Effects of Securitization and Covered Bonds on Bank Stability

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Abstract

This paper empirically investigates the relationship of securitization and covered bonds with bank stability and highlights that this relationship varies with the level of a bank's involvement in a specific instrument. The study uses the data from 46 securitizing and covered bond issuing listed banks in Europe for 2000-2014. The initial results show that some banks have been heavily involved in securitization activity, while covered bond issuance does not go beyond a certain limit. The results obtained using a quadratic model and a generalized additive model show a U-shaped relationship between securitization and systemic risk of banks. However, some interesting results are obtained for covered bonds. Initial results do not show a significant impact of covered bonds on systemic risk, but further analysis shows the presence of a size effect. The systemic risk of smaller banks increases after the issuance of covered bonds, while larger banks remain unaffected. The study does not support imposing uniform limits on covered bond issuance; rather such limits should be linked to the bank size. However, some regulatory framework is needed to limit banks' involvement in securitization.

Keywords: Securitization, Covered Bonds, European Banks, Systemic Risk, Bank Stability, Non-Linearity

1. Introduction

Asset-Backed Securities (ABS) — generated through the process of securitization — and Covered Bond (CB) remained widely used funding sources by European Banks. These two instruments are close counterparts but structurally different from each other. Traditionally, ABS issuance was considered having a benign impact on bank risk (Santomero and Trester, 1998; Cantor and Rouyer, 2000), but this view was tarnished after the Global Financial Crisis (GFC). Banks, reliant on ABS for funding, faced liquidity pressure to a point that transformed into a systemic crisis (Blommestein et al., 2011). However, CBs remained relatively resilient during the crisis. The investors' interest remained intact in this class of assets because of the *dual course*. Many new banks started issuing CBs to meet their funding needs.

Post-crisis regulations provide favorable treatment to CBs, but a stringent one to securitization[1], because of CBs' resilience and the collapse of securitization. Many market participants are of the view that such treatment may result in over-reliance on CBs (AFME, 2014; EBA, 2014b; GFMA,

[1]See Regulation (EU) No. 575/2013 (Capital Requirement Regulations (CRR)) Articles 129(5), 395, 400(1a), 416(2a), 509(3a), Credit Rating Agency (CRA) Regulations (EU) No. 462/2013 Article 8c (1), Liquidity Coverage Ratio (LCR) and the securitization frameworks of Basel III and the haircut regulations of European Central Bank (ECB).

2013), having severe implications for the banks' stability. Moreover, such a treatment is also undermining the efforts to revive the securitization market. As banks must actively manage the underlying pool of collateral in the case of CBs, therefore, they might not prove to be risk-free. An over-reliance on them may result in risk concentration in the banking system (Anand et al., 2012). The empirical analysis performed in this study is likely to provide a foundation to evaluate such regulations.

The literature studying the impact of securitization on bank risk can be divided into "securitization-stability" and "securitization-fragility" perspectives. Authors supporting the former perspective, argue that securitization helps to shed the risk out of the banking system, thereby improving the diversification (Santomero and Trester, 1998; Cantor and Rouyer, 2000; Jiangli and Pritsker, 2008). However, the proponents of latter perspective are of the view that securitization increases the risk appetite of banks that results in the generation of risky assets, thereby putting the bank stability at stake (Keys et al., 2010, 2012; Kara et al., 2019; Wu and Shen, 2019). While securitization has gained significant attention in the literature, the impact of CBs on banks' risk remains understudied.

This study makes a two-fold contribution to the literature. First, the study includes CBs in the analysis along with ABS [hereinafter collectively referred to as Securities and Bonds (SB)]. Both instruments share many similarities, making them a good candidate for comparison. Second, the study provides an alternative perspective that I call "securitization-scalability". I argue that instead of SB issuance per se, their respective volumes determine their implications on bank stability. The intended benefits of these funding sources might not be accessible either beyond or below a certain level. For these reasons, it is often argued that limits should be imposed on the issuance of these instruments, already implemented in some countries like Australia and Belgium in the case of CBs. To the best of my knowledge, this perspective is not presented in any other study.

To evaluate the link between SB issuance and systemic risk of banks, this study performs an extended analysis with data taken from 46 ABS and CB issuing listed banks from Europe between 2000-2014. The analysis focuses on variation in the relationship of SB with bank stability with respect to changes in the scale of their issuance. The study also analyzes the impact of size on the relationship between SB issuance and the systemic risk of banks. The analysis starts with a quadratic model and extends to a partially linear setting that uses the Generalised Additive Model (GAM).

Results show the presence of a U-Shaped relationship between ABS and systemic risk. The issuance of ABS initially helps banks control their systemic risk, but this relationship is reversed when banks continue issuing ABS. This is dubbed by some as 'securitization beyond limits', and by this study as "securitization-scalability". For covered bonds, initial estimations show that CBs do not have a relationship with systemic risk. However, some further analysis, while taking into account the size of banks, provides some interesting results. The small issuance of CBs leads to an increase in systemic risk, but large scale issuance of CBs decreases the systemic risk in the case of small banks. Whereas, bigger banks remain unaffected by the issuance of CBs. I attribute this relationship to bank size and jumbo CBs. These findings do not support the proposal of putting a uniform limit on CB issuance and argue for a framework that could control the limitless issuance of ABS.

The remainder of this paper is organized as follows. Section 2 provides a review of relevant literature. Section 3 discusses the theoretical underpinning of the model being tested here. Section 4 provides the empirical model to test the suggested relationship and explains the characteristics of the data including the sample details and descriptive statistics. Section 5 provides the empirical results of the model tested herein. This section provides results of the quadratic model and generalized additive specification of a partially linear model. Section 6 discusses the results and concludes.

2. Related Literature

2.1. Securitization and Bank Stability

Researchers have argued that securitizing banks follow an aggressive business strategy (Chen et al., 2017; Bakoush et al., 2019). They start issuing loans to subprime borrowers in the absence of prime borrowers, resulting in lax screening and lower lending standards (Keys et al., 2010, 2012; Kara et al., 2019). This situation threatens the stability of the banking system by creating imbalances in the credit markets, thereby increasing the fragility of the financial system (Altunbas et al., 2009). The stability implications are visible in the form of an increase in lending, a reduction in monitoring and screening efforts, and higher leverage (Keys et al., 2012).

Nijskens and Wagner (2011) find that some banks may become less risky because of securitization but they make a significant contribution to the systematic risk in the financial system for two main reasons. First, banks also take exposures in securities issued by other banks. Second, banks also buy Credit Default Swap (CDS) to protect themselves against undiversified positions and simultaneously sell CDS in the market to other banks. This ends up in a greater correlation between them. Hence, the risk is amplified in the financial system because of this high correlation resulting from the aggressive business model and race for risk transfer (Bostandzic and Weiß, 2018).

The effect of securitization on financial stability is an important question for regulators, who have introduced strict regulations for securitization focusing on a higher level of transparency in this process and eliminating the opaqueness as mentioned by (Buchanan, 2014). Securitization may motivate banks to take more risks — thereby putting the stability at stake (Gibson et al., 2014), especially in the long-run (Chen et al., 2017). However, the risk should not be viewed in an isolated manner for each institution. Securitization affects risk sharing between banks and the market.

2.2. Covered Bonds and Bank Stability

CBs are considered highly secured instruments for investors as they only face credit risk in the event of bankruptcy of the issuer (Adrian and Shin, 2009). Unlike the securities issued under the process of securitization, CBs do not have the pass-through nature. Investors do not incur any losses in case of a prepayment event against the assets held in the cover pool, as such assets are replaced by the issuer and the value of the cover pool remains intact. Thus, this prepayment risk is borne by CB issuers, those are accordingly exposed to thinner margins as losses may not be covered by the prepayment penalties (Poulain, 2003). These penalties vary from country to country and losses for the lenders may rise significantly in countries like France where these penalties are capped by the regulations[2].

Angelos (2015) has expressed his concern that CBs may increase market instability in times of stress because of the factors explained below:

1. If many investors decide to sell their CBs, banks (in their role of market-makers) must be able to respond and be ready to buy them. This situation may result in higher risk retention on the balance sheets of banks.
2. CBs may have higher funding liquidity because of the lower haircuts so banks can use them as collateral in the repo market. However, CBs are relatively less liquid because of their long-term maturity. Therefore, under strained market conditions, a large part of the liquidity buffer available in the form of CBs may become unusable.
3. The asset encumbrance does not allow the banks to deleverage when required by a financial crisis. This may result in restricting banks' activities and raising concerns among the investors about its financial health.

The large-scale issuance of CBs results in bigger cover pools, thereby leaving fewer assets for the unsecured creditors. As a result, they will demand higher risk premia as compensation for the elevated risk being taken by them (Haldane, 2012). These larger pools of ring-fenced assets might also result in more jittery creditors. The unsecured creditors may receive a noisy signal about the returns generated by the assets other than those ring-fenced and they may either decide to run or roll-over based on this signal (Gai, 2013). A panic may arise if many unsecured creditors decide to run. Hence, the large issuance of CBs may result in the creation of systemic risk for the issuing institutions. The ring-fencing of high-quality assets also increases the risk for taxpayers as they ultimately provide a guarantee to deposits (Nomura, 2015) through Deposit Guarantee Schemes (DGS). A proposed way to deal with the problems explained above is to impose limits on the level of CB issuance. However, ECBC (2013) opposes such limits and emphasizes the importance of increasing transparency in CB issuance.

