a market for lemons (Downing, Jaffee, & Wallace, 2009). The risk of the MBS depends on the effort that banks spend on monitoring or screening the quality of the supporting asset. However, this effort is not observable to security buyers. In this case, the MBS is undervalued. Banks need to signal their effort, for example, by retaining some of supporting asset on their own book (DeMarzo & Duffie, 1999; Gorton & Pennacchi, 1995), to attract securities buyers. Moreover, the price that buyers are willing to pay for the MBS also depends on the policy rate, because their cost of fund depends on it. Lower interest rate booms the demand for MBS and causes its price to appreciate, and vice versa. In all, our model shows that if policy rate is high, the benefits from issuing MBS are small whereas the costs are large. Banks restrain themselves from taking too much risk, and their incentives to securitize mortgages are limited. By contrast, if policy rate is low, banks increase their risk taking, and they want to and can securitize their investment and sell it at high price because low interest rate alleviates the adverse selection problem.

Assume a commercial bank in a two-period model. The bank finances its investment by collecting deposits from households and its own equity. It pays risk-free interest to deposits at the rate set by the central bank. The cost of bank's equity is assumed to be higher than the risk-free interest rate, which is consistent with an equity premium (Dell'Ariccia, Laeven, & Marquez, 2010). This assumption implies that the bank prefers to finance its investment with more external fund than internal fund. However, we make another assumption that the bank cannot perfectly diversify the risk of its investment (Carlstrom & Samolyk, 1995; Cerasi & Rochet, 2014) such that its leverage (defined as the ratio of deposit over total investment size) is subjected to a "capital constraint": The bank must supply sufficient equity to remain solvent in case of investment failure. By partly securitizing the investment and selling to third party investors in exchange for liquidity, the bank bears less risk. Its capital constraint could be relaxed such that the bank needs less equity as input but can use more external finance. This shows the bank's demand for liquidity. In addition, if the bank is risk averse, issuing MBS and sharing risk with market bring utility gain. To maximize its utility, the bank chooses simultaneously the leverage, the fraction of the investment to be securitized, and the level of monitoring. The loan will be invested in a project with uncertain returns. Although costly, monitoring the investment may increase the probability of success. However, the bank's monitoring level is not observable to everyone, especially to the risk-neutral financial investors who purchase the MBS. We thus have a typical asymmetric information problem here. Because the bank's assets portfolio, particularly the retention of MBS, is publicly observable, it plays the role of signalling the effort level.

By including multiple players, we examine the interactions between monetary policy, the banking industry, and the financial market. In contrast, most previous works in the banking literature focus on only one aspect of these essentially complex issues. No less important, however, by deriving two propositions from the model, we establish a linkage from monetary policy to financial innovation and try to explain the coincidence of surge in MBS selling and low interest rates (Figure 1 shows that the total MBS issuance erupted after 2002 when Fed cut the interest rate to a historical low level).

Under the assumption of risk-neutral bank, we show that when the central bank cuts interest rates, the commercial bank takes more risks by increasing leveraging and decreasing their monitoring efforts (see Dell'Ariccia et al., 2010; Maddaloni & Peydro, 2011). It securitizes and sells larger portion of the investment. Although the returns on the project decline with the level of monitoring, the saving in monitoring cost *plus* the saving in equity may yield a higher expected total net income. Thus, we have Proposition I, formally confirming the causality from policy rate to MBS. Furthermore, the financial investor purchases more MBS at a lower policy rate not only because the securities are "mispriced" following asymmetric information but also because the opportunity cost of his capital is lower.

For a risk-averse bank, the results discussed before still hold. In addition, the bank has another motive to securitize its loans, namely, transferring its risk to a third party in the financial market. We show that when the bank is risk averse, the causality from monetary easing to MBS issuance becomes stronger.

This study is therefore a synthesis of the following studies. Dell'Ariccia et al. (2010) explained why policy rate cuts induce banks to take more risks but did not discuss the implications of the increased portfolio risk for their operation. Gorton and Pennacchi (1995), DeMarzo and Duffie (1999), and Malekan and Dionne (2012) study the optimal MBS contract. However, none of these studies address how changes in policy rate affect banks' decisions on the magnitude of risk taking and proportion of loans to be securitized.

The rest of the paper is organized as follows. Section 2 presents a literature review. Section 3 describes the model of risk-neutral banks. We show the effects of monetary policy on financial innovation, and we discuss the role financial regulation as a comparison. Section 4 models the risk-averse bank. Section 5 concludes the paper.

2 | LITERATURE REVIEW

The development of MBS markets has significantly changed the traditional banking business. Banks today are not only originators and holders of loans but also distributors of credit risk. This originate-to-distribute model of modern banking has been criticized as one of the reasons for the recent financial crisis. As banks pass on their asset risks to financial investors through securitization, they have less incentive to monitor borrowers and thus increase the risk of the entire financial system (Berndt & Gupta, 2009; Keys, Mukherjee, Seru, & Vig, 2010; Wang & Xia, 2014). Worse still, securitization of bank loans could spread the risk of the banking industry as a whole and paralyse the entire financial system (Allen & Carletti, 2006; Bank for International Settlements, 2006; Rajan, 2010). However, not many studies have researched why banks issue MBS, as they are lemons, and why investors are willing to purchase high-risk MBS at high prices.

