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ORIGINAL RESEARCH

Securitization and risk appetite: empirical evidence from US banks

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Abstract
I investigate the impact of securitization on the risk-taking by bank holding companies (BHCs). For 2001 to 2017, I find a negative relationship between securitization and the risk appetite of BHCs. I find a negative relationship between securitization and the risk appetite of BHCs that is consistent with the recourse hypothesis of securitization. I also discover that the equilibrium in this relationship changes from the pre-crisis to the crisis period (*crisis effect*). This crisis effect hampers BHCs' ability to engage in securitization that leads them to accumulate more risky assets on their books due to the deteriorated quality of their loan portfolios. This equilibrium then reverses after the crisis (*post-crisis effect*) due to policy makers' response to the excessive risk-taking that manifested during the crisis. Moreover, I find that the securitization of residential mortgages not only boosts the recourse hypothesis but also triggers the crisis effect. My findings provide novel empirical insights into the different nexuses between the securitization and risk appetite of BHCs around the financial crisis.

Keywords Securitization · Bank · Credit risk · Mortgage · Risk appetite · Financial crisis

JEL Classification G01 · G21 · G28

1 Introduction

In the 1970s, Fannie Mae and Freddie Mac began securitizing the mortgages they had purchased into mortgage-backed securities (MBS), which contributed to the growth of the secondary market for mortgages, partly motivated by an increased tendency to securitize loans that began in late 70s and 80s due to the maturity mismatch of mortgages and deposits (FDIC Quarterly 2019). Historically, lenders (banks and non-banking organizations) used deposits to fund loans that they held on their balance sheets until maturity. Over

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time, however, lenders began expanding their sources of funds by securitizing loans that led them to replace the traditional originate-to-hold model of lending with the so-called originate-to-distribute model according to which lenders originate loans and sell them to nonbanks that package the loans and issue asset-backed securities (ABS) in the market. Indeed, while originating institutions had entirely borne credit risk under the originate-to-hold model, under the originate-to-distribute model, banks could now securitize their loans and transfer credit risk to third-party investors in the market. Despite the well-recognized benefits that are associated with securitization, the concern of policy makers is the potential moral hazard that could arise from it. The reason is that securitization could encourage banks to lower their lending standards in the belief that there is a constant opportunity to securitize and sell their worst securities to third-party investors in the market. This distorted behavior represents a concern for policy makers as inadequate screening and monitoring could ultimately lead to banks taking on excessive risk that leads to fragility in the banking sector.

Specifically, securitization had arguably contributed to the increased risk appetite of financial institutions in the run-up to the financial crisis (Filomeni 2011; Casu et al. 2022; Goenner 2024). However, contractual arrangements and reputational concerns can mitigate such moral hazard. Specifically, there are two forces at play in this context. The first force would push banks to lower their lending standards and increase bank risk-taking, relying on the belief to be capable of securitizing bad loans and sell the latter to third-party investors in the market. The second force, represented by contractual arrangements related to the securitization transaction and possible negative reputational kickbacks in the market, would mitigate this distorted behavior and the related moral hazard, in a context where retained risk or implicit guarantees might act as a disciplinary device to align incentives between originators and third-party investors.[1] This would therefore keep banks within the ringfencing of their own securitization deals and, in some ways, hold them accountable for the success of the transaction. The empirical question tested in this paper lies precisely in the investigation of what of those forces dominates, which is the motivation of this study.

Since securitization provides banks with an additional source of loan financing and liquidity with the transfer of credit risk to the market, it might motivate them to shift their portfolios towards higher risk/return assets (Cebenoyan and Strahan 2004; Purnanandam 2011). However, the extant empirical evidence has shown that, in securitization, risk often remains substantially with the originator due to both implicit moral obligations to final investors in the form of reputational risk and explicit substantial contractual obligations that arise with the transaction. Indeed, typically issuing banks retain first-loss contractual interests and/or provide implicit recourse in securitizations. While the former requires any securitizer to retain an economic interest in a portion of the credit risk for any asset that the securitizer, through the issuance of asset-backed securities, transfers, sells, or conveys to a third party in a securitization transaction, the latter arises from an institution providing post-sale, non-contractual support to either improve the credit quality or cash flow in a securitization series. Indeed, despite the provision of implicit recourse violates the 'true sale' condition, it allows issuers to maintain their reputation for consistent credit quality over repeated transactions. These arrangements mean that the risks inherent in the securitized assets have not been transferred to investors and are, in effect, still held by the issuing bank, but off-balance sheet (Casu et al. 2011; Calomiris and Mason 2004; Chen et al. 2008; Higgins and Mason 2004; Niu and Richardson 2006; Vermilyea et al. 2008).

[1] This disciplinary effect may not occur in the unlikely case of securitizations carried out without any forms of recourse.

According to the current literature, such evidence is consistent with the 'recourse hypothesis' according to which the recourse commonly provided in securitization might affect the risk-taking appetite of the issuing bank. Therefore, understanding the nexus between securitization and risk-taking becomes even more relevant for policy makers. To this end, I investigate the effect of securitization on the risk appetite of banks by focusing on a sample of 170 US bank holding companies (BHCs) during the period from 2001 to 2017. First, I investigate whether securitization affects bank risk-taking by focusing on the entire sample period. Second, I divide the sample period into two transitional periods where the latter refer to periods in which things are changing from one state to another, i.e., to the time between two distinct periods. Based on the sample period, the first transitional period refers to the period characterizing the run-up to the 2007–2009 financial crisis period that ends with the occurrence of the crisis, i.e., from 2001q2 to 2009q2, whereas the second transitional period refers to the crisis period that terminates when the financial crisis is over, i.e., from 2007q3 to 2017q4. Specifically, I first investigate whether there is a switch in the equilibrium in the relationship between securitization and risk-taking from the pre-crisis to the crisis period. I define this switch as the *crisis effect* that pushed BHCs to increase their risk-taking in the years of the crisis. Then, I focus on the transition from the crisis to the post-crisis to explore whether a *post-crisis effect* exists that reverses the *crisis effect*. This result occurs because of the policy makers' action to correct the risk-taking that manifested during the crisis. This therefore results in two transitional periods being investigated in the context of this paper. Furthermore, I disaggregate bank securitization activity into its underlying asset classes to test the effect of securitization breakdown by asset type on bank risk-taking.

My paper is close to that of Casu et al. (2011) who investigate the effect of securitization on the risk-taking of US BHCs from 2001 to 2007. However, I offer a novel contribution to the literature by examining this same relationship over a longer sample period and by investigating the effect of both the financial crisis, *crisis effect*, and attention by policy makers, *post-crisis effect*, on that relationship.

My results confirm that securitization has an active and negative effect on the risk-taking of BHCs. Indeed, I find that BHCs with a high outstanding balance of securitized assets choose to invest in less risky assets. This finding is supportive of the recourse hypothesis of securitization under which risk remains substantially with the originating bank through the presence of explicit or implicit arrangements arising with the transaction. Next, my results provide novel evidence on the existence of a *crisis effect* that arises from a switch in equilibrium in the relationship between securitization and risk-taking from the pre-crisis to the crisis period. This *crisis effect* hampers BHCs' ability to engage in securitization that leads them to accumulate more risky assets on their books due to the deteriorated quality of their loan portfolios. As such, the *crisis effect* paves the way for the snowballing of a more desirable off-crisis equilibrium into a worse in-crisis one that caused the financial crisis to occur. Then, I show that the *post-crisis effect* results in the aftermath of the financial crisis as the policy makers' response to the excessive risk-taking that manifested during the crisis reverses the *crisis effect*. Thus, the *post-crisis effect* brings back confidence in securitization in the eyes of market participants that ultimately re-establishes a more disciplinary framework and a more prudential attitude of BHCs towards securitization. When breaking down securitization by asset type, I also find that the securitization of family residential mortgage loans not only boosts the recourse hypothesis but also triggers the *crisis effect*.

To the best of my knowledge, there are no empirical studies that have explored the different equilibria that characterize the nexuses between securitization and risk-taking of BHCs during crisis and non-crisis periods. On the one hand, my findings are consistent

with the recourse hypothesis of securitization theoretically made by Gorton and Pennacchi (1995) and empirically demonstrated by Casu et al. (2011). Such evidence indicates that having 'skin in the game' during the securitization transaction in the form of either retained risk or implicit guarantees may act as a disciplinary device to align incentives between originators and third-party investors in the market. Therefore, the recourse hypothesis could explain why market participants buy loans. Gorton and Pennacchi (1995) support this argument by stating that 'banks will not conduct credit risk analysis or monitor borrowers if they are not at risk for failing to perform these services'. On the other hand, my results on the *crisis effect* support the evidence in Gorton and Pennacchi (1995) that banks use securitization in an aggressive way because of moral hazard problems, and this use leads to increased risk-taking should problems emerge related to the securitized loans.

The remainder of this paper is organized as follows. In Sect. 2, I provide an overview of the related literature and develop my testable hypotheses. In Sect. 3, I describe the data. In Sect. 4, I explain the estimated models and the variables used. In Sect. 5, I discuss my findings. In Sect. 6, I perform several robustness tests, while in Sect. 7, I conclude.

2 Related literature and hypothesis development

2.1 The recourse hypothesis: theoretical, empirical, and institutional evidence

The recent empirical work has doubted the occurrence of an effective risk transfer due to the recourse commonly provided in securitization transactions that supports the recourse hypothesis. The theoretical foundation of the recourse hypothesis was anticipated by Gorton and Pennacchi (1995) who show that retained risk or implicit guarantees might act as a disciplinary device to align incentives between originators and third-party investors. Furthermore, recourse should keep BHCs within the ringfencing of their own securitization deals and, in some ways, hold them accountable for the success of the transaction, whether recourse is explicit or implicit. Therefore, under the assumption that BHCs understand that, by providing recourse, they only seemingly transfer credit risk, then the idea that the credit risk exposure that stems from the securitized pool of assets should influence the risk-taking of BHCs in some ways is reasonable. Studies that test the recourse hypothesis in securitization rely on this assumption. My paper falls within this group of studies and provides evidence that BHCs with high outstanding securitized balances choose to invest in less risky assets as they are aware of being directly accountable should problems emerge in relation to the securitization transaction. Indeed, in a context where banks securitize their risky assets but retain exposure to those assets through contractual (i.e., explicit) and/or non-contractual (i.e., implicit) arrangements, I investigate whether the outstanding securitization, representing this exposure, affects the credit risk-taking behavior of the banks. My overall findings are indeed supportive of the recourse hypothesis.

