Credit Asset Securitization, Cross Holdings, and Systemic Risk in Banking

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Abstract

We present a theoretical framework for studying how the cross holdings of credit asset securitization (CAS) products may affect systemic risk in banking. We demonstrate that cross holdings can be understood from the perspective of pursuing profit and credit creation; these motives drive up banks' leverage. We also show that the capital adequacy ratio (CAR) regulatory constraint may become invalid with cross holdings, which adversely impacts the monitoring of the stability of a system. We demonstrate that, generally, the impact of CAS on systemic risk is nonmonotonic and critically hinges on the banking asset structure, cross-holding degree among banks, and CAS characteristics including its state of risk retention. We empirically examine

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theoretical predictions using a comprehensive set of data from 27 countries/regions spanning the past 15 years.

Keywords: Credit asset securitization; Cross holdings; Systemic risk; Banking system

1 Introduction

Credit asset securitization (CAS) has become a common instrument for bank risk management. According to a report by the International Monetary Fund (IMF) in 2009, approximately 20-60% of new residential mortgage loans were subject to a securitization transaction in the United States, Western Europe, and Australia. The securitization market, however, collapsed in 2007 and 2008. Since then, the impact of CAS on financial systemic risk has been widely debated. A common view argues that CAS not only reduces banks' own risk and the reliance on deposits (Instefjord, 2005; Allen and Carletti, 2006), but also provides greater asset diversification in the financial system (Jobst, 2006). In contrast, others have suggested that CAS has limited banks to effectively transferring risk (Gorton, 2009) and functioning as a destabilizing force in the banking system (Shleifer and Vishny, 2010). Using a three-period model, Shleifer and Vishny (2010) discuss the cases of securitization with and without leveraged banks. The authors find that leverage accelerates banks' balance sheets; they explain how banks' involvement in securitization is motivated by profit-seeking, and how this business model is inherently unstable. There are other mechanisms through which securitization can influence banks' systemic risk. Specifically, securitization increases banks' lending (Wagner, 2007), which can result in price bubbles and systemic risk (Loutskina and Strahan, 2009; Mian and Sufi, 2009; Shin, 2009; Demyanyk and Van Hemert, 2011). Meanwhile, securitization affects banks' lending policies (Shivdasani and Wang, 2011) or risk preferences (Keys et al., 2012; Battaglia and Gallo, 2013; Casu et al., 2013) and weakens their effort on ex post monitoring (Keys et al., 2009, 2010; Nadauld and Sherlund, 2013; Wang and Xia, 2014). Even if securitization does not increase individual banks' risks, it can increase systemic risk (Nijskens and Wagner, 2011). Further, while securitization is ostensibly beneficial, reducing the costs of idiosyncratic shocks and shrinking interest rate spreads, it leads to amplified systemic risks in equilibrium (Brunnermeier and Sannikov, 2014).

To reconcile the conflicting perspectives mentioned above, this study provides a theoretical framework for studying how the cross holdings involved in CAS may affect systemic risk in banking. Our models are motivated by a financial system in which different banks are linked to one another through the cross holdings of CAS products. Our approach enables us to compare a sequence of theoretical results that highlights the implications of the cross-holding structure of CAS products for the extent of financial contagion and systemic risk. The approach is crucial, although it has been overlooked for a long time. More than ten years ago, there is a consensus that banks that purchased large quantities of securitized products from other banks suffered severe and considerable losses during the subprime crisis (Diamond and Rajan, 2009). However, the importance of focusing on cross-holding behaviors and the lack of related studies are still emphasized in the recent study (Deku et al., 2019).

We present a set of banking business models in which CAS products and their cross holdings are considered sequentially. We begin with a basic business model for a bank that only accepts deposits and extends loans. We then add the functions of CAS to the model, which we call the Securitized model, to illustrate how the bank can create credit and transfer risk. Last, we introduce banks' cross-holding behaviors and present a more comprehensive view of banking credit creation within a profit-seeking context.

More specifically, we demonstrate that crossing-holding behavior weakens both the credit creation and the risk transfer functions associated with CAS products in a period. Surprisingly, through cross-holding behavior, banks not only have the capability, but are also willing to indefinitely issue CAS products without breaching the regulatory constraint on capital adequacy ratio (CAR). Noteworthily, in the presence of relatively small shocks, the trade-offs between the strengthened inter-bank correlation and the weakened credit expansion result in nonmonotonic effects in shaping the systemic risk in banking.

We conclude the study with an illustration of the model using a comprehensive set of data from 27 countries spanning the past 15 years. We consider the issuance volume of the CAS products for each country/region to be its securitization stream, and measure the level of systemic risk as SRISK (Brownlees and Engle, 2012, 2017). We find that there is a U-shaped relationship between the size of CAS products and the country-regional level of systemic risk. Relatively, mortgage-backed securities (MBS) may have a more significant impact on systemic risk than asset-backed securities (ABS). Notably, theoretical results indicate that the relationship between systemic risk and CAS is nonmonotonic and highly dependent on various factors. However, no such data are available for a rigorous test based on the theoretical analysis. However, through theory and simulation, we find that the issuance volume of CAS products is monotonous in some key factors; thus, we conclude that the finding of the empirical test is consistent with the theoretical predictions mentioned above.

We contribute to the literature in several ways. First, there has been a growing body of literature on the impact of banks' interdependence on systemic risk; our study is unique, to the best of knowledge, especially in respect of the results regarding the regulation implication and the nonmonotonicities in shaping systemic risk. The study by Elliott et al. (2014) and the related one by Gofman (2017) are the closest to ours. They each examine how shocks of varying magnitude propagate through networks based on debt holdings or interbank lending. Additionally, they are interested in how the propagation of risk depends on the architecture of the banking network. Our focus is on the complementary question of whether shocks may propagate differently through a network based on the cross holdings of CAS products. We vary the degree of cross holdings in the model and ask how the impact of a given shock on banking systemic risk depends on the relevant characteristics of the CAS products and the asset structure of the banking system. The results highlight that it can be problematic to allow unlimited cross-holding behavior among banks. Second, the previous literature on banking regulation paid scant attention to its impact on systemic risk, while the ineffective monitoring and supervision by official agencies has been regarded as a critical cause of the global financial crisis (GFC) of 2007-2008 (Goodhart, 2008; Schwarcz, 2008; Acharya, 2009; Laeven and Levine, 2009). Many studies have empirically examined this relationship. Our study, on the other hand, mathematically demonstrates that the current capital adequacy regulation has failed in effectively monitoring the systemic risk in banking, while the cross-holding behavior will ultimately increase the correlated risk that banks assume, which can lead to joint failures. Specifically, we present theoretical explanations that cross holdings can render the CAR constraint invalid, which will lead to higher leverage and the accumulation of systemic risk in the banking system. It is thus necessary to consider cross holdings in the monitoring of banks. Third, the proposed framework in the study can accommodate further extensions in respect of other financial products with different features, alternative definitions of financial institutions, and even some inter-temporal transactions that are incurred.

The remainder of the paper proceeds as follows: Considering cross-holding behaviors, Section 2 provides a theoretical framework for the impact of CAS on systemic risk. Section 3 describes the data and variables used in our empirical model. For cross-validation with Section 2, we present and report our empirical result based on a quadratic polynomial regression in Section 3, followed by concluding remarks in Section 4.

2 Modeling and Theoretical Analysis

In this section, inspired by Shleifer and Vishny (2010), we propose a set of nested and upgraded models to describe the process of credit securitization with cross-holding behaviors. We first construct a Basic model that comprises the basic business of banks. We then incorporate CAS into the Basic model and generate a new model, the Securitized model. Furthermore, we consider cross-holding behavior and suggest the Cross-holding model. We then examine the properties of these models, focusing on their created credits, transferred risks, and expected profits. We further examine whether cross-holding behaviors affect the effectiveness of CAR restrictions, and the impact of CAS on systemic risk. We verify the theoretical conclusion using a numerical example. Additionally, we introduce shock into all three models, and compare the other models with the Cross-holding model. Last, we perform a simulation to visualize our result.

2.1 Nested and Upgraded Models

In this subsection, we conduct three models: the Basic, Securitized, and Cross-holding models, the latter model being an extension of the former two. Through these models, we can theoretically analyze the impacts of CAS on the financial system, including systemic risk. Our models are two-period models. The bank starts operating at Time 0, with no settlement until Time 1.

2.1.1 Basic Model

We begin with the Basic model, i.e., the business model in which the bank only accepts deposits and loans. Figure 1 depicts a financial system in which there are only capital providers, final borrowers, and a banking system. We indicate one bank in this model by the superscript, b, and set the deposit and loan terms to unity. We assume that there are no statutory reserve requirements and CAR constraints.

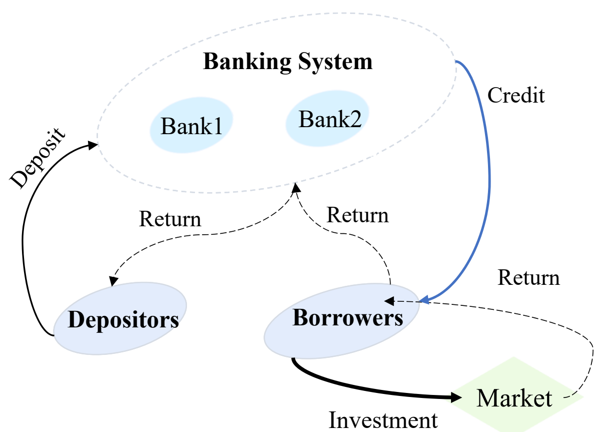

Figure 1: A schematic diagram of the Basic model. This figure is a schematic diagram of the Basic model. There are banks, depositors, and borrowers. Depositors conserve their capital in banks and earn interest returns thereon. Banks borrow money from depositors and lend it to borrowers in return for interest payments paid by the latter. The borrowers invest in target markets with the capital borrowed from the banks.

Without loss of generality, at Time 0, it is assumed that a representative bank has equity, E, while deposits amount to D, which should be repaid to the bank at a rate of interest of r_c. The bank utilizes all of its available cash (asset) to extend loans, charging an interest rate of r_a on senior loans and r_b on subordinate loans. The ratios of senior loans and subprime loans to total loans are α and η, respectively, such that $\alpha + \eta = 1$.

Denote the bank's assets as A, which equals $E+D$. Then, the leverage, μ, of the bank is

$$\mu = \frac{D}{A} = \frac{D}{E+D}.$$

The credit creation, B^b, can be expressed as

$$B^b = A = \frac{E}{1-\mu}. \tag{1}$$

Remark 1 $\dfrac{\partial B^b}{\partial \mu} = \dfrac{E}{(1-\mu)^2}$ *and* $\dfrac{\partial B^b}{\partial E} = \dfrac{1}{1-\mu}$.

Remark 1 reveals that the total amount of credit that a bank can create is determined by its leverage ratio, μ, and its capital, E. Other things being equal, the higher the leverage, or the higher its own capital, the stronger the credit creation capacity.

At Time 1, the bank recovers both the principals and the interest on issued loans. For senior loans, we set the probability of default at p_a, whereas for subprime loans, we set it at p_b. Denoting the profit in this case as π^b, its expected value is therefore

$$E(\pi^b) = A\{\alpha\left[(1+r_a)(1-p_a)-1\right] + \eta\left[(1+r_b)(1-p_b)-1\right]\} - r_c D. \tag{2}$$

2.1.2 Securitized Model

We explore this model, which is shown in Figure 2, by allowing the bank to issue CAS products. We refer to it as the Securitized model, and denote the representative bank by the superscript, s.

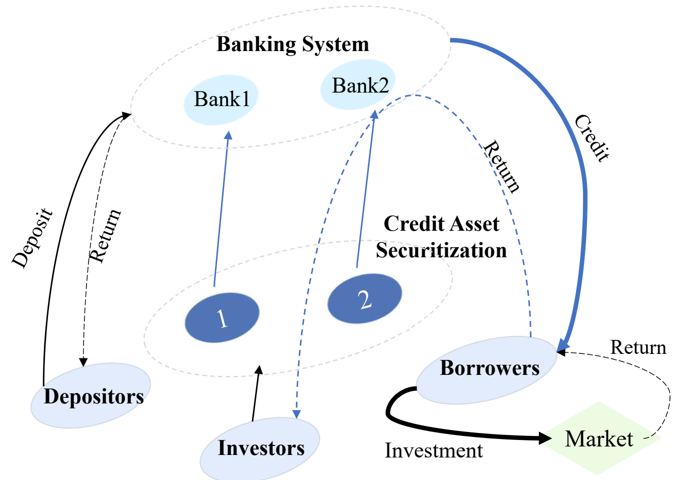

Figure 2: A schematic diagram of the Securitized model. This figure is a schematic diagram of the Securitized model. In this case, banks issue CAS products that are purchased by investors. Hence, with increased liquidity, the banking system can lend more money to borrowers, while borrowers can obtain more money to invest. The solid lines describing investment and credit in Figure 2 are noticeably coarser than the corresponding lines in Figure 1, which means that, in the Securitized model, credit and investment are generally on a higher scale than in the Basic model.

At Time 0, the bank's deposit and lending operations are set similarly to those in the Basic model. Denote the times of issuance of the CAS products as n. To simplify the analysis, it is assumed that all the issuances occur at Time 0. When $n = 0$, all credit assets (loans) of the bank are sold to a special-purpose entity (SPE), and cash is recovered. The SPE, using the above credit assets as an underlying asset pool, issues CAS products that are fully purchased by outside investors at an interest rate of r_d. For the sake of simplicity, we disregard the price fluctuations associated with the securitized products. Due to the risk retention requirement, we assume that the bank sells all of the senior loans, αA, and some of the subordinated loans, βA, to the SPE, while the rest, γA, of the subordinated loans remain on the balance sheet, where $\beta + \gamma = \eta$ and $\alpha + \beta + \gamma = 1$. The bank then uses the cash for credit expansion. The business described above is repeated until all of the bank's on-balance sheet assets are converted into subordinated loans as n approaches infinity. Figure 3 shows part of the process.

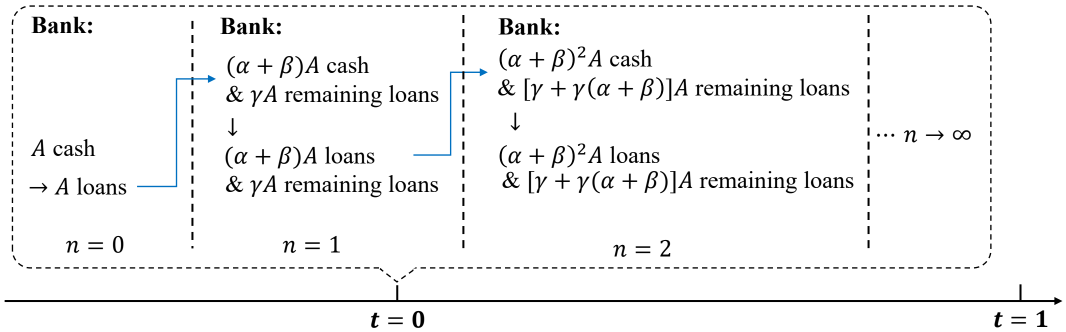

Figure 3: A schematic diagram of the issuance process for CAS products. This figure shows the issuance process for CAS products. When $n = 1$, through the securitization based on A in loans from $n = 0$, the bank gains $(\alpha + \beta)A$ in cash and γA in subordinated loans that require balancing. When $n = 2$, $(\alpha + \beta)A$ in cash is used for credit. The securitization brings $(\alpha + \beta)^2 A$ in cash and $\gamma(1 - \gamma)A$ in subordinated loans to the bank. We use this setting in Gong and Wang (2013) to simplify our model.