Banks issue MBS mainly for two reasons. One, it eases their capital constraint, and the other, it transfers out their credit risk. Banks have economic as well as regulatory capital requirements. The former relates to the internal need for liquidity, whereas the latter is imposed by regulation or law. When bound by capital constraints, banks either increase their equity or shift their portfolio towards low risk-weighted assets (RWAs). MBS provide a convenient vehicle for banks to remove their high-risk and low-liquidity loans from the balance sheet and replace them with cash (Altunbas et al., 2009; Berger & Udell, 1993; Carlstrom & Samolyk, 1995; Cerasi & Rochet, 2014; DeMarzo & Duffie, 1999). Even if banks' capital constraints are not very tight, they might feel uncomfortable with risk on their loans and may decide to convert some of them into MBS (Dahiya et al., 2003; Dell'Ariccia et al., 2012; Marsh, 2006). These assumptions on bank securitization are generally supported by empirical studies (Affinito & Tagliaferri, 2010; Cardone-Riportella, Samaniego-Medina, & Trujillo-Ponce, 2010).

Although banks have strong incentives to offer MBS, why do financial investors buy such "lemon" products (Downing et al., 2009)? With the presence of information asymmetry, investors could try to mitigate the so-called adverse selection problem by hiring independent rating agencies to evaluate the securities (J. He, Qian, & Strahan, 2011) or ask for issuer guarantee (Gorton & Pennacchi, 1995; Higgins & Mason, 2003). They may also require the selling bank to retain part of the security offering (retention) so that the bank continues to monitor the underlying mortgages for its own interest (Gorton & Pennacchi, 1995; Malekan & Dionne, 2012).

Although previous studies explain the existence of the MBS market, they fail to explain the eruption of MBS during the 2002–2006 period. Reiss (2009) blames the rating agencies for misleading investors and for the consequent financial crisis. Dokko et al. (2009) attribute the sudden popularity of MBS to the failure of investors to fully understand the lemon problem. However, one critical question remains unanswered: What caused the rating agencies to lower their standards and investors to increase their risk appetite? Demyanyk and Van Hemert (2011) argue that the risk of MBS was probably masked under the seemingly ever-rising house prices during that period. This argument brings us to the analysis of the housing bubble of the 2000s. We show that unusually low policy rates contribute directly to not only house price inflation (Xu & Zhang, 2017) but also extraordinary growth of the MBS market in this paper.

In the theoretical banking literature related to securitization, the rate of retention plays a key role (DeMarzo & Duffie, 1999; Z. He, 2009; Malamud, Rui, & Whinston, 2013; Malekan & Dionne, 2012). It signals the underlying assets' quality as well as strength of commitment to monitoring the assets. This study shows that the optimal retention rate is also a function of policy interest rate.

3 | MODEL: RISK-NEUTRAL BANKS

3.1 | Model set-up

We present a two-period bank lending and securitization model in this section. A representative risk-neutral bank finances its loans using deposits from households as well as its internal funds (equity) in the first period. It also determines whether to securitize and sell the loan to a third party investor and, if so, how much to retain. The loan is invested in a risky project generating either a high return rate R^H if succeeds or a low return rate $R^L \leq 1$ if fails. The investment has to be monitored to decrease the probability of failure $p(a)$, where a is the monitoring effort exerted by the bank. We assume that the marginal benefit of monitoring is decreasing such that $p^{'}(a) < 0$, $p^{''}(a) > 0$, and also, we impose $p(0) < 1$, $\lim_{a \to \infty} p(a) = 0$. This monitoring effort is not publicly observable and entails a cost equal to $c(a)$. Following the traditional literature (e.g., Gorton & Pennacchi, 1995), we assume that $c(a)$ is a linear and increasing function of a: $c(a) = c \times a$.

The total investment size is normalized as 1. In the first period, the bank supplies its own equity k and collects households deposit $1 - k$ to finance the investment. Households are willing to supply deposit if and only if the bank can repay them $R^f(1 - k)$ in the second period (Carlstrom & Samolyk, 1995; Dell'Ariccia et al., 2010). R^f is the risk-free rate set by the central bank's monetary policy. Equity is more costly, with a yield R^I, which features the equity premium. We assume that $R^H > R^I > R^f > R^L$, and we impose the condition that $(1 - p(0))R^H + p(0)R^L \geq R^f$ such that investment is at least profitable for the bank even if it spends no monitoring effort. Because equity is more costly than deposit, external fund has the priority in bank's funding. Nevertheless, following Carlstrom and Samolyk (1995) and Cerasi and Rochet (2014), we assume that the bank cannot perfectly diversify its investment risk. As a bunch of literature emphasizes (e.g., Cerasi & Daltung, 2000; Diamond, 1984), bank equity is therefore required by the market participants to be willing to supply their fund to the bank. This assumption is conventional to feature the economic capital constraint (different to regulated capital constraint) faced by banks. In our model, in case of investment failure, the bank gains only R^L from investment. Therefore, for a plausible commitment of repaying-$R^f(1 - k)$, depositors will have to impose the economic capital constraint mentioned above (which we call it solvency constraint hereafter) on the bank as prerequisite for supplying on-balance-sheet funding. We thus have $R^L - c(a) \geq R^f(1 - k)$, where the left-hand side of the inequality is the bank's returns if investment fails and the bank does not securitize and sell any of the investment. This constraint will be relaxed if the bank issue MBS, as we shall discuss later.