Among the empirical studies that support the recourse hypothesis, Benveniste and Berger (1987) find that banks that partake in securitization with recourse experience a decrease in their risk and an improvement in the loan selection process that, in turn, reduces moral hazard.[2] Securitization with recourse also induces banks to retain a higher portion of

[2] The moral hazard effect of securitization on lenders' screening efforts is also investigated by a growing literature that exploits cutoff rules for credit scores (Keys et al. 2009; Keys et al. 2010; Keys et al. 2012; Bubb and Kaufman 2014; Krainer and Laderman 2014; Jiang et al. 2014; Rajan et al. 2015).

the underlying securitized assets that reduces their incentives to take on additional risks. In this regard, Gorton and Pennacchi (1995) show that when the issuing bank maintains a portion (typically the most risky one) of the underlying securitized assets, outside investors are more willing to purchase the loan due to the 'signalling effect' provided by the originator in the securitization market.[3] However, Fender and Mitchell (2009) find that, to align the incentives between originators and investors, the retention of the equity (most risky) tranche does not always represent the most effective mechanism. Moreover, increased tranching worsens agency frictions by increasing coordination costs among investors and impeding their monitoring of the agent (Korgaonkar 2023). Chen et al. (2008) investigate risk retention in the context of different characteristics of banks' loan securitizations. Calomiris and Mason (2004) provide evidence that credit card securitization results in risk that remains with the originating bank as a result of implicit recourse that could be exploited by banks to avoid minimum capital requirements. Vermilyea et al. (2008) also test a model of implicit recourse in portfolios with credit card securitizations. Casu et al. (2011) focus on the period from 2001 to 2007 and find that banks that participate in securitization transactions choose asset portfolios with less credit risk.

Overall, these empirical studies concur that when banks make loans with some form of contractual agreement, be it implicit or explicit, the assumption that the originating bank converts to asset portfolios with lower credit risk rather than taking on additional risks is reasonable.

The discussion of the recourse hypothesis can be summarized in my first hypothesis (*H1*) being tested, which is related to the effect of securitization on the risk-taking of BHCs:

H1. If the recourse hypothesis holds true, securitization negatively and significantly affects the risk-taking by BHCs.

Confirmatory evidence of the recourse hypothesis is also provided by the institutional space that shows that the occurrence of a true sale rarely materializes in practice that keeps originators directly accountable of their securitization transactions. Specifically, such institutional evidence highlights several cases in which a true sale might be deemed ineffective, as detailed below.

First, the reputational concerns of the originator in the market may invalidate the occurrence of a true sale. For instance, during the crisis Citigroup Inc. moved more than $55 billion in dubious assets back on to its balance sheet as a signal of being directly accountable, should problems emerge related to the given securitization deal. This signal had the objective of maintaining a good reputation in the market that could ultimately lead to repeated securitization transactions.

Second, the bankruptcy court may view the securitization transaction as a secured loan instead of a true sale. In such a case, the assets will become part of the originator's bankruptcy estate, and the court will treat the special purpose vehicle as a secured creditor. This treatment, in turn, would lead the bankruptcy court to substantively consolidate the assets and liabilities of the originator with those of the special purpose vehicle in much the same way that a court may pierce the corporate veil when a company acts as the alter ego of another (Committee on Bankruptcy and Corporate Reorganization of The Association of the Bar of the City of New York 1995; Cohn 1998).

[3] This 'signalling effect' provides investors with reassurance about the securitization transaction due to originators generally having an information advantage about the underlying securitized pool of assets.

Third, there is the lawsuit route in which the buyers of securities could argue that they were sold lemons. For instance, Citigroup Inc. agreed to pay $7 billion to resolve claims related to the fact that it misled investors about shoddy mortgage-backed securities in the run-up to the financial crisis. This payout was the largest civil fraud penalty ever levied by the US Justice Department. While Citigroup Inc. acknowledged it was aware that 'significant percentages' of sample loans did not comply with underwriting guidelines, the bank pooled them into securities anyway. The same destiny occurred for Bank of America Corp. that negotiated with the US Justice Department over similar claims. Overall, these cases corroborate the idea that the securities were marketed as safe, even though the BHCs knew they were destined to collapse; these sales not only fuelled the 2007–2009 financial crisis but also kept BHCs accountable of their own securitization deals.

2.2 The effects of the financial crisis: crisis and post-crisis

Early theoretical studies argue that securitization provides a means of reducing bank risk through the effective transfer of credit risk, that is, a 'true sale' (Greenbaum and Thakor 1987; Pavel and Phillis 1987; Hess and Smith 1988).[4] Therefore, if a bank knows that it can effectively transfer and ringfence credit risk through a true sale, then the incentive to shift towards more risky assets could be appealing due to the bank's possibility to constantly engage in securitization after loan origination. However, this economic mechanism, although attractive in the short run, appears unsustainable in the long term as it relies on the assumption of constant liquidity in the securitization market in which originators are always capable of transferring credit risk by offloading loans to third parties. As a matter of fact, when problems related to securitized loans began to emerge at the onset of the financial crisis, the sudden freeze of the securitization market drastically undermined originators' ability to sell their loans to investors. Thus, the freeze ultimately led to increased risks being concentrated in the banking system rather than passed on to investors (Sarkisyan and Casu 2013). Moreover, the onset of the financial crisis ignited the spark that caused the securitization market to suddenly freeze and left originators with large quantities of relatively inferior loans on their books that they were incapable of securitizing. My specific findings on the *crisis effect* are supportive of this scenario. I conjecture that this *crisis effect* hampers BHCs' ability to engage in securitization that leads them to accumulate more risky assets on their books due to the deteriorated quality of their loan portfolios. Specifically, my investigation of the *crisis effect* materializes in my second hypothesis (*H2*), formulated as follows:

> *H2. The crisis effect significantly moderates the relationship between securitization and the risk-taking by BHCs in the transition from the pre-crisis to the crisis period.*

However, in response to the deficiencies revealed during the recent financial crisis that had hampered the continued growth and efficiency of the securitised market (Filomeni 2011), the Federal Reserve (and in general policy makers) implemented a number of programs designed to support the liquidity of financial institutions and foster improved conditions in financial markets (Federal Reserve 2009). Policy makers' action to correct the

[4] Essentially, a 'true sale' occurs when the originator has completely relinquished any legal or equitable rights with regard to the assets sold. Therefore, the assets will not become a part of the originator's bankruptcy estate should the originator become the subject of a bankruptcy proceeding.

Fig. 1 Residential mortgage originations in the United States over the period 2002–2018. Note: Values expressed in USD billions

risk-taking that manifested during the crisis possibly caused the *crisis effect* to reverse after the financial crisis, giving rise to the *post-crisis effect* in the aftermath of the financial crisis. Specifically, I now investigate whether the policy makers' actions towards risk-taking indeed brings back confidence in securitization in the eyes of market participants, ultimately re-establishing a more disciplinary securitization framework and a more prudential attitude of BHCs towards securitization. I therefore test for the *post-crisis effect* due to policy makers' attention in my third hypothesis (*H3*), formulated as follows:

> *H3. The post-crisis effect significantly moderates the relationship between securitization and the risk-taking by BHCs in the transition from the crisis to the post-crisis period.*

2.3 Residential mortgages: the run-up to the financial crisis

The motivation behind the role of residential family mortgages in triggering the *crisis effect* has its roots on both theoretical and institutional evidence. Overall, such evidence highlights that in the 2002–2007 pre-crisis period, home prices rose rapidly. In this context, the share of residential mortgage originations sold into private-label securitizations grew rapidly, fuelled by investor demand. This situation ultimately ended with the crash and financial panic of 2007 that then caused the private securitization market to dry up (FCIC 2011; Buchak et al. 2018). Undeniably, the magnitude of the share of residential mortgages for the US economy was apparent in the run-up to the financial crisis, as they contributed to the largest amount of real estate loans for US BHCs.[5]

[5] Residential mortgages accounted for 30% and 70.9% of the real estate loans of US institutions and US mortgage lenders as of December 2004, respectively. Such an incidence looks even more pronounced when considering that, as of December 2004, residential family mortgages accounted for 17.62% of US commercial banks' total assets out of a total impact of real estate loans on US commercial banks' total assets of 31.2% (Koch and MacDonald 2015).

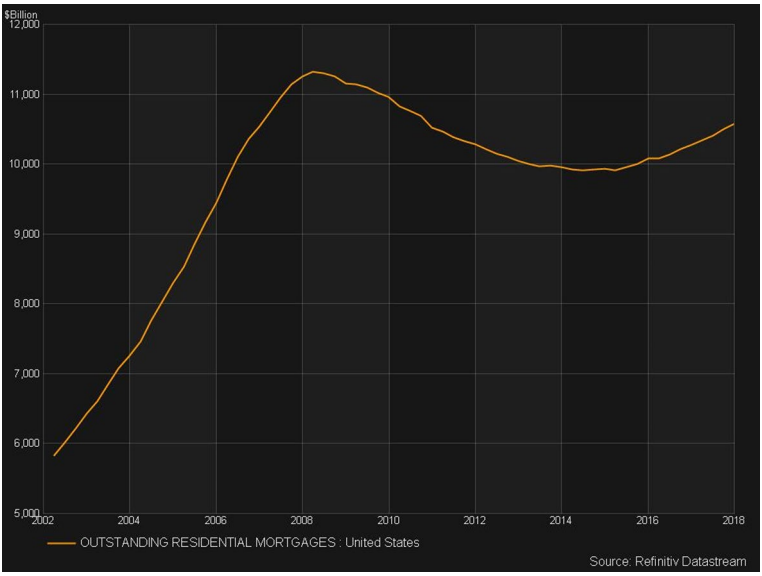

Fig. 2 Outstanding residential mortgages in the United States over the period 2002–2018. Note: Values expressed in USD billions

However, this boom in mortgage origination was then followed by a rapid contraction with large shifts in the composition of the mortgage market in the US. Graphical evidence of this contraction is shown in Fig. 1 that displays the evolution of residential mortgage originations over the period from 2002 to 2018 and in Fig. 2 that depicts the volume of outstanding residential mortgages over the period from 2002 to 2018.

Moreover, the period from 2002 to 2007 was particularly notable as the mortgage market changed quickly with an increase in the importance of subprime lending and a rapid decline in loan quality that led to a drastic increase in delinquencies of residential mortgages from 2007 onwards (Piskorski et al. 2010).[6] Figure 3 provides graphical evidence of this trend by showing the delinquency rate of residential mortgages in the US over the period from 2002 to 2018.

Within this context, the US home mortgage market underwent a dramatic transformation beginning with the development of mortgage-backed securities and the shadow banking system. Shadow banks and traditional banks differ dramatically in mortgage financing. While traditional banks continue to hold between 30 and 50% of their originated loans on their balance sheets, shadow banks finance their originations almost entirely through securitization and the originate-to-distribute model (Buchak et al. 2018). Many papers have studied the structure of the chain for mortgage origination by paying particular attention to the originate-to-distribute model and the costs and benefits thereof (e.g., Berndt and Gupta 2009; Keys et al. 2010, 2013; Piskorski et al. 2010; Purnanandam 2011; Buchak et al.