By deduction, the total credit scale, B^s, created by the bank in the Securitized model is given by

$$B^s = \sum_{n=0}^{\infty} (\alpha + \beta)^n A = \frac{1}{\gamma} A. \tag{3}$$

The volume of loans, $B^{s,o}$, that the bank transfers off its balance sheet in this model is given by

$$B^{s,o} = \sum_{n=0}^{\infty} (\alpha + \beta)^n (\alpha + \beta) A = \frac{1 - \gamma}{\gamma} A.$$

At Time 1, borrowers repay the principal and interest to the SPE and the bank, depositors receive the bank's repayment, while investors who purchased the CAS products receive their return from the SPE. Based on this setting, it is easy to conclude that there is a proportion, α, of senior loans and a proportion, $(\beta + \gamma)$, of subprime loans in the loans that the bank creates. Hence, we can compute the expectation of the bank's profit, π^s, as follows:

$$E(\pi^s) = \frac{A}{\gamma}\{\alpha\left[(1+r_a)(1-p_a)-1\right]+(\beta+\gamma)\left[(1+r_b)(1-p_b)-1\right]-r_d(1-\gamma)\}-r_cD, \quad (4)$$

where, on the right-hand side (RHS), the first term is the expected profit from the senior loans, the second term is the expected profit from the subprime loans, the third term captures the interest cost paid to the investors, and the fourth term is the interest cost of the deposits.

2.1.3 Cross-holding Model

Next, we allow banks to purchase CAS products from others, which is realistic behavior for banks. With heterogeneities among banks, cross-holding behaviors help match different liquidity demands and enhance inter-bank liquidity. Meanwhile, CAS products have a relatively high-quality asset pool that is strictly supervised following the GFC, which ensures banks' safety requirement. Regarding profitability, the yield to maturity of CAS products is generally higher than that of general bonds with the same rating.

We now examine the impact of credit securitization on banks in terms of cross-holding behavior. We denote the representative bank by the superscript, c, and refer to the model as the Cross-holding model, which is shown in Figure 4. The settings in the Cross-holding model are similar to those in the previous models, including the bank's credit business and the process of issuing CAS products. The difference is that, at Time 0, after selling credit assets to the SPE, the bank uses a proportion, ρ, of the cash to issue loans and the remainder, θ, to purchase CAS products issued by other banks, at a return rate of r_d. Noting that $\rho+\theta=1$, θ is used to represent the cross-holding degree. As with the Securitized model, the bank can repeat the business until its on-balance sheet assets are converted into subordinated loans due to risk retention and the CAS products it purchased from other banks.

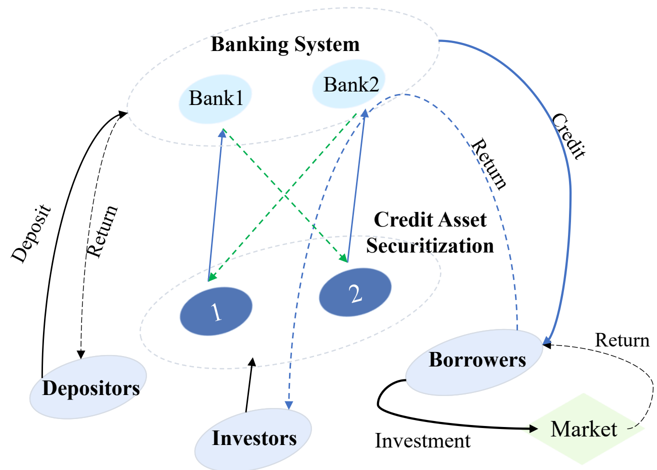

Figure 4: A schematic diagram of the Cross-holding model. This figure is a schematic diagram of the Cross-holding model. Cross-holding behavior is represented by the green dotted line linking banks and CAS products. It will be noted that both the solid black line representing investment and the solid blue line representing credit are thinner than their counterparts in Figure 2. That is, in the Cross-holding model, the scales of credit and investment are generally smaller than in the Securitized model.

In this model, B^c, the credit scale created by the bank, is given by

$$B^c = \sum_{n=0}^{\infty} \left[\rho(\alpha+\beta)\right]^n A = \frac{1}{\theta+\gamma-\theta\gamma} A. \tag{5}$$

$B^{c,o}$, the off-balance sheet subordinated loan asset, becomes

$$B^{c,o} = \sum_{n=0}^{\infty} \left[\rho(\alpha+\beta)\right]^n (\alpha+\beta) A = \frac{1-\gamma}{\theta+\gamma-\theta\gamma} A. \tag{6}$$

$B^{c,k}$, the on-balance sheet subordinated loan assets, are given by

$$B^{c,k} = \sum_{n=0}^{\infty} \left[\rho(\alpha+\beta)\right]^n \gamma A = \frac{\gamma}{\theta+\gamma-\theta\gamma} A. \tag{7}$$

$B^{c,p}$, the total amount of others' CAS products purchased by the bank is given by

$$B^{c,p} = \sum_{n=0}^{\infty} [\rho(\alpha+\beta)]^n (1-\rho)(\alpha+\beta)A = \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A. \tag{8}$$

The partial derivatives of $B^{c,o}$ with respect to γ and θ are given by

$$\frac{\partial B^{c,o}}{\partial \gamma} = \frac{-1}{(\theta+\gamma-\theta\gamma)^2} < 0 \text{ and } \frac{\partial B^{c,o}}{\partial \theta} = \frac{-(\gamma-1)^2}{(\theta+\gamma-\theta\gamma)^2} < 0, \tag{9}$$

respectively. It is obvious that $B^{c,o}$ is a decreasing function of γ and θ, which means that the higher the intensity of risk retention and the cross-holding degree, the less the risk transfer.

At Time 1, borrowers repay principal and interest to the SPE and the bank. The bank pays the principal and interest to depositors. In return for purchasing CAS products, the SPE pays investment costs and returns to investors. The expected value of the bank's profit, π^c, is given by

$$E(\pi^c) = \frac{A}{\theta+\gamma-\theta\gamma}\{\alpha[(1+r_a)(1-p_a)-1] + (\beta+\gamma)[(1+r_b)(1-p_b)-1] - \rho r_d(1-\gamma)\} - r_c D. \tag{10}$$

2.2 CAS's Functions and Profitability

Thus far, we have developed three models for further analysis. In this section, we first analyze the functions of CAS and the effect of cross-holding behavior on these. We then compare the different models' profits, and find that using CAS may encourage the bank to improve its leverage, which can affect systemic risk.

2.2.1 Functions of CAS

We first explore the credit creation function of CAS and the effect of cross-holding behavior on this function. In particular, we compare the amounts of credits in the three models above.

In terms of credit creation, the differences among between the three models are as follows:

$$\Delta B^{s-b} = B^s - B^b = \frac{1-\gamma}{\gamma}A, \tag{11}$$

$$\Delta B^{c-b} = B^c - B^b = \frac{1-\theta-\gamma+\theta\gamma}{\theta+\gamma-\theta\gamma}A, \tag{12}$$

$$\Delta B^{c-s} = B^c - B^s = \frac{-\theta(1-\gamma)}{\gamma(\theta+\gamma-\theta\gamma)}A. \tag{13}$$

Obviously, $\Delta B^{s-b} > 0$, i.e., B^s is higher than B^b; $\Delta B^{c-b} > 0$, i.e., B^c is higher than B^b; and $\Delta B^{c-s} < 0$, i.e., B^c is smaller than B^s. Thus, CAS products assist banks in creating more credit, which is the credit creation function. The incremental credit provided by CAS is related to own capital, E, leverage, μ, and the degree of risk retention, γ, in the securitized process (recall (11)). Regarding the effect of cross-holding behavior on the credit creation function of CAS, it obviously weakens but does not eliminate the credit creation function brought about by credit securitization (recall (12) and (13)). The partial derivative of ΔB^{c-b} with respect to θ is $\dfrac{\partial \Delta B^{c-b}}{\partial \theta} = \dfrac{(\gamma-1)A}{(\theta+\gamma-\theta\gamma)^2} < 0$, which implies that the greater the cross-holding degree, the lower the credit creation capacity in the Cross-holding model.

Next, we explore the risk transfer function of CAS and the effect of cross-holding behavior on this function. There is no transferred risk in the Basic model; thus, we compare the amount of transferred risk between the cross-holding and the Securitized models, that is,

$$\Delta B^{c,o-s,o} = B^{c,o} - B^{s,o} = \frac{-\theta(1-\gamma)^2}{\theta+\gamma-\theta\gamma}A.$$

Obviously, $\Delta B^{c,o-s,o} < 0$, since $B^{s,o}$ is higher than $B^{c,o}$. Hence, the incremental transferred risk brought about by CAS is reduced by cross-holding behaviors. Furthermore, the partial derivative of $\Delta B^{c,o-s,o}$ with respect to θ is $\frac{\partial \Delta B^{c,o-s,o}}{\partial \theta} = \frac{-\gamma\left(1-\gamma\right)^2}{\left(\theta+\gamma-\theta\gamma\right)^2}A < 0$, which implies that the greater the degree of cross-holding, the lower the risk transfer capacity in the Cross-holding model.

To summarize, CAS products have credit-creating and risk transfer functions, which are weakened by cross-holding behavior.

2.2.2 Additional Profit from CAS

Although the bank could create a greater scale of credit and transfer the asset risk by using CAS products, its ultimate objective remains more profit, which can also be achieved with CAS products. Indeed, based on the greater scale of credit and the transferred risk, the bank is likely to gain more profit from interest. We compare the expected profits from the three models. The change in expected profit from the Securitized model to the Basic model is given by

$$\begin{aligned}\Delta E(\pi^{s-b}) &= E(\pi^s) - E(\pi^b) \\ &= \{\alpha\left[(1+r_a)(1-p_a)-1\right] + (\beta+\gamma)\left[(1+r_b)(1-p_b)-1\right] - r_d\}\frac{\alpha+\beta}{\gamma}A\end{aligned} \tag{14}$$

Noting that $\Delta E(\pi^{s-b})$ is related to the probabilities of default rates, p_a and p_b, we define

$$F = \alpha\left[(1+r_a)(1-p_a)-1\right] + (\beta+\gamma)\left[(1+r_b)(1-p_b)-1\right] \tag{15}$$

to simplify the expression. Including the probability of default rates, to some extent, F can be regarded as the state of the economy. We then rewrite (14) as

$$\Delta E(\pi^{s-b}) = E(\pi^s) - E(\pi^b) = (F - r_d)\frac{\alpha+\beta}{\gamma}A = \frac{1-\gamma}{\gamma}(F-r_d)A. \tag{16}$$

Thus, when the default probabilities, p_a and p_b, are sufficiently low for $F - r_d > 0$, we have $\Delta E(\pi^{s-b}) > 0$, and CAS can generate additional positive profits for banks. However, when the default probabilities increase and result in $F - r_d < 0$, we have $\Delta E(\pi^{s-b}) < 0$. That is, there is no additional profit but further loss through CAS.

The change in expected profit from the Cross-holding model to the Basic model is given by

$$\Delta E(\pi^{c-b}) = E(\pi^c) - E(\pi^b) = \frac{1-\theta-\gamma+\theta\gamma}{\theta+\gamma-\theta\gamma}(F-r_d)A. \tag{17}$$

According to the definition of F, credit securitization can bring about additional profits for banks when the default probabilities, p_a and p_b, are sufficiently low for $F - r_d > 0$ and $\Delta E(\pi^{c-b}) > 0$. However, when the default probabilities, p_a and p_b, satisfy $F - r_d < 0$, so that $\Delta E(\pi^{c-b}) < 0$, the credit securitization business not only prevents the bank from gaining additional profit, but also causes further losses.

By (16) and (17), and recalling (1), we have

$$
\begin{aligned}
\frac{\partial \Delta E(\pi^{s-b})}{\partial \mu} &= \frac{1-\gamma}{\gamma(\mu-1)^2}(F-r_d)E, \\
\frac{\partial \Delta E(\pi^{c-b})}{\partial \mu} &= \frac{1-\theta-\gamma+\theta\gamma}{(\theta+\gamma-\theta\gamma)(\mu-1)^2}(F-r_d)E.
\end{aligned}
$$

Accordingly, we have the following results on the relationship between the profit from CAS and the leverage.

Proposition 1 $\frac{\partial \Delta E(\pi^{s-b})}{\partial \mu} > 0$ *if and only if* $F - r_d > 0$*. Similarly,* $\frac{\partial \Delta E(\pi^{c-b})}{\partial \mu} > 0$ *if and only if* $F - r_d > 0$*.*

Proposition 1 means that when the bank can earn an additional return through CAS products in an economic boom, the higher the leverage of the bank, the higher the additional profits. Thus, regardless of cross-holding behaviors, CAS could strengthen banks' motivation to increase leverage, which might lead to the accumulation of systemic risk. Specifically, as the leverage rises, the credit scale of the economic-finance system becomes larger. From an endogenous perspective, the marginal rate of return declines and the interest rate rises as credit expands, which influences the development of the economy. From an exogenous perspective, an economy with a high level of leverage is more sensitive to exogenous shocks and easily collapses. Once the economy stagnates or experiences a shock, investors will realize that debt financing may not be repaid from future returns, which will negatively impact investment demand. Additionally, banks will be unwilling to borrow money, leading to a severe drop in the money supply. Thus, the system becomes more and more sensitive to investors' expectations and interest rates. Such mechanisms will lead to a decline in economic conditions. Thus, it is easy for the system to enter a Minsky moment (Minsky, 1986). Naturally, the system itself, with a high level of leverage, is unstable.

2.3 Further Discussion on Cross-holding Behavior

After analyzing the impact of CAS on banks' leverage, we examine it in a realistic model, i.e., the Cross-holding model, and how cross-holding behavior may affect a bank. We conclude that this behavior is beneficial to a bank's operation, especially in an economic downturn. Finally, we highlight the result that cross-holding behavior can help a bank evade regulatory constraints.

2.3.1 Effect of Cross-holding Behavior on Banks' Profits and Credit Creation

First, we discuss the problem of whether $E(\pi^c)$ is always smaller than $E(\pi^s)$. The difference between the two, $\Delta E(\pi^{c-s})$, is given by

$$\Delta E(\pi^{c-s}) = E(\pi^c) - E(\pi^s) = \frac{-\theta\,(1-\gamma)\,(F-r_d)\,A}{\gamma\,(\theta+\gamma+\theta\gamma)} = \frac{-\theta\,(1-\gamma)\,(F-r_d)}{\gamma\,(\theta+\gamma+\theta\gamma)}\frac{E}{1-\mu}.$$

Proposition 2 *$\Delta E(\pi^{c-s}) > 0$ if and only if $F < r_d$, and $\dfrac{\partial \Delta E\left(\pi^{c-s}\right)}{\partial \mu} > 0$ if and only if $F < r_d$.*

Proposition 2 says that when the default probabilities, p_a and p_b, are sufficiently low for $F \geq r_d$, we have $\Delta E(\pi^{c-s}) \leq 0$, i.e., the bank gains less profit from the cross-holding of CAS. Moreover, when the probability of default increases to the extent that $F < r_d$, $\Delta E(\pi^{c-s}) > 0$, since the bank purchases other banks' products that are about to pay returns to the bank. Therefore, $E(\pi^c)$ is not always smaller than $E(\pi^s)$. When there is a high probability of default, banks with cross-holding behavior are more likely to gain additional profits, so that $E(\pi^c)$ may be higher than $E(\pi^s)$.