The bank can securitize b share of the investment and sell it to a risk-neutral third party investor in exchange for liquidity, $0 \leq b < 1$. By doing so, $1 - b$ share of the investment is retained on the bank's book. The bank takes the retention of $1 - b$ as the signal that it also bears the risk of the investment and thus has incentives to monitor it. The investor is willing to buy the security only if its expected return is equal to or greater than the opportunity cost of the fund spent on purchasing it. Such opportunity cost depends on the policy rate set by the central bank.

3.2 | Benefits and costs of issuing MBS

By issuing MBS, there are two kinds of benefits. The first one is the relaxation of solvency constraint, and the second one is risk sharing. For risk-neutral banks, the second benefit does not matter. We consider the first benefit here and the second one in the model of risk-averse bank.

Denote the price of the security b as T, the investor is willing to pay T if and only if (which is binding in equilibrium)

$$(1-p(a))R^H b + p(a)R^L b \geq R^f T. \tag{1}$$

As the bank only retains $1 - b$ share of risky investment and sells b in exchange for liquidity, its return in case of investment failure is given by $R^L(1-b) + T - c(a)$. Therefore, the solvency constraint imposed by depositors is given by

$$R^L(1-b) - c(a) + T \geq R^f(1-k). \tag{2}$$

Under the assumptions of $R^H > R^f > R^L$ and $(1 - p(0))R^H + p(0)R^L \geq R^f$, it is straightforward to obtain $R^L(1-b) + T - c(a) > R^L - c(a)$ (see Appendix A). In other words, in case of investment failure, the bank's return with MBS selling is larger than that without. Therefore, selling MBS relaxes the solvency constraint and enables the bank to leverage up and to reduce the supply of equity k. Because equity is more expensive than deposit, selling MBS benefits the bank by bringing gains in the expected return of the investment.

Note that such benefit depends negatively on the policy rate. Condition (1) shows that the selling price of MBS, T, is decreasing in R^f, other things equal. Higher interest rate implies lower price of MBS, which we confirm in equilibrium as well. In addition, as R^f increases and approaches to R^I, external finance becomes less appealing. When policy rate is lower, the bank's preference to external finance is more significant, and its incentive to securitize the investment in order to be able to use more external finance is stronger.

There is also a cost associated with MBS issuance because MBS is mispriced or undervalued, due to asymmetric information problem. MBS buyers can only observe the portfolio of the bank but not its monitoring effort. For a bank to sell MBS, the benefit from monitoring that increases the expected return is shared by third party investors, but the cost of monitoring is completely born by itself. Therefore, the larger the portion of investment securitized, the lower is the monitoring effort that the bank will spend. MBS buyers understand this adverse selection problem, and they are perfectly aware that the bank may cheat them by reducing monitoring effort on the supporting asset of MBS without telling them. Therefore, to make sure the monitoring effort is at the second best level, MBS buyers require the bank to retain a portion of the investment as a signal that it bears at least some risk,[1] and they impose an incentive compatibility constraint on the bank. Following the contract design literature (DeMarzo & Duffie, 1999; Gorton & Pennacchi, 1995; Hart & Holmstrom, 1987), the incentive compatibility constraint can be written as

$$-p'(a)\left(R^H - R^L\right)(1-b) = c'(a). \tag{3}$$

This constraint says that the marginal benefit of monitoring the retained investment equals to the marginal cost.

3.3 | The bank's problem and optimal retention

In Period 1, the bank decides its leverage ratio $1 - k$, monitoring effort a, and retention level $1 - b$ simultaneously based on the potential lump-sum liquidity gain T from selling the security. The bank maximizes its expected return from the investment, subjected to the participation constraint of security buyers (constraint 1), solvency constraint (2), incentive compatibility constraint (3), and $0 \leq b < 1$.

$$\max_{k,a,b} \; (1-p(a))R^H(1-b) + p(a)R^L(1-b) - c(a) - R^f(1-k) - R^I k + T \tag{4}$$

$$s.t. \;\; (1-p(a))R^H b + p(a)R^L b \geq R^f T \tag{i}$$

$$R^L(1-b) + T - c(a) \geq R^f(1-k) \tag{ii}$$

$$-p'(a)\left(R^H - R^L\right)(1-b) = c'(a) \tag{iii}$$

$$0 \leq b \leq 1 \tag{iv}$$

Here, because security buyers are competitive and risk neutral, the participation constraint (i) is binding. The solvency constraint (ii) is also binding under our assumption about depositors. We will check whether (iv) is satisfied ex post.