[6] Lenders that reach aggressively for growth use less stringent lending practices and underwriting standards that cause a rapid rise in risk. These lenders increasingly offer loans with limited or no documentation of the consumer's income or assets, negative amortization, interest-only payments, and adjustable rates with low initial monthly payments and subsequent payment resets (Urban Institute 2019).

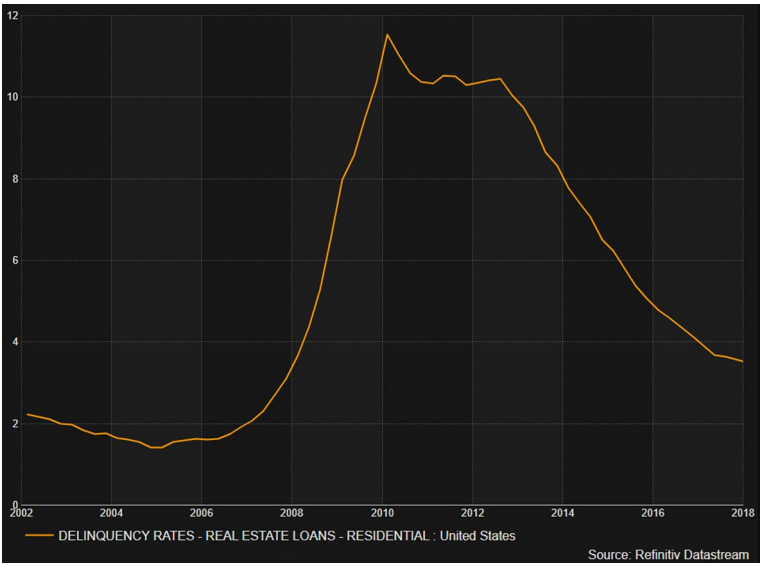

Fig. 3 Delinquency rate on residential mortgages in the United States over the period 2002–2018

2018). These studies concur that banks with aggressive involvement in the originate-to-distribute market had lower screening incentives that, in turn, resulted in the origination of loans with excessively poor soft information by those banks. Indeed, banks make lending decisions based on a number of borrower characteristics. While some of these characteristics are easy to credibly communicate to third parties, there are soft pieces of information that cannot be easily verified by parties other than the originating institution itself (Stein 2002; Berndt and Gupta 2009; Purnanandam 2011; Bose et al. 2021; Filomeni et al. 2020, 2021; Filomeni et al. 2023a, 2023b). As the originating institution sheds the credit risk, and as the distance between the originator and the ultimate holder of risk increases, loan officers' ex ante incentives to collect soft information decrease (Rajan et al. 2015).

As long as the secondary market for mortgages was functioning normally, originating institutions were able to easily offload these loans to third parties.[7] However, when the secondary mortgage market came under pressure in the middle of 2007, banks with higher volumes of originate-to-distribute loans were stuck with large quantities of relatively inferior mortgage loans (Allen and Carletti 2010; Purnanandam 2011; Kim et al. 2018).[8] Moreover, the latter could not be offloaded to third parties when the MBS market froze in mid-2007.[9] Graphical evidence of this trend is provided in panels (a) and (b) of Fig. 4. The figure shows

[7] The mortgage market was functioning normally until the first quarter of 2007. In March 2007, several subprime mortgage lenders filed for bankruptcy that provided some early signals of the oncoming mortgage crisis. The sign of stress in this market became visibly clear by the middle of 2007 (Greenlaw et al. 2008).

[8] It can take about two to three quarters from the origination to the sale of these loans in the secondary market (Gordon and D'Silva 2008). In addition, the originators typically guarantee the loan performance for the first 90 days (Mishkin 2008).

[9] By reassessing risks previously overlooked, investors withdrew from the markets and liquidity dried up (Allen and Carletti 2010).

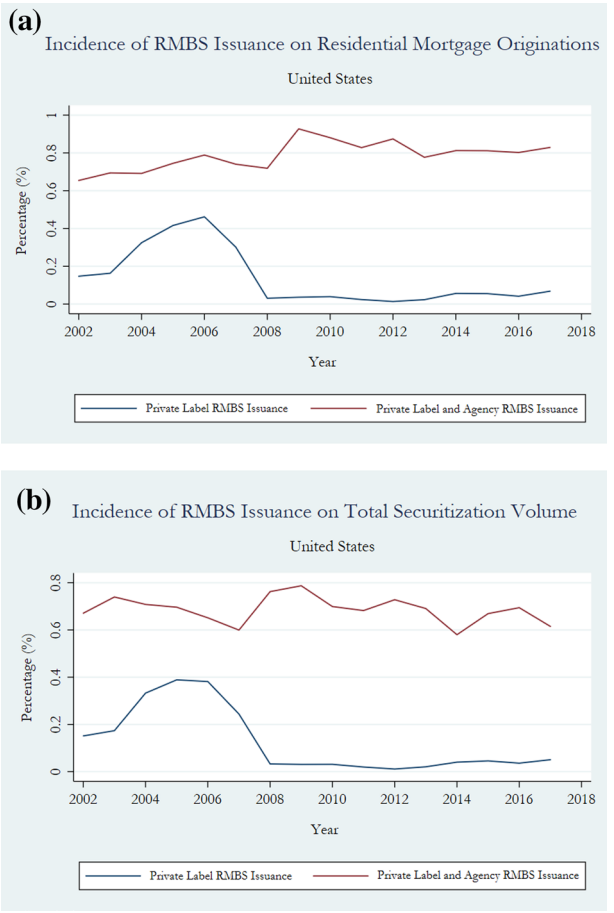

Fig. 4 **a** Incidence of securitized originated residential mortgages out of residential mortgage originations in the United States over the period from 2002–2017. Note: Author's own elaborations based on data collected from the MBA and SIFMA. **b** Incidence of securitized originated residential mortgages out of total securitization volume in the United States over the period from 2002 to 2017. Note: Author's own elaborations based on data collected from the MBA and SIFMA

the incidence of securitized originated residential mortgages out of both the total residential mortgage originations and total securitization volume in the US over the period from 2002 to 2017.

Further evidence is provided by Demyanyk and Loutskina (2016) who show that when the secondary mortgage market came under pressure in 2007, banks were stuck with large quantities of inferior loans they previously originated to securitize. This situation, in turn, led to significant amounts of originated-to-distribute loans rapidly deteriorating while accumulating on lenders' balance sheets. My discussion of residential mortgages in boosting the recourse hypothesis and triggering the *crisis effect* can be summarized in my fourth and last hypothesis (*H4*), formulated as follows:

> *H4. Given that the recourse hypothesis holds true, it is precisely the securitization of residential mortgages that (i) boosts the recourse hypothesis and (ii) triggers the crisis effect.*

3 Data

To study the effect of securitization on the risk-taking by BHCs, I exploit an expanded version of the database used by Casu et al. (2011). My database comprises data on individual US BHCs collected from the Y-9C forms of the Federal Reserve Bank of Chicago that are published on a quarterly basis for the supervision and regulation of the US banking industry.[10] Following Casu et al. (2011), I use data for BHCs rather than those for commercial banks because risk and capital management are typically managed at the highest level of the banking group. Additionally, securitization may involve several subsidiaries of a BHC that can affect the capital and liquidity planning for the whole group (Aggarwal and Jacques 2001). Specifically, each FR Y-9C form collects basic financial information from financial institutions on a consolidated basis in the form of balance sheets, income statements, and detailed supporting schedules, as well as a schedule that comprises off-balance sheet activities. Further, the FR Y-9C form contains more schedules than any of the FR Y-9 series of reports and is the most widely requested and reviewed report at the BHC level. With this data, I have a final panel dataset that comprises 170 BHCs for a total of 11,390 bank/quarter observations for the sample period from June 2001 to December 2017.

The starting date of the dataset reflects the fact that, since June 2001, the Fed has introduced changes to regulatory forms and has required US BHCs to add an HC-S schedule to each Y-9C form that not only reports the aggregate securitization volume but also gives a breakdown of securitization into several categories according to the underlying asset type, thus allowing to also test whether the effect differs across securitizations of different asset classes: (i) 1–4 family residential mortgage loans, (ii) home equity lines of credit, (iii) credit card receivables, (iv) auto loans, (v) other consumer loans, and (vi) commercial and industrial loans.

Among collected FR Y-9C data, the main covariate of interest is represented by bank securitization. Specifically, US BHCs report the principal balance outstanding on a quarterly basis for the loans, leases, and other assets that they have sold and securitized with recourse while (i) retaining the right to service those assets or (ii) when servicing has not been retained, retaining recourse or providing other seller-provided credit enhancements to the securitization structure.[11] While servicing responsibilities reflect the originator's continuing involvement in the transferred assets, recourse or other seller-provided credit enhancement reflect an arrangement in which the reporting bank retains, in form or in substance, any risk of credit loss directly or indirectly associated with a transferred (sold) asset that exceeds its pro rata claim on the asset. In this paper, the focus is therefore on securitizations carried out with recourse attached to them. Consistent with Casu et al. (2011), my findings are indeed supportive of the recourse hypothesis according to which BHCs with high outstanding balances of assets originated and securitized with some forms of recourse choose to invest in less risky assets as they are aware of being directly accountable (due to

[10] A detailed list of the Y-9C forms' data item and construction is provided in Table 11 reported in the Appendix to this paper.

[11] US BHCs report, in their FR Y-9C forms, the principal balance outstanding on a quarterly basis for the loans, leases, and other assets that they have sold and securitized with recourse, without specifically disentangling those securitized assets with servicing retained from those without servicing retained but with recourse or other seller-provided credit enhancements. Nonetheless, my empirical analysis remains unaffected as I investigate whether the originator's continuing involvement in the securitized assets might affect their risk-taking appetite.

retained risk or implicit guarantees) should problems emerge in relation to the securitization transaction.

Regarding the dependent variable, I measure the risk-taking by BHCs by using the ratio of risk-weighted assets to total assets (*RWATA*) as in Filomeni (2023), Aggarwal and Jacques (2001), Avery and Berger (1991), Berger and Udell (1994), Berger (1995), Casu et al. (2011), and Shrieves and Dahl (1992). This measure captures the allocation of assets across different risk categories and the quality of a bank's loan portfolio (Shrieves and Dahl 1992). It supports the idea that the relative weights used in the framework of the risk-based capital standards correlate with the risky behaviour of BHCs and have adequate informational value in predicting their future failures and portfolio losses (Avery and Berger 1991).