3. Theoretical Underpinnings

Banks use SB to mitigate their funding and liquidity risks. They might help banks meet these objectives, resulting in a reduction in the systemic risk at an initial stage. The problem originates when banks increase their reliance on one instrument. In the case of ABS, it may result in three main effects. First, the bank's reliance on traditional liquid assets is decreased and securitization becomes a major source of liquidity generation. This creates concentration risk. Second, a liquidity glut is created, or in the words of Acharya and Naqvi (2012), banks are flushed with liquidity and they create new assets where some might have a higher risk. The third problem is linked with the

[2]The maximum prepayment penalty charged by a French bank should be a 6-month interest on the prepaid amount that should not exceed 3% of the outstanding balance.

second one. Banks heavily involved in the ABS issuance are not able to cut back the size of their balance sheets during a crisis. This is because of the generation of long-term assets that are financed by short-term liabilities. Consequently, the systemic risk of Financial Institutions (FIs) increases as a result of new risks taken (Shin, 2009). Hence, the problem might not be securitization per se, but the out of bounds securitization gives rise to the problems for banks.

In the case of CB issuance, the over-reliance also results in at least three problems. The first problem is analogous to securitization. A bank issuing CBs may face difficulties in deleveraging when it is needed, because of the high asset encumbrance. The assets that are already ring-fenced cannot be liquidated when a bank needs to deleverage. Second, a higher asset encumbrance, makes the balance sheet of a bank vulnerable to the market and economic shocks — mainly for two reasons: (i) high-quality assets are used for CB issuance and the remaining assets are riskier ones, (ii) the dynamic nature of the cover pool requires banks to replenish it in case of any deterioration. The susceptibility of unencumbered assets is increased at the time of economic shock. This situation leads to two potential effects: (i) the price of unsecured funding might increase because of the susceptibility of unencumbered assets (EBA, 2014a), and (ii) unsecured creditors might receive a signal at the time of an economic downturn that unencumbered assets will also be encumbered (Gai, 2013). They might decide to roll-over or run based on this signal. Third, CBs serve as a source of cheap funding for banks, but the issuance of large-scale CBs ties up a larger share of capital that may increase the funding cost. Hence, it is possible to argue that the potential costs of CB issuance may outweigh its benefits for the issuer after a certain stage. However, the European Covered Bond Council (ECBC) calls it a myth that an increase in CB issuance might lead to a higher asset encumbrance that may destabilize the system (ECBC, 2013).

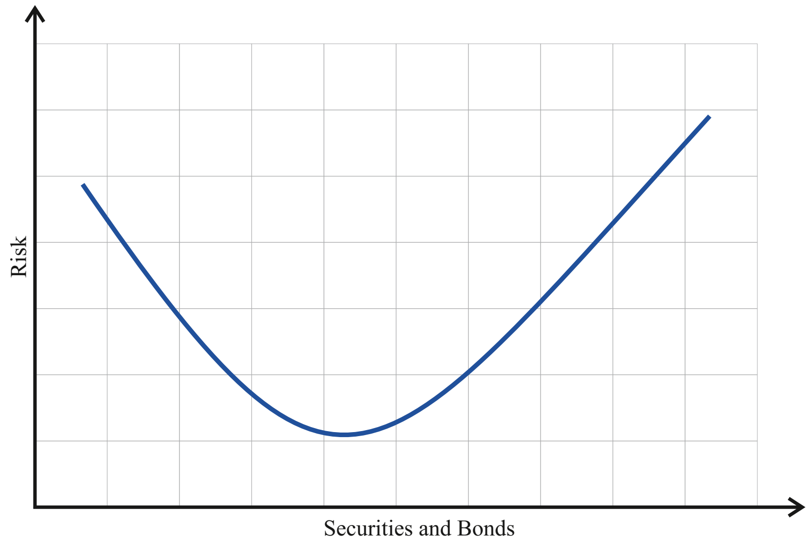
The above discussion explicates that the problem starts when a bank increases its focus on one particular funding source. Pacces (2010) is of the view that the problem in securitization is that it went beyond what financial markets could stand. I call it the "scalability" aspect of the securitization. The issuance of SB might initially help the banks reduce their systemic risk by providing multiple benefits related to liquidity, funding cost and risk transfer. However, the nature of this relationship may change when a bank increases its focus on one particular instrument. An increase in systemic risk beyond this level can be observable because of the problems explained above. Hence, the problem does not lie in securitization or CBs per se but in the way these instruments are used. A hypothetical graph of the relationship between SB and systemic risk is provided in Figure 1.

4. Research Methodology

4.1. Systemic Risk Measures

A good risk measure should account for the contribution of an FI to the aggregate risk, along with the stand-alone risk. Banks have been widely using Value at Risk (VaR) to measure their risk before the GFC. However, this measure does not account for the tail risk and the contribution of a financial institution to systemic risk. Many of the previous studies use the firm's stock Beta, by following Capital Asset Pricing Model (CAPM), as a measure of systemic risk (Battaglia et al., 2014; Nijskens and Wagner, 2011). However, Beta has several limitations as a measure of systemic

Figure 1: Hypothetical Relationship of Risk and SB



risk and it is often criticized for its lack of informativeness. Many other studies argued about using Conditional Value at Risk (CoVaR) as a measure of systemic risk, as it provides a better insight about the tail risk (Laeven et al., 2016; Trapp and Weiß, 2016). Other important measures of systemic risk include the Expected Shortfall (ES) and the Marginal Expected Shortfall (MES) of Acharya et al. (2010), as well as *SRISK* of Brownlees and Engle (2017).

4.1.1. Long Run Marginal Expected Shortfall (LRMES)

MES has been very popular among many researchers as a measure of systemic risk after the GFC (see e.g. Laeven et al., 2016; Bostandzic and Weiß, 2018). However, Acharya et al. (2012) express the concern that MES is a short-run indicator. They propose the use of Long-Run Marginal Expected Shortfall (LRMES). LRMES is measured as:

$$LRMES_{i,t} = E_t(R_{i,t+1:t+h} | R_{m,t+1:t+h} < C) \tag{1}$$

where $R_{i,t+1:t+h}$ is the multi-period return of bank i between period $t+1$ and $t+h$ and $R_{m,t+1:t+h} < C$ is the systemic event. The systemic event is defined as a decline in market return below a threshold C (that depicts a crisis) over a time horizon h. Following Acharya et al. (2012), a crisis scenario is considered when the index falls by 40% over the next six months. More specifically, C = 40% and h = 180 days.

According to Acharya et al. (2012), a crisis is a situation of under-capitalization of the financial system. Another definition of crisis, apart from the 40% criterion mentioned above, is given by:

$$E < \frac{k}{1-k} D \tag{2}$$

where E is the sum of all equities in the financial system, D is the cumulative book value of debt and k is the prudential capital fraction that is taken as 8%. $LRMES$ would be evaluated based on scenarios satisfying equation (2).

4.1.2. SRISK

SRISK gained significant attention in the recent literature (Laeven et al., 2016; Bostandzic and Weiß, 2018; Faia et al., 2019). *SRISK* follows a hybrid approach, as it combines the market-based (sophisticated) and accounting-based (simple) measures. *SRISK*, as shown in equation (3), can be defined as a function of bank size, its leverage and the expected devaluation in equity conditional on the market decline. Zhang et al. (2015) proved empirically that *SRISK* has a better ability to generate an early warning about the vulnerability of an FI to a systemic shock. It is defined as:

$$SRISK_{i,t} = W_{i,t}[kLVG_{it} - (1-k)LRMES_{i,t} - 1] \tag{3}$$

where $W_{i,t}$ is the market value of equity, k is the prudential capital fraction, $LVG_{i,t}$ is quasi-leverage (that shows the level of capitalization) and $LRMES_{i,t}$ is the Long-Run Marginal Expected Shortfall (that shows the expected loss in capital conditional on the market decline). LVG is measured as:

$$LVG_{i,t} = \frac{D_{i,t} + W_{i,t}}{W_{i,t}} \tag{4}$$

where $D_{i,t}$ is the book value of debt and $W_{i,t}$ is the market value of equity. The financial distress of the system with N banks operating in it can be measured as:

$$SRISK_t = \sum_{i=1}^{N} (SRISK_{i,t})+ \tag{5}$$

The plus sign in equation (5) shows that only positive values are taken to calculate the aggregate risk of the system that shows the amount of the capital required to bail-out the financial system conditional on the systemic shock. Brownlees and Engle (2017) recommend using a percentage version of *SRISK* to get greater insight, as it shows how much contribution is made by each bank to the aggregate risk. Acharya et al. (2012) have also argued that systemic risk should not be described in terms of an institution's failure, but of its overall contribution to system-wide risk. The percentage version of *SRISK* captures this contribution, measured as:

$$SRISK\%_{i,t} = \frac{SRISK_{i,t}}{SRISK_t} \; if \; SRISK_{i,t} > 0 \tag{6}$$

SRISK shows the EURO amount of the capital that a bank needs if the market index falls by 40% over six months. This measure captures the sensitivity of a bank to a decline in the market index. In what follows, I divide the *SRISK* by total assets of the bank. This normalization ensures that the results are not driven by the size of the bank, as large banks usually have a higher *SRISK*. Following Langfield and Pagano (2016), I label this variable as Systemic Risk Intensity (SRI).

4.2. Data and Sample

This study targets the European market as previous studies on securitization are mostly focused on the US market. The CB market in the US is in its nascent stages, whereas it has deep roots in Europe, especially in Germany, France, and Spain, and operates under well-defined regulations. This study focuses on the largest players in the ABS and CB markets i.e. Austria, France, Germany, Ireland, Italy, Netherlands, Portugal, and Spain.