We substitute k and T by constraints i and ii and assign β as the Lagrange multipliers of constraint (iii) to obtain the first-order conditions of the bank's problem as follows:

$$b = 1 - \frac{-p'(a)\left(R^H - R^L\right)R^I - \left(R^I + R^I R^f - R^{f2}\right)c}{\dfrac{p''(a)}{-p'(a)}\left(R^I\theta - R^I R^L R^f - R^{f2}\left(\theta - R^L\right)\right)}, \tag{5}$$

$$p'(a) = -\frac{c}{\left(R^H - R^L\right)(1-b)}, \tag{6}$$

$$k = 1 - \frac{\dfrac{\theta}{R^f}b + R^L(1-b) - c(a)}{R^f}, \tag{7}$$

where $\theta \equiv R^H(1-p(a)) + R^L p(a)$ is the expected rate of return of risky investment. Equation (5) shows that the optimal retention by the bank, $(1-b)$, is a function of the risk-free rate. Equation (6) shows that the optimal monitoring effort level is a function of the retention $(1-b)$, and Equation (7) determines the optimal leverage of the bank. To further interpret these equations, we need to make an explicit assumption regarding the effect of credit screening on a given loan's expected return. We choose a simple parametric form that is consistent with our earlier assumptions about the bank's credit screening technology and also possesses sensible implications (see Gorton & Pennacchi, 1995, for a similar treatment):

$$p(a) = \alpha \cdot e^{-\eta \cdot a},$$

where α and η are positive parameters, $0 < \alpha < 1$, and $\eta > 1$.

$$p'(a) = -\alpha\eta \cdot e^{-\eta \cdot a} < 0, \quad p''(a) = \alpha\eta^2 \cdot e^{-\eta \cdot a} > 0, \quad p(0) = \alpha, \quad p(\infty) = 0.$$

Thus, $p''(a)/(-p'(a)) = \eta$. Using Equation (6) to substitute $p'(a)$ in Equation (5), we obtain the solution of b as follows:

$$b = 1 - \frac{\left[\left(\frac{R^I - R^f}{R^f}c + \frac{R^I}{R^{f2}}c\right)^2 + 4\Delta\frac{R^I}{R^{f2}}c\right]^{\frac{1}{2}} - \left(\frac{R^I - R^f}{R^f}c + \frac{R^I}{R^{f2}}c\right)}{2\Delta}, \tag{8}$$

in which

$$\Delta = \eta\left[\frac{R^I}{R^f}\left(\frac{\theta}{R^f} - R^L\right) - \left(\theta - R^L\right)\right].$$

From Equation (8), we can see that b is increasing in Δ and $\lim_{\Delta \to \infty} b = 1$. On the other hand, $b \geq 0$ if and only if $\Delta \geq 0$. This gives a threshold level of risk-free interest rate $\overline{R}^f$:

$$\overline{R}^f \equiv \frac{\left[R^{L2} + 4R^I\theta\left(\theta - R^L\right)\right]^{1/2} - R^L}{2\left(\theta - R^L\right)}. \tag{9}$$

If $R^f \leq \overline{R}^f$, the bank will securitize a portion b of its loan according to Equation (8); if $R^f > \overline{R}^f$, the bank will not securitize any loan, that is, $b = 0$. In addition, because Δ is decreasing in R^f, it is straightforward to show that, if $R^f \leq \overline{R}^f$, the lower the risk-free interest rate, the larger is the portion of the loan securitized. The bank can do so because an interest rate cut reduces the opportunity cost of the security buyers' funds and the bank therefore does not need to keep high retention level to signal its monitoring effort.

The existence of $\overline{R}^f$ is interesting but not surprising. As discussed before, issuing MBS has benefits as well as costs, with both depending on the policy rate. When policy rate is high, the price of MBS is low and the external finance becomes less appealing. When $R^f > \overline{R}^f$, the cost of security buyers' fund is "too high" that, due to the lemon property of the MBS,[2] securitization is not the optimal choice for the bank. This explains the increase in MBS in the United States in 2002 when the Fed cut the interest rate to a historical low level. This occurred not because security buyers did not understand the lemons problem of MBS (as argued by Dokko et al., 2009) but because they increased their risk appetite when the cost of funds became significantly lower. Formally, we have the following lemma and proposition regarding the optimal retention level:

Lemma 1. *There exists a threshold level $\overline{R}^f$ such that the bank will securitize a portion* b *of its loan if and only if $R^f \leq \overline{R}^f$. $\overline{R}^f$ is determined by Equation (9).*

Proof: See Appendix A.

Proposition 1. *If $R^f \leq \overline{R}^f$, the lower the interest rate, ceteris paribus, the greater is the portion of loans securitized by the bank; that is,* b *is decreasing in* R^f.

Proof: See Appendix A.

We provide a numerical example in Figure 3, where the calibrations of our model parameters are shown in Table 1. In particular, regarding the bank's monitoring technology, we let $\alpha = 0.99$ and $\eta = 10$; the return rate in the good state is assumed to be $R^H = 1.2$, whereas that in the bad state is assumed to be $R^L = 1$; bank's equity requires a return rate of $R^I = 1.1$; and the cost of

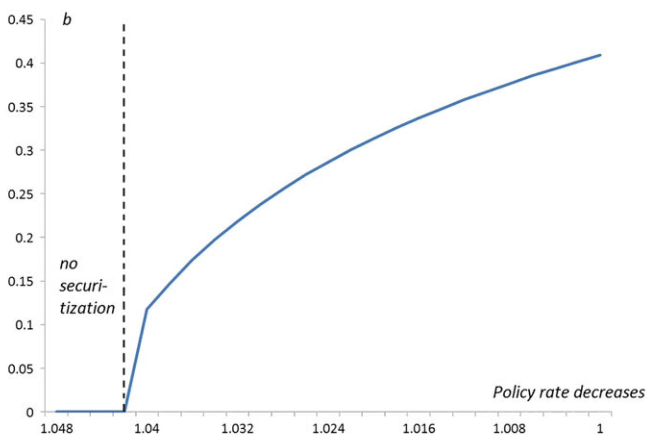

FIGURE 3 Size of securitization sold to third party investors (horizontal axis: risk-free rate decreases from 1.05 to 1) [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Calibration of the model

α	η	R^H	R^L	c	R^I	R^f
0.99	10	1.2	1	0.1	1.1	1.05

monitoring is $c = 0.1$. The principle of this calibration is to make sure that these parameters do not violate our assumptions and they approximate realities. Notice that the predictions given by Lemma 1 and Proposition 1 do not depend on the special choices of parameters value. The numerical example shown here simply serves as providing a more intuitive understanding of our model.