To avoid the effect of outliers driving the results (Barnett and Lewis 1994), data are winsorized at the 2.5% level.[12] The description of the collected variables as well as their descriptive statistics are presented in Table 1.

4 Estimated models

4.1 Testing the recourse hypothesis

I first investigate the effect of securitization on the risk-taking by US BHCs by focusing on the entire sample period. Specifically, I test the recourse hypothesis according to which securitization activity affects risk-taking by assuming that BHCs properly assess the recourse risk of securitization.

In my model specification, risk-taking is expressed as the first difference of the ratio of the risk-weighted assets over total assets of BHCs between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). Securitization is computed as the ratio of the BHC's outstanding balance of securitized assets scaled by total assets and expressed in the previous quarter $t-1$ ($TSATA_{t-1}$). The descriptive statistics show that the average $\Delta RWATA_t$ is negative at -0.38% for BHCs with greater securitization and is positive at $+0.10\%$ for those with low securitization volumes. Such descriptive evidence illustrates the negative relationship between securitization and risk-taking proved by my main empirical results.

My baseline model of the recourse hypothesis takes the following form:

$$\begin{aligned}\Delta RWATA_{i,t} = \alpha + \beta_1 TSATA_{i,t-1} + \beta_2 SIZE_{i,t-1} + \beta_3 TLTD_{i,t-1} + \beta_4 T1RBCR_{i,t-1} \\ + \beta_5 ROA_{i,t-1} + \beta_6 PLLTA_{i,t-1} + \delta D_{quarter_t} + \varepsilon_{i,t}\end{aligned} \tag{1}$$

where the control variables $SIZE_{i,t-1}$, $TLTD_{i,t-1}$, $T1RBCR_{i,t-1}$, $ROA_{i,t-1}$, and $PLLTA_{i,t-1}$ represent specific characteristics of bank i in the previous quarter $t-1$; $D_{quarter_t}$ are quarterly

[12] Given that it is often not encouraged to reject outliers, especially when there is no tangible explanation about the occurrence of outliers as in the context of this paper, one remedy suggested by the related literature is to lower the impact of the outlying observations by implementing winsorization (Dixon and Tukey 1969; Dixon and Yuen 1974). Winsorization is a popular accommodation method to reduce the weights of outliers by replacing them with a specific percentile of data-dependent values (Dixon and Yuen 1974; Orr et al. 1991). The percentile of winsorization is suggested to be adjusted according to the shape of the distribution (Dixon and Yuen 1974; Tukey 1962). Therefore, to minimize such influence, data are winsorized at the 2.5% level, i.e., 2.5% in each tail, following a focused visual inspection of the distribution of my sample values in order to minimize the disproportionate influence of outliers on statistical analyses that might lead to distortions in the statistical significance tests.

Table 1 Variable definition and descriptive statistics

Variable	Description	Obs	Mean	Std. Dev	Min	Max
BHC risk						
RWATA	Risk-weighted assets/total assets	8790	0. 7402689	0. 1245793	0. 4358502	1
ΔRWATA	First difference of RWATA	8591	0.0003175	0. 0273237	− 0. 0809948	0. 0825239
Securitization						
TSATA	Total securitized assets/total assets	8692	0. 0377444	0. 0995189	0	0. 4,926,494
Securitization by asset type						
FAMTA	1-4 Family residential mortgages securitized assets/total assets	8694	0. 0296603	0. 0859317	0	0. 4,190,286
HELTA	Home equity line securitized assets/total assets	8694	0.0002179	0. 0011346	0	0. 0067325
CCTA	Credit card securitized assets/total assets	8694	0.0001482	0.0008894	0	0.0056344
ALTA	Auto loan securitized assets/total assets	8694	0. 0004204	0. 0019393	0	0. 0110958
OLTA	Other consumer securitized assets/total assets	8694	0.0000824	0. 0003995	0	0. 0023319
CITA	Commercial and industrial securitized assets/total assets	8685	0. 0001944	0. 0009746	0	0. 0058415
BHC characteristics						
SIZE	Ln (total assets)	8694	15.38583	2.128203	12.48224	20.64353
TLTD	Total loans/total deposits	8622	12.80494	11.76257	2.004438	57.32712
T1RBCR	Core equity capital/risk-weighted assets	7482	12.15178	3.573455	5.75	22.92
ROA	Net income/total assets	8694	0.0067052	0.0093635	− 0. 0087744	0. 053398
PLLTA	Provision for loans and leases/total assets	8694	0. 0032394	0. 0057607	− 0.0001342	0. 0294026

Values expressed after winsorization at the 2.5% level

dummies to control for time-specific effects; and ε is the error term for bank *i* in quarter *t*. The timing applied in this model mitigates reverse causality issues and ensures that the direction of causality goes from the explanatory variables to the dependent variable (Demsetz and Strahan 1997; Stiroh 2006; Casu et al. 2011).

In Eq. (1), I perform the empirical test of the recourse hypothesis by investigating the sign and the significance of the coefficient $\widehat{\beta}_1$ that is associated with the independent variable *TSATA*. This coefficient reflects the relationship between the securitization and risk-taking of a BHC. If $\widehat{\beta}_1$ is not significantly different from zero, then risk-taking is not affected by securitization. In contrast, a negative and statistically significant coefficient of $\widehat{\beta}_1 < 0$ indicates that greater securitization is associated with a decrease in the BHC's risk appetite, while $\widehat{\beta}_1 > 0$ indicates that risk-taking increases with the volume of securitization. I assume that a coefficient $\widehat{\beta}_1 < 0$ is consistent with the recourse hypothesis. Regarding the other regressors, if $\widehat{\beta}_2$ is not significantly different from zero, then risk-taking is not affected by bank size. In contrast, a negative and statistically significant coefficient of $\widehat{\beta}_2 < 0$ indicates that being large is negatively associated with the BHC's risk appetite, while $\widehat{\beta}_2 > 0$ indicates that risk-taking is increasing in bank size. I assume that a coefficient $\widehat{\beta}_2 > 0$ is consistent with evidence provided by Loutskina (2005) that large US banks have a sufficient quantity of homogeneous loans that allows them to independently enter the securitization market and engage in higher risk and return activities that increase their proportion of risky assets. Moreover, larger BHCs might be able to diversify or manage their credit risk exposure better or simply might be deemed 'too big to fail' and, consequently, they might have incentives to take on additional risks (Kara et al. 2016). If $\widehat{\beta}_3$ is not significantly different from zero, then risk-taking is not affected by the ratio of total loans to total deposits (*TLTD*). In contrast, a negative and statistically significant coefficient of $\widehat{\beta}_3 < 0$ indicates that the size of the loan portfolio is negatively associated with the BHC's risk appetite, while $\widehat{\beta}_3 > 0$ indicates that risk-taking is increasing in the size of the loan portfolio, consistent with evidence that growth in banks' loan activities lowers credit quality and increases credit risk (Wu et al. 2022). If $\widehat{\beta}_4$ is not significantly different from zero, then risk-taking is not affected by the Tier 1 risk-based capital ratio (*T1RBCR*). In contrast, a negative and statistically significant coefficient of $\widehat{\beta}_4 < 0$ indicates that the Tier 1 risk-based capital ratio is negatively associated with the BHC's risk appetite, while $\widehat{\beta}_4 > 0$ indicates that risk-taking is increasing in that ratio, consistent with the notion that high capital ratios relative to regulatory standards can increase bank risk-taking by spurring banks to invest in more risky assets (Kim and Santomero 1988; Dionne and Harchaoui 2003). If $\widehat{\beta}_5$ is not significantly different from zero, then risk-taking is not affected by bank performance, measured as the bank's return on assets (*ROA*). In contrast, a negative and statistically significant coefficient of $\widehat{\beta}_5 < 0$ indicates that greater bank performance is associated with a decrease in bank risk appetite, while $\widehat{\beta}_5 > 0$ indicates that risk-taking is increasing in bank performance, consistent with evidence that higher profitability loosens bank borrowing constraints, thus enabling profitable banks to take risk on a larger scale, thus inducing risk-taking (Martynova et al. 2020). If $\widehat{\beta}_6$ is not significantly different from zero, then risk-taking is not affected by the ratio of loan loss provisions to total assets (*PLLTA*). In contrast, a negative and statistically significant coefficient of $\widehat{\beta}_6 < 0$ indicates that the loan loss provision ratio is negatively associated with bank risk appetite, while $\widehat{\beta}_6 > 0$ indicates that risk-taking is increasing in loan loss provisioning, consistent with the notion that higher loan loss provisions affect bank credit quality concerns and risk-taking (Schmidt 2023; Villaluz and Khalid 2023).

Moreover, I further investigate whether my main results might differ across BHCs of different securitization exposures. Large securitizers could be more oriented to shift to less risky assets due to their higher credit exposure to recourse and reputational concerns, while low securitizers have lower credit exposure to recourse and might be more tempted to shift to more risky assets. To test these conjectures, I create the dummy variable *large securitizer* that equals one for BHCs whose ratio of *TSATA* is above the 90th percentile of the distribution and zero otherwise based on the full sample period.[13] I then split my data sample into the two subsamples of small and large securitizers, and estimate my baseline model of the recourse hypothesis generated by Eq. (1).

4.2 Testing the *crisis effect*

I now divide the sample period into two transitional periods and focus on the pre-crisis to the crisis period first. I address this period first to test whether the effect of securitization on bank risk-taking significantly differs in crisis and non-crisis periods that gives rise to different equilibria observed at different times. To conduct such an analysis, I interact *TSATA* with the time dummy d_{crisis} that equals one in the quarters from 2007q3 to 2009q2 and zero otherwise. This binary variable allows to capture the specific effects of the crisis that lead to different results regarding the effect of securitization on bank risk-taking. I label this effect as the *crisis effect.*

My predictive model for the *crisis effect* takes the following form:

$$\Delta RWATA_{i,t} = \alpha + \beta_1 TSATA_{i,t-1} + \beta_2 TSATA_{t-1} * d_{crisis} + \beta_3 d_{crisis} + \sum_{j=1}^{k} \delta_j X_{i,t} + \delta D_{quarter_t} + \varepsilon_{i,t} \tag{2}$$

where $X_{i,t}$ is the vector of independent variables that represent the specific characteristics of bank i in the previous quarter $t-1$ as in Eq. (1); $D_{quarter_t}$ are quarterly dummies to control for time-specific effects; the time dummy d_{crisis} reflects the occurrence of the financial crisis; and ε is the error term for bank i in quarter t. The timing applied in this model is the same as in the baseline model of Eq. (1).