The data come from multiple sources. A total of 1,041 securitization transactions from the ABS-Alert and 2,588 transactions of CBs are identified from the Bloomberg terminal and ECBC Label. Data for SB are available with respect to the date of the transaction and have been transformed into yearly data. Bank-level data, comprising of the information from the financial statements, are obtained from Bankscope (Bureau van Dijk). Data regarding *SRISK*, LRMES and market volatility is collected from V-lab maintained by the NY Stern Business School.[3] The data covers the period from 2000 to 2014. Non-listed banks and banks who never issued ABS or CBs during the sample period are excluded. Banks with missing information about total assets, loans, and net income are also excluded. These adjustments provide a final sample of 46 banks.

The study uses three measures of systemic risk: *SRISK*%, SRI (*SRISK* divided by total assets), and LRMES. To add robustness, the study also uses an accounting measure of bank soundness, i.e. the Z-Score as defined in section 5.4. The securitization and CB issuance are captured by ratios of ABS (ABS Ratio) or CBs (CB Ratio) issued during time t to total assets at time $t-1$.

4.2.1. Control Variables

A set of control variables is being considered to reduce the omitted-variable bias, consisting of bank-specific attributes. Details on these variables are provided in Table 1. The most important bank-specific variable affecting systemic risk is the size of a bank. Larger banks make a greater contribution to systemic risk (Wu and Shen, 2019) and they are also likely to issue more SB. Therefore, taking size as a control variable helps disentangle the size effect from the SB effect. Tier 1 Capital Ratio (T1Cap) is another important variable as large capital buffer helps banks stabilize (Trapp and Weiß, 2016). Securitization is criticized for deteriorating the loan quality. The variable of Loan Loss Provision (LLP) is taken as the proxy for the quality of the bank loan portfolio (Bostandzic and Weiß, 2018). Liquidity risk can be a slayer for a bank (Arif and Anees, 2012), so the ratio of liquid assets to total assets is taken as a measure of liquidity. Diversification may help a bank control volatility in interest income that makes it an important variable affecting bank stability (Bostandzic and Weiß, 2018; Chen et al., 2017). Volatility is taken as a measure of stand-alone bank risk (Laeven et al., 2016). Net Interest Margin (NIM) captures a bank's profitability (Bakoush et al., 2019; Wu and Shen, 2019), and non-interest income ratio is taken as a measure of bank efficiency (Chen et al., 2017). All ratio variables are winsorized at the 1% level to prevent the problem of any potential outliers.

[3]The values of ABS and *SRISK* were in US $ and converted to Euro by using the currency converter available at Statistical Data Warehouse of the ECB. http://sdw.ecb.europa.eu/curConverter.do

Table 1: Description of Variables

Variable	Description	Sources
SRISK%	This is the percentage version fo SRISK. The calculation is provided above.	V-Lab
SRI	Systemic Risk Intensity - SRISK normalized by the total assets of the bank	V-Lab, Author's Calculation
LRMES	Long Run Marginal Expected Short Fall	V-Lab
Z-Score	Modified Version of Altman Z-Score	Bankscope, Author's Calculation
ABSTA	Asset-Backed Securities issued during the time \$t\$ divided by Total Assets at \$t-1\$	AB-Alert, Bankscope, Author's Calculation
SABSTA	Square of ABSTA	Author's Calculation
CBTA	Covered Bonds issued during the time \$t\$ divided by Total Assets at \$t-1\$	Bloomberg, ECBC, Bankscope, Author's Calculation
SCBTA	Square of CBTA	Author's Calculation
Vol	Volatility of the Bank	V-Lab
T1Cap	Tier 1 Regulatory Capital Ratio	Bankscope
LLP	Loan Loss Provision	Bankscope
DTA	Deposits to Total Assets	Bankscope
Liq	Liquid Assets to Total Assets	Bankscope
Size	Natural Log of Total Assets	Bankscope, Author's Calculation
NIM	Net Interest Margin	Bankscope
Div.	Diversification Ratio - Non Interest Income to Total Operating Income	Bankscope
NIETA	Non-Interest Expense to Total Assets	Bankscope
FC	Financial Crisis Dummy, equal to 1 if year is between 2007-2009, 0 otherwise	-
SDC	Sovereign Debt Crisis Dummy, equal to 1 if year is between 2010-2012, 0 otherwise	-

4.3. Descriptive Analysis

Table 2 reports descriptive statistics and shows trends of ABS and CBs issuance and different risk levels in European countries. The maximum values of *SRISK%* show that most of the contribution to the overall systemic risk is made by certain big banks. The variance of ABS issuance is quite large but CB issuance does not exceed a certain level (9% in most cases). This is in line with the arguments stated earlier that the inherent limitations of CBs do not let banks issue CBs beyond a certain threshold. The table also shows that Italy, Netherlands, and Spain are market leaders in the European securitization market. Despite a high issuance of ABS, their banks are not found riskier than banks operating in other jurisdictions. Austrian banks have a minimal presence in the securitization market, but these banks are not found less risky than others. Banks in Portugal, Italy, Spain, and Germany have a high presence in the CBs market.

Table 2: Descriptive Statistics

Note: This table reports the results of country-wise descriptive statistics. The table reports mean, standard deviation, minimum and maximum values for all variables.

Country	stats	SRISK%	SRI	LRMES	Z-Score	ABSTA	CBTA	Vol.	T1Cap	LLP	DTA	Liq.	Size	NIM	NIETA	Div.
Austria	mean	32.92	3.59	34.39	35.74	0.18	0.69	36.73	37.78	9.03	52.32	15.85	10.16	2.14	1.82	33.78
	sd	36.15	2.84	21.68	35.23	0.00	0.77	17.22	33.02	2.19	6.11	6.61	1.38	0.75	0.66	7.38
	min	0.09	-5.55	5.15	-0.92	0.18	0.03	23.30	10.80	5.84	40.51	8.90	8.12	0.69	0.87	18.84
	max	100.00	7.48	68.28	137.50	0.18	2.98	84.80	173.70	14.08	62.17	33.02	12.27	4.31	3.82	43.82
Germany	mean	12.70	9.41	40.97	20.27	0.40	1.76	36.60	38.89	8.82	35.97	19.49	11.48	0.85	0.90	39.14
	sd	16.88	8.53	15.74	22.59	0.57	2.60	19.00	27.80	3.33	18.92	11.15	1.56	0.33	0.50	20.49
	min	0.48	2.84	9.17	-2.07	0.02	0.00	13.30	13.30	4.40	5.54	6.46	9.14	0.18	0.18	-7.50
	max	56.96	41.07	67.48	102.56	2.65	9.01	87.10	225.20	18.50	76.74	83.12	14.62	1.67	2.71	86.53
Spain	mean	17.66	1.35	38.72	18.57	4.83	1.89	41.58	42.37	9.14	50.90	15.31	11.35	2.00	1.89	38.83
	sd	22.52	4.52	13.22	12.51	4.07	1.78	17.92	41.45	1.74	18.27	18.71	1.54	0.80	1.40	17.72
	min	0.23	-10.90	1.96	-4.25	0.01	0.17	14.90	14.90	6.32	0.00	0.00	4.45	0.32	0.57	19.03
	max	89.87	8.53	62.38	55.01	17.44	9.07	115.10	447.40	13.00	93.33	84.62	14.05	4.20	8.88	93.08
France	mean	17.21	9.17	46.05	14.84	0.14	0.70	37.74	41.36	10.22	39.71	44.27	12.89	0.63	0.72	39.61
	sd	11.14	5.49	18.72	10.76	0.09	1.08	20.10	19.94	1.90	27.58	26.99	1.34	0.44	0.48	26.23
	min	1.31	-0.44	-32.61	-1.49	0.03	0.09	17.20	17.20	7.60	0.00	0.00	10.53	-0.49	0.00	-20.47
	max	34.28	24.34	70.38	43.56	0.35	4.70	106.70	106.70	13.70	93.33	84.62	14.55	1.49	1.51	79.93
Italy	mean	10.10	3.91	41.73	18.86	10.14	2.49	30.44	34.46	14.18	35.44	21.42	10.44	1.89	2.41	42.63
	sd	15.11	7.30	15.31	19.04	17.85	1.81	19.33	16.17	11.50	19.83	14.97	1.59	1.05	3.41	28.36
	min	0.08	-23.75	-2.74	-0.22	0.05	0.11	0.00	10.20	5.39	0.00	0.14	7.04	-0.61	0.08	-20.47
	max	70.48	30.20	74.64	95.93	82.55	6.63	98.30	98.30	67.64	73.36	57.34	13.86	5.07	26.27	147.38
Netherlands	mean	32.24	69.82	45.76	10.74	6.68	1.23	29.89	29.89	12.30	47.06	15.60	10.62	1.78	1.60	34.90
	sd	33.55	122.19	14.52	7.15	8.80	0.97	14.74	14.74	5.27	26.77	12.26	1.40	1.03	0.89	34.80
	min	0.19	-229.03	16.60	0.45	0.03	0.09	16.10	16.10	6.80	0.00	0.00	8.54	0.30	0.55	-20.47
	max	98.01	370.20	70.51	31.64	37.30	3.39	84.10	84.10	32.49	93.33	52.47	13.23	5.43	5.27	147.38
Portugal	mean	32.50	2.65	29.45	10.57	3.11	2.74	32.53	33.05	8.42	47.41	13.18	10.42	1.84	1.88	40.90
	sd	20.83	3.59	14.05	5.90	2.64	2.00	20.73	23.07	2.40	7.19	5.22	0.94	0.44	0.40	7.84
	min	4.17	-6.72	8.94	-0.32	0.51	0.57	12.10	12.10	5.45	29.97	6.01	8.33	0.87	0.54	25.19
	max	100.00	7.51	65.93	21.38	10.15	6.34	115.10	142.40	16.20	65.78	31.87	11.50	2.76	2.79	58.65
Total	mean	18.71	10.31	39.89	18.89	5.45	1.77	34.78	37.19	11.20	42.38	19.81	10.94	1.66	1.75	39.82
	sd	23.48	40.97	16.31	20.03	10.54	1.93	19.10	27.81	7.75	21.03	17.17	1.65	0.95	2.06	23.95
	min	0.08	-229.03	-32.61	-4.25	0.01	0.00	0.00	10.20	4.40	0.00	0.00	4.45	-0.61	0.00	-20.47
	max	100.00	370.20	74.64	137.50	82.55	9.07	115.10	447.40	67.64	93.33	84.62	14.62	5.43	26.27	147.38