For completeness, we consider the business operation in the next term, starting from Time 1 and ending at Time 2. That is, we focus on both the Securitized and the Cross-holding models at Time 2. Recalling Remarks 1, (3), and (5), it is obvious that the bank's capital, E, is an important factor in the bank's credit creation ability. When $\Delta E(\pi^{c-s}) > 0$, the initial capital in the Cross-holding model is higher than that in the Securitized model at time 1, which may influence the bank's ability to originate credits in the next term. In the next round of operations, denote the expected initial capitals of the representative banks in the Securitized and the Cross-holding models as E_1^s and E_1^c, respectively. Thus, we have

$$E_1^s = E + E(\pi^s) \text{ and } E_1^c = E + E(\pi^c).$$

Without loss of generality, let us assume that the leverage in this period remains μ, which is defined as deposits divided by assets. When the bank's own capital changes, it can keep its leverage by absorbing more deposits than D. Recalling (1), (3), and (5), at Time 1, the expected credit scales created in the Securitized and the Cross-holding models are given by

$$B_1^s = \frac{E_1^s}{\gamma(1-\mu)} \text{ and } B_1^c = \frac{E_1^c}{(1-\mu)(\theta+\gamma-\theta\gamma)},$$

respectively. We then have the following result in terms of credit creation.

Proposition 3 *$B_1^c > B_1^s$ if and only if* $\Delta E(\pi^{c-s}) > \dfrac{\theta}{\gamma}\left[\Delta E(\pi^{s-b}) + (1-\gamma)(1-\mu-r_c\mu+r_d)A\right].$

Proposition 3 says that when the probabilities of default are high and $\Delta E(\pi^{c-s})$ satisfies a certain condition, the bank's holdings of other banks' products provide capital replenishment under the Cross-holding model, so that the subsequent credit creation function is likely to be higher than in the Securitized model. Therefore, as the leverage becomes higher, it becomes easier for $\Delta E\left(\pi^{c-s}\right)$ to satisfy the condition in Proposition 3, which will result in more credit creation preferred by banks. In other words, in the Cross-holding model, banks' motivation to raise their leverages remains strong.

These propositions establish that the cross-holding behavior brings about additional profits to the bank, especially in bad economic conditions, and helps the bank maintain its credit creation ability. However, it also encourages the bank to evade regulatory constraints, which could lead to the accumulation of systemic risk. In the next subsection, we examine the mechanism that invalidates the regulatory restriction in the Cross-holding model.

2.3.2 Invalid CAR Constraint Due to Cross-holding Behavior

The previous discussion is intended to simplify the model and therefore does not consider any regulatory restrictions on the banking system. However, in practice, there always exist some regulatory constraints in banks' operation; the most typical of these is the CAR. In the following, we briefly discuss whether the CAR constraint is effective for the most realistic model, the Cross-holding model, compared with the Securitized model. Should the CAR constraint be valid for the Securitized model but fail in the Cross-holding model, it would suggest that cross-holding behavior should not be ignored when setting the constraint.

The CAR constraint is a restriction on the ratio of equity to risk-weighted assets, which is widely used to protect depositors and improve the stability of banking systems globally.

Denote the risk weights for senior loans and subordinated loans in calculating CAR as w_1 and w_2, respectively. Considering the credit enhancement, and noting that the CAS products issued by banks are essentially a mixture of senior loans and subordinated loans, we reasonably assume that its risk weight, w_3, for the CAR calculation satisfies

$$w_1 < w_3 < w_2.$$

Suppose that the CAR restriction should be satisfied when issuing CAS products. Notice that the CAS products are assumed to be issued at Time 0. Setting the required CAR to be ζ^q, therefore, means that the maximum risk-weighted asset, ξ^q, should satisfy

$$\frac{E}{\xi^q} = \frac{E}{w_1 \times \text{senior loans} + w_2 \times \text{subordinated loans} + w_3 \times \text{CAS products}} = \zeta^q.$$

Notice that there is no such term as "$w_3 \times$ CAS products" in the Securitized model. By assuming, reasonably, that not all the bank's loans are subordinated loans, we then obviously have

$$\xi^q < w_2 A.$$

Intuitively, if there is a CAR constraint, the bank cannot indefinitely issue CAS products, and its maximum issuance times n should be limited. To simplify the expression, define

$$\widetilde{w}^q = \frac{\xi^q}{A}.$$

We consider the case of the Securitized model first. After the issuance of n^s times at

Time 0, the bank's balance sheet resembles Table 1.

Table 1: **The Balance Sheet of the Bank which is subject to CAR in the Securitized Model.**
This table presents the bank's balance sheet with a CAR constraint in the Securitized model after the issuance of n^s times.

Asset A		**Liability and Equity** $(L+E)$
Senior loans	$\alpha(\alpha+\beta)^{n^s}A$	Deposit D
Subprime loans	$(\beta+\gamma)(\alpha+\beta)^{n^s}A$	Equity E
Subprime loans(Risk retention)	$\left[1-(\alpha+\beta)^{n^s}\right]A$	

In the process of issuing CAS products, the bank must satisfy the CAR constraint

$$w_1\alpha A\phi^s + w_2(\beta+\gamma)A\phi^s + w_2(1-\phi^s)A \leq \widetilde{w}^q A < w_2 A,$$

where $\phi^s = (\alpha+\beta)^{n^s}$. We must then have

$$n^s \leq [\ln(\alpha+\beta)]^{-1} \ln\left[\frac{\widetilde{w}^q - w_2}{\alpha\,(w_1 - w_2)}\right]. \tag{18}$$

Without confusion, in the following, we also denote the largest times of CAS issuance in the Securitized model under the CAR constraint as n^s, for simplicity. According to (3), we can calculate $\widehat{B^s}$, the credit scale in the Securitized model with the CAR constraint, as

$$\widehat{B^s} \leq \sum_{n=0}^{n^s}(\alpha+\beta)^n A = \frac{A(1-\phi^s)}{\gamma} < B^s;$$

recalling (4), we can also calculate $E(\widehat{\pi^s})$, the expected profit in the Securitized model with the CAR constraint, as

$$
\begin{aligned}
E(\widehat{\pi^s}) \le & \left\{\alpha\left[(1+r_a)(1-p_a)-1\right]+(\beta+\gamma)\left[(1+r_b)(1-p_b)-1\right]\right\}\frac{A(1-\phi^s)}{\gamma} \\
& -r_d\frac{(1-\gamma)A(1-\phi^s)}{\gamma}-r_cD \\
= & \frac{FA(1-\phi^s)}{\gamma}-\frac{r_dA(1-\phi^s)(1-\gamma)}{\gamma}-r_cD<E(\pi^s).
\end{aligned} \tag{19}
$$

The above analysis claims that the CAR regulatory restriction in the Securitized model is a valid constraint that can reduce credit expansion, which affects profit. We now consider the case of the Cross-holding model. We assume that the same CAR restriction set in the Securitized model applies to the Cross-holding model. After the issuance of n^c times at Time 0, the bank's balance sheet resembles Table 2.

Table 2: **The Balance Sheet of the Bank which is subject to CAR in the Cross-holding Model.**
This table presents the bank's balance sheet with a CAR constraint in the Cross-holding model after the issuance of n^c times.

Asset A		**Liability and Equity** $(L+E)$
Senior loans	$\alpha\left[\rho(\alpha+\beta)\right]^{n^c}A$	Deposit D
Subprime loans	$(\beta+\gamma)\left[\rho(\alpha+\beta)\right]^{n^c}A$	Equity E
Products from other banks	$\frac{1-\left[\rho(\alpha+\beta)\right]^{n^c}}{1-\rho(\alpha+\beta)}\theta(\alpha+\beta)A$	
Subprime loans(Risk retention)	$\frac{1-\left[\rho(\alpha+\beta)\right]^{n^c}}{1-\rho(\alpha+\beta)}\gamma A$	

Denote $\left[\rho(\alpha+\beta)\right]^{n^c}$ as ϕ^c. Thus, the risk-weighted asset, ξ^c, is

$$
\begin{aligned}
\xi^c &= w_1\alpha A\phi^c+w_2(\beta+\gamma)A\phi^c+w_3\frac{1-\phi^c}{1-\rho(\alpha+\beta)}\theta(\alpha+\beta)A+w_2\frac{1-\phi^c}{1-\rho(\alpha+\beta)}\gamma A \\
&= \left[w_1\alpha+w_2(\beta+\gamma)-\frac{w_2\gamma+w_3\theta(\alpha+\beta)}{1-\rho(\alpha+\beta)}\right]A\phi^c+\frac{w_2\gamma+w_3\theta(\alpha+\beta)}{1-\rho(\alpha+\beta)}A.
\end{aligned}
$$

Define

$$K_1 = \left[w_1\alpha + w_2(\beta+\gamma) - \frac{w_2\gamma + w_3\theta(\alpha+\beta)}{1-\rho(\alpha+\beta)} \right] A \text{ and } K_2 = \left[\widetilde{w}^q - \frac{w_2\gamma + w_3\theta(\alpha+\beta)}{1-\rho(\alpha+\beta)} \right] A$$

for convenience of expression. Thus, if

$$K_1\phi^c \leq K_2, \tag{20}$$

we have $\xi^c \leq \xi^q$ (recall $\xi^q = \widetilde{w}^q A$), i.e., the CAR constraint is satisfied.

If $\rho \to 0$ ($\theta \to 1$), we have

$$K_1 \to [(w_1 - w_3)\alpha + (w_2 - w_3)\beta]\, A \text{ and } K_2 \to [\widetilde{w}^q - w_2\gamma - w_3(\alpha+\beta)]\, A.$$

Thus, clearly, both K_1 and K_2 can be non-negative or non-positive, depending on some specific parameters. Notice that when $K_1 > 0$, $K_2 = 0$ or, for $K_1 \geq 0$, $K_2 < 0$; then the CAR constraint is not satisfied, which is excluded from the analysis.

Suppose $K_2 > 0$. If $K_1 \leq 0$, then the CAR constraint is always satisfied, irrespective of the value of n^c. That is, the CAR constraint is invalid. Otherwise, if $K_1 > 0$, by (20), we have that

$$n^c \geq \{\ln[\rho(\alpha+\beta)]\}^{-1} \ln \frac{K_2}{K_1}.$$

Thus, we can claim that for the case $K_2 > 0$, the CAR constraint becomes invalid in the sense that the times of CAS issuance, n^c, can go to infinity. For the case of $K_2 = 0$, if $K_1 \leq 0$, then the CAR constraint is always satisfied for any n^c, which means that the CAR constraint is invalid. Consider the case of $K_2 < 0$. If $K_1 < 0$ and the CAR constraint is satisfied, we have $\phi^c \geq \dfrac{K_2}{K_1}$. Noting that $\phi^c < 1$, there is a positive upper limit to n^c such that

$$n^c \leq \{\ln[\rho(\alpha+\beta)]\}^{-1} \ln \frac{K_2}{K_1},$$

which indicates that the CAR constraint is valid.

Hence, for the Cross-holding model with the CAR regulatory restriction, under the condition that $K_2 > 0$ or $K_2 = 0$ and $K_1 \leq 0$, the bank can still securitize indefinitely, as the CAR constraint is invalid. In other words, n^c could approach infinity, because the bank purchases securitized products issued by others with lower risk weight (w_3) than subprime loans' (w_2), which drives the bank to continue securitizing. Thus, both the credit, $\widehat{B^c}$, and the profit, $E(\widehat{\pi^c})$, of the Cross-holding model with the CAR regulatory restriction are the same as those without such a constraint, that is, $\widehat{B^c} = B^c$ and $E(\widehat{\pi^c}) = E(\pi^c)$.

Suppose the CAR constraint is invalid for the Cross-holding model. By (5), if

$$\frac{A}{\gamma}(1-\phi^s) < \frac{A}{\theta+\gamma-\theta\gamma}, \tag{21}$$

we then have $\widehat{B^s} \leq \dfrac{A}{\gamma}(1-\phi^s) < \widehat{B^c} = B^c$. By a simple calculation, we have that (21) is equivalent to

$$n^s < [\ln(\alpha+\beta)]^{-1} \ln\left(\frac{\theta-\theta\gamma}{\theta+\gamma-\theta\gamma}\right). \tag{22}$$

Noting (18), we have that

$$\frac{\widetilde{w}^q - w_2}{\alpha\,(w_1-w_2)} > \frac{\theta-\theta\gamma}{\theta+\gamma-\theta\gamma} \tag{23}$$

is a sufficient condition for $\widehat{B^s} < \widehat{B^c} = B^c$.

Rewrite (23) as $\dfrac{(\alpha+\beta)\theta+1-(\alpha+\beta)}{\alpha(\alpha+\beta)\theta} > \dfrac{w_2-w_1}{w_2-\widetilde{w}^q}$ and denote the left hand side (LHS) as $g(\theta,\alpha)$. Calculating the partial derivatives of $g(\theta,\alpha)$ with respect to θ and α, respectively, we have

$$\frac{\partial g(\theta,\alpha)}{\partial\theta} = \frac{\alpha+\beta-1}{\alpha(\alpha+\beta)\theta^2} < 0, \tag{24}$$

$$\frac{\partial g(\theta,\alpha)}{\partial\alpha} = \frac{(1-\theta)\alpha^2+2(\beta-\beta\theta-1)\alpha+\beta(\beta-\beta\theta-1)}{\alpha^2(\alpha+\beta)^2\theta}. \tag{25}$$

It is obvious that as θ increases, the condition in (23) becomes more difficult to achieve. That is, the cross-holding behavior weakens the credit creation function of the Cross-holding model, which we discussed in Section 2.2.1. According to (25), by a simple calculation, we can conclude that the numerator of $\dfrac{\partial g(\theta,\alpha)}{\partial\alpha}$ is negative when α lies in $(0,1)$, so that the condition in (23) becomes easier to achieve as α decreases. Intuitively, when α decreases, i.e., the share of high-quality assets becomes smaller, the CAR constraint of the Securitized model becomes relatively stronger; thus, its credit creation is reduced, which results in easier achievement of the condition in (23).

By (10) and (19), if

$$\frac{FA(1-\phi^s)}{\gamma} - \frac{r_dA(1-\phi^s)(\alpha+\beta)}{\gamma} - r_cD \le \frac{FA}{\theta+\gamma-\theta\gamma} - \frac{\rho\,(\alpha+\beta)\,r_dA}{\theta+\gamma-\theta\gamma} - r_cD, \tag{26}$$

we have $E(\widehat{\pi^s}) < E(\widehat{\pi^c}) = E(\pi^c)$.

Simplifying the formula, Condition (26) can be reformulated as

$$\phi^s\left[F-(\alpha+\beta)r_d\right] > \frac{\theta-\theta\gamma}{\theta+\gamma-\theta\gamma}\,(F-r_d),$$

which is equivalent to

$$n^{s} < [\ln(\alpha+\beta)]^{-1}\left\{\ln\left(\frac{\theta-\theta\gamma}{\theta+\gamma-\theta\gamma}\right)+\ln\left[\frac{F-r_{d}}{F-r_{d}\,(\alpha+\beta)}\right]\right\} \tag{27}$$

under the condition that $F > r_d$. Noting (18), we have that

$$\frac{\widetilde{w}^{q}-w_{2}}{\alpha\,(w_{1}-w_{2})} > \left(\frac{\theta-\theta\gamma}{\theta+\gamma-\theta\gamma}\right)\left[\frac{F-r_{d}}{F-r_{d}\,(\alpha+\beta)}\right] \text{ and } F > r_{d} \tag{28}$$

is a sufficient condition for $E(\widehat{\pi^{s}}) < E(\widehat{\pi^{c}}) = E(\pi^{c})$. The analysis of (28) is similar to that of (23).