The empirical test of the *crisis effect* is performed by investigating the sign and the statistical significance of the coefficient $\widehat{\beta_2}$ that is associated with the interaction term $TSATA * d_{crisis}$ in Eq. (2). This coefficient reflects the relationship between securitization and risk-taking by BHCs during the financial crisis. If $\widehat{\beta_2}$ is not significantly different from zero, then the effect of securitization on risk-taking does not depend on the occurrence of the financial crisis. In contrast, a statistically significant coefficient for the interaction term $TSATA * d_{crisis}$, that is either $\widehat{\beta_2} < 0$ or $\widehat{\beta_2} > 0$, indicates that securitization affects BHCs' risk appetite differently in the years of the financial crisis. On the one hand, $\widehat{\beta_2} < 0$ indicates that securitization more negatively affects bank risk-taking during the financial crisis; on the other hand, $\widehat{\beta_2} > 0$ acts in the opposite direction by pushing BHCs to take on more risk that deteriorates the quality of their loan portfolios in periods of financial distress. Therefore, in the interaction analysis generated by Eq. (2), the effect of securitization now also depends on the value of the time dummy d_{crisis} that reflects the occurrence of the financial crisis. When its value is zero (normal economic conditions), the effect of the lower-order

[13] The 90th cut-off percentile used to distinguish small and large securitizers is chosen following inspection of the *TSATA* distribution that shows little securitization for values below the 90th percentile of the *TSATA* distribution.

term *TSATA* is given by $\widehat{\beta}_1$. However, when its value is one (during the financial crisis), the effect of *TSATA* is given by adding $\widehat{\beta}_1$ and $\widehat{\beta}_2$, where $\widehat{\beta}_2$ is the coefficient on the interaction term $TSATA * d_{crisis}$. To rule out causality due to the incorporation of policy changes occurring in the post-crisis period, the observations pertaining to the post-crisis period are excluded from the *crisis effect* analysis.

4.3 Testing the *post-crisis effect*

I now focus on the transition from the crisis to the post-crisis period to explore whether the *crisis effect* reverses after the financial crisis giving rise to the *post-crisis effect* that results from policy makers' actions to correct the risk-taking that manifested during the crisis. Specifically, I acknowledge that the *post-crisis effect* may account for policy changes introduced after the outbreak of the crisis since the Federal Reserve (and in general policy makers) implemented a number of programs designed to support the liquidity of financial institutions and foster improved conditions in financial markets (Federal Reserve 2009). To this purpose, I now interact *TSATA* with the time dummy $d_{post-crisis}$ that equals one for the period from 2009q3 to 2017q4 and zero otherwise. The binary variable $d_{post-crisis}$ allows to capture the effect of the attention paid by policy makers to risk-taking in the post-crisis period, which might significantly affect its relationship with securitization. I label this effect as the *post-crisis effect.*

My predictive model for the *post-crisis effect* takes the following form:

$$\Delta RWATA_{i,t} = \alpha + \beta_1 TSATA_{i,t-1} + \beta_2 TSATA_{t-1} * d_{post-crisis} + \beta_3 d_{post-crisis} + \sum_{j=1}^{k} \delta_j X_{i,t} + \delta D_{quarter_t} + \varepsilon_{i,t} \tag{3}$$

where $X_{i,t}$ is the vector of independent variables that represent the specific characteristics of bank i in the previous quarter $t-1$ as in Eq. (1). $D_{quarter_t}$ are quarterly dummies to control for time-specific effects, the time dummy $d_{post-crisis}$ reflects the aftermath of the financial crisis; and ε is the error term for bank i in quarter t. The timing applied in this model is the same as in the baseline model generated by Eq. (1).

I perform the empirical test of the *post-crisis effect* by investigating the sign and the statistical significance of the coefficient $\widehat{\beta}_2$ that is associated with the interaction term $TSATA * d_{post-crisis}$ in Eq. (3). This coefficient reflects the moderating effect of post-crisis policy changes on the relationship between securitization and bank risk-taking. If $\widehat{\beta}_2$ is not significantly different from zero, then the effect of securitization on risk-taking does not depend on policy makers' post-crisis actions. In contrast, a statistically significant coefficient on the interaction term $TSATA * d_{post-crisis}$, that is either $\widehat{\beta}_2 < 0$ or $\widehat{\beta}_2 > 0$, indicates that the policy makers' attention significantly moderates the relationship between securitization and BHCs' risk appetite in the aftermath of the financial crisis. On the one hand, $\widehat{\beta}_2 < 0$ indicates that the *crisis effect* reverses in post-crisis period that would confirm the relevance of policy makers' actions of smoothing the excessive risk-taking that materialized during the financial crisis; on the other hand, $\widehat{\beta}_2 > 0$ acts in the opposite direction by indicating that BHCs take on more risk and deteriorate the quality of their loan portfolios in the post-crisis period. As with the predictive model for the *crisis effect*, to rule out causality due to the incorporation of crisis period effects, the observations pertaining to the pre-crisis period are removed from the *post-crisis effect* analysis.

4.4 Testing the recourse hypothesis and the *crisis effect* by asset class

Here, I break down the aggregate securitization into its underlying asset classes to investigate which asset class mostly explains bank variation in risk-taking. The granularity of the information reported in each HC-S schedule allows to break down securitization into (i) 1–4 family residential mortgage loans, (ii) home equity lines of credit, (iii) credit card receivables, (iv) auto loans, (v) other consumer loans, and (vi) commercial and industrial loans. To test the recourse hypothesis, I use the baseline model in Eq. (1). I then investigate the sign and the statistical significance of each $\widehat{\beta}$ coefficient in Eq. (4) that is associated with the underlying asset class being securitized.

My model of the recourse hypothesis by asset type takes the following form:

$$\begin{aligned}\Delta RWATA_{i,t} = \alpha + \beta_1 FAMTA_{i,t-1} + \beta_2 HELTA_{i,t-1} + \beta_3 CCTA_{i,t-1} + \beta_4 ALTA_{i,t-1} \\ + \beta_5 OLTA_{i,t-1} + \beta_6 CITA_{i,t-1} + \sum_{j=1}^{k} \delta_j X_{i,t} + \delta D_{quarter_t} + \varepsilon_{i,t}\end{aligned} \tag{4}$$

where *FAMTA* is the ratio of BHCs' family residential mortgage loans to total assets, *HELTA* is the ratio of BHCs' home equity lines to total assets, *CCTA* is the ratio of BHCs' credit card receivables to total assets, *ALTA* is the ratio of BHCs' auto loans to total assets, *OLTA* is the ratio of BHCs' other consumer loans to total assets, and *CITA* is the ratio of BHCs' commercial and industrial loans to total assets; all ratios are expressed in the previous quarter $t-1$, and $X_{i,t}$ is the vector of independent variables that represent the specific characteristics of bank i in the previous quarter $t-1$ as in Eq. (1). $D_{quarter_t}$ are quarterly dummies to control for time-specific effects; and ε is the error term for bank i in quarter t. The timing applied in this model is the same as in the baseline model generated by Eq. (1).

I acknowledge that, since banks have superior information (relative to investors) about the credit risk of the transferred assets, they provide some form of recourse to protect investors against potential losses on securitized assets. Banks often provide contractual ('explicit') recourse by retaining first-loss contractual interests and non-contractual ('implicit') recourse to make up some portion of the losses not covered by the retained interest in securitized assets (Chen et al. 2008). The extent of recourse provision differs based on the type of asset being securitized. Existing evidence indeed shows how banks' retention of the risks of their off-balance sheet securitized loans depends on securitization characteristics (Chen et al. 2008; Ryan et al. 2016). Banks indeed retain larger contractual or non-contractual first-loss interests in off-balance sheet securitized loans with higher and/or less externally verifiable credit risk in order to protect ABS purchasers against adverse selection (Yesol and Kim 2023). Issuers can assume these positions either by retaining contractual interests or by providing implicit recourse. More homogeneous/standardized loans generally have more externally verifiable credit risk. On average, commercial loans have relatively high and difficult to verify credit risk, consumer loans (including credit cards) have relatively high but easier to verify credit risk, and mortgages (including home equity lines of credit) have relatively low and easy to verify credit risk. Hence, I hypothesize that banks' total equity risk is, on average, associated most positively with their securitized commercial loans, next positively with their securitized consumer loans, and least positively with their securitized mortgages. Specifically, in the case of revolving loan securitizations with no fixed maturity (i.e., credit card receivables or home equity lines of credit) two features provide issuers with more incentive and ability to provide implicit recourse in those securitizations: the use of early amortization provisions (i.e., accelerated payout to ABS holders) when the securitized loans

under-perform and the use of master trusts that do not segregate the loans from different securitizations (Chen et al. 2008; Ryan et al. 2016). This discussion leads me to conjecture that the signs of the $\widehat{\beta}$ coefficients associated with the different loan types in Eq. (4) should be negative (consistent with the recourse provided) and that greater $\widehat{\beta}$ coefficients should be associated with securitized loans with higher and/or less externally verifiable credit risk depending on the expected level of recourse for each loan type.

Next, I interact each securitized asset class in Eq. (4) with my time dummy d_{crisis} that reflects the occurrence of the financial crisis. That is, I break down the aggregate securitization into its underlying asset classes and interact each of them with the crisis dummy d_{crisis}. Equation (5) generates the sign and the statistical significance of each $\widehat{\beta}$ coefficient that is associated with the underlying securitized asset class interacted with the crisis dummy d_{crisis}. To rule out causality due to the incorporation of policy changes occurred in the post-crisis period, the observations pertaining to the post-crisis period are excluded from the *crisis effect* analysis by asset type.

My predictive model for the *crisis effect* by asset type takes the following form:

$$\begin{aligned}\Delta RWATA_{i,t} = {} & \alpha + \beta_1 FAMTA_{i,t-1} + \beta_2 FAMTA_{i,t-1} * d_{crisis} + \beta_3 HELTA_{i,t-1} + \beta_4 HELTA_{i,t-1} * d_{crisis} \\ & + \beta_5 CCTA_{i,t-1} + \beta_6 CCTA_{i,t-1} * d_{crisis} + \beta_7 ALTA_{i,t-1} + \beta_8 ALTA_{i,t-1} * d_{crisis} \\ & + \beta_9 OLTA_{i,t-1} + \beta_{10} OLTA_{i,t-1} * d_{crisis} + \beta_{11} CITA_{i,t-1} + \beta_{12} CITA_{i,t-1} * d_{crisis} \\ & + \beta_{13} d_{crisis} + \sum_{j=1}^{k} \delta_j X_{i,t} + \delta D_{quarter_t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

where $X_{i,t}$ is the vector of independent variables that represent the specific characteristics of bank i in the previous quarter $t-1$ as in Eq. (1). $D_{quarter_t}$ are quarterly dummies to control for time-specific effects; the time dummy d_{crisis} reflects the occurrence of the financial crisis; and ε is the error term for bank i in quarter t. The timing applied in this model is the same as in the baseline model generated by Eq. (1).