4.4. Empirical Model

This study is aimed at identifying the relationship between SB issuance and bank stability and focuses on two instruments i.e. ABS and CBs, and investigates the possible non-linearity in the target relationship. The idea is that the relationship may vary with the level of involvement of a bank in the issuance of these instruments. I start the analysis with the estimation of a simple polynomial (quadratic) model, given by:

$$y_{i,t+1} = \alpha + \beta_1 z_{i,t} + \beta_2 z_{i,t}^2 + \sum \gamma X_{i,t} + \varepsilon_{i,t} \tag{7}$$

where $y_{i,t+1}$ denotes the measure of systemic risk for bank i at time $t+1$, z_{it} is the ratio of ABS (ABS Ratio) or CBs (CB Ratio) during time t to total assets at time $t-1$, z_{it}^2 is the square of this ratio and $X_{i,t}$ represents a $K \times 1$ vector of additional controls. ε_{it} is the error term and α, β_1, β_2, and γ are the parameters to be estimated.

The systemic risk of a bank varies with the issuance of ABS and CBs if $\beta_1 \neq \beta_2$. The vertex of this quadratic function can be estimated using:

$$v = \frac{-\beta_1}{2 * \beta_2} \tag{8}$$

The model given in Equation (7) is fitted to the data using the Fixed Effect (FE) estimator. Heteroskedasticity is addressed by clustering the standard errors at the bank level. The Modified Wald test for the group-wise heteroskedasticity rejects the null hypothesis of homoskedasticity ($p < 0.01$). Driscoll-Kraay standard errors method is also applied and the associated results remain consistent with earlier estimations. Moreover, the multi-way clustering method of Cameron et al. (2011) is also used and standard errors are clustered at the bank and time level. However, results are found consistent with earlier estimations. The Sargan-Hansen test is used to check whether FEs should be preferred to the Random Effects (REs) as the standard Hausman test is not suitable for models with clustered standard errors. This test is also known as the generalized Hausman test (Arellano, 1993). The null hypothesis that the regressors are uncorrelated with individual-specific errors is rejected here ($p < 0.01$),[4] thereby supporting the use of FEs.

In addition to FE estimations, the Tobit model for panel data is applied, following Brownlees and Engle (2017). Bank fixed effects are included separately in these estimations. The Tobit model is relevant in this case as *SRISK* is not always positive and non-positive values of *SRISK* do not contribute to the systemic risk, I truncate *SRISK*% and SRI at 0. The Tobit model is given by:

$$y_{i,t+1}^* = \alpha + \beta_1 z_{i,t} + \beta_2 z_{i,t}^2 + \sum \gamma X_{i,t} + \varepsilon_{i,t} \tag{9}$$

$$y_{i,t+1}^* = y_{i,t+1} \text{ if } y > 0,\ y_{i,t+1}^* = 0 \text{ if } y < 0$$

[4] $E(X_{it} * u_i \neq 0)$

After estimating the quadratic model, I extend the analysis to a non-parametric approach. Non-parametric methods are consistent under less restrictive assumptions than parametric estimators. However, a fully non-parametric approach has limited applicability because of the curse of dimensionality. A possible way to deal with this problem is the partially linear model, given by:

$$y_{i,t+1} = \Theta(z_{i,t}) + \gamma X_{i,t} + \varepsilon_{i,t} + \text{Net Income} \tag{10}$$

The vector of controls $X_{i,t}$ appears in a linear specification, but $z_{i,t}$ enters through an unknown smooth function $\Theta(.)$. The partially linear model is being estimated here using the Generalised Additive Model (GAM). GAM provides a framework to extends the standard linear model through the non-linear functions of each variable, but it maintains the additivity. A linear model can be extended as follows:

$$y_i = \beta_0 + \beta_1 z_{i1} + \beta_2 z_{i2} ..... + +\beta_q z_{iq} + \varepsilon_i \tag{11}$$

Each linear function $\beta_j z_{ij}$ in Equation (11) with a smooth non-linear function $f_j(z_{ij})$ to allow for the non-linear relationship between each feature and response. The model is rewritten as:

$$y_i = \beta_0 + \sum_{j=1}^{q} f_j(z_{ij}) + \varepsilon_i \tag{12}$$

It is called an additive model because a separate f_j is calculated for each Z_j and then added together. The estimation of Θ, given in equation (10), through GAM is done by choosing a basis function that is treated as a known function. If $b_i(x)$ is the i^{th} basis function, then Θ can be represented as:

$$\Theta(z_{i,t}) = \sum_{i=1}^{q} b_i(z_{i,t})\beta \tag{13}$$

where β is a vector of unknown parameters. Equation (13) can be changed to equation (10) as:

$$y_{i,t+1} = \sum_{i=1}^{q} b_i(z_{i,t})\beta + \gamma X_{i,t} + \varepsilon_{i,t} \tag{14}$$

5. Results and Discussion

This section presents the empirical results of various tests including the findings of the robustness checks.

5.1. Estimation of the Quadratic Model

The quadratic model is fitted separately for ABS and CBs. Results are reported for ABS and CBs in Tables 3 and 5 respectively. Table 3 reports the results of FE with robust standard errors for ABS. The coefficients of the ABS ratio in models 1 and 2 are negative and significant, suggesting a negative relationship between ABS Ratio and LRMES. The square term of the ABS ratio is positive and significant in models 1 and 2. These results suggest that the issuance of ABS initially helps bank control their systemic risk, but this relationship is reversed when the bank increases its ABS issuance. These results may suggest that the relationship of ABS with the systemic risk of banks does not follow a linear trend but changes with the scale of ABS issuance. These results endorse the "scalability-view" about securitization, presented earlier in this paper. These coefficients are not significant here for SRI and *SRISK*%. The estimated vertex of model 1 and model 2 are slightly different but it remains within the range in both models, suggesting the presence of a U-Shaped relationship of ABS Ratio with LRMES.

Among the control variables, volatility has a significant and positive relationship with measures of systemic risk, suggesting that the stand-alone risk of a bank increases the systemic risk (Laeven et al., 2016). Tier 1 Regulatory Capital Ratio shows a negative relationship with SRI and SRISK% from model 4 to 6. LLP has a positive impact on measures of systemic risk. This suggests that banks with a poor quality of loans might have higher systemic risk (Bostandzic and Weiß, 2018; Bakoush et al., 2019). Liquidity shows a negative and significant coefficient for LRMES. These findings may suggest that liquid banks are less likely to face a greater amount of systemic risk (Anderson, 2019). Size has a significant and positive relationship with LRMES and SRI, highlighting that larger banks have greater exposure to the risk (Trapp and Weiß, 2016; Chen et al., 2017). NIM has significant and negative coefficients in models 3 and 4, suggesting that profitability might help bank control their systemic risk.

The estimation of models 2, 4 and 6 allows investigating if the results differ when the GFC and the SDC are taken into account. The inclusion of these two important events helps evaluate whether a crisis decreases the systemic risk or otherwise. A possible decrease can be ascribed to the increase in awareness about the risk implied in various funding instruments. However, the risk might also increase as it might become harder to manage during turbulent times. Table 3 provides some interesting results. The GFC and the SDC have positive coefficients for LRMES and SRI. The coefficients of SDC remain significant in both models 2 and 4. Models 2 and 4 in Table 3 also show a greater impact of the SDC on the systemic risk of banks as compared to the GFC. These positive coefficients point towards the increase in the systemic risk during the crisis.

The coefficient of both crises becomes negative in the case of *SRISK*%. As explained earlier, the *SRISK*% shows the contribution of each bank to the overall systemic risk and the descriptive statistics reported in Table 2 show that most of the contribution to the overall systemic risk is made by a few large banks. These results suggest that on the one hand awareness among big banks about the risk involved in various funding instruments increases, and on the other, the risk is more evenly distributed on the market as other banks are also hit by the crisis.

The results of Tobit estimation for ABS are reported in Table 4. A similar relationship between ABS and systemic risk is observed for SRI and *SRISK*% as observed for LRMES in Table 3. The ABS Ratio has a negative and significant coefficient for both risk measures, while the Square of the ABS Ratio has a positive and significant coefficient in all models. These results again suggest the presence of a U-shaped relationship between ABS and the systemic risk of banks as shown in Figure 1. The coefficients of the control variables are not very different from the earlier estimations

Table 3: Asset-Backed Securities and Systemic Risk - Fixed Effect Estimations

Note: This table provides the results of the quadratic model estimation for ABS and Systemic Risk Measures through Fixed Effects. All standard errors are heteroskedasticity consistent and are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and the SDC, while other model does not include them. All standard errors are clustered for banks.