We can now summarize these findings in the following proposition.

Proposition 4 *Suppose that $K_2 > 0$ or $K_2 = 0$ and $K_1 \leq 0$. Then the CAR constraint is invalid for the Cross-holding model. Furthermore, given the same CAR constraint for both the Cross-holding and the Securitized models, $\widehat{B^{s}} < \widehat{B^{c}}$ holds under Condition (23) and $E(\widehat{\pi^{s}}) < E(\widehat{\pi^{c}})$ holds under Condition (28).*

Proposition 4 essentially suggests that holding CAS products issued by other banks may be a natural demand by banks due to the pursuit of credit creation and profitability under CAR supervision. Recall Propositions 2 and 3: the bank in the Cross-holding model, i.e., the most realistic model, can gain additional profit and create a greater scale of credit, especially during an economic boom. Thus, cross-holding behavior is a natural choice in a bank's operation, which can essentially drive up a bank's leverage, and thus may finally result in the accumulation of potential systemic risk.

We next provide a numerical example to verify the theoretical results in this subsection.

Example 1 We consider two banks that are from the Securitized and the Cross-holding models, respectively. Initially, both of their assets are $A = 10$, and they are faced with the same CAR constraint. Table 3 presents the basic parameters that we set and some key values that we calculated.

Table 3: **Parameters in the Illustration Example on the Invaild CAR Constraint.** This table shows basic parameters and key values in our example. RHS in the table refers to value setting for the right hand side of the corresponding equation/inequation in the paper. LHS in the table refers to value setting for the left hand side of the corresponding equation/inequation in the paper.

Parameter setting					
α	0.460	r_a	0.030	w_1	0.100
β	0.530	p_a	0.001	w_2	0.800
γ	0.010	r_b	0.090	w_3	0.300
μ	0.950	p_b	0.030	ζ_q	0.080
θ	0.010	r_c	0.015		
ρ	0.990	r_d	0.040		
Key values					
K_1	-0.733	ξ_q	6.250	ξ_c	5.513
K_2	0.737	LHS of (23)	0.544	RHS of (23)	0.498
RHS of (18)	60.671	LHS of (28)	0.544	RHS of (28)	0.455
RHS of (22)	69.469	$\widehat{B^s}$	452.843	$\widehat{B^c}$	502.513
RHS of (27)	78.382	$E(\widehat{\pi^s})$	1.989	$E(\widehat{\pi^c})$	2.402

Noting that K_2 is positive, and according to Proposition 4, the CAR constraint of the Cross-holding model should be invalid. Recalling (5), (10), and Table 3, we obtain $B^c = 502.513$ and $E(\pi^c) = 2.402$, which are the same as $\widehat{B^c}$ and $E(\widehat{\pi^c})$ in this table, respectively. Meanwhile, $\xi_c < \xi_q$, the CAR constraint of the Cross-holding model, is satisfied. Hence, the CAR constraint of the Cross-holding model is certainly invalid in this case.

Recalling (15), we have $F = 0.044 > r_d$. The LHSs of (23) and (28) are higher than their respective RHSs. That is, both Conditions (23) and (28) are satisfied. Considering Proposition 4, $\widehat{B^s} < \widehat{B^c}$ and $E(\widehat{\pi^s}) < E(\widehat{\pi^c})$ should hold. As can be seen from the table,

$\widehat{B^s} = 452.843 < \widehat{B^c} = 502.513$ and $E(\widehat{\pi^s}) = 1.989 < E(\widehat{\pi^c}) = 2.402$. In other words, for the Securitized model with the CAR constraint, its upper bound of times of securitization is 60.671. It cannot reach 69.469, let alone 78.382, which is a critical value for $\widehat{B^s} = \widehat{B^c}$ or $E(\widehat{\pi^s}) = E(\widehat{\pi^c})$. This further demonstrates the accuracy of Proposition 4.

To summarize, the issuance and the cross-holding behavior of CAS products do not only facilitate banks' flexibility and profitability, but also affect their individual risks and the risk of the banking system. Hence, it is necessary to examine the level of systemic risk when faced with a severe shock, which is the highlight of the discussion in the next section.

2.4 Nonmonotonic Impact of CAS on Systemic Risk

In this subsection, we further discuss the impact of CAS products on the systemic risk of the banking system by introducing a severe shock to the system. Without loss of generality, we consider a banking system that comprises three representative banks: Bank 1, Bank 2, and Bank 3. Denote the equity of Bank 1 as E_1. Similarly, E_2 and E_3 denote the equities of the other banks. The relationship among them is as follows:

$$E_2 = \lambda_2 E_1 \text{ and } E_3 = \lambda_3 E_1, \tag{29}$$

where λ_2 and λ_3 represent the size of Bank i relative to Bank 1.

As mentioned earlier, to observe a property of the banking system under a situation of distress, it is necessary to introduce some severe shock into our models. We therefore suppose that the banking system is subject to an external shock that leads to default on all loans issued by one of the banks. Furthermore, we calculate the capital loss rate, v, defined as the capital loss divided by the total initial capital. According to the definition of systemic risk and the severity of the shock we set, it is reasonable to regard the capital loss rate as an indicator of systemic risk. A higher capital loss rate means higher systemic risk. By comparing the capital loss rates of the banking system under the different models, we theoretically investigate the impact of the issuance and cross-holding of CAS products on the systemic risk.

2.4.1 Capital Loss Rates in the Basic and Securitized Models

Suppose that there are no differences in the leverage, μ, of the banks, and that they are all in the same position in terms of having completed the business process but not yet having reached settlement. We describe the pre-shock state of Bank 1's balance sheet in the Basic model. The assets of Bank 1, A_1, comprise αA_1 senior loans and $(\beta + \gamma)A_1$ subordinated loans. The liabilities and equity are D_1 (deposits) and E_1 (own capital), respectively. The same procedure is used to obtain the states of Banks 2 and 3. Notice that the respective equities are E_2 and E_3, which are equal to $\lambda_2 E_1$ and $\lambda_3 E_1$.

Suppose that the shock happens to Bank 1. Considering the limited liability in clearing, the upper bound for Bank 1's capital loss is its own capital, E_1. Under this shock, all of Bank 1's assets are lost. Bank 1 therefore becomes insolvent and loses all of its capital, E_1, while Banks 2 and 3 are not affected in any way. Thus, the capital loss rate, ν^b, of the banking system is given by

$$\nu^b = \frac{E_1}{E_1 + E_2 + E_3} = \frac{1}{1 + \lambda_2 + \lambda_3}. \tag{30}$$

We then describe the pre-shock state of Bank 1's balance sheet in the Securitized model. All of Bank 1's assets comprise subordinated loans that equal A_1. The liabilities and equity are D_1 (deposits) and E_1 (own capital), respectively. The same procedure is used to obtain the state of Bank 2's balance sheet. Given the aforementioned shock, Bank 1 loses its capital, while the shock has no effect on Banks 2 and 3, since there is no business connection between them. The capital loss rate, ν^s, for the banking system is given by

$$\nu^s = \frac{E_1}{E_1 + E_2 + E_3} = \frac{1}{1 + \lambda_2 + \lambda_3}. \tag{31}$$

Recalling (30) and (31), the following proposition is suggested:

Proposition 5 *For the Basic and the Securitized models, with two representative banks, the capital loss rates, v^b and v^s, for the system are $\dfrac{1}{1 + \lambda_2 + \lambda_3}$, a monotonically decreasing function of $(\lambda_2 + \lambda_3)$.*

Proposition 5 implies that the lower λ_2 is, the higher the capital loss rate. That is, when the shock happens to a larger bank, the capital loss rate will be higher. Proposition 5 also claims that the Basic and the Securitized models have the same capital loss rates. The reason is that there is no connection among banks. Thus, the impact on Bank 1 cannot transmit to the other banks through the balance sheet channel. We note that having the same capital loss rates does not imply that the two models have the same impact on the economy. Recalling the credit creation scales in the Basic and the Securitized models ((1) and (3)), the number of defaults in the former is $\dfrac{E_1}{1-\mu}$, while that in the latter is $\dfrac{E_1}{\gamma(1-\mu)}$. Depending on the model used, the spillover effects of the same default event on the economy differ. It is worth mentioning that when calculating v^b and v^s, it is not necessary to use the parameters related to securitization, i.e., θ and γ. Obviously, the result of Proposition 5 can be extended to a general banking system with more than three banks.

2.4.2 Capital Loss Rate in the Cross-holding Model

We have learned that the capital loss rates in the Basic and the Securitized models are at the same level that depends only on the parameters, λ_2 and λ_3. Naturally, we analyze the capital loss rate in the Cross-holding model comprising three representative banks and explore whether it is influenced by parameters such as γ or θ that are related to CAS. Table 4 describes the state of Bank 1's pre-shock balance sheet in the Cross-holding model.

Table 4: **The Balance Sheet of Bank 1 in the Cross-holding Model.**
Recalling (7) and (8), this table shows the balance sheet of Bank 1 in the Cross-holding model.

Asset A_1		**Liability and Equity** $(L_1 + E_1)$
Products from other banks	$\frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_1$	Deposit D_1
Subprime loans(Risk retention)	$\frac{\gamma}{\theta+\gamma-\theta\gamma}A_1$	Equity E_1

The characteristics of Bank 2 are similar to Bank 1's, while Bank 2's equity is E_2, which is equal to $\lambda_2 E_1$. For simplicity, without loss of generality, the parameters, α, β, γ, θ, and μ, are set the same for these two representative banks. It is noteworthy that in the Cross-holding model, Bank 3 is only used to make up the balance of CAS products and to ensure that Banks 1 and 2 can purchase the CAS products they need from the banking market; there is no other relationship between Bank 3 and the other banks.

Since the shock is imposed on Bank 1, we pay attention to two characteristics related to the cross-holding: One is $B_1^{c,o}$, the total volume of CAS products offered by Bank 1.

According to (6), we have $B_1^{c,o} = \dfrac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1$. The other is $B_2^{c,p}$, the total volume of CAS products purchased by Bank 2. Recalling (8), we have $B_2^{c,p} = \dfrac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2$. Comparing $B_1^{c,o}$ with $B_2^{c,p}$, we can divide the problem into two cases and discuss them separately.

In the one case, $B_1^{c,o} \leq B_2^{c,p}$, following the shock that results in all the loans issued by Bank 1 going into default, all the securitizations issued by Bank 1 and purchased by Bank 2 are also in default. On the asset side of Bank 1, the products from the other banks are not influenced while the retention loans are in default. Considering the limited liability in liquidation, the upper bound for Bank 1's capital loss is its own capital, E_1. Hence, Bank 1's capital loss is $\min\left\{E_1, \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1\right\}$. On Bank 2's asset side, all the products offered by Bank 1 are in default. Similarly, Bank 2's capital loss is $\min\left\{E_2, \dfrac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1\right\}$. Combining this with (29), the capital loss rate of the banking system, v^{c_1}, is shown in (32).

$$v^{c_1} = \begin{cases} \frac{1}{(1-\mu)(1+\lambda_2+\lambda_3)(\theta+\gamma-\theta\gamma)}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{\gamma}{(1-\mu)(1+\lambda_2+\lambda_3)(\theta+\gamma-\theta\gamma)} + \frac{\lambda_2}{1+\lambda_2+\lambda_3}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{1-\gamma}{(1-\mu)(1+\lambda_2+\lambda_3)(\theta+\gamma-\theta\gamma)} + \frac{1}{1+\lambda_2+\lambda_3}, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{1+\lambda_2}{1+\lambda_2+\lambda_3}, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \end{cases} \tag{32}$$

In the other case, $B_1^{c,o} > B_2^{c,p}$, following the shock in which all the loans issued by Bank 1 go into default, all the others' products on Bank 2's records will also be in default. Similarly, Bank 1's capital loss is $\min\left\{E_1, \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1\right\}$. On Bank 2's asset side, all the products it purchased are in default. Thus, Bank 2's capital loss is $\min\left\{E_2, \dfrac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2\right\}$. The capital loss rate, v^{c_2}, for the banking system is shown in (33).

$$v^{c_2} = \begin{cases} \frac{\gamma+\lambda_2\theta(1-\gamma)}{(1-\mu)(1+\lambda_2+\lambda_3)(\theta+\gamma-\theta\gamma)}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\gamma}{(1-\mu)(1+\lambda_2+\lambda_3)(\theta+\gamma-\theta\gamma)} + \frac{\lambda_2}{1+\lambda_2+\lambda_3}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\lambda_2\theta(1-\gamma)}{(1-\mu)(1+\lambda_2+\lambda_3)(\theta+\gamma-\theta\gamma)} + \frac{1}{1+\lambda_2+\lambda_3}, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{1+\lambda_2}{1+\lambda_2+\lambda_3}, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \end{cases} \tag{33}$$

v^c, the capital loss rate in the Cross-holding model, comprises v^{c_1} and v^{c_2}. According to (32) and (33), we have the following propositions, which are proven in the appendices. We first consider the relationship between v^c and v^b.

Proposition 6 *v^c may be higher or lower than v^b, depending on the parameters, θ, γ, μ, and λ_2.*

Proposition 6 says that when subjected to shocks, the banking system with cross-holding behavior could suffer a greater capital loss rate than other systems. The reason is that the issuance and cross-holding of credit securitization products enhance the correlation among banks through the channel of asset overlap. By holding products issued by the other banks, the bank is essentially holding the same loan assets as they do. The risks and shocks that an individual bank faces are transmitted to other banks in the cross-holding network through the credit securitization products they issue, and risk contagion occurs. Similarly, Proposition 6 also claims that the banking system in the Cross-holding model may suffer from a lower capital loss rate than the other models in the presence of shocks. Therefore, CAS may increase or reduce systemic risk with cross-holding behavior.

To explore the impact of μ on v^c, we have Proposition 7.

Proposition 7 *In the Cross-holding model,* $\dfrac{\partial v^{c_1}}{\partial \mu} > 0$ *and* $\dfrac{\partial v^{c_2}}{\partial \mu} > 0$ *always hold.*

Proposition 7 says that the higher the banking system's leverage, the higher the capital loss rate. Combining Propositions 1 and 7, it is obvious that banks obtain additional profits by using CAS products, which reinforces banks' incentive to raise their leverages. As their leverage rises, the banking system's capital loss rate increases when a severe shock occurs. That is, the effect of CAS of increasing banks' leverage raises the banking system's systemic risk.

In contrast to the Basic and the Securitized models, the leverage, μ, can raise the capital loss rate. It is natural to discuss whether other parameters could also influence the capital loss rate. To some extent, the risk retention degree, γ, and the cross-holding degree, θ, may be regarded as related parameters describing the issuance and trading process of CAS. We discuss the impact of these parameters further. Calculating the partial derivatives with respect to γ and θ, respectively, (recall (32) and (33)), we have Proposition 8.

Proposition 8 *In the Cross-holding model, the impacts of both γ and θ on v^c are non-monotonic.*

For the impact of γ on the capital loss rate, v^c, Proposition 8 says that, under certain conditions, the higher the degree of risk retention, the lower the banking system's capital loss rate when shocks occur. Under other specific conditions, the opposite conclusion holds. In the former case, the number of CAS products increases and other banks purchase a large proportion of the CAS products due to cross-holding behavior. In the latter case, although the number of securitized products issued increases, other banks do not purchase many of them due to some limitations, such as their small-scale assets.