We vary the policy rate from 1.05 (or 5%) to R^L, and Figure 3 shows that the securitization level b increases as the interest rate reduces. As stated before, when the risk-free rate becomes lower, risky investment becomes more attractive, the value of the loan retained as signal of the bank's monitoring effort decreases, and the bank tends to securitize larger portions of its investment.

In addition, Equation (6) determines the optimal monitoring level. Because bank's retention of the loan $(1 - b)$ decreases when interest rate is lower, an interest rate cut reduces the bank's monitoring effort. In addition, Equation (7) shows that k decreases as the policy rate becomes lower (the bank supplies less equity and becomes more levered). These results are consistent with the empirical findings of Maddaloni and Peydro (2011). Interest rate cut reduces the cost on repaying deposit. With the solvency problem alleviated, depositors will allow the bank to leverage up. This shows risk taking of banks under lower policy rate. We formally have the following Proposition 2:

> **Proposition 2.** *Ceteris paribus, an interest rate cut induces the bank to take up more risk by decreasing the monitoring of investment projects and increasing the leverage.*

Proof: See Appendix A.

The literature has widely argued on securitization leading to the lax screening of banks (Berndt & Gupta, 2009; Keys et al., 2010; Purnanandam, 2011; Wang & Xia, 2014). Our model supports this argument. Particularly, Equation (6) implies that when a bank sells a portion of its loan ($b > 0$), the level of credit monitoring, a, is less than it would be if the bank had retained the entire loan ($b = 0$). The reduced monitoring effort level is a result of the moral hazard problem of banks, as discussed earlier; Equation (6) shows that, ceteris paribus, the larger the portion of loans securitized, the smaller is the monitoring effort.

However, our model also shows that the loan amount securitized is a function of policy rate. Thus, we cannot directly conclude whether a policy rate cut or securitization alone is more significant in driving the risk-taking behaviour of banks. Theoretically, however, as MBS have lemon-like features, the incentives of banks to securitize more or securitize loans of poorer quality can be expected, and investors price them. In fact, banks try to minimize this information asymmetry problem by optimally choosing the loan portion to securitize. To sell MBS at a higher price, some banks securitize loans of better quality and retain those of poorer quality (Jiang, Nelson, & Vytlacil, 2014). This MBS pricing argument shows that the lemon problem, to a certain extent, restrains the risk-taking incentive following the originate-to-distribute model. In fact, Lemma 1 in the previous subsection shows that banks will securitize their loans only when interest rate is too low. Monetary easing not only affects the banks' cost of funds and provides them with incentives to take more risk but also has the direct effect of reducing the security buyers' cost of funds. In this sense, monetary policy can be a stronger and wider variable affecting the general attitude towards risks. Thus, we argue that Fed's persistent monetary easing during 2001 and 2005 was the reason of excessive risk-taking of financial market. In fact, our argument explains why MBS did not erupt until 2002 (see Figure 1).

3.4 | The role of financial regulation and banks' regulatory capital arbitrage

In reality, commercial banks are subjected to regulatory capital constraint. For example, Basel Accord III requires that the commonly equity tier 1 over the RWAs of commercial banks must be greater than 4.5%. In our model, if none of the investment is securitized, the commonly equity tier 1 is k and RWA is the total investment of size 1 (we assume that the risk weight on the loan is 1). According to regulation, we thus have $k \geq 4.5\%$. This regulatory capital constraint is exogenously given, and according to many discussions in the literature, financial deregulation attributed largely to the financial innovation such as massive securitization (Bernanke, 2010; Dokko et al., 2009).

In our model, nevertheless, financial regulation, rather than deregulation, actually provides another motive for banks to securitize investment. As Equation (7) shows, when R^f approaches to R^L, k approaches to 0 (see Appendix A for the proof). The same property applies when $b = 0$. This might violate the regulatory capital constraint. However, by securitization, the bank removes part of the risky asset off its book and replaces it with riskless liquidity. If b share is securitized and $1 - b$ is retained, RWA in this case is $1 - b$, and the regulatory capital constraint becomes $\frac{k}{1-b} \geq 4.5\%$. The smaller the retention, the smaller is the equity required according to regulation.