	(1)	(2)	(3)	(4)	(5)	(6)
	$LRMES_{it+1}$	$LRMES_{it+1}$	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
ABS Ratio	-1.594***	-1.245***	-0.420	-0.192	-0.693	-1.003
	(0.460)	(0.408)	(0.325)	(0.281)	(0.624)	(0.602)
ABS Square Ratio	0.0892***	0.0773***	0.00124	-0.00469	0.0379	0.0458
	(0.0254)	(0.0223)	(0.0188)	(0.0158)	(0.0371)	(0.0361)
Volatility	0.123***	0.101***	0.0434***	0.0158*	0.0193	0.0580**
	(0.0346)	(0.0331)	(0.0115)	(0.00789)	(0.0292)	(0.0257)
Tier 1 Capital Ratio	0.284	0.0825	-0.0516	-0.153**	-0.473**	-0.337*
	(0.184)	(0.148)	(0.0578)	(0.0641)	(0.208)	(0.186)
Loan Loss Provision	1.304*	0.803	0.593**	0.479**	-0.230	-0.0933
	(0.756)	(0.557)	(0.239)	(0.198)	(1.162)	(1.111)
Deposit to Total Assets	0.116	0.0573	0.00618	-0.0186	-0.0110	0.0216
	(0.0757)	(0.0618)	(0.0174)	(0.0159)	(0.0693)	(0.0861)
Liquid Assets to Total Assets	-0.152**	-0.152***	-0.00491	-0.00716	0.0980	0.101
	(0.0731)	(0.0504)	(0.0292)	(0.0317)	(0.0786)	(0.0854)
Size	9.429***	5.559**	2.819***	-0.221	2.114	6.292
	(2.280)	(2.349)	(0.688)	(0.509)	(4.796)	(5.037)
Net Interest Margin	-0.489	-0.274	-1.737**	-1.773**	-5.485	-5.422
	(2.184)	(2.064)	(0.736)	(0.709)	(3.683)	(3.477)
Diversification Ratio	-5.892***	-5.240***	-1.670**	-1.054*	4.742	3.888
	(2.091)	(1.609)	(0.707)	(0.567)	(4.012)	(3.122)
Non-Interest Expense Ratio	0.00950	0.00856	0.00644	0.00793	-0.00355	-0.00576
	(0.0107)	(0.0120)	(0.00782)	(0.00798)	(0.0202)	(0.0190)
Financial Crisis		3.146*		4.179***		-5.863*
		(1.827)		(0.695)		(3.064)
Sovereign Debt Crisis		7.924***		4.897***		-6.637*
		(2.430)		(0.832)		(3.795)
Constant	-64.78**	-20.38	-18.22**	15.61**	-3.300	-49.72
	(29.17)	(27.88)	(8.448)	(6.772)	(59.74)	(60.31)
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
No. of Observations	381	381	381	381	381	381
R-squared	0.497	0.526	0.493	0.544	0.075	0.090
Vertex	8.935%	8.05%	-	-	-	-

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$

through FEs. Vertex has been computed for the quadratic relationship here that ranges between 8 to 11% in all models.

Table 5 reports the FE estimation of the quadratic model for CBs. The CB Ratio and square

Table 4: Asset-Backed Securities and Systemic Risk - Tobit Estimations

Note: This table provides the results of the quadratic model estimation for ABS and Systemic Risk Measures through Tobit. Bank effects are included in the estimations. Standard errors are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and the SDC, while other model does not include them.

	(1)	(2)	(3)	(4)
	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
ABS Ratio	-1.038***	-0.462*	-1.610**	-1.740***
	(0.281)	(0.239)	(0.669)	(0.670)
ABS Square Ratio	0.0488***	0.0213	0.0911**	0.0933**
	(0.0185)	(0.0146)	(0.0460)	(0.0458)
Volatility	0.429***	0.169**	0.0452	0.0629
	(0.0866)	(0.0670)	(0.0436)	(0.0457)
Tier 1 Capital Ratio	-0.227	-0.351*	-0.712***	-0.625***
	(0.171)	(0.182)	(0.186)	(0.195)
Loan Loss Provision	4.014**	3.007*	-0.0821	0.0317
	(1.711)	(1.591)	(1.091)	(1.098)
Deposit to Total Assets	-0.0173	-0.104*	-0.0183	0.00151
	(0.0486)	(0.0551)	(0.0865)	(0.0878)
Liquid Assets to Total Assets	0.103	0.0375	0.119	0.120
	(0.0749)	(0.0699)	(0.0873)	(0.0866)
Size	3.368**	-1.360	4.373**	6.592**
	(1.703)	(1.409)	(2.166)	(2.646)
Net Interest Margin	-2.196	-1.174	-8.746***	-8.618***
	(1.497)	(1.245)	(1.971)	(1.963)
Diversification Ratio	-2.063	-1.254	3.942*	3.444
	(1.795)	(1.397)	(2.297)	(2.307)
Non-Interest Expense Ratio	0.0561	0.0155	-0.00242	-0.00239
	(0.0484)	(0.0422)	(0.0375)	(0.0372)
Financial Crisis		10.91***		-2.863
		(2.241)		(2.351)
Sovereign Debt Crisis		20.43		-3.690
		(1074.5)		(2.560)
Constant	-29.51	34.67	38.17	11.52
	(1400.5)	(1865.1)	(29.14)	(34.30)
Bank Fixed Effects	Yes	Yes	Yes	Yes
No. of Observations	381	381	381	381
AIC	439.6	397.1	2597.1	2599.0
Log-likelihood	-172.8	-149.6	-1250.5	-1249.5
Vertex	10.635%	10.845%	8.836%	9.325%

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

of CB Ratio have insignificant coefficients here. These results do not support the idea that CBs help banks control their risk or increase it. The coefficients of most of the other control variables are similar to earlier estimations for ABS. Volatility has a significant and positive relationship with

Table 5: Covered Bonds and Systemic Risk - Fixed Effect Estimations

Note: This table provides the results of the quadratic model estimation for CBs and Systemic Risk Measures through Fixed Effects. All standard errors are heteroskedasticity consistent and are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and the SDC, while other model does not include them. All standard errors are clustered for banks.

	(1)	(2)	(3)	(4)	(5)	(6)
	LRMES_{it+1}	LRMES_{it+1}	SRI_{it+1}	$\text{SRI\_}it+1$	$\text{SRISK\%}_{it+1}$	$\text{SRISK\%}_{it+1}$
CB Ratio	1.751	1.377	0.141	0.216	-2.009	-2.123
	(1.117)	(1.078)	(0.273)	(0.271)	(1.574)	(1.637)
CB Sqaure Ratio	-0.135	-0.0978	-0.0120	-0.0274	0.292	0.316
	(0.155)	(0.153)	(0.0414)	(0.0392)	(0.241)	(0.254)
Volatility	0.105***	0.0772**	0.0380***	0.0157**	0.00647	0.0441
	(0.0348)	(0.0356)	(0.00933)	(0.00689)	(0.0309)	(0.0298)
Tier 1 Capital Ratio	0.314	0.265	-0.0140	-0.0200	-0.369	-0.357
	(0.216)	(0.209)	(0.0602)	(0.0600)	(0.231)	(0.233)
Loan Loss Provision	2.275**	2.206**	0.516*	0.596**	0.475	0.345
	(0.968)	(0.934)	(0.258)	(0.291)	(1.337)	(1.345)
Deposit to Total Assets	0.137	0.126	0.000504	0.00558	-0.0427	-0.0509
	(0.0840)	(0.0860)	(0.0200)	(0.0187)	(0.0933)	(0.0975)
Liquidity Ratio	-0.201*	-0.198**	-0.00177	0.000535	0.0658	0.0619
	(0.101)	(0.0929)	(0.0230)	(0.0224)	(0.116)	(0.115)
Size	8.524***	6.208**	3.067***	1.643**	2.694	5.108
	(2.312)	(2.393)	(0.746)	(0.664)	(4.720)	(4.852)
Net Interest Margin	-0.996	-1.644	-1.278*	-1.756**	-6.068	-5.260
	(2.103)	(2.063)	(0.717)	(0.706)	(3.961)	(3.797)
Diversification Ratio	-4.477	-3.139	-2.135***	-1.207**	6.197	4.629
	(2.866)	(2.637)	(0.652)	(0.557)	(4.273)	(3.858)
Non Interest Expense Ratio	-0.0103	-0.0161	0.0192	0.0145	-0.00989	-0.00199
	(0.0287)	(0.0272)	(0.0139)	(0.0115)	(0.0242)	(0.0232)
Financial Crisis		2.335*		2.365***		-3.971**
		(1.273)		(0.429)		(1.529)
Sovereign Debt Crisis		5.106***		2.238***		-3.831**
		(1.483)		(0.461)		(1.472)
Constant	-58.50*	-32.62	-27.17***	-11.94	-9.886	-35.74
	(30.50)	(30.65)	(8.810)	(7.899)	(57.77)	(58.63)
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Observations	389	389	389	389	389	389
R-squared	0.482	0.503	0.489	0.544	0.072	0.086

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$

LRMES and SRI. This is in line with earlier results that banks having high stock volatility face a higher systemic risk. Size and LLP have a consistently positive relationship with LRMES and SRI. Diversification also shows a negative relationship with SRI. The GFC and the SDC also have a significant impact on the systemic risk of banks.

Table 6: Covered Bonds and Systemic Risk - Tobit Estimations

Note: This table provides the results of the quadratic model estimation for CBs and Systemic Risk Measures through Tobit. Bank effects are included in the estimations. Standard errors are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and the SDC, while other model does not include them.