Regarding the impact of θ on the capital loss rate, v^c, Proposition 8 suggests the same nonmonotonic mode as that for γ. A possible explanation is that, although cross-holding behavior enhances inter-bank correlation, which may contribute to risk contagion, it also limits the extent of credit expansion and helps banks replenish their capital.

Thus far, we have analyzed the impact of γ and θ on the capital loss rate, v^c. Both are key parameters that describe the securitization process. Recalling Proposition 5, we can rigorously conclude that it is the cross-holding behavior that creates the nonmonotonic relationship between CAS products and the capital loss rate. For completeness, we briefly analyze the impact of λ_2 on v^c. Based on the partial derivatives with respect to λ_2 (recall (32) and (33)), we have Proposition 9.

Proposition 9 *In the Cross-holding model, the impact of λ_2 on v^c is nonmonotonic.*

Proposition 9 states that, in contrast to the situation in the Basic and the Securitized models, the impact of λ_2 on the systemic risk is nonmonotonic in this model. On the one hand, under certain conditions, the higher the λ_2, the lower the rate of capital losses in the banking system when shocks occur. This phenomenon usually occurs when a bank's equity is sufficient to cover its losses. In that case, the higher λ_2 indicates more capital in the banking system, and the capital loss rate declines accordingly. On the other hand, Proposition 9 also suggests that, under certain conditions, the higher the λ_2, the higher the capital loss rate, especially when the bank's equity is insufficient to cover losses and the cross-holding degree is at a high level. That is, increased capital is sometimes insufficient to stabilize a banking system, while the degree of cross-holding aggravates the instability.

2.5 Simulation Analysis

To elucidate the nonmonotonic relationship between CAS and systemic risk in the above subsection, we focus on the effects of γ and θ. Figure 5 presents an example of a numerical simulation. The simulation results confirm Proposition 8, i.e., that the relationship between CAS issuance and systemic risk is nonmonotonic. Our simulation results are also consistent with the theoretical conclusions of Section 2.4. Notably, according to our setting for Bank 3, when λ_3 is close to 0, it can still work. To simplify and visualize our simulation, we let λ_3 equal to 0 in the calculation, which does not influence the shapes of the panels and the relative relations. Hence, the λ in Figure 5 is equivalent to λ_2 in the above discussion.

Considering Panels (a), (d), and (g), which are at the same level of leverage in the pair of examples, we analyze the relationship between the capital loss rate, two parameters (recall γ and θ), and the issuance amount. In Panel (a), when γ and θ are high and lead to a low issuance amount, the loss rate is high. When the issuance amount increases slightly, for example, at the point where $\gamma = 0.99$ and $\theta = 0.01$, the issuance amount reaches a median level. In this case, the capital loss rate is almost the lowest. When the issuance amount reaches a high level, for example, at the point where $\gamma = 0.01$ and $\theta = 0.01$, the corresponding capital loss rate is almost the highest. Panel (a) means that there may exist a U-shaped relationship between the issuance amount and systemic risk. In Panel (d), a particular case in which banks' assets are at the same level, clearly, when at least one of γ and θ is close to 1, the capital loss rate is at a low level; and when the condition above is not satisfied, the capital loss rate rises rapidly. It is evident from Panel (d) that the issuance amount has a nonlinear relationship with the capital loss rate. However, Panel (g) shows that the capital loss rate and the issuance amount are essentially synchronous.

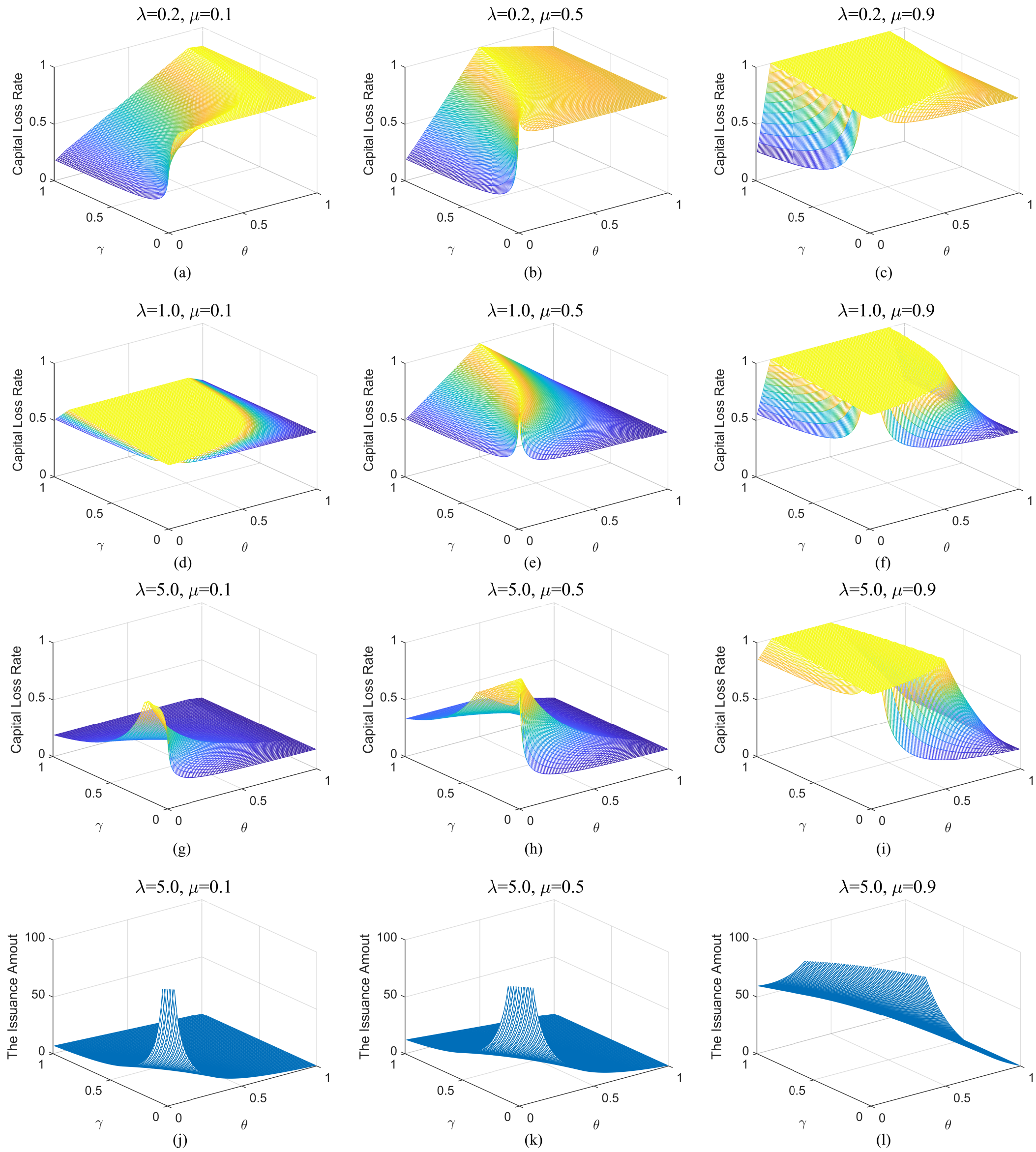

Figure 5: The capital loss rates in different conditions. This figure shows a set of capital loss rates and the issuance amount of CAS products. Notably, the abscissa and ordinate ranges of all the panels are from 0.01 to 1. Specifically, Panels (a) to (i) respectively describe the capital loss rates under parameter conditions of $\lambda = 0.2$ and $\mu = 0.1$, $\lambda = 0.2$ and $\mu = 0.5$, and so on. We provide information on the parameters above each panel. We also provide the corresponding CAS issuance amounts. Panels (j) to (l) present the relationships between the CAS issuance amount, γ, and θ under the respective parameter conditions of $\lambda = 5.0$ and $\mu = 0.1$, $\lambda = 5.0$ and $\mu = 0.5$, and $\lambda = 5.0$ and $\mu = 0.9$, which correspond to Panels (g), (h), and (i), respectively. Considering that too high a critical value may mask some characteristics when the related value is low, we limit the upper bounds of Panels (g), (h), and (i). Panels (j), (k), and (l) show similar relationships between the issuance, γ, and θ; that is, as γ or θ increases, the issuance amount declines. We therefore omit the panels that correspond to Panels (a) to (f) to simply the figure.

We illustrate the nonmonotonic relationship between CAS and systemic risk in the Cross-holding model through simulation and verify the associated propositions. Thus far, some exciting conclusions have been drawn from comparing these models.

Compared to the Basic model, the Securitized model demonstrates that CAS provides both credit creation and risk transfer capabilities. Research has shown that these functions can contribute to the accumulation of systemic risk through the interaction of market risk, credit risk (Jiangli and Pritsker, 2008), and liquidity risk (Loutskina, 2011). Additionally, CAS provides positive profits for banks when the economy appreciates, which enhances banks' leverage (recall Proposition 1). Combined with Proposition 7, it is fully demonstrated that CAS can drive up banks' leverage and further raise systemic risk: This is the indirect impact of CAS on risk.

Due to its authenticity, we mainly focus on the Cross-holding model. On the one hand, a moderate level of cross-holding improves the stability of the banking system. We showed, in Proposition 3, that banks in the Cross-holding model could obtain capital replenishment at the time of settlement of non-defaulted securitized credit assets. Meanwhile, the cross-holding behavior weakens banks' credit creation function, which may slow down the recovery of the underlying assets' prices and help to reduce the market risk caused by price bubbles. On the other hand, the cross-holding behavior may also alleviate the systemic risk of the banking system. Proposition 4 suggests that cross-holdings may help banks evade capital adequacy regulation, which may raise systemic risk. Faced with severe shock, the capital loss rate in the Cross-holding model may be higher than that in the Basic or the Securitized model (recall Proposition 6). This is due to the fact that the cross-holding behavior enhances the inter-bank correlation, thus exposing the other individuals to the shock due to risk contagion.

Moving a step further, in Proposition 8, we demonstrated that from the perspective of those parameters that directly described the real operation of CAS characterized by cross-holding, the impact of credit securitization on systemic risk was nonmonotonic. In the next section, we consider a quadratic model to examine the specific form of relationship between CAS and systemic risk via empirical tests.

3 Empirical Test

As we discussed earlier, CAS product issuance has a nonmonotonic impact on systemic risk. While the use of this securitization can reduce systemic risks by increasing liquidity and other channels, it can also lead to excessive credit expansion and increase systemic risks. Thus, we now investigate this special relationship based on relevant data from 27 countries and regions globally, spanning the past 15 years.

The previous theoretical and simulation results imply that the relationship between systemic risk and CAS is nonmonotonic and highly dependent on various factors. However, it is impossible for us to conduct a rigorous empirical test based on the theoretical analysis due to lack of relevant data. However, recalling (9) and our simulation, the issuance amount rises as γ and θ decrease. In other words, the issuance volume of CAS products is monotonous in some key factors. Thus, the issuance volume of the CAS products can be used as a synthetical factor to conduct the empirical test on the relationship between systemic risk and CAS.

3.1 Samples and Pre-analysis

The MBS and ABS issuance data from the Bloomberg database are used in our empirical tests. After excluded countries and regions with a low frequency of issuance, we obtained data on 27 countries and regions, as shown in Table B1. The time interval is 2005Q4-2019Q4, while the data frequency is quarterly.

To measure systemic risk, we choose SRISK (Brownlees and Engle, 2012, 2017), which was originally defined as an individual institution's expected capital shortfall in a systemic crisis event. In detail, SRISK is defined as

$$SRISK_{it} = E_t(CS_{it}|Crisis),$$

where CS_{it} is the capital shortfall for Institution i at Time t, while a crisis event is defined as one in which the market yield falls below a certain critical value within a given time range.

The value of $SRISK_{it}$ is related to $LRMES_{it}$, the long run marginal expected shortfall (Brownlees and Engle, 2012, 2017) for Institution i at Time t, which represents the expectation of multi-period institutional returns under systemic crisis conditions. We use LRMES to measure systemic risk. Note that systemic risk in this study is measured at the country/region level, i.e., the original "institution" is replaced by a country or region.

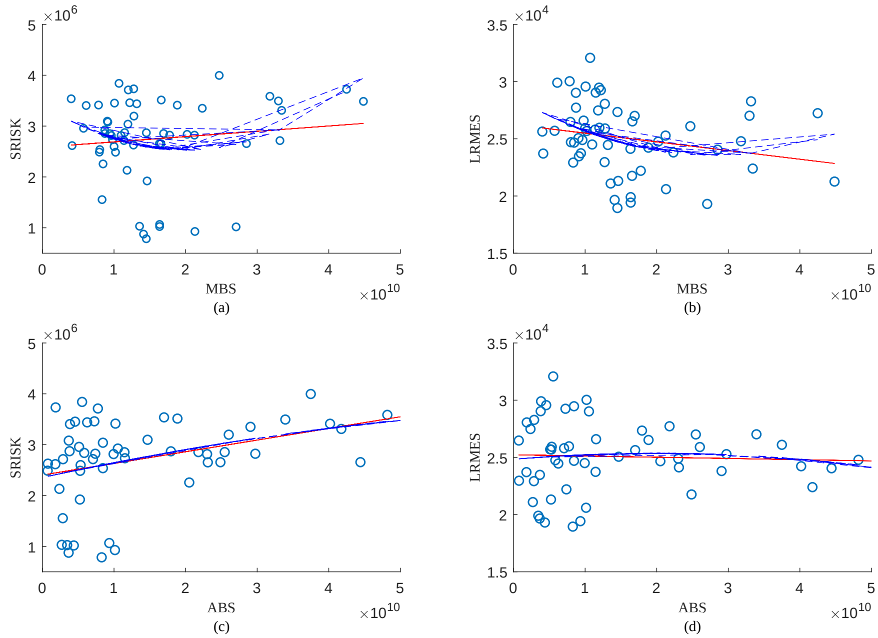

Figure 6: The quantity of issuance of CAS products and systemic risk in practice. This figure shows the correlation between product issuance (MBS/ABS) and systemic risk (SRISK/LRMES). The horizontal and vertical coordinates of the scatter points are the mean values of product issuance and systemic risk during the current period (e.g., in 2005Q4), respectively. The linear and nonlinear fitting of issuance and systemic risk are drawn as solid and dashed lines, respectively. Panel (a) presents the relationship between MBS and SRISK. Panel (b) is similar to Panel (a), with its vertical coordinate representing LRMES. Both show that the model with a quadratic curve is more suitable. Panels (c) and (d) show the relationship between ABS and systemic risk (SRISK/LRMES), respectively, while the nonlinearity is not as obvious as in Panels (a) and (b). Interestingly, Panels (a) and (b) demonstrate that the linear model may lead to different conclusions under different systemic risk measures, which explains why previous empirical studies have yielded opposite conclusions.

Before going further, we first visually inspect the relationship between CAS product issuance and systemic risk. Figure 6 shows scatter plots of the issuance volume of CAS products (MBS/ABS) vs. systemic risk (SRISK/LRMES). As shown, issuance quantity and systemic risk appear to be nonlinearly correlated, particularly in Panels (a) and (b). It is reasonable to suspect a U-shaped relationship between the issuance volume of CAS products and systemic risk. Specifically, CAS's development may lead to a decline in systemic risk initially; however, systemic risk rises as the quantity of CAS product issuance increases. From this observation, we incorporate the quadratic term into our empirical model to describe the nonlinear relationship between CAS and systemic risk.

3.2 Data and Descriptive Analysis

Our pre-analysis shows that the issuance quantity of MBS and ABS and their quadratic terms are key explanatory variables for systemic risk. Additionally, a set of control variables that may affect systemic risk are considered. Table B2 reports the details of these variables.