4.5 Control variables

In all estimated models, I control for several bank-specific characteristics that could influence the risk-taking by US BHCs other than their securitization activity.

Bank size (*SIZE*), measured as the natural logarithm of total assets, is included in all model specifications to control for its possible effects on BHCs' risk appetite through various channels, such as funding and risk management opportunities. In this regard, Loutskina (2005) states that large US banks have a sufficient quantity of homogeneous loans that allows them to independently enter the securitization market that grants them better access to external funds and the transfer market for credit risk. Thus, these large institutions should engage in higher risk and return activities that increase their proportion of risky assets. Moreover, larger BHCs might be able to diversify or manage their credit risk exposure better or simply might be deemed 'too big to fail' and, consequently, they might have incentives to take on additional risks (Kara et al. 2016).

Additional characteristics of BHCs' balance sheets and income statements are included in the estimated models. Indeed, all model specifications control for the Tier 1 risk-based capital ratio (*T1RBCR*) that is computed as the ratio of core equity capital to total risk-weighted assets. Following Kim and Santomero (1988) and Dionne and Harchaoui (2003), I predict that BHCs with high capital ratios relative to regulatory standards can increase

their risk-taking by investing in more risky assets. Estimated models also control for the ratio of loan loss provisions to total assets (*PLLTA*) that reflects the credit quality of a bank's loan portfolio. Furthermore, to control for the bank's liquidity position and for the size of its loan portfolio, the ratio of total loans to total deposits (*TLTD*) is included in all model specifications. Regarding the data on income statements, the bank's return on assets (*ROA*) is included as an additional control variable to account for the possible impact of bank performance and the incentives to take on additional risks.

5 Results

Table 2 shows the results from running the baseline model[14] generated by Eq. (1) on the entire sample period from 2001 to 2017. Column (3) in Table 2 shows that the coefficient $\widehat{\beta}_1$ on *TSATA* is negative and statistically significant at the 1% level that indicates that an increase in securitization is associated with a decreased proportion of risky assets held by BHCs, ceteris paribus. The statistical significance of the coefficient on TSATA also persists in columns (1) and (2) that report reduced forms of the full model specification generated by Eq. (1) reported in column (3) in Table 2. This finding is consistent with the recourse hypothesis of securitization.

To assuage concerns about potential endogeneity that might affect my estimation results given that BHCs endogenously choose which assets to securitize, I perform instrumental variable (IV) estimation with respect to the baseline model generated by Eq. (1) that uses two instruments in separate regressions: bank size (*SIZE)* and deposits-to-assets ratio (*TDTA*). IV estimation results, reported in Table 3, show the second stage of the regressions and the value of the coefficients and standard errors of the two instruments in the first stage. The estimation results confirm the negative effect of securitization on BHCs' risk-taking that is statistically significant and persistent for both instruments. On the one hand, the choice of using the bank size as an instrument is motivated by the fact that bank size is likely to affect the propensity of the BHC's business model to be more prone to originate-to-distribute rather than originate-to-hold loans on its balance sheet through securitization.[15] Furthermore, larger BHCs enjoy greater access to the securitization market, thus affecting their securitization activity. On the other hand, the deposits-to-assets ratio could potentially affect the BHC's amount of securitization as an alternative funding source.[16] The Kleibergen-Paap rk LM statistic rejects the null hypothesis for irrelevant instruments for both instruments. Therefore, both bank size and the deposits-to-assets ratio

[14] In model selection, the Hausman test determines the implementation of a fixed-effects panel data model. Moreover, I use heteroskedasticity-robust standard errors clustered at the BHC level as the modified Wald test for groupwise heteroskedasticity in FE regression models detects heteroskedasticity of residuals. Furthermore, the Breusch-Godfrey LM test for serial correlation rules out issues related to serial correlation and augmented Dickey–Fuller and Phillips–Perron tests, using the Schwarz information criterion for lag length determination (Im et al. 2003), indicate the non-existence of a unit root for all variables.

[15] Consistent with evidence provided by Loutskina (2005), large US banks have a sufficient quantity of homogeneous loans that allows them to independently enter the securitization market in a context where large banks have grown significantly in size and added a wide range of market-based operations to the traditional business of making loans since the late 1990s, including the origination and/or holding of securitized debt.

[16] Both bank size and the deposits-to-assets ratio could be referred to as pure numbers that significantly affect securitization without directly affecting the dependent variable of bank risk-taking.

Table 2 Baseline model for the *recourse hypothesis* of securitization

Variables	(1) FE panel model	(2) FE panel model	(3) FE panel model
$TSATA_{t-1}$	−0.010**	−0.011**	−0.019***
	(0.005)	(0.005)	(0.005)
$SIZE_{t-1}$		0.003***	0.004***
		(0.001)	(0.001)
$TLTD_{t-1}$			−0.000***
			(0.000)
$T1RBCR_{t-1}$			0.001***
			(0.000)
ROA_{t-1}			−0.262*
			(0.137)
$PLLTA_{t-1}$			−0.644***
			(0.136)
Observations	8,591	8,591	7,337
R^2	0.30	0.30	0.34
Number of BHCs	176	176	176
BHC FE	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis for the baseline model for the *recourse hypothesis* of securitization where the dependent variable is the change in the credit risk of the bank portfolio measured as the first difference of the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). All variables are defined in Table 1. Columns (1) and (2) are reduced forms of the full model specification generated by Eq. (1) reported in column (3). Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

are relevant instruments in the IV setting. Overall, the IV estimation results corroborate my main empirical findings and thus confirm the negative and statistically significant relationship between securitization and bank risk-taking.

Moreover, as explained earlier in the paper, I further investigate whether my main results might differ across BHCs of different securitization exposures as large securitizers could be more oriented to shift to less risky assets due to their higher credit exposure to recourse and reputational concerns, while low securitizers have lower credit exposure to recourse and might be more tempted to shift to more risky assets. The results of this analysis are reported in Table 4. For ease of comparison, column (1) in Table 4 presents my previous results for the whole sample comprising all BHCs. The results for the two subsamples of small and large securitizers are reported in columns (2) and (3) in Table 4, respectively. Again, my main empirical findings prove to be robust since the results of this analysis confirm a negative and statistically significant effect of securitization on bank risk-taking. Specifically, the effect is greater for large securitizers due to their higher credit exposure to the securitized pool of assets and their need to maintain a good reputation in the market to be constantly able to engage in repeated securitization transactions.

Table 3 IV Estimation: Baseline model for the *recourse hypothesis* of securitization

Variables	(1) IV estimation	(2) IV estimation
$TSATA_{t-1}$	−0.171***	−0.413**
	(0.041)	(0.172)
$TLTD_{t-1}$	−0.000***	−0.000**
	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.001***	0.001***
	(0.000)	(0.000)
ROA_{t-1}	−0.499***	−0.182
	(0.079)	(0.219)
$PLLTA_{t-1}$	−1.267***	−0.941***
	(0.096)	(0.241)
Observations	7,337	7,337
Number of BHCs	176	176
BHC FE	Yes	Yes
Tests:		
Kleibergen-Paap	0.0000	0.0030
Anderson-Rubin	0.0000	0.0006
Stock-Wright	0.0000	0.0006
Weak identification (Kleibergen-Paap rk Wald F statistic)	64.942	8.925
First Stage		
$SIZE_{t-1}$	−0.023*** (0.002)	
$TDTA_{t-1}$		0.080*** (0.022)

The table shows the results of IV estimation with respect to the baseline model generated by Eq. (1). Columns (1) and (2) present the coefficient estimates and robust standard errors (in parentheses) for the two-stage treatment effects model generated by Eq. (1). The sample period is 2001–2017. The first stage includes all explanatory variables in the second stage. The dependent variable is the change in the credit risk of the bank portfolio measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). The Kleibergen-Paap is a test of under-identification distributed as a chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM S statistics are weak-instrument-robust inference tests that are distributed as a F-test and a chi-square respectively under the null that the coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid. The Hansen J statistic is a test of the over-identifying restrictions that are distributed as chi-square under the null of instrument validity. The first stage Kleibergen-Paap's Wald F statistic is a test for a weak instrument. All variables are defined in Table 1. In the margin, I report coefficients and standard errors for the two instrumental variables. Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

Table 4 Baseline model for the *recourse hypothesis* of securitization by securitization volume

Variables	(1) All securitizers	(2) Small securitizers	(3) Large securitizers
$TSATA_{t-1}$	−0.019***	−0.024***	−0.041***
	(0.005)	(0.009)	(0.015)
$SIZE_{t-1}$	0.004***	0.004***	−0.005
	(0.001)	(0.001)	(0.005)
$TLTD_{t-1}$	−0.000***	−0.000***	−0.000
	(0.000)	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.001***	0.001***	0.000
	(0.000)	(0.000)	(0.001)
ROA_{t-1}	−0.262*	−0.183	0.217
	(0.137)	(0.120)	(0.341)
$PLLTA_{t-1}$	−0.644***	−0.661***	−0.139
	(0.136)	(0.119)	(0.380)
Observations	7,337	6,638	697
R^2	0.34	0.32	0.47
Number of BHCs	176	172	62
BHC FE	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis of the baseline model for the *recourse hypothesis* of securitization across BHCs of different securitization volumes where the dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

Column (1) in Table 5 shows the results from running the predictive model of the *crisis effect* generated by Eq. (2). Specifically, Eq. (2) shows whether the effect of securitization on bank risk-taking significantly differs during the financial crisis by generating the sign and the statistical significance of the coefficient $\widehat{\beta}_2$ that is associated with the interaction term $TSATA * d_{crisis}$. My empirical findings show that this coefficient is positive and statistically significant which indicates that the effect of securitization on risk-taking is effectively moderated by the occurrence of the financial crisis. This *crisis effect* hampers BHCs' ability to engage in securitization that leads them to accumulate more risky assets on their books due to the deteriorated quality of their loan portfolios.

Column (2) in Table 5 shows the results from running the predictive model of the *post-crisis effect* generated by Eq. (3). Specifically, Eq. (3) shows whether the *crisis effect* reverses after the crisis by generating the sign and the statistical significance of the coefficient $\widehat{\beta}_2$ that is associated with the interaction term $TSATA * d_{post-crisis}$. My empirical results show that this coefficient is negative and statistically significant that indicates the *crisis effect* reverses in the aftermath of the financial crisis due to the attention paid by policy makers to correct the risk-taking that materialized during the crisis.