	(1)	(2)	(3)	(4)
	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
CB Ratio	0.0752	0.132	-2.295	-2.317
	(0.227)	(0.217)	(1.436)	(1.464)
CB Sqaure Ratio	-0.00826	-0.0210	0.338	0.349
	(0.0365)	(0.0345)	(0.230)	(0.233)
Volatility	0.0292***	0.0103	0.0260	0.0497
	(0.00681)	(0.00686)	(0.0429)	(0.0461)
Tier 1 Capital Ratio	0.0321	0.0322	-0.555***	-0.544***
	(0.0338)	(0.0315)	(0.210)	(0.211)
Loan Loss Provision	0.532***	0.594***	0.794	0.717
	(0.184)	(0.173)	(1.162)	(1.165)
Deposit to Total Assets	0.000729	0.00542	-0.0852	-0.0893
	(0.0155)	(0.0145)	(0.0976)	(0.0978)
Liquidity Ratio	-0.00895	-0.00799	0.0716	0.0695
	(0.0149)	(0.0139)	(0.0939)	(0.0934)
Size	2.741***	1.443***	5.520**	7.115***
	(0.356)	(0.373)	(2.222)	(2.485)
Net Interest Margin	-0.568*	-0.973***	-8.085***	-7.497***
	(0.331)	(0.314)	(2.094)	(2.123)
Diversification Ratio	-2.008***	-1.157***	4.990*	3.931
	(0.416)	(0.403)	(2.599)	(2.695)
Non Interest Expense Ratio	0.0154**	0.0116*	0.00243	0.00677
	(0.00724)	(0.00678)	(0.0459)	(0.0458)
Financial Crisis		1.997***		-2.497
		(0.296)		(1.991)
Sovereign Debt Crisis		1.924***		-2.651
		(0.310)		(2.089)
Constant	-20.85***	-11.46***	-29.67	-41.40*
	(3.598)	(3.578)	(22.61)	(24.00)
Bank Fixed Effect	Yes	Yes	Yes	Yes
Observations	389	389	390	390
AIC	1529.6	1483.4	2746.5	2748.5
Log-likelihood	-714.8	-689.7	-1323.2	-1322.2

*p < 0.1, **p < 0.05, ***p < 0.01

Table 6 reports the results of Tobit estimations for CBs. The coefficients of the CB ratio and square of the CB ratio are insignificant in all models. A situation similar to the one reported for CB in Table 6 is visible for SRI and SRISK%. These results suggest that CBs might not effect the systemic risk of banks. Hence, the concerns about asset encumbrance resulting from CB issuance are not supported by these results.

5.2. *The Partially Linear Model*

The partially linear model specified in Equation (10) is estimated using the GAM approach. The main advantage of GAM is that it allows fitting non-linear functions to different variables and multiple transformations on these variables are not required. This non-linear fit obtained through GAM can provide accurate predictions for y, that are impossible for a linear model. Because of the additive nature of this method, it is possible to evaluate the impact of each variable individually on y while holding all the other variables fixed (James et al., 2013).

Since this study investigates if the risk level of a bank varies with the level of ABS and CB issuance, the variables of ABS Ratio and CB ratio enter the model with a non-linear setting, while control variables enter linearly. Table 7 reports the results of the parametric part of GAM estimations for ABS and systemic risk. Most of the R-Square values reported here are higher than the ones reported in Table 3. This shows that the partially linear model provides a better fit compared to FE estimations. This table reports the coefficients of the parametric part of the model. The coefficients of the control variables reported in Table 7 are not very different from the ones reported in Table 3. Volatility, LLP, liquidity, size, NIM and diversification ratio are found to significantly affect the systemic risk of the bank.

The graphical representation of the relationship between ABS and the systemic risk measures is presented in Figure 2. The solid line shows the pattern of the relationship between ABS and the relevant risk measure. The dotted lines here represent confidence intervals. The significance of the relationship can be determined based on the distance of dotted lines from the solid line showing the relationship. Figures 2a and 2b show that the issuance of ABS first helps banks reduce their LRMES. However, this relationship is reversed at one point and further issuance of ABS leads to an increase in the bank's LRMES. Models 3 and 4 in figures 2c and 2d show that the slope of the relationship between SRIand ABS swiftly changes after a certain level and keeps on increasing afterward. However, no change in the relationship is observable in models 5 and 6. These results reinforce the initial findings of FE and Tobit estimations, reported in Tables 3 and 4.[5]

Table 8 reports the results of GAM estimation for CBs. This Table shows that the effects of control variables are consistent with Table 5. The results of the non-parametric part are reported in Figure 3. The results for CBs are mixed here across various models. Figures 3a and 3b show that the issuance of CBs leads to a consistent increase in the system risk. However, confidence intervals go on increasing here. Model 3 and 4 in Figures 3c and 3d show that CBs have a positive relationship with SRI in the beginning but this relationship becomes negative when a bank increases the issuance of CBs. The effect of CBs remains insignificant for $SRISK\%$ in models 5 and 6, as shown in Figures 3e and 3f.

[5]The estimates of coefficients for the non-parametric part are available upon request.

Table 7: Asset-Backed Securities and Systemic Risk — Generalized Additive Model

Note: This table provides the results of GAM estimations for ABS and Systemic Risk Measures. Individual bank effects are included in the estimations. Standard errors are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and the SDC, while other model does not include them.

	(1)	(2)	(3)	(4)	(5)	(6)
	$LRMES_{it+1}$	$LRMES_{it+1}$	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
Volatility	0.125***	0.104***	0.027	-0.011	0.022	0.058
	-0.03	-0.031	-0.03	-0.031	-0.042	-0.044
Tier 1 Capital Ratio	0.276**	0.071	0.2	0.099	-0.466***	-0.348*
	-0.126	-0.128	-0.124	-0.128	-0.172	-0.18
Loan Loss Provision	1.339*	0.816	-0.004	-0.043	-0.07	0.005
	-0.757	-0.74	-0.743	-0.74	-1.032	-1.04
Deposit to Total Assets	0.120**	0.062	0.034	0.013	-0.008	0.019
	-0.058	-0.057	-0.057	-0.057	-0.079	-0.08
Liquidity Ratio	-0.161***	-0.160***	-0.015	-0.018	0.094	0.098
	-0.059	-0.057	-0.059	-0.058	-0.081	-0.081
Size	9.355***	5.506***	2.903**	-0.764	1.896	5.766**
	-1.466	-1.731	-1.445	-1.738	-2.013	-2.43
Net Interest Margin	-0.362	-0.223	-2.629**	-2.782**	-5.564***	-5.400***
	-1.292	-1.251	-1.279	-1.258	-1.774	-1.761
Diversification Ratio	-5.965***	-5.320***	-0.476	0.325	4.735**	3.919*
	-1.565	-1.526	-1.543	-1.53	-2.148	-2.149
Non Interest Expense Ratio	0.006	0.003	-0.033	-0.031	-0.002	-0.002
	-0.026	-0.025	-0.026	-0.026	-0.036	-0.035
Financial Crisis		2.994*		5.728***		-5.459**
		-1.54		-1.561		-2.155
Sovereign Debt Crisis		7.993***		5.388***		-6.083***
		-1.676		-1.687		-2.339
Constant	-18.669***	-10.471	-10.420	-10.465	-36.909***	-43.534***
	(7.021)	(6.837)	(19.594)	(19.965)	(9.461)	(9.542)
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
edf s(ABS Ratio)	2.113**	2.48 ***	2.338***	2.349***	7.561**	7.684**
No. of Observations	381	381	381	381	381	381
Deviance Explained	70.8%	73%	96.6%	97.1%	75.5%	76.2%
R-Square (Adj.)	0.668	0.69	0.965	0.967	0.723	0.729

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$,

5.3. Further Findings For Size Effects

The results reported in Figure 3 may highlight another perspective of CBs that can be linked with bigger banks. Investors might be more interested in jumbo CBs[6] that are issued in a larger size.

[6]The minimum size of an issue of jumbo CBs is €1 bn. There is a requirement of minimum three market makers. These bonds are more liquid than other CBs (Prokopczuk et al., 2013).

Table 8: Covered Bonds and Systemic Risk — Generalized Additive Model

Note: This table provides the results of the GAM for CBs and Systemic Risk Measures. Bank effects were included in the estimations. Standard errors are reported in parenthesis. Two models are estimated for each risk measure. One model includes the dummies for GFC and SDC, while other model does not include these dummies.

	(1)	(2)	(3)	(4)	(5)	(6)
	$LRMES_{it+1}$	$LRMES_{it+1}$	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
Volatility	0.103***	0.074**	0.038***	0.013	0.009	0.044
	-0.03	-0.031	-0.009	-0.009	-0.042	-0.045
Tier 1 Capital Ratio	0.324**	0.151	-0.007	-0.097**	-0.383*	-0.29
	-0.142	-0.143	-0.043	-0.039	-0.2	-0.206
Loan Loss Provision	2.556***	1.910**	0.530**	0.291	0.489	0.699
	-0.812	-0.803	-0.249	-0.222	-1.144	-1.156
Deposit to Total Assets	0.116*	0.051	0.001	-0.026	-0.044	-0.02
	-0.067	-0.067	-0.021	-0.018	-0.094	-0.096
Liquidity Ratio	-0.235***	-0.210***	-0.003	0.012	0.065	0.049
	-0.064	-0.063	-0.02	-0.017	-0.09	-0.09
Size	8.507***	3.573**	3.092***	-0.01	2.677	6.466**
	-1.509	-1.822	-0.463	-0.506	-2.12	-2.61
Net Interest Margin	-0.987	-1.743	-1.317***	-1.885***	-6.161***	-5.309***
	-1.406	-1.384	-0.43	-0.382	-1.975	-1.991
Diversification Ratio	-4.489**	-1.848	-2.163***	-0.381	6.375**	4.139
	-1.788	-1.84	-0.55	-0.511	-2.505	-2.643
Non-Interest Expense Ratio	-0.001	-0.005	0.020**	0.014*	-0.012	-0.004
	-0.032	-0.031	-0.01	-0.009	-0.044	-0.044
Financial Crisis		5.389***		4.247***		-5.737**
		-1.617		-0.448		-2.324
Sovereign Debt Crisis		9.067***		4.843***		-5.901**
		-1.834		-0.503		-2.655
Constant	-60.151***	-15.376	3.615	31.352***	-19.057	-52.933**
	-15.488	-17.893	-4.758	-4.968	-21.742	-25.637
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
edf s(CB Ratio)	2.91	6.111	0.00	1.448e-09	0.1141	1.414
No. of Observations	389	389	389	389	389	389
Deviance Explained	75%	76.6%	85.1%	88.7%	74.5%	74.9%
R-Square (Adj.)	0.715	0.733	0.831	0.871	0.708	0.712

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$,

Non-jumbo CBs may not enjoy the same market liquidity. Therefore, the issuance of non-jumbo bonds may not provide the intended benefits to banks. Jumbo covered bonds can only be issued by larger banks because of their size.