Therefore, there is a mechanism that financial regulation motivates banks' securitization. Suppose there is no securitization for a start. When policy rate is low, banks leverage up (Equation 7 when $b = 0$). Further policy rate cut causes k to decrease and approach to the regulation limit. As MBS provide a convenient vehicle for banks to remove their high-risk and low-liquidity loans from the balance sheet and replace them with cash, or in other words, MBS relaxes the regulatory capital constraint from $k \geq 4.5\%$ to $\frac{k}{1-b} \geq 4.5\%$, banks have incentive to securitize their investment such that they can reduce the supply of equity further. This phenomenon is often referred to as regulatory capital arbitrage (Ambrose, Lacour-Little, & Sanders, 2005; Kashyap, Rajan, & Stein, 2008). It contrasts to the view that blames financial deregulation for the massive securitization. Figure 4 gives an example of how financial regulation provides incentives for banks to securitize.

4 | MODEL: RISK-AVERSE BANKS

In this section, we consider risk-averse banks to feature their need for credit risk sharing. The basic structure of risky investment and monitoring technology is the same as previously mentioned, except that banks now maximize their utility $U(.)$ instead of the expected profit. The assumption of risk-averse banks implies that $U(.)$ is increasing and concave and that, formally, $U'(.) > 0$, $U''(.) < 0$, and $U(0) = 0$. All other agents, namely, the depositors and security buyers, are still risk neutral. We show that besides internal need for liquidity, banks have an incentive to transfer their risk to third parties by securitizing their loans. Interest rate cuts strengthen this incentive, and banks securitize larger portions of their loans.

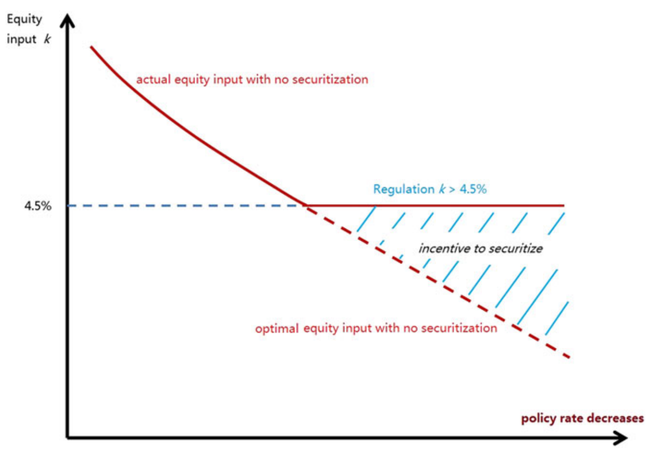

FIGURE 4 The incentives to securitize. (The solid red curve gives the actual equity input of the bank, and the dashed red curve gives the potential optimal equity input when the policy rate decreases. For a start, securitization is not allowed such that regulatory capital constraint is given by $k > 4.5\%$. Because the optimal equity input is lower than the regulation limit, banks have the incentive to securitize.) [Colour figure can be viewed at wileyonlinelibrary.com]

If we denote the share of loan securitized and sold as b, the bank's return in case of success is $R^H(1-b) + T - c(a) - R^f(1-k)$, and its return in case of bad state is $R^L(1-b) + T - c(a) - R^f(1-k)$. T is the liquidity generated from selling MBS. Because the security buyers are risk neutral, the following participation constraint still holds:

$$(1-p(a))R^H b + p(a)R^L b = R^f T.$$

The bank maximizes

$$\max_{a,b,k} \overline{U} = (1-p(a))U\left(R^H(1-b) + T - c(a) - R^f(1-k)\right) + p(a)U\left(R^L(1-b) + T - c(a) - R^f(1-k)\right) - R^I k$$

$$s.t. \quad R^L(1-b) + T - c(a) \geq R^f(1-k) \qquad \text{(i)}$$

$$(1-p(a))R^H b + p(a)R^L b = R^f T \qquad \text{(ii)}$$

$$\overline{U} \geq U^* \qquad \text{(iii)}$$

$$0 \leq b \leq 1 \qquad \text{(iv)}$$

Constraint (i) is the solvency constraint imposed by depositors, exactly the same as Equation (2) for the case of risk-neutral banks. Constraint (ii) determines the price of the MBS. Constraint (iii) indicates that the bank will securitize its loan if and only if its utility from doing so is not less than that from not doing so. In this constraint, U^* is the maximized utility level when there is no securitization,[3] or,

$$U^* = \max_{a,k}(1-p(a))U\left(R^H - c(a) - R^f(1-k)\right) + p(a)U\left(R^L - c(a) - R^f(1-k)\right) - R^I k s.t.$$

$$R^L - c(a) \geq R^f(1-k).$$

To solve this problem, we assume that constraint (iii) is not binding. We examine whether this constraint is satisfied through an ex post test. The optimal solutions are given by

$$b = 1 - \frac{1}{R^H - R^L} U'^{-1}\left[\frac{\frac{R^I}{R^f}\left(\frac{\theta}{R^f} - R^L\right)}{(1-p)\left(R^H - R^L\right)}\right], \qquad (10)$$

$$p'(a) = -\frac{R^I c}{R^f U\left[\left(R^H - R^L\right)(1-b)\right] + \frac{R^I}{R^f}\left(R^H - R^L\right)b}, \tag{11}$$

$$k = 1 - \frac{\frac{\theta}{R^f}b + R^L(1-b) - c(a)}{R^f}. \tag{12}$$

Equation (10) determines the optimal portion of loans to securitize. Under the assumption that $U''(.) < 0$, it is straightforward to see that b is decreasing in R^f. This confirms our prediction that following an interest rate cut, the bank will securitize and sell a larger portion of its loan.