The larger the banking system, the higher the level of systemic risk; i.e., the size of the banking system significantly affects systemic risk (Laeven et al., 2016). We therefore regard the size of the banking system as a control variable. As a channel connecting credit securitization products, individual bank risk, and systemic risk, bank loan quality has an impact on system risk. Therefore, the non-performing loan (NPL) ratio is also considered as a control variable. Since CAS is associated with a process of credit expansion, which may affect the level of economic leverage and ultimately increase systemic risk, we use the ratio of credit to GDP as a proxy for measuring an economy's leverage level. Other variables are also used to control for factors that may affect systemic risk, such as liquidity and volatility of the financial market, financialization, and macroeconomic conditions. The descriptive statistics for these variables are shown in Table 5. Although we use standardized data in our regressions, we have provided the descriptive statistics of variables that have not been standardized to directly describe their descriptive statistics. The standard deviations of MBS and ABS are very similar. Table B3 lists the correlation coefficient matrix of variables and shows that most of the explanatory variables are significantly correlated with explained variables.

Table 5: **Descriptive Statistics.**
This table reports the mean, standard deviation, minimum and maximum for the list of CAS products considered in the empirical experiments.

Variable	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
SRISK	1,539	72.451	85.345	0.000	565.361
LRMES	1,539	92.681	111.257	2.232	610.717
MBS	1,539	2.358	6.765	0.000	24.262
MBS2	1,539	51.294	148.476	0.000	588.630
ABS	1,539	3.377	7.609	0.000	24.585
ABS2	1,539	69.260	158.780	0.000	604.400
OTHER	1,539	14.064	10.697	0.000	28.860
OTHER2	1,539	312.132	248.759	0.000	832.872
SIZE	1,539	14.296	1.585	9.205	17.429
NPL	1,539	4.130	5.946	0.080	45.570
LEND	1,539	7.191	8.874	0.673	75.590
M1	1,539	8.825	8.727	−22.578	96.163
M2	1,539	8.018	7.977	−25.138	53.423
FINANCE	1,539	90.580	57.304	1.588	311.154
VOL	1,539	17.691	9.526	3.417	73.493
GDP	1,539	2.334	3.590	−10.940	28.780
FIXEDI	1,539	2.919	12.819	−67.703	260.525
EXCHANGE	1,539	99.445	14.691	49.800	161.256
DEFLATOR	1,539	3.485	5.991	−12.837	51.667
CREDIT	1,539	153.583	66.143	16.900	401.600

3.3 Empirical Model

In light of the conclusions from our theoretical model and pre-analysis, it is evident that the impact of asset securitization products on the systemic risk of the banking system is nonmonotonic. Therefore, we perform the following regression to formally examine the above relationship:

$$y_{i,t} = \alpha + \boldsymbol{\beta} \boldsymbol{X}_{i,t} + \boldsymbol{\gamma} \boldsymbol{Z}_{i,t} + \boldsymbol{\delta} \boldsymbol{W}_{i,t} + \varepsilon_{i,t},$$

where $y_{i,t}$ denotes the systemic risk of Individual i at Time t, and $\boldsymbol{X}_{i,t}$ is a vector comprising MBS issuance, ABS issuance, and other collateralized bond issuance for Individual i at Time

t. $\boldsymbol{Z}_{i,t}$ is a vector comprising the quadratic terms of corresponding elements in Vector $\boldsymbol{X}_{i,t}$, and $\boldsymbol{W}_{i,t}$ represents the control variables for Individual i at Time t. $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$, and $\boldsymbol{\delta}$ are coefficient vectors that must be estimated. α is the constant term and $\varepsilon_{i,t}$ the error term.

We correct autocorrelation, heteroscedasticity, and cross-sectional correlation by Driscoll-Kraay estimation. Therefore, the R^2 values reported in the following tables are with-in sample. Considering the heteroscedasticity of the panel data, we make judgments based on the modified Hausman statistics and the Wald statistics based on the overidentification test, which indicate that the fixed-effect model should be selected in the regressions. We therefore control for individual effects at both country and time levels.

3.4 Estimation of the Empirical Model

First, we set SRISK as the explained variable, and gradually introduce core explanatory variables into the regression. The results are reported in Table 6. It can be seen from Models (1), (3), and (5) that, without considering the squared terms, the issuance of MBS, ABS, and other collateralized bonds has a positive effect on systemic risk. The coefficients of the linear and the squared terms for MBS are 0.2233 and 0.2646, respectively, which are larger than those of other types of products, indicating that MBS has a more significant impact on systemic risk.

As shown in Models (7), (8), and (9), if the squared terms of issuances are introduced in turns, the coefficients of the linear terms become significant and negative, while the coefficients of the squared terms are significant and positive. The introduction of the squared term better portrays the relationship between issuance and systemic risk, which is consistent with the results of the theoretical analysis. The regression coefficients associated with MBS issuance are significant at the 1% level, and are the most significant compared with those associated with other CAS products.

Model (10) reports the results when both the linear and the square terms of all CAS product issuances are included in the regression. In this model, the products excluded MBS; neither the linear nor the squared terms of the issuance quantity have a significant impact on systemic risk, whereas the MBS issuance quantity and its squared term are significant at the 1% level. Specifically, the coefficient of the MBS issuance quantity is -1.2702, which is significant and negative, while the coefficient of its square is 1.6003, which is significant and positive. This suggests that when issuance quantity is low, MBS can reduce systemic risk. However, as the issuance increases, the above relationship will change so that increased MBS issuance ultimately leads to increased systemic risk. The impact of CAS on systemic risk is nonmonotonic but depends on the scale of CAS product issuance. In Table B4, we present the results when control variables are introduced stepwise into the regression equation.

Among the control variables, the positive relationship between the banking size and SRISK is significant. The magnitude of its regression coefficient is second only to that of the squared term of MBS quantity, which implies the vital impact of banking size on systemic risk. The relationship between the NPL ratio and systemic risk is also significant and positive, indicating that the worse the quality of credit assets in the economy, the higher the systemic risk (Bostandzic and Weiß, 2018). The significant and positive coefficient of CREDIT indicates that systemic risk is higher when the credit size of an economy is larger. Notably, the credit size of an economy can be regarded as the level of leverage in some way. The year-on-year GDP growth rate shows a negative relationship with systemic risk. Thus,

Table 6: **Time-series Regression Results on SRISK.**

This table reports the regressions of explanatory and control variables on SRISK. Specifically, we run regressions with stepwise introductions of explanatory variables. We firstly regress the core explanatory variables(recall MBS, ABS, other collateralized bonds and their squared terms) and control variables on SRISK, respectively. The first to sixth columns correspond to results of using MBS, ABS, other collateralized bonds, and their squared terms as core explanatory variables. Further, for comparison, we also regress the couple of core explanatory variables and control variables on SRISK, respectively. Models (7) (8) (9) present results of the above regressions. Finally, we show our prime regression in the last column, i.e., the Model (10). ***, **, and * denote significant values at the levels of 1%, 5%, and 10%, respectively.

SRISK	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
MBS	0.2233***						−1.2799***			−1.2702***
MBS2		0.2646***					1.6209***			1.6003***
ABS			0.0571***					−0.5061*		0.1100
ABS2				0.0669***				0.5873*		−0.0908
OTHER					0.0539***				−0.3658**	−0.0944
OTHER2						0.0679***			0.4700**	0.1414
SIZE	0.7041***	0.7127***	0.5117***	0.5065***	0.5224***	0.5179***	0.6515***	0.4852***	0.4975***	0.6296***
NPL	0.0458***	0.0483***	0.0370***	0.0381***	0.0424***	0.0449***	0.0523***	0.0405***	0.0505***	0.0620***
LEND	−0.1159**	−0.1161**	−0.1046**	−0.1024**	−0.1290***	−0.1307***	−0.1169**	−0.0971**	−0.1287***	−0.1217***
M1	−0.0028	−0.0047	0.0019	0.0015	0.0016	0.0015	−0.0110	−0.0003	0.0018	−0.0111
M2	0.0321*	0.0333**	0.0278	0.0281	0.0261	0.0256	0.0350**	0.0272	0.0210	0.0354**
FINANCE	−0.2784***	−0.2810***	−0.2578***	−0.2588***	−0.2657***	−0.2658***	−0.2819***	−0.2672***	−0.2600***	−0.2823***
VOL	0.0312	0.0337	0.0269	0.0278	0.0234	0.0239	0.0401	0.0290	0.0251	0.0432
GDP	−0.0690***	−0.0667***	−0.0826***	−0.0818***	−0.0843***	−0.0838***	−0.0647***	−0.0784***	−0.0816***	−0.0636***
FIXEDI	0.0035	0.0035	0.0027	0.0028	0.0019	0.0018	0.0031	0.0042	0.0028	0.0017
EXCHANGE	−0.0538**	−0.0626***	0.0010	−0.0022	0.0059	0.0046	−0.0689***	−0.0174	0.0012	−0.0710***
DEFLATOR	−0.0329	−0.0330	−0.0388	−0.0398	−0.0285	−0.0277	−0.0331	−0.0408	−0.0261	−0.0324
CREDIT	0.2550**	0.2357**	0.3441***	0.3387***	0.3483***	0.3433***	0.1969**	0.3071***	0.3185***	0.1913*
C	−0.0842**	−0.0821**	−0.1012**	−0.1013**	−0.0988**	−0.0997**	−0.0823**	−0.1032**	−0.1082***	−0.0830**
N	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	139.9309	144.3958	281.2502	252.1911	420.7428	378.1292	282.3350	237.5083	489.4890	508.9313
R^2	0.3230	0.3338	0.2842	0.2865	0.2812	0.2827	0.3606	0.2957	0.2873	0.3647

Table 7: **Time-series Regression Results on LRMES.**

This table reports the regressions of explanatory and control variables on LRMES. Specifically, we run regressions with stepwise introductions of explanatory variables. We firstly regress the core explanatory variables(recall MBS, ABS, other collateralized bonds and their squared terms) and control variables on LRMES, respectively. The first to sixth columns correspond to results of using MBS, ABS, other collateralized bonds, and their squared terms as core explanatory variables. Further, for comparison, we also regress the couple of core explanatory variables and control variables on LRMES, respectively. Models (7) (8) (9) present results of the above regressions. Finally, we show our prime regression in the last column, i.e., the Model (10). ***, **, and * denote significant values at the levels of 1%, 5%, and 10%, respectively.

LRMES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
MBS	0.0636***						−0.4225***			−0.3664***
MBS2		0.0765***					0.5242***			0.4532***
ABS			0.0264***					−0.2501***		−0.0997**
ABS2				0.0311***				0.2883***		0.1237**
OTHER					0.0017				−0.0775**	0.0235
OTHER2						0.0035			0.0887**	−0.0338
SIZE	0.3415***	0.3447***	0.2835***	0.2809***	0.2917***	0.2913***	0.3245***	0.2704***	0.2870***	0.3103***
NPL	−0.0040	−0.0033	−0.0056	−0.0051	−0.0078	−0.0074	−0.0020	−0.0039	−0.0062	−0.0022
LEND	−0.0195*	−0.0196*	−0.0144	−0.0133	−0.0198*	−0.0201*	−0.0198*	−0.0107	−0.0197*	−0.0130
M1	0.0020	0.0014	0.0032	0.0030	0.0035	0.0035	−0.0007	0.0021	0.0035	−0.0007
M2	0.0064	0.0068	0.0058	0.0060	0.0043	0.0043	0.0074	0.0055	0.0034	0.0081*
FINANCE	−0.0323	−0.0332	−0.0264	−0.0269	−0.0267	−0.0269	−0.0335*	−0.0311	−0.0257	−0.0338*
VOL	−0.0156	−0.0148	−0.0158	−0.0154	−0.0183*	−0.0183*	−0.0127	−0.0148	−0.0180*	−0.0116
GDP	−0.0225***	−0.0218***	−0.0259***	−0.0255***	−0.0271***	−0.0271***	−0.0211***	−0.0239***	−0.0266***	−0.0206***
FIXEDI	0.0066	0.0066	0.0062	0.0062	0.0066	0.0066	0.0065	0.0069	0.0068	0.0066
EXCHANGE	0.0342**	0.0314*	0.0482**	0.0466**	0.0524***	0.0522***	0.0293*	0.0392**	0.0515***	0.0267*
DEFLATOR	−0.0040	−0.0041	−0.0069	−0.0074	−0.0037	−0.0036	−0.0041	−0.0079	−0.0033	−0.0073
CREDIT	0.1158***	0.1098***	0.1394***	0.1369***	0.1438***	0.1434***	0.0970***	0.1212***	0.1382***	0.0956***
C	0.0017	0.0024	−0.0030	−0.0030	−0.0034	−0.0034	0.0023	−0.0039	−0.0052	0.0016
N	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	29.1535	27.9312	47.4128	49.0263	41.4917	39.8215	40.6122	68.0656	49.2190	60.8523
R^2	0.4031	0.4121	0.3849	0.3897	0.3690	0.3691	0.4381	0.4095	0.3710	0.4492

the better the economic condition, the lower the systemic risk.

For completeness and robustness, we additionally use LRMES as the explained variable and report the results of the regressions in Tables 7 and B5. The results of Model (10) in Table 7 and Model (13) in Table B5 are similar to those discussed above, in that the coefficient of MBS is significant and negative while that of its squared term is significant and positive. Meanwhile, the relationship between bank size, leverage, and year-on-year GDP growth and systemic risk is consistent with the results when SRISK is the systemic risk measure.

The difference is that ABS issuance and its squared term are significant when LRMES is used as the measure of systemic risk. Specifically, the coefficients of ABS issuance and its squared term, -0.0997 and 0.1237, respectively, are smaller and less significant than those of their MBS counterparts, which are -0.3664 and 0.4532, respectively. Meanwhile, the coefficients of MBS in this regression are smaller than those in the model with SRISK (recall -1.2702 and 1.6003) as the systemic risk measure.

A possible explanation is the difference in the underlying assets between ABS and MBS. MBS primarily comprise housing mortgage loans, while ABS primarily comprise auto- and credit card loans. The real estate industry, one of the most critical sectors in an economy, is closely linked to macroeconomic and systemic risks. Therefore, the effect of MBS is more evident: the quadratic impact of MBS on systemic risk is reflected under both types of systemic risk indicators, while ABS only show a quadratic impact on LRMES.

3.5 Robustness Checks

Although we have shown that there is a strong quadratic relationship between CAS product issuance and systemic risk (see Tables 6-7), it would be interesting to examine whether this relationship remained robust when another measure of systemic risk and other combinations of control variables were used.

Considering that banks with large capital buffers can reduce systemic risk during crisis events, we adjust the compute mode for SRISK and substitute an adjusted variable as a new proxy for systemic risk, denoted ASRISK. Specifically, we consider the negative capital shortfall rather than only the positive values. This variable now comprises negative values rather than being restricted to values above zero. As a measure of systemic risk, ASRISK is relatively slack compared to SRISK. That is, it measures less systemic risk. Should the core explanatory variables remain statistically significant using ASRISK, the regression robustness would be further verified. The results shown in Table 8 are consistent with the above conjecture. The coefficient of the MBS term is significant and negative, while the coefficient of the square term for MBS is significant and positive. Meanwhile, the coefficients of MBS in this regression are smaller than those in the model with SRISK.

In addition, other combinations of control variables are chosen for robustness testing. In these combinations, we find that the linear and the squared terms for MBS quantity are significantly positive, especially the latter. Additionally, for Panel B in Table 9, the coefficients of MBS, ABS, and their squared terms remain significant. These multiple alternative checks confirm the robustness of our findings.