Table 6 shows the results from running the estimated model of the recourse hypothesis by asset type generated by Eq. (4). My empirical results indicate that family residential mortgage

Table 5 Predictive models of the *crisis effect* and the *post-crisis effect*

Variables	(1) FE panel model Pre-crisis transition Switch in equilibrium	(2) FE panel model Crisis – post transition Attention by policy makers
$TSATA_{t-1}$	−0.020***	−0.009**
	(0.006)	(0.008)
$TSATA_{t-1} * d_{crisis}$	0.016***	
	(0.006)	
d_{crisis}	−0.001	
	(0.004)	
$TSATA_{t-1} * d_{post-crisis}$		−0.011**
		(0.007)
$d_{post-crisis}$		−0.051***
		(0.005)
$SIZE_{t-1}$	0.004***	0.011**
	(0.001)	(0.004)
$TLTD_{t-1}$	−0.000**	−0.000***
	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.002***	0.001***
	(0.000)	(0.000)
ROA_{t-1}	−0.233	−0.225*
	(0.247)	(0.122)
$PLLTA_{t-1}$	−0.827***	−0.616***
	(0.212)	(0.150)
Observations	4,357	4,159
R^2	0.44	0.10
Number of BHCs	175	165
BHC FE	Yes	Yes
Quarterly FE	Yes	Yes

The table presents the results of the predictive models of the *crisis effect* and the *post-crisis effect*. Column (1) reports the results of the FE panel regression for the first predictive model for the *crisis effect,* while column (2) gives the results of the FE panel regression for the second predictive model for the *post-crisis effect.* The dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t - 1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). Only for model specification reported in column (1) the independent variables include, among others: (vii) the interaction term $TSATA_{t-1}{}^{*}d_{crisis}$; and (viii) the crisis period dummy d_{crisis}. Only for model specification reported in column (2), the independent variables include, among others: (ix) the interaction term $TSATA_{t-1}{}^{*}d_{post-crisis}$; and (x) the *post-crisis* period dummy $d_{post-crisis}$ All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, respectively

loans are the driving factor behind the effect of securitization on BHCs' risk-taking. Indeed, column (2) in Table 6 shows that the coefficient $\widehat{\beta}_1$ that is associated with *FAMTA* is negative and statistically significant at the 1% level. The estimation results also show that the effects of all the remaining securitized asset classes on risk-taking are not statistically significant.

Table 7 shows the results from running the predictive model of the *crisis effect* by asset type generated by Eq. (5). Specifically, by investigating the coefficient $\widehat{\beta}_2$ that is associated with the interaction term $FAMTA * d_{crisis}$, I observe that it is positive and statistically significant that indicates it is precisely the securitization of family residential mortgage loans that triggers the *crisis effect*. Securitisation indeed relies predominantly on residential mortgages, and the latter represent the market's biggest asset class by far. Undeniably, the magnitude of the share of residential family mortgages for the US economy was apparent in the run-up to the financial crisis, as they contributed to the largest amount of real estate loans for US BHCs. As long as the secondary market for mortgages was functioning normally before the onset of the crisis, originating institutions were able to easily offload these loans to third parties. However, when the secondary mortgage market came under pressure in the middle of 2007, banks with higher volumes of originate-to-distribute loans were stuck with large quantities of relatively inferior mortgage loans (Allen and Carletti 2010; Purnanandam 2011; Kim et al. 2018) that could not be offloaded to third parties when the MBS market froze in mid-2007, consistent with the magnitude of recourse provided being risk-relevant. Based on this reasoning, the non-significant coefficients on the other loan types are likely due to their small magnitude relative to the US home mortgage market. Moreover, equality tests on correlation coefficients confirm a significant difference between the securitization of residential mortgages and that of the other asset classes, further corroborating my main results on the peculiar role of the securitization of family residential mortgage loans in boosting the recourse hypothesis and triggering the *crisis effect* as they contributed to the largest amount of real estate loans for US BHCs in the run-up to the financial crisis.

6 Robustness tests

To confirm my empirical results on the negative relationship between securitization and bank risk-taking, I perform several robustness tests that leave my main findings unaffected.

6.1 The financial crisis

Following Casu et al. (2011), I run my baseline regression model of the recourse hypothesis generated by Eq. (1) by removing the quarters during the financial crisis to investigate whether my main results are influenced by the US subprime mortgage crisis. The results, reported in column (1) in Table 8, show that the effect of securitization on bank risk-taking remains qualitatively unchanged. Moreover, unlike in Casu et al. (2011), the time extension of my dataset allows to further split the sample period into two subperiods as represented by two time dummies: $d_{pre-crisis}$ and $d_{post-crisis}$. Specifically, the time dummy $d_{pre-crisis}$ equals one for the period from 2001q2 to 2007q2 and zero otherwise, while the time dummy $d_{post-crisis}$ equals one for the period from 2009q3 to 2017q4 and zero otherwise. I then run my baseline model of the recourse hypothesis generated by Eq. (1) on these two subperiods to capture any differences in the effect of securitization on BHCs' risk appetite in the pre- versus post-financial crisis periods. The estimation results, reported in columns (2) and (3) in Table 8, leave my main findings on the effect of securitization on risk-taking unaffected. Moreover, the results reported in column (2) in Table 8 yield an explanatory

Table 6 Baseline model for the *recourse hypothesis* of securitization by asset type

Variables	(1) FE panel model	(2) FE panel model	(3) FE panel model	(4) FE panel model	(5) FE panel model	(6) FE panel model	(7) FE panel model
$TSATA_{t-1}$	−0.019***						
	(0.005)						
$FAMTA_{t-1}$		−0.017***					
		(0.005)					
$HELTA_{t-1}$			0.361				
			(0.355)				
$CCTA_{t-1}$				−1.560			
				(0.549)			
$ALTA_{t-1}$					−0.051		
					(0.167)		
$OLTA_{t-1}$						−0.756	
						(0.874)	
$CITA_{t-1}$							−0.233
							(0.358)
$SIZE_{t-1}$	0.004***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$TLTD_{t-1}$	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA_{t-1}	−0.262*	−0.261*	−0.262*	−0.263*	−0.261*	−0.261*	−0.258*
	(0.137)	(0.141)	(0.142)	(0.142)	(0.142)	(0.142)	(0.142)
$PLLTA_{t-1}$	−0.644***	−0.654***	−0.666***	−0.651***	−0.665***	−0.663***	−0.654***
	(0.136)	(0.140)	(0.141)	(0.140)	(0.141)	(0.141)	(0.141)
Observations	7,337	7,337	7,337	7,337	7,337	7,337	7,329
R^2	0.34	0.34	0.34	0.34	0.34	0.34	0.34

Table 6 (continued)

Variables	(1) FE panel model	(2) FE panel model	(3) FE panel model	(4) FE panel model	(5) FE panel model	(6) FE panel model	(7) FE panel model
Number of BHCs	176	176	176	176	176	176	176
BHC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis for the baseline model for the *recourse hypothesis* of securitization by asset type where the dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); (vi) loan loss provision ratio ($PLLTA_{t-1}$); and (vii) the underlying securitized asset classes. All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

Table 7 Predictive model of the *crisis effect* by asset type

Variables	(1) FE panel model	(2) FE panel model	(3) FE panel model	(4) FE panel model	(5) FE panel model	(6) FE panel model	(7) FE panel model
$TSATA_{t-1}$	−0.020***						
	(0.006)						
$TSATA_{t-1} * d\_crisis$	0.025***						
	(0.010)						
d_crisis	−0.001	−0.001	−0.001	−0.001	−0.000	−0.001	−0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$FAMTA_{t-1}$		−0.021***					
		(0.008)					
$FAMTA_{t-1} * d\_crisis$		0.019***					
		(0.007)					
$HELTA_{t-1}$			−0.262				
			(0.504)				
$HELTA_{t-1} * d\_crisis$			0.493				
			(0.606)				
$CCTA_{t-1}$				−2.356*			
				(0.801)			
$CCTA_{t-1} * d\_crisis$				0.442			
				(0.673)			
$ALTA_{t-1}$					−0.025		
					(0.191)		
$ALTA_{t-1} * d\_crisis$					−0.868*		
					(0.429)		
$OLTA_{t-1}$						−1.812	
						(1.118)	
$OLTA_{t-1} * d\_crisis$						2.239	
						(1.914)	

Table 7 (continued)

Variables	(1) FE panel model	(2) FE panel model	(3) FE panel model	(4) FE panel model	(5) FE panel model	(6) FE panel model	(7) FE panel model
$CITA_{t-1}$							−0.494
							(0.326)
$CITA_{t-1} * d\_crisis$							1.878*
							(0.478)
$SIZE_{t-1}$	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$TLTD_{t-1}$	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA_{t-1}	−0.235	−0.229	−0.238	−0.250	−0.235	−0.237	−0.241
	(0.247)	(0.259)	(0.258)	(0.256)	(0.263)	(0.258)	(0.259)
$PLLTA_{t-1}$	−0.826***	−0.828***	−0.824***	−0.819***	−0.810***	−0.823***	−0.804***
	(0.212)	(0.219)	(0.219)	(0.218)	(0.221)	(0.219)	(0.221)
Observations	4,357	4,357	4,357	4,357	4,357	4,357	4,355
R^2	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Number of BHCs	175	175	175	175	175	175	175
BHC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis of the predictive model for the *crisis effect* by asset type where the dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); (vi) loan loss provision ratio ($PLLTA_{t-1}$); (vii) the underlying securitized asset classes; and (viii) the interaction terms between the underlying securitized asset classes and the crisis period dummy *d_crisis*. All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

power that is significantly higher than that provided in Casu et al. (2011) for the effect of securitization on risk-taking over the pre-crisis period. In this regard, my estimation results have an R^2 of 0.53 as opposed to the R^2 of 0.06 reported in Casu et al. (2011). This difference may be due to the choice of the explanatory variables used in the estimated model with respect to those included in Casu et al.'s (2011) study. Specifically, my regressions control for the loan-to-deposit ratio *TLTD*, the tier 1 risk-based capital ratio *T1RBCR*, and the loan loss provision ratio *PLLTA*. The addition of these explanatory variables is likely to increase the goodness of fit of the model of bank risk-taking that consequently leads to a higher explanatory power with respect to that provided in Casu et al. (2011).

Moreover, I examine whether there has been a noticeable shift in the securitization after the financial crisis by checking whether the difference in the coefficient on *TSATA* between column (2) and column (3) in Table 8 is statistically significant. I do this check by testing the equality of these two correlation coefficients drawn from the two independent groups in the pre-crisis and post-crisis periods. In this regard, the equality test transforms the correlation coefficient values, or r values, into z scores. This transformation, also known as Fisher's r to z transformation (Fisher 1915) is performed so that the z scores can be compared and analyzed for statistical significance. By observing the z test statistic and choosing the desired level of significance, statistical significance can be assessed by checking if the observed value is greater than the critical value. In this regard, my results show that the difference in the coefficient on *TSATA* between column (2) and column (3) in Table 8 is not statistically significant, as the observed p-value of 0.4532 is greater than the 5% chosen level of significance; thus, I cannot reject the null hypothesis of the equality of the two coefficients that then indicates there has not been a noticeable shift in the securitization after the financial crisis. Nevertheless, as shown in panels (a) and (b) in Fig. 4, securitization volumes decreased in the years following the financial crisis. In this regard, the larger negative and significant coefficient for *TSATA* in the post-crisis period reported in column (3) in Table 8 shows that even though BHCs were risk-averse to begin with, they have become even more cautious of their risky activities after the crisis.