For risk-averse banks, sharing credit risk is another incentive to sell MBS. However, selling MBS incurs a cost from the adverse selection problem when MBS are "undervalued." When the policy rate is high, the investors' opportunity cost to purchase MBS is large and the adverse selection problem becomes more severe. For the same MBS, its price will be lower if interest rate is higher. In this case, it might not be optimal for the bank to sell MBS, or, in other words, constraint (iii) might not be satisfied. For example, assume that the utility function has the form $U(x) = x^\sigma$, where $0 < \sigma < 1$. Now, Figure 5 shows the relationship between the bank's utility and risk-free interest rate.

From Figure 5, when the interest rate is high, *not to* securitize means higher utility for the bank because, if the monetary policy is tight, the bank restrains itself from risk taking in the first place and the gain from risk sharing through securitization becomes limited. On the other hand, because the security buyers' cost of funds is high, they would require a larger retention and higher monitoring effort. Put these two effects together (the gain is limited, whereas the cost is large), selling MBS results in lower utility for the bank than retaining all its investment.

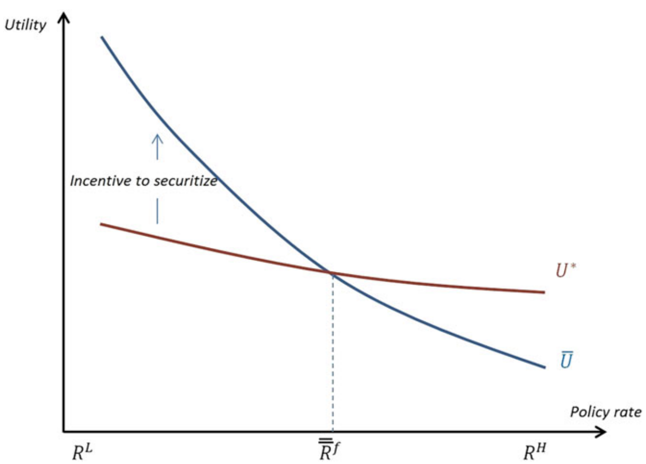

FIGURE 5 The bank's utility as a function of risk-free interest rate [Colour figure can be viewed at wileyonlinelibrary.com]

However, when the interest rate is low, the results are reversed. Banks take too much risk in an easy environment, and risk sharing brings in significant utility gain. Meanwhile, security buyers would demand only a small retention, and the cost of MBS would decrease. The utility of banks selling MBS would surpass that of retaining all their loans. In our model, there exists a threshold value of risk-free rate $\bar{\bar{R}}^f$; if $R^f < \bar{\bar{R}}^f$, the bank will securitize its loans. The lower the interest rate, the stronger would be the bank's incentive to securitize. Risk sharing brings about a utility gain only when the monetary policy rate is low.

Lemma 2. *There exists a threshold level* $\bar{\bar{R}}^f$ *such that the risk averse bank will securitize a portion* b *of its loan if and only if* $R^f \le \bar{\bar{R}}^f$.

Proof: See our simulation result (Figure 5) and the above discussion.

Proposition 3. *If* $R^f \le \bar{\bar{R}}^f$*, ceteris paribus, an interest rate cut enables a risk-averse bank to securitize a larger portion of its loans. Here,* b *is decreasing in risk-free interest rate.*

Proof: See Equation (10).

5 | DISCUSSION AND CONCLUDING REMARKS

A low short-term interest rate is historically seen to have preceded many financial crises (Calomiris, 2008). For the recent crisis, low monetary policy rate may have had greater impact, given the concurrence of high-level financial innovation. Some empirical studies have shown that a low monetary policy rate is crucial for risk taking because a significant bank agency problem can turn abundant liquidity into an excessive softening of lending standards (Maddaloni & Peydro, 2011). Other empirical studies have shown that financial innovation (securitization) significantly amplified risk taking or is the main reason for risk taking (Keys et al., 2010; Mian & Sufi, 2009). What is not shown is that a low monetary policy rate may motivate banks to securitize, and this is what this study investigates.

We analyse a bank and security buyers' behaviour model in which implicit contract features make securitization incentive compatible. If the seller bank retains a fraction of the loan it securitizes, this would explain why market participants buy the security. Because of information asymmetry between the sellers and buyers, implicit contract features restrict sellers from exploiting their informational advantage over the buyers by taking additional risk or securitizing riskier mortgages. Thus, financial innovation *alone* cannot explain the excessive risk-taking behaviour of banks when the security buyers are smart. Without additional factors, it would be difficult to explain the financial innovation that erupted in early 2000s. The low monetary policy rate, nevertheless, does explain the excessive risk taking and the eruption of financial innovation.

A low monetary policy rate leads to cheap credit so that banks rationally leverage up and reduce their monitoring effort. This leads to the build-up of risk on banks' assets, further providing them with strong incentives to securitize and sell those assets. On the other hand, a low monetary policy reduces the cost of funds for security buyers, who would then accept high-risk securities at high prices. Without easy monetary policy, security buyers would demand a high return on the securities and thereby dampen the gain of securitization.

This study therefore complements our previous research (Xu & Zhang, 2017) on the cause of the U.S. housing bubble. We show that low interest rate not only directly boomed the mortgage lending and softened banks' lending standards but also was an important motive for banks to securitize. Massive financial innovations were not the cause of the housing bubble but a rational response of banks to easy monetary policy.