3.6 Results and Discussion

Based on the global samples, our empirical study indicates a U-shaped relationship between the quantity of CAS product issuance and systemic risk. This finding means that there is an optimal level of CAS issuance that minimizes systemic risk. This level is also the critical point at which the effect of CAS products on systemic risk shifts. Noteworthily, the effects of MBS issuance on systemic risk are significantly greater than those of ABS, which may be due to their different underlying asset pools. Our results on the relationships between systemic risk and variables such as bank size, economic development status, and credit expansion are consistent with existing research (Laeven et al., 2016; Bostandzic and Weiß, 2018).

Table 8: **Time-series Regression Results on ASRISK.**

This table presents the regressions of explanatory variables on ASRISK, which is used to replace SRISK or LRMES in our prime regression. Specifically, we run regressions with stepwise introductions of explanatory variables. We firstly regress the core explanatory variables (recall MBS, ABS, other collateralized bonds and their squared terms) and control variables on ASRISK, respectively. The first to sixth columns correspond to results of using MBS, ABS, other collateralized bonds, and their squared terms as core explanatory variables. Further, for comparison, we also regress the couples of core explanatory variables and control variables on ASRISK, respectively. Models (7) (8) (9) present results of the above regressions. Finally, we show our prime regression in the last column, i.e., the Model (10). ***, **, and * denote significant values at the levels of 1%, 5%, and 10%, respectively.

ASRISK	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
MBS	0.0633***						−0.4914***			−0.4193***
MBS2		0.0774***					0.5981***			0.5078***
ABS			0.0271***					−0.2925***		−0.1341***
ABS2				0.0325***				0.3332***		0.1605***
OTHER					0.0001				−0.0934**	0.0177
OTHER2						0.0021			0.1048**	−0.0294
SIZE	0.3137***	0.3178***	0.2557***	0.2529***	0.2643***	0.2640***	0.2943***	0.2406***	0.2588***	0.2773***
NPL	−0.0102	−0.0093	−0.0116	−0.0111	−0.0142*	−0.0138	−0.0078	−0.0096	−0.0124	−0.0083
LEND	−0.0175*	−0.0176*	−0.0122	−0.0111	−0.0174	−0.0178*	−0.0179*	−0.0080	−0.0173	−0.0099
M1	0.0008	0.0002	0.0020	0.0018	0.0024	0.0023	−0.0022	0.0008	0.0024	−0.0021
M2	0.0044	0.0048	0.0038	0.0040	0.0023	0.0023	0.0055	0.0035	0.0011	0.0060
FINANCE	−0.0353	−0.0362*	−0.0294	−0.0299	−0.0295	−0.0297	−0.0366*	−0.0348	−0.0282	−0.0370*
VOL	−0.0255***	−0.0247***	−0.0257**	−0.0252**	−0.0283***	−0.0283***	−0.0223**	−0.0245**	−0.0280***	−0.0212**
GDP	−0.0221***	−0.0212***	−0.0254***	−0.0250***	−0.0267***	−0.0266***	−0.0205***	−0.0230***	−0.0261***	−0.0198***
FIXEDI	0.0075	0.0075	0.0071	0.0071	0.0076	0.0075	0.0074	0.0079*	0.0078*	0.0077*
EXCHANGE	0.0372**	0.0341**	0.0510***	0.0493***	0.0554***	0.0552***	0.0317**	0.0405***	0.0544***	0.0286**
DEFLATOR	−0.0006	−0.0006	−0.0035	−0.0041	−0.0004	−0.0003	−0.0007	−0.0047	0.0001	−0.0042
CREDIT	0.1256***	0.1191***	0.1490***	0.1462***	0.1536***	0.1533***	0.1042***	0.1279***	0.1470***	0.1018***
C	0.0100	0.0108	0.0055	0.0054	0.0049	0.0050	0.0107	0.0043	0.0028	0.0096
N	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	36.4419	35.3502	86.3256	89.4219	57.2809	56.3667	45.7816	75.8937	60.3225	70.5790
R^2	0.4127	0.4238	0.3946	0.4008	0.3767	0.3767	0.4613	0.4298	0.3796	0.4765

Table 9: **Robustness Checks.**
This table presents the regressions whose control variables have been replaced. Specifically, in Panel A, Model (1) replaces VOL with VOLG that is the volatility of stock indexes in recent two year. Model (2) uses the change in consumer prices (called CPIP) as a substitute for DEFLATOR. Model (3) uses the ratio of the total non-financial credit to GDP, named NF CREDIT, to replace CREDIT. Models (4) and (5) introduce budget balance and public debt to the original regression model. The models in Panel B are similar to those in Panel A at explanatory variables, while its explained variable is LRMES. ***, **, and * denote significant values at the levels of 1%, 5%, and 10%, respectively.

Panel A: SRISK	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
MBS	−1.2589***	−1.2724***	−1.2187***	−1.2668***	−1.2783***
MBS2	1.5858***	1.6026***	1.5355***	1.5966***	1.6115***
ABS	0.1035	0.0990	0.1578	0.1106	0.1373
ABS2	−0.0847	−0.0791	−0.1422	−0.0903	−0.1183
OTHER	−0.0965	−0.0959	−0.1196	−0.1048	−0.1332
OTHER2	0.1434	0.1406	0.1727	0.1518	0.1887
SIZE	0.6107***	0.6412***	0.6325***	0.6161***	0.6396***
NPL	0.0609***	0.0575***	0.0135	0.0639***	0.0268
LEND	−0.1155**	−0.0950**	−0.1265***	−0.1222***	−0.1301***
M1	−0.0125	−0.0150	−0.0171	−0.0119	−0.0163
M2	0.0382**	0.0348**	0.0465***	0.0381**	0.0460**
FINANCE	−0.2961***	−0.2957***	−0.2831***	−0.2759***	−0.2825***
VOL		0.0432	0.0371	0.0421	0.0386
GDP	−0.0767***	−0.0651***	−0.0689***	−0.0617***	−0.0653***
FIXEDI	0.0009	0.0005	0.0001	0.0027	0.0009
EXCHANGE	−0.0737***	−0.0743***	−0.0528**	−0.0708***	−0.0602**
DEFLATOR	−0.0348		−0.0264	−0.0310	−0.0319
CREDIT	0.1946*	0.1851*		0.1823*	0.2008**
VOLG	0.0169				
CPIP		−0.0632**			
NF CREDIT			0.3456***		
BUDGET				−0.0151	
PUBLICDEBT					0.1618*
C	−0.0768	−0.0848**	−0.0103	−0.0864**	−0.0377
N	1539	1539	1539	1539	1539
Time&Country	Yes	Yes	Yes	Yes	Yes
F	535.8506	518.7352	828.8722	477.9952	1049.6238
R^2	0.3620	0.3662	0.3791	0.3653	0.3700
Panel B: LRMES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
MBS	−0.3713***	−0.3668***	−0.3475***	−0.3679***	−0.3688***
MBS2	0.4592***	0.4537***	0.4299***	0.4548***	0.4565***
ABS	−0.0982**	−0.1000**	−0.0807*	−0.0999**	−0.0917*
ABS2	0.1227**	0.1239**	0.1033*	0.1235**	0.1157**
OTHER	0.0233	0.0228	0.0088	0.0280	0.0122
OTHER2	−0.0332	−0.0329	−0.0159	−0.0382	−0.0199
SIZE	0.3154***	0.3112***	0.3171***	0.3161***	0.3132***
NPL	−0.0020	−0.0022	−0.0221**	−0.0030	−0.0125
LEND	−0.0147*	−0.0147	−0.0152*	−0.0128	−0.0154*
M1	−0.0007	−0.0011	−0.0036	−0.0003	−0.0022
M2	0.0077	0.0075	0.0124***	0.0069*	0.0112**
FINANCE	−0.0282	−0.0340*	−0.0341*	−0.0366**	−0.0339*
VOL		−0.0115	−0.0139	−0.0112	−0.0130
GDP	−0.0165***	−0.0209***	−0.0229***	−0.0214***	−0.0210***
FIXEDI	0.0070	0.0064	0.0060	0.0062	0.0064
EXCHANGE	0.0275*	0.0265*	0.0336**	0.0266*	0.0298*
DEFLATOR	−0.0065		−0.0050	−0.0079	−0.0071
CREDIT	0.0937***	0.0955***		0.0995***	0.0984***
VOLG	−0.0015				
CPIP		−0.0044			
NF CREDIT			0.1493***		
BUDGET				0.0065	
PUBLICDEBT					0.0474***
C	−0.0014	0.0019	0.0320***	0.0031	0.0149
N	1539	1539	1539	1539	1539
Time&Country	Yes	Yes	Yes	Yes	Yes
F	65.3597	62.8910	56.1098	61.8122	60.3269
R^2	0.4472	0.4490	0.4690	0.4502	0.4532

4 Concluding Remarks

Despite numerous studies that have explored the relationship between credit securitization and systemic risk, most do not consider bank behavior. To some extent, this implies the assumption that bank behavior cannot influence securitization and systemic risk, which is not the case in practice. Evidently, banks' behavior does affect CAS product issuance and the risks associated with it.

Regarding the cross-holding behavior in respect of CAS products, we construct theoretical models to explore the effect of CAS products and their impact on systemic risk. We also conclude that the cross-holding behavior regarding CAS products helps banks evade the CAR constraint. To verify the theoretical results, we conduct an empirical study based on the panel data of 27 countries and regions over the period 2005Q4-2019Q4. Furthermore, to better meet the definition of systemic risk, we use country-level rather than bank-level data. Both theoretical and empirical results indicate a nonmonotonic relationship between CAS product issuance and systemic risk, which may be described as a U-shaped relationship in practice, when CAS is characterized by its issuance quantity. These findings suggest an optimal securitization level that minimizes systemic risk.

Last, we offer an unprecedented perspective related to banks' cross-holding behaviors that allows further research. Based hereon, future research could consider how other important characteristics and financial innovations of the banking system affected systemic risk. While CAS may lead to the formation and transmission of systemic risk, its capacity to reduce systemic risk and its positive role in revitalizing bank assets cannot be ignored. Therefore, there remains considerable theoretical and practical significance in exploring the relationship between financial products and systemic risk, especially in the context of the cross-holding phenomenon, which has been naturally created in actual transactions but has received little attention.

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Appendix A

Proof of Proposition 6. When $B_1^{c,o} \leq B_2^{c,p}$(recall (32)), it is easy to conclude that $v^{c_1} > v^b$ holds for the case $E_1 \leq \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1$ and $E_1 > \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \dfrac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1$. For the case $E_1 > \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1$ and $E_2 \leq \dfrac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1$, $v^{c_1} < v^b$ if and only if $\lambda_2 < 1 - \dfrac{\gamma}{(1-\mu)(\theta+\gamma-\theta\gamma)}$ is satisfied. When $B_1^{c,o} > B_2^{c,p}$(recall (33)), it is easy to conclude that $v^{c_2} > v^b$ holds for the case $E_1 \leq \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1$. For the case $E_1 > \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1$ and $E_2 > \dfrac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2$, $v^{c_2} < v^b$ if and only if $\lambda_2 < 1-\mu+\dfrac{\mu\gamma}{\theta(1-\gamma)}$ is satisfied. For the case $E_1 > \dfrac{\gamma}{\theta+\gamma-\theta\gamma}A_1$ and $E_2 \leq \dfrac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2$, $v^{c_2} < v^b$ if and only if $\lambda_2 < 1 - \dfrac{\gamma}{(1-\mu)(\theta+\gamma-\theta\gamma)}$ is satisfied.

□

Proof of Proposition 7. According to (32) and (33), taking the partial derivatives of v^{c_1} and v^{c_2} with respect to μ yields

$$\frac{\partial v^{c_1}}{\partial \mu} = \begin{cases} \frac{1}{(1+\lambda_2+\lambda_3)(\mu-1)^2(\theta+\gamma-\theta\gamma)} > 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{\gamma}{(1+\lambda_2+\lambda_3)(\mu-1)^2(\theta+\gamma-\theta\gamma)} > 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{1-\gamma}{(1+\lambda_2+\lambda_3)(\mu-1)^2(\theta+\gamma-\theta\gamma)} > 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \end{cases}$$

and

$$\frac{\partial v^{c_2}}{\partial \mu} = \begin{cases} \frac{\gamma+\lambda_2\theta-\lambda_2\theta\gamma}{(1+\lambda_2+\lambda_3)(\mu-1)^2(\gamma+\theta-\gamma\theta)} > 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\gamma}{(1+\lambda_2+\lambda_3)(\mu-1)^2(\gamma+\theta-\gamma\theta)} > 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\lambda_2\theta(1-\gamma)}{(1+\lambda_2+\lambda_3)(\mu-1)^2(\gamma+\theta-\gamma\theta)} > 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \end{cases}$$

Notice that that $\frac{\partial v^{c_1}}{\partial \mu} \geq 0$ and $\frac{\partial v^{c_2}}{\partial \mu} \geq 0$ always hold. This fact indicate that the higher the leverage of the banking system when it encounters a shock, the higher the capital loss rate of the banking system in the Cross-holding model. □

Proof of Proposition 8. Recalling (32) and (33), the partial derivatives of v^{c_1} and v^{c_2} with respect to γ are given as

$$\frac{\partial v^{c_1}}{\partial \gamma} = \begin{cases} \frac{\theta-1}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{\theta}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} > 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{-1}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \end{cases}$$

and

$$\frac{\partial v^{c_2}}{\partial \gamma} = \begin{cases} \frac{\theta(1-\lambda_2)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\theta}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} > 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{-\lambda_2\theta}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \end{cases}$$

respectively. It is obvious that both $\dfrac{\partial v^{c_1}}{\partial \gamma}$ and $\dfrac{\partial v^{c_2}}{\partial \gamma}$ could be negative, zero or positive under different conditions.

Recalling (32) and (33), the partial derivatives of v^{c_1} and v^{c_2} with respect to θ are shown as

$$\frac{\partial v^{c_1}}{\partial \theta} = \begin{cases} \frac{\gamma-1}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{\gamma(\gamma-1)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{-(\gamma-1)^2}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \end{cases}$$

and

$$\frac{\partial v^{c_2}}{\partial \theta} = \begin{cases} \frac{\gamma(\lambda_2-1)(1-\gamma)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{-\gamma(1-\gamma)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} < 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\lambda_2\gamma(1-\gamma)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)^2} > 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \end{cases}$$

respectively.