6.2 Bank heterogeneity

I now test whether my main results hold when taking bank heterogeneity into consideration. On the one hand, I verify whether my results might be different across BHCs of different sizes. Therefore, following the criterion proposed by Loutskina (2005) and subsequently followed by Casu et al. (2011), I assign a BHC to the group of small BHCs if its size is in the bottom 75% of the size distribution and to the group of large BHCs if its size is in the top 10% of the size distribution based on the full sample period.[17] Thus, I create the binary variable *large bank* that equals one if a BHC is considered as being large and zero otherwise. I then estimate my baseline model of the recourse hypothesis generated by Eq. (1) on the two subgroups of small and large

[17] My results remain unchanged even when applying the criterion proposed by the Federal Reserve (2019) to categorize as 'large financial institutions' those banks whose amount of total assets is at least $100 billion and as 'small financial institutions' those banks whose total assets fall below this threshold. Moreover, my findings remain qualitatively unaffected even if I apply the criterion to assign to the group of large banks those banks whose amount of total assets exceeds the median and to the group of small banks those banks whose total assets are equal to or fall below the median, based on the full sample period. As a matter of fact, the median, as a measure of central tendency, is less affected by outliers and skewed data and divides the sample into the top 50% and the bottom 50% of the values' distribution.

Table 8 Robustness: Baseline model for the *recourse hypothesis* of securitization by subperiod

Variables	(1) Off-crisis period	(2) Pre-crisis	(3) Post-crisis
$TSATA_{t-1}$	−0.022***	−0.020***	−0.036**
	(0.005)	(0.007)	(0.020)
$SIZE_{t-1}$	0.004***	0.005***	0.014**
	(0.001)	(0.001)	(0.006)
$TLTD_{t-1}$	−0.000**	−0.000	−0.000***
	(0.000)	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.001***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)
ROA_{t-1}	−0.336**	−0.364	−0.363***
	(0.144)	(0.359)	(0.134)
$PLLTA_{t-1}$	−0.641***	−0.758***	−0.681***
	(0.146)	(0.232)	(0.173)
Observations	6,158	3,178	2,980
R^2	0.38	0.53	0.12
Number of BHCs	176	158	149
BHC FE	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis of the baseline model for the *recourse hypothesis* of securitization across different subperiods where the dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

BHCs. The estimation results are reported in Table 9. For ease of comparison, column (1) in Table 9 presents my previous results for the whole sample of all BHCs. The results for the two subgroups of small and large BHCs are reported in columns (2) and (3) in Table 9, respectively. Again, my main empirical findings are confirmed since the effect of securitization on bank risk-taking remains negative and statistically significant for both subgroups.

Next, I further exploit the granularity of my dataset by investigating the nexus between securitization and bank risk-taking during the pre-crisis and the post-crisis periods for small and large BHCs separately. The estimation results, reported in Table 10, show that the negative and statistically significant effect of securitization on large BHCs' risk-taking is persistent in both the pre- and the post-crisis periods. Moreover, the results indicate that the negative effect of securitization on small BHCs' risk-taking is significant only in the pre-crisis period, possibly due to the increased difficulty for small banks to access the securitization market after the financial crisis.

Table 9 Robustness: Baseline model for the *recourse hypothesis* of securitization by BHC size

Variables	(1) All BHCs	(2) Small BHCs	(3) Large BHCs
$TSATA_{t-1}$	−0.019***	−0.025***	−0.020**
	(0.005)	(0.006)	(0.014)
$SIZE_{t-1}$	0.004***	0.005***	0.022**
	(0.001)	(0.001)	(0.009)
$TLTD_{t-1}$	−0.000***	−0.000***	−0.000
	(0.000)	(0.000)	(0.000)
$T1RBCR_{t-1}$	0.001***	0.001***	0.002
	(0.000)	(0.000)	(0.001)
ROA_{t-1}	−0.262*	−0.318**	−0.151
	(0.137)	(0.157)	(0.481)
$PLLTA_{t-1}$	−0.644***	−0.678***	−1.045**
	(0.136)	(0.156)	(0.429)
Observations	7,337	5,707	583
R^2	0.34	0.34	0.34
Number of BHCs	176	160	23
BHC FE	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis of the baseline model for the *recourse hypothesis* of securitization across BHCs of different sizes where the dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

7 Conclusions

Securitization has become a vital instrument for financial institutions over the last few decades. When banks participate in securitization activities, they remove the securitized assets, or pool of assets, from their balance sheets and sell them to a special purpose vehicle (SPV) that finances the purchase of the pool of assets by issuing ABS securities to outside investors in the market. Through this mechanism, the issuing institution can convert illiquid assets into marketable securities and is able to diffuse the associated credit risk among external investors.

In this paper, I investigate the impact of securitization on the risk appetite of US BHCs during the period from 2001 to 2017. Based on a sample of 170 US BHCs, my results are supportive of the recourse hypothesis of securitization according to which securitization negatively affects the risk-taking by BHCs. Such evidence highlights that the recourse commonly provided in securitization may act as an effective disciplinary mechanism on originators of securitization.

Table 10 Robustness: Baseline model for the *recourse hypothesis* of securitization by subperiod and BHC size

Variables	Pre-crisis		Post-crisis	
	(1) Small BHCs	(2) Large BHCs	(3) Small BHCs	(4) Large BHCs
$TSATA_{t-1}$	−0.029***	−0.032*	−0.014	−0.039*
	(0.008)	(0.020)	(0.014)	(0.024)
$SIZE_{t-1}$	0.006***	0.043***	0.010	0.062***
	(0.002)	(0.010)	(0.006)	(0.015)
$TLTD_{t-1}$	−0.000	−0.000	−0.000**	−0.000
	(0.000)	(0.000)	(0.000)	(0.001)
$T1RBCR_{t-1}$	0.002***	0.001	0.001**	0.005**
	(0.001)	(0.003)	(0.000)	(0.002)
ROA_{t-1}	−0.463	0.987*	−0.365**	−0.363
	(0.407)	(0.538)	(0.170)	(0.430)
$PLLTA_{t-1}$	−0.803***	−1.515***	−0.560***	−2.034***
	(0.289)	(0.342)	(0.210)	(0.331)
Observations	2,530	196	2,253	281
R^2	0.52	0.55	0.11	0.35
Number of BHCs	150	13	114	19
BHC FE	Yes	Yes	Yes	Yes
Quarterly FE	Yes	Yes	Yes	Yes

The table presents the results of the FE panel regression analysis of the baseline model for the *recourse hypothesis* of securitization across different subperiods and BHCs of different sizes where the dependent variable is the change in the credit risk of the bank portfolio that is measured as the first difference in the ratio of BHCs' risk-weighted assets over total assets between the previous quarter $t-1$ and the current quarter t ($\Delta RWATA_t$). The independent variables are: (i) securitization ratio ($TSATA_{t-1}$); (ii) size ($SIZE_{t-1}$); (iii) loan to deposit ratio ($TLTD_{t-1}$); (iv) tier 1 risk-based capital ratio ($T1RBCR_{t-1}$); (v) ROA (ROA_{t-1}); and (vi) loan loss provision ratio ($PLLTA_{t-1}$). All variables are defined in Table 1. Quarterly dummies are incorporated in all regressions (not reported). Robust errors are reported in parentheses and are clustered at the BHC level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, respectively

Further, I provide novel evidence that during the financial crisis, BHCs' inability to engage in securitization led to increased risk-taking due to the deteriorated quality of their loan portfolios. My results indeed identify a switch in equilibrium in the relationship between securitization and risk-taking from the pre-crisis to the crisis period that pushed BHCs to accumulate excessive risk on their books that paved the way for the snowballing of a more desirable off-crisis equilibrium into a worse in-crisis one that led to the financial crisis. I label this effect as the *crisis effect*.

Next, I show that the *crisis effect* reverses after the financial crisis that gives rise to the *post-crisis effect* that was triggered by policy makers' responses to the excessive risk-taking that manifested during the crisis. The policy makers' actions towards risk-taking indeed brings back confidence in securitization in the eyes of market participants that thus ultimately re-establishes a more disciplinary framework and a more prudential attitude of BHCs towards securitization.

Lastly, when breaking down securitization by asset type, I find that the securitization of residential mortgages is not only the driving force behind the recourse hypothesis but also

the triggering factor of the *crisis effect*. Indeed, as mortgage delinquencies and defaults accelerated and securitization markets were strained at the onset of the financial crisis, several BHCs with mortgage businesses could not offload originations to third parties and were instead left with large quantities of relatively inferior mortgage loans on their books that thus ultimately led to their increased risk-taking.

To conclude, my findings provide novel empirical insights into the different nexuses between the securitization and risk appetite of BHCs during and outside of the financial crisis. On the one hand, my results confirm that the recourse commonly provided in securitization acts as an effective disciplinary tool to mitigate information asymmetries that may plague securitization transactions. On the other hand, securitization and increased risk-taking in the years of the financial crisis should be given attention by policy makers whose actions to reverse the effects of the crisis and to lead BHCs to a more prudential and conscious use of securitization has turned out to be effective in the post-crisis period.

Appendix

See Table 11.

Table 11 FR Y-9C Data item and construction

Variable	FR Y-9C Data Item
Risk-weighted assets/total assets	BHCKB704/BHCK2170
Total securitized assets/total assets	(BHCKB705 + BHCKB706 + BHCKB707 + BHCKB708 + BHCKB709 + BHCBK710)/BHCK2170
1-4 Family residential mortgages securitized assets/total assets	BHCKB705/BHCK2170
Home equity line securitized assets/total assets	BHCKB706/BHCK2170
Credit card securitized assets/total assets	BHCKB707/BHCK2170
Auto loan securitized assets/total assets	BHCKB708/BHCK2170
Other consumer securitized assets/total assets	BHCKB709/BHCK2170
Commercial and industrial securitized assets/total assets	BHCKB710/BHCK2170
Tier I risk-based capital ratio	BHCK7206
Total loans/total deposits	BHCK2122/BHCB2210
Loan loss provision/total assets	BHCK4230/BHCK2170
Net income/total assets	BHCK4340/BHCK2170

Variables used in the study. Data items are taken from FR Y-9C forms from the Federal Reserve Bank of Chicago

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