I have performed some further analysis to test for the potential bank size effects on the relationship of ABS and CBs with the systemic risk. Two dummy variables are generated for the size variable named as 'dsize75a' and 'dsize75b'. The variable 'dsize75a' is equal to 1 if bank size is above 75^th percentile and 0 otherwise. The variable 'dsize75b' is equal to 1 if bank size is below 75^th percentile and 0 otherwise. Interaction terms of these dummy variables were generated with the ABS Ratio and the CB Ratio. These interaction terms were replaced with the ABS Ratio and the CB Ratio in the model given in equation (7). A quadratic model is tested through FE estimations with these interaction terms.

The effect of ABS was found similar in the case of bigger or smaller banks and no notable differences were found in these estimations. These results suggest that ABS has a uniform effect across various classes of banks with respect to their size. However, some differences were seen in the case of CBs for smaller banks. Results of the quadratic model are reported in Table 9 for banks falling above the 75^th percentile and Table 10 for banks falling below the 75^th percentile. Results reported in Table 9 are similar to earlier estimations. However, Table 10 provides some interesting results. The coefficient of the CB Ratio is positive and significant here. This suggests that the small issuance of CBs increases bank risk. However, Square of the CB Ratio has a negative and significant coefficient here for the smaller banks in models 1 and 2. The coefficients of CB Ratio and Square of the CB ratio are not significant for the bigger banks. A possible explanation of these results is that smaller banks are not able to reap the benefits of the CB market with small issuance of these bonds, as investors might be concerned about their ability to deal with the problem of asset encumbrance. However, these concerns can be addressed when these banks enter into the jumbo CBs transactions, as these bonds are issued as part of a syndicate and investors might be less concerned about the individual bank's ability to deal with the problem of asset encumbrance. The analysis with these interaction terms was also performed through GAM and Tobit and qualitatively similar results were found.

5.4. Robustness Check

After the quadratic model estimations and the GAM, further robustness checks were performed using an accounting measure of bank stability i.e. the modified version of the Altman Z-score. The Z-score reflects a bank's distance to default and it is measured as:

$$Z_{it} = \frac{\mu_{it} + k_{it}}{\sigma_{it}} \tag{15}$$

where μ is the Return on Average Assets before Taxes (*ROAA*), k is the ratio equity capital to total assets and σ is the standard deviation of *ROAA*. Thus, the value of the *Z*-score is determined by the level of capitalization and the stability of a bank's profitability. The denominator is the standard deviation of the bank's profitability and the numerator includes the bank-level capital. Therefore, the Z-Score shows how much capital is available to a bank to bear the shock of earnings volatility. In other words, how many standard deviations are required to deplete the equity of a bank? Therefore, a higher (lower) value of the *Z*-score shows a higher (lower) stability of the bank and a lower(higher) probability of default. Hence, ABS and CBs should exhibit a pattern opposite to systemic risk.

The two models estimated earlier for ABS and CBs were estimated for Z-Score as well. The results of the quadratic model estimated with FEs for ABS showed a positive and significant

Table 9: Covered Bonds and Systemic Risk — FE Estimations for Size Above 75 Percentile

This table provides the results of the quadratic model estimation for CBs and measures of systemic risk. The variables of CB Ratio and Square of CB Ratio have been multiplied with the size dummy for the banks above 75 percentile as explained in section 5.3. All standard errors are heteroskedasticity consistent and are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and SDC, while other model does not include them. All standard errors are clustered for banks.

	(1)	(2)	(3)	(4)	(5)	(6)
	$LRMES_{it+1}$	$LRMES_{it+1}$	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
CBxSize (Above 75 percentile)	-1.763	-3.024	-0.534	-0.866*	-5.929	-5.766
	(2.028)	(1.875)	(0.514)	(0.487)	(4.035)	(4.191)
Sq. CBxSize (Above 75 percentile)	0.544	0.719*	0.113	0.153	1.166	1.153
	(0.421)	(0.384)	(0.105)	(0.0987)	(0.865)	(0.885)
Volatility	0.102***	0.0801**	0.0379***	0.0136*	0.00892	0.0429
	(0.0341)	(0.0361)	(0.00928)	(0.00723)	(0.0303)	(0.0266)
Tier 1 Capital Ratio	0.397*	0.176	-0.00901	-0.106*	-0.411*	-0.318
	(0.216)	(0.180)	(0.0575)	(0.0615)	(0.217)	(0.213)
Loan Loss Provision	2.463**	1.795**	0.552**	0.318	0.538	0.723
	(0.990)	(0.852)	(0.262)	(0.221)	(1.317)	(1.240)
Deposit to Total Assets	0.141	0.0692	0.000714	-0.0278	-0.0405	-0.0153
	(0.0880)	(0.0781)	(0.0204)	(0.0220)	(0.0930)	(0.111)
Liquid Assets to Total Assets	-0.223**	-0.194**	-0.00376	0.0119	0.0752	0.0579
	(0.105)	(0.0834)	(0.0231)	(0.0284)	(0.109)	(0.115)
Size	9.030***	4.430	3.168***	0.0685	3.420	7.179
	(2.570)	(2.744)	(0.799)	(0.530)	(4.587)	(4.910)
Net Interest Margin	-1.452	-2.120	-1.360*	-1.978***	-6.225	-5.396
	(2.416)	(2.269)	(0.742)	(0.686)	(3.888)	(3.597)
Diversification Ratio	-4.873	-2.311	-2.175***	-0.374	6.420	4.202
	(3.083)	(2.445)	(0.687)	(0.565)	(4.256)	(3.382)
Non-Interest Expense Ratio	-0.00626	-0.0151	0.0186	0.0123	-0.0217	-0.0137
	(0.0288)	(0.0317)	(0.0128)	(0.0113)	(0.0245)	(0.0221)
Financial Crisis		4.692**		4.241***		-5.646**
		(1.967)		(0.673)		(2.721)
Sovereign Debt Crisis		8.946***		4.997***		-5.584
		(3.041)		(0.935)		(3.445)
Constant	-62.70*	-11.06	-28.01***	5.975	-17.62	-58.48
	(33.65)	(33.76)	(9.315)	(6.544)	(56.11)	(57.79)
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Observations	389	389	389	389	389	389
R-squared	0.472	0.512	0.490	0.616	0.084	0.101

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$,

coefficient of the ABS ratio and a negative and significant coefficient of the Square of the ABS Ratio. These results suggest that the issuance of ABS may increases bank stability in the beginning but this relationship turns into a negative one when the ABS issuance is increased by the bank.

Table 10: Covered Bonds and Systemic Risk — FE Estimations for Size Below 75 Percentile

This table provides the results of the quadratic model estimation for CBs and measures of systemic risk. The variables of CB Ratio and Square of CB Ratio have been multiplied with the size dummy for the banks below 75 percentile as explained in section 5.3. All standard errors are heteroskedasticity consistent and are reported in parenthesis. Two models are estimated for each risk measure. One model includes dummies for the GFC and the SDC, while other model does not include them. All standard errors are clustered for banks.

	(1)	(2)	(3)	(4)	(5)	(6)
	$LRMES_{it+1}$	$LRMES_{it+1}$	SRI_{it+1}	SRI_{it+1}	$SRISK\%_{it+1}$	$SRISK\%_{it+1}$
CBxSize (Below 75 percentile)	3.419**	3.176**	0.520	0.604	0.290	0.210
	(1.426)	(1.361)	(0.488)	(0.536)	(1.111)	(1.044)
Sq. CBxSize (Below 75 percentile)	-0.380**	-0.370*	-0.0651	-0.0930	-0.0218	0.0113
	(0.186)	(0.183)	(0.0658)	(0.0715)	(0.145)	(0.131)
Volatility	0.105***	0.0797**	0.0381***	0.0123*	0.00695	0.0404
	(0.0350)	(0.0363)	(0.00939)	(0.00702)	(0.0316)	(0.0275)
Tier 1 Capital Ratio	0.255	0.0854	-0.0249	-0.107*	-0.407*	-0.293
	(0.218)	(0.180)	(0.0637)	(0.0610)	(0.231)	(0.224)
Loan Loss Provision	2.384**	1.735*	0.515*	0.273	0.254	0.605
	(1.028)	(0.861)	(0.268)	(0.230)	(1.343)	(1.245)
Deposit to Total Assets	0.137	0.0755	0.000555	-0.0245	-0.0416	-0.00585
	(0.0902)	(0.0783)	(0.0202)	(0.0208)	(0.0950)	(0.109)
Liquid Assets to Total Assets	-0.188*	-0.164**	0.00113	0.0159	0.0835	0.0635
	(0.0964)	(0.0788)	(0.0234)	(0.0280)	(0.113)	(0.123)
Size	9.007***	4.440*	3.122***	0.0393	2.538	6.684
	(2.381)	(2.593)	(0.734)	(0.512)	(4.807)	(5.075)
Net Interest Margin	-1.304	-1.843	-1.289*	-1.864***	-5.639	-4.893
	(2.073)	(1.950)	(0.690)	(0.667)	(3.969)	(3.689)
Diversification Ratio	-4.290	-1.850	-2.085***	-0.297	6.604	4.217
	(2.922)	(2.339)	(0.659)	(0.544)	(4.518)	(3.512)
Non-Interest Expense Ratio	-0.0221	-0.0258	0.0174	0.0124	-0.0123	-0.00584
	(0.0309)	(0.0331)	(0.0140)	(0.0126)	(0.0241)	(0.0219)
Financial Crisis		4.813**		4.292***		-5.639**
		(1.883)		(0.673)		(2.677)
Sovereign Debt Crisis		8.220***		4.821***		-6.577*
		(2.837)		(0.897)		(3.639)
Constant	-62.98*	-12.55	-27.77***	5.728	-9.897	-55.02
	(31.33)	(31.66)	(8.748)	(6.330)	(58.74)	(59.87)
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
Observations	389	389	389	389	389	389
R-squared	0.487	0.521	0.492	0.615	0.066	0.086

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$,

These results reinforce the earlier findings for the measures of systemic risk.