When $B_1^{c,o} \leq B_2^{c,p}$, $\dfrac{\partial v^{c_1}}{\partial \theta}$ is constantly less than zero, which implies that in the case where the CAS products issued by Bank 1 are purchased in full by Bank 2, the higher degree of cross-holding, the lower the capital loss rate of the banking system. However, in the case $B_1^{c,o} > B_2^{c,p}$, $\dfrac{\partial v^{c_2}}{\partial \theta}$ can be negative, zero or positive under different conditions. □

Proof of Proposition 9. Recalling (32) and (33), the partial derivatives of v^{c_1} and v^{c_2} with respect to λ_2 are given as

$$\frac{\partial v^{c_1}}{\partial \lambda_2} = \begin{cases} \frac{-1}{(1+\lambda_2+\lambda_3)^2(1-\mu)(\theta+\gamma-\theta\gamma)} < 0, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{1}{1+\lambda_2+\lambda_3} + \frac{\lambda_2(\mu-1)(\theta+\gamma-\theta\gamma)-\gamma}{(1+\lambda_2+\lambda_3)^2(1-\mu)(\theta+\gamma-\theta\gamma)}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{\gamma-1-(1-\mu)(\theta+\gamma-\theta\gamma)}{(1+\lambda_2+\lambda_3)^2(1-\mu)(\theta+\gamma-\theta\gamma)} < 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \\ \frac{\lambda_3}{(1+\lambda_2+\lambda_3)^2} > 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{1-\gamma}{\theta+\gamma-\theta\gamma}A_1 \end{cases}$$

and

$$\frac{\partial v^{c_2}}{\partial \lambda_2} = \begin{cases} \frac{\lambda_2\theta(\gamma-1)-\gamma}{(1+\lambda_2+\lambda_3)^2(1-\mu)(\theta+\gamma-\theta\gamma)} + \frac{\theta(1-\gamma)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{1}{1+\lambda_2+\lambda_3} + \frac{\lambda_2(\mu-1)(\theta+\gamma-\theta\gamma)-\gamma}{(1+\lambda_2+\lambda_3)^2(1-\mu)(\theta+\gamma-\theta\gamma)}, & E_1 > \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\theta(1-\gamma)}{(1+\lambda_2+\lambda_3)(1-\mu)(\theta+\gamma-\theta\gamma)} - \frac{(1-\mu)(\theta+\gamma-\theta\gamma)+\lambda_2\theta(1-\gamma)}{(1+\lambda_2+\lambda_3)^2(1-\mu)(\theta+\gamma-\theta\gamma)}, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 > \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \\ \frac{\lambda_3}{(1+\lambda_2+\lambda_3)^2} > 0, & E_1 \leq \frac{\gamma}{\theta+\gamma-\theta\gamma}A_1, E_2 \leq \frac{\theta(1-\gamma)}{\theta+\gamma-\theta\gamma}A_2 \end{cases}$$

respectively. Obviously, both $\frac{\partial v^{c_1}}{\partial \lambda_2}$ and $\frac{\partial v^{c_2}}{\partial \lambda 2}$ could be negative, zero or positive under different conditions.

□

Appendix B

Table B1: **The Sample Countries and Regions as well as Their Corresponding Stock Indices.**

This table presents the sample countries and regions, as well as their corresponding stock indices, which are used to calculate the volatility of their stock markets. To ensure the representativeness of our results, we select worldwide countries from Asia, Europe, America, Oceania, and Africa.

Countries and Regions	Stock Index	Countries and Regions	Stock Index
Argentina	MERV	Korea, Rep.	KS11
Australia	AS51	Malaysia	KLS
Belgium	BFX	Mexico	MXX
Brazil	MSCI Brazil	Netherlands	AEX
Canada	GSPTSE	New Zealand	NZSE.GI
China Mainland	000001.SH	Portugal	PSI
Finland	HEX	Russian Federation	MOEX
France	CAC40	South Africa	MSCI South Africa
Germany	DAX	Spain	IBEX
Greece	ASE	Sweden	OMXSPI
India	SENSEX	Switzerland	SMI
Ireland	ISEQ	United Kingdom	FTSE
Italy	MSCI Italy	United States	S&P500
Japan	TPX		

Table B2: **Description of Variables and Data Sourse.**
This table summarizes the data source of variables and their description. We obtain the data of explanatory variables from the NYUVLab[1], and collect the macro-economic data mainly from World Development Indicators (WDI) and Economist Intelligence Unit (EIU). We use the Chow-in method to convert annual indicators to quarterly frequencies.

Variable Category	**Variable**	**Description**	**Data Source**
Explained Variables	SRISK	Systemic risk measures	V-lab
	LRMES	Long Run Marginal Expected Shortfall	V-lab
Explanatory Variables	MBS	MBS issuance	Bloomberg
	MBS2	Square of MBS	Bloomberg; Author's calculation
	ABS	ABS issuance	Bloomberg
	ABS2	Square of ABS	Bloomberg; Author's calculation
	OTHER	Other collateralized bonds' issuance	Bloomberg
	OTHER2	Square of OTHER	Bloomberg; Author's calculation
Control Variables	SIZE	Bank size	CEIC; National Central Banks
	NPL	Non-performing loan ratio	CEIC; National Central Banks
	LEND	Lending interest rate	EIU
	M1	M1 (% pa)	EIU
	M2	M2 (% pa)	EIU
	FINANCE	Market value of stock market accounts for GDP %	CEIC; Wind; Author's calculation
	VOL	Volatility of stock index in recent one year	Wind; Author's calculation
	GDP	GDP (% real change pa)	EIU
	FIXEDI	Gross fixed investment (%GDP; real change pa)	EIU
	EXCHANGE	Real effective exchange rate (CPI-based)	EIU
	DEFLATOR	GDP deflator (% change; av)	EIU
	CREDIT	Total credit(%GDP)	BIS

[1] https://vlab.stern.nyu.edu/zh

Table B3: **Correlation Coefficient Matrix.**
This table presents the correlation coefficient matrix consisting of all variables. Our two measures of systemic risk, i.e, SRISK and LRMES, have a significantly positive correlation. The correlation coefficients between financial products and systemic risk are also significantly positive.

Variables	SRISK	LRMES	MBS	MBS2	ABS	ABS2	OTHER	OTHER2	SIZE	NPL	LEND	M1	M2	FINANCE	VOL	GDP	FIXEDI	EXCHANGE	DEFLATOR	CREDIT
SRISK	1.000																			
LRMES	0.763***	1.000																		
MBS	0.344***	0.085***	1.000																	
MBS2	0.353***	0.090***	0.997***	1.000																
ABS	0.391***	0.519***	0.099***	0.101***	1.000															
ABS2	0.411***	0.547***	0.112***	0.115***	0.995***	1.000														
OTHER	0.370***	0.353***	0.087***	0.096***	0.227***	0.237***	1.000													
OTHER2	0.419***	0.452***	0.060**	0.069***	0.280***	0.295***	0.985***	1.000												
SIZE	0.415***	0.454***	0.182***	0.199***	0.230***	0.255***	0.435***	0.495***	1.000											
NPL	-0.050**	-0.132***	-0.135***	-0.136***	-0.003	-0.008	-0.087***	-0.098***	-0.172***	1.000										
LEND	-0.211***	-0.137***	-0.087***	-0.091***	0.006	0.004	-0.259***	-0.272***	-0.261***	-0.018	1.000									
M1	-0.130***	-0.088***	-0.037	-0.038	-0.040	-0.043*	-0.112***	-0.128***	-0.210***	-0.059**	0.147***	1.000								
M2	-0.158***	-0.086***	-0.042*	-0.046*	-0.029	-0.030	-0.155***	-0.172***	-0.274***	-0.220***	0.368***	0.643***	1.000							
FINANCE	0.020	0.186***	-0.041*	-0.036	-0.041*	-0.042*	0.060**	0.050**	-0.036	-0.365***	-0.124***	0.049*	0.025	1.000						
VOL	-0.019	-0.113***	-0.082***	-0.082**	-0.036	-0.031	-0.124***	-0.138***	-0.146***	0.212***	0.455***	0.079***	0.212***	-0.214***	1.000					
GDP	-0.052**	0.027	0.027	0.024	0.065**	0.060**	-0.065**	-0.086***	-0.150***	-0.083***	-0.023	0.307***	0.348***	0.117***	-0.290***	1.000				
FIXEDI	-0.079***	-0.019	-0.009	-0.011	0.019	0.012	-0.008	-0.022	-0.087***	-0.028	-0.038	0.208***	0.218***	0.055**	-0.201***	0.514***	1.000			
EXCHANGE	0.014	0.149***	-0.050**	-0.052**	0.203***	0.222***	0.001	0.034	0.308***	-0.076***	0.208***	-0.164***	0.002	-0.239***	0.012	0.057**	0.010	1.000		
DEFLATOR	-0.216***	-0.156***	-0.092***	-0.094***	-0.056**	-0.058**	-0.153***	-0.179***	-0.366***	-0.089***	0.587***	0.415***	0.579***	0.015	0.339***	0.075***	0.060**	-0.265***	1.000	
CREDIT	0.062**	0.058**	0.061**	0.069***	-0.035	-0.030	0.212***	0.235***	0.297***	-0.023	-0.501***	-0.312***	-0.476***	0.081***	-0.357***	-0.054**	0.008	0.092***	-0.543***	1.000

Table B4: **Time-series Regression Results on SRISK: Alternative Estimations.**
This table reports results of regressions whose explained variable is SRISK. In those regressions, control variables are introduced gradually into the regression equation. Without controlling other variables, i.e., in Model (1), the regression coefficients of the primary and quadratic terms of MBS and other collateralized bond are significant. Gradually adding bank-level, macro-level and financial market-level control variables, coefficients of other collateralized bond issuance are insignificant after controlling the leverage of the economy, while the significance of coefficients of both MBS and its secondary term have not changed significantly. ***, **, and * denote significant values at the levels of 1%, 5%, and 10%, respectively.

SRISK	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
MBS	−1.3936***	−1.2631***	−1.2484***	−1.2501***	−1.2544***	−1.2552***	−1.2796***	−1.3240***	−1.3213***	−1.3216***	−1.3206***	−1.3184***	−1.2702***
MBS2	1.6951***	1.5961***	1.5778***	1.5808***	1.5849***	1.5859***	1.6124***	1.6628***	1.6517***	1.6521***	1.6713***	1.6685***	1.6003***
ABS	−0.1421	0.0881	0.0995	0.1115	0.1116	0.1119	0.0883	0.1064	0.1169	0.1173	0.0880	0.0849	0.1100
ABS2	0.1860	−0.0778	−0.0868	−0.1014	−0.1016	−0.1018	−0.0779	−0.0907	−0.1020	−0.1024	−0.0691	−0.0645	−0.0908
OTHER	−0.4743***	−0.2485**	−0.2937***	−0.2932***	−0.2937***	−0.2927***	−0.2048**	−0.1872*	−0.1646	−0.1641	−0.1562	−0.1508	−0.0944
OTHER2	0.5490***	0.2786**	0.3452***	0.3481***	0.3486***	0.3475***	0.2618**	0.2452**	0.2205**	0.2201**	0.2125*	0.2053*	0.1414
SIZE		0.7090***	0.7975***	0.7934***	0.7829***	0.7841***	0.6613***	0.6668***	0.5995***	0.5982***	0.7136***	0.7113***	0.6296***
NPL			0.0947***	0.0934***	0.0936***	0.0943***	0.0711***	0.0737***	0.0788***	0.0787***	0.0816***	0.0787***	0.0620***
LEND				−0.0431	−0.0452*	−0.0455*	−0.1226***	−0.1402***	−0.1527***	−0.1530***	−0.1502***	−0.1243***	−0.1217***
M1					−0.0079	−0.0089	−0.0181	−0.0170	−0.0131	−0.0131	−0.0176	−0.0164	−0.0111
M2						0.0023	−0.0078	0.0018	0.0159	0.0160	0.0244	0.0283	0.0354**
FINANCE							−0.3411***	−0.2729***	−0.2507***	−0.2509***	−0.2770***	−0.2826***	−0.2823***
VOL								0.0845***	0.0532	0.0531	0.0491	0.0478	0.0432
GDP									−0.0699***	−0.0692***	−0.0662***	−0.0647***	−0.0636***
FIXEDI										−0.0016	0.001	0.002	0.0017
EXCHANGE											−0.0848***	−0.0846***	−0.0710***
DEFLATOR												−0.0364	−0.0324
CREDIT													0.1913*
C	−0.2011*	−0.1164	−0.0802	−0.0785	−0.0792	−0.0798	−0.1078**	−0.1334***	−0.1275***	−0.1278***	−0.0963**	−0.0988**	−0.0830**
N	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	16.1859	60.9899	108.5927	96.9990	108.5109	109.2283	376.1118	325.1969	470.3791	456.9378	492.3339	379.3078	508.9313
R^2	0.2075	0.2642	0.2775	0.2789	0.2791	0.2791	0.3256	0.3406	0.3498	0.3498	0.3565	0.3574	0.3647

Table B5: **Time-series Regression Results on LRMES: Alternative Estimations.**

This table reports results of regressions whose explained variable is LRMES. In those regressions, control variables are introduced gradually into the regression equation. Without controlling other variables, i.e., in Model (1), the regression coefficients of the primary and quadratic terms of core explanatory variables are significant. Gradually adding bank-level, macro-level and financial market-level control variables, coefficients of other collateralized bond issuance are insignificant after controlling the leverage of the economy, while the significance of coefficients of both MBS and its secondary term have not changed significantly. ***, **, and * denote significant values at the levels of 1%, 5%, and 10%, respectively.

LRMES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
MBS	−0.4629***	−0.3892***	−0.3880***	−0.3884***	−0.3898***	−0.3911***	−0.3942***	−0.3928***	−0.3921***	−0.3908***	−0.3911***	−0.3905***	−0.3664***
MBS2	0.5489***	0.4930***	0.4915***	0.4921***	0.4934***	0.4952***	0.4985***	0.4969***	0.4941***	0.4925***	0.4880***	0.4873***	0.4532***
ABS	−0.2493***	−0.1194**	−0.1185**	−0.1162**	−0.1162**	−0.1157**	−0.1187**	−0.1193**	−0.1166**	−0.1183**	−0.1114**	−0.1122**	−0.0997**
ABS2	0.2943***	0.1453**	0.1446**	0.1419**	0.1418**	0.1414**	0.1444**	0.1448**	0.1420**	0.1435**	0.1357**	0.1369**	0.1237**
OTHER	−0.1441***	−0.0166	−0.0202	−0.0201	−0.0202	−0.0184	−0.0074	−0.0079	−0.0023	−0.0041	−0.0060	−0.0046	0.0235
OTHER2	0.1617***	0.0090	0.0143	0.0148	0.0150	0.0130	0.0022	0.0028	−0.0034	−0.0018	0.0000	−0.0018	−0.0338
SIZE		0.4003***	0.4073***	0.4066***	0.4032***	0.4055***	0.3901***	0.3900***	0.3731***	0.3787***	0.3517***	0.3511***	0.3103***
NPL			0.0075	0.0073	0.0073	0.0086	0.0057	0.0056	0.0069	0.0076	0.0069	0.0061	−0.0022
LEND				−0.0079	−0.0086	−0.0091	−0.0188**	−0.0182*	−0.0214**	−0.0202*	−0.0208*	−0.0142	−0.0130
M1					−0.0025	−0.0044	−0.0056	−0.0056	−0.0046	−0.0046	−0.0036	−0.0033	−0.0007
M2						0.0042	0.0030	0.0027	0.0062	0.0054	0.0035	0.0045	0.0081*
FINANCE							−0.0427***	−0.0449***	−0.0393***	−0.0386***	−0.0325*	−0.0339**	−0.0338*
VOL								−0.0027	−0.0105	−0.0099	−0.009	−0.0093	−0.0116
GDP									−0.0175**	−0.0208**	−0.0215**	−0.0211***	−0.0206***
FIXEDI										0.0071	0.0065	0.0068	0.0066
EXCHANGE											0.0198	0.0199	0.0267*
DEFLATOR												−0.0093	−0.0073
CREDIT													0.0956***
C	−0.0479	−0.0002	0.0027	0.0030	0.0028	0.0017	−0.0018	−0.0010	0.0005	0.0017	−0.0057	−0.0063	0.0016
N	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539	1,539
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	6.0380	17.9057	34.0892	35.7358	33.7750	90.8400	71.8128	111.2535	99.9364	97.9967	115.7992	100.4765	60.8523
R^2	0.2536	0.4145	0.4152	0.4157	0.4158	0.4161	0.4226	0.4227	0.4278	0.4292	0.4325	0.4330	0.4492