ACKNOWLEDGEMENTS

We thank Prof. John Taylor, Prof. Philip Strahan, Prof. Yiping Huang, Prof. Chun Zhang, and all colleagues at various seminars for their helpful comments. We thank China Europe International Business School Faculty Research Grant for financial support.

ENDNOTES

[1] Retention is one form of banks' guarantee. Ex post repurchase in case of failure is a different form as mentioned by Gorton and Pennacchi (1995). For simplicity, we only model retention here, without loss of generality.

[2] Selling MBS of $((1 - p(a))R^H + p(a)R^L)b$ in exchange for T is discounted by risk-free interest rate. Ceteris paribus, higher R^f means lower price of the MBS.

[3] For detailed solution of U^*, see Appendix A.

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How to cite this article: Zhang J, Xu X. Securitization as a response to monetary policy. *Int J Fin Econ*. 2019;1–12. https://doi.org/10.1002/ijfe.1721

APPENDIX A

We provide supplementary explanations of properties and predictions of our models.

A.1 | Benefit of issuing MBS

In the risk neutral bank model, if the bank securitize b share of the investment, the return of the investment in case of failure is given by $\widetilde{R} = R^L(1-b) + T - c(a)$, where T is given by Equation (1):

$$(1-p(a))R^H b + p(a)R^L b \geq R^f T.$$

Substitute T, we have

$$\widetilde{R} = R^L(1-b) + \frac{(1-p(a))R^H + p(a)R^L}{R^f} b - c(a).$$

On the other hand, if the bank does not securitize, that is, $b = 0$, the return of the investment in case of failure is given by $R^L - c(a)$. Therefore, $\widetilde{R} > R^L - c(a)$ if and only if

$$\frac{(1-p(a))R^H + p(a)R^L}{R^f} > R^L.$$

As we have assumed that $(1-p(0))R^H + p(0)R^L \geq R^f$, it is straightforward to show that

$$\frac{(1-p(a))R^H + p(a)R^L}{R^f} > \frac{(1-p(0))R^H + p(0)R^L}{R^f} > 1 \geq R^L.$$

Therefore, selling MBS brings gains in case of investment failure, and this is one benefit of issuing MBS. With such benefit, the bank's solvency constraint is relaxed, and it can leverage up more.

A.2 | Proof of Lemma 1 and Propositions 1 and 2

Equation (8) determines the optimal retention when the bank securitizes its investment.

where $\Delta = \eta\left[\frac{R^I}{R^f}\left(\frac{\theta}{R^f} - R^L\right) - \left(\theta - R^L\right)\right]$. It is straightforward to see that $\frac{\partial b}{\partial \Delta} > 0$, $\lim_{\Delta \to \infty} b = 1$.

Because $\frac{\partial \Delta}{\partial R^f} < 0$, and the expected return rate of investment $\theta \equiv R^H(1-p(a)) + R^L p(a)$ has the property that

$$\theta \geq R^H(1-p(0)) + R^L p(0) \geq R^f,$$

there is an upper bound of Δ, which is achieved when R^f approaches to R^L.

Therefore, $0 \leq b < 1$ if and only if $\Delta \geq 0$, which gives the threshold level of risk-free interest rate $\overline{R}^f$ such that

$$\overline{R}^f \equiv \frac{\left[R^{L2} + 4R^I\theta\left(\theta - R^L\right)\right]^{1/2} - R^L}{2\left(\theta - R^L\right)}$$

When $R^f \leq \overline{R}^f$, $b \geq 0$, and $\frac{\partial b}{\partial R^f} < 0$.

In addition, by Equations 6 and 7, and use the property of $\frac{\partial b}{\partial R^f} < 0$, it is straightforward to see that

$$\frac{\partial p'(a)}{\partial R^f} = \frac{c}{R^H - R^L} \frac{1}{(1-b)^2} \frac{\partial b}{\partial R^f} < 0.$$

Because $p''(a) > 0$, we thus have $\frac{\partial a}{\partial R^f} > 0$. Lower policy rate reduces monitoring effort level. Besides, as $\frac{\theta}{R^f} > 1 \geq R^L$, we obtain $\frac{\partial k}{\partial R^f} > 0$.

A.3 | U^* in risk-averse bank model

$$\begin{aligned} U^* = \max_{a,k} & (1-p(a))U\left(R^H - c(a) - R^f(1-k)\right) \\ & + p(a)U\left(R^L - c(a) - R^f(1-k)\right) \\ & - R^I k s.t. \; R^L - c(a) \geq R^f(1-k). \end{aligned}$$

The first-order conditions with respect to monitoring effort a and equity input k are given by

$$p'(a) = -\frac{R^I c}{R^f U\left(R^H - R^L\right)}, \tag{A1}$$

$$k = 1 - \frac{R^L - c(a)}{R^f}. \tag{A2}$$

Equations A1 and A2 show that the optimal monitoring effort and leverage ratio depend on the risk-free rate. It is straightforward to see that, with interest rate cut, the bank reduces its monitoring effort and equity input (or leverages up). When $b = 0$, Equations 11 and 12 boil down to Equations A1 and A2.

U^* is utility obtained when a and k are determined by Equations A1 and A2.