A similar model is tested for CBs. The results here reinforce the findings reported in Models 1 and 2 of Table 5. The coefficient of the CB Ratio remains insignificant. These results again suggest that the issuance of CBs might not effect bank stability. The analysis with the Z-score was also extended to GAM for both ABS and CBs, and the results were qualitatively similar to the ones obtained using the quadratic and Tobit models[7]. Furthermore, the GAM models are also tested with the loess curve. The earlier GAM estimations were made with a smoothing spline. Loess is also known as local regression. It fits the non-linear function by computing the fit at a target point z_0 using the nearby observations. Weights are assigned to different points in the neighborhood and these weights are later on used for estimation of the fit. The results here are consistent with the earlier GAM estimations reported in Tables 7 and 8 and Figures 2 and 3. These multiple robustness checks ensure that results are not driven by a particular model and settings.

6. Conclusion

The empirical analysis performed in this study provides important insights about the securitization and CB markets. This study examines the impact of these instruments on systemic risk and bank stability. Contrary to other studies, this study investigates the possibility of a non-linear relationship of these instruments with the banks' risk and stability. The empirical analysis suggests the presence of a U-Shaped relationship between systemic risk and securitization. The implications of the ABS issuance on bank stability stem from the level of a bank's reliance on this funding tool.

Initially, the ABS issuance help banks control their funding cost and provide liquidity benefits (Cantor and Rouyer, 2000). However, these positive effects are reversed when a bank increases its reliance on ABS. On the one hand, over-reliance creates a concentration risk and banks face funding and liquidity problems when this market is frozen. A shift back to other funding sources at this point might increase the funding cost. On the other hand, a high level of involvement in securitization increases the bank's risk appetite because of the liquidity gluts created by the continuous securitization (Acharya and Naqvi, 2012; Shin, 2009). The materialization of these risks increases the systemic risk of the bank and adversely affects stability. The empirical results in this study endorse the view of "securitization-scalability" introduced earlier in this study. The ratio of ABS to total assets where its relationship with bank stability is reversed varies from 6% to 11% across various models used in this study[8].

The empirical results do not support the concerns about the increasing use of CBs, as no significant impact of CBs on systemic risk is found. A piece of anecdotal evidence is found that smaller banks might get adversely affected by the small issuance of CBs. This might be ascribed to two possible reasons. First, these banks have limited assets and the encumbrance of some assets might create problems for them. On the contrary, bigger banks have a larger number of assets and are less prone to the adverse effects of asset encumbrance. In a crisis, the large stock of unencumbered assets can be used to meet the liquidity and funding needs. Second, small banks are mostly not able to issue Jumbo CBs, because of the large size of these bonds. However, if these banks can enter

[7]Complete results are available upon request.

[8]These figures are estimated by taking the first derivative of the quadratic model and graphs obtained through GAM.

into the jumbo market by issuing a large amount of CBs, then it might help control their systemic risk. However, most of the CBs are issued by bigger banks.

The analysis also shows that the issuance of CBs never crosses a certain threshold. This is because of the inherent limitations of CBs, whereas the issuance of ABS varies a lot across banks and no such limit is observable for ABS. Most of the legal frameworks across various jurisdictions for CBs feature risk cushions. These legal frameworks are characterized by strict supervision, eligibility criteria for assets to be used in the cover pool and continuous monitoring of the cover pool. Strict eligibility criteria and continuous monitoring of the cover pool are important factors that do not allow FIs to encumber assets beyond a certain threshold that might imperil their stability.

Based on the empirical results presented in this study, the following financial and regulatory implications are derived. Changes in the systemic risk of a bank due to securitization have important implications for the investors who need to reassess their portfolios. Before increasing the issuance of ABS, financial managers should consider the implications of ABS on systemic risk, along with the availability of other funding sources. Before CB issuance, banks should consider the size of their balance sheets and the number of unencumbered assets following the issuance of CBs.

This study proposes separate policy implications for ABS and CB. Concerning CBs, the study does not support the imposition of a uniform limit on their issuance. If the imposition of such a limit is deemed necessary, the bank size should be considered while devising such limits. Concerning ABS, a regulatory mechanism is required to restrain the unbounded securitization. A strict regulatory framework for securitization, without considering the relative size of the ABS issuance, may deprive banks of realizing the economic benefits of this important funding tool and undermine the efforts to revive this market in Europe.

6.1. Recommendations for Future Research

Future research should focus on the type of different ABS. An analysis of various classes of ABS can provide greater insights about the contribution of these classes to the systemic risk of the banking system. Along similar lines, a differentiated analysis of jumbo and non-jumbo CBs can also help better understand the dynamics of this market.

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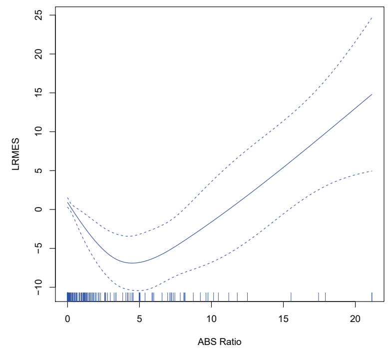
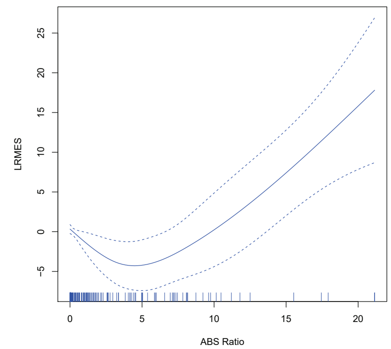
Figure 2: Asset-Backed Securities and Systemic Risk — Generalized Additive Model

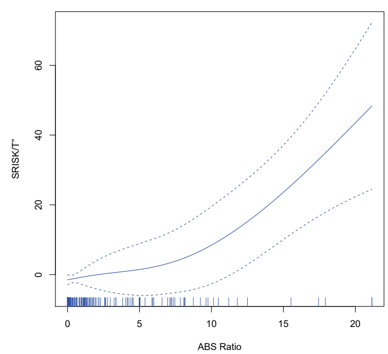
(a) ABS and LRMES - Model 1



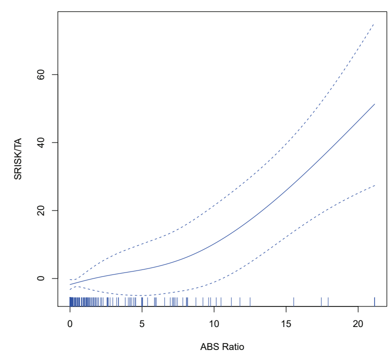
(b) ABS and LRMES - Model 2



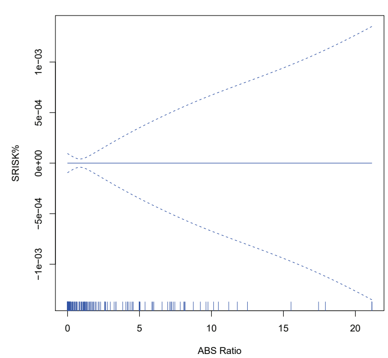
(c) ABS and SRI - Model 3



(d) ABS and SRI - Model 4



(e) ABS and SRISK% - Model 5



(f) ABS and SRISK% - Model 6

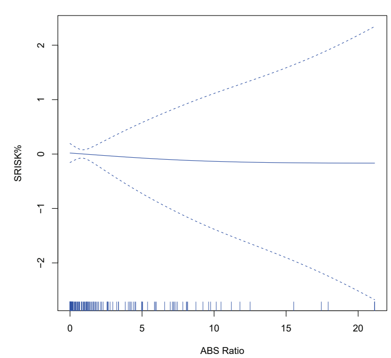
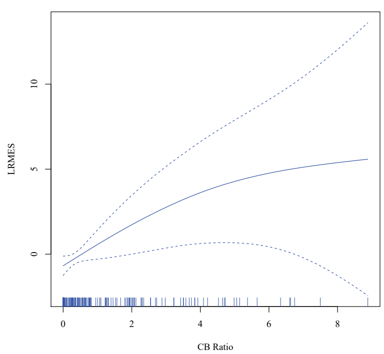
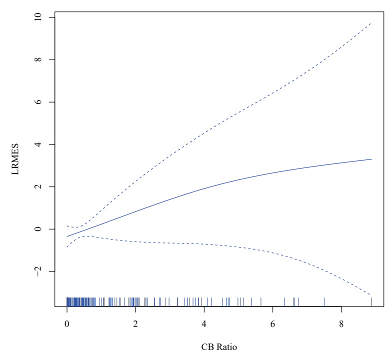


Figure 3: Covered Bonds and Systemic Risk — Generalized Additive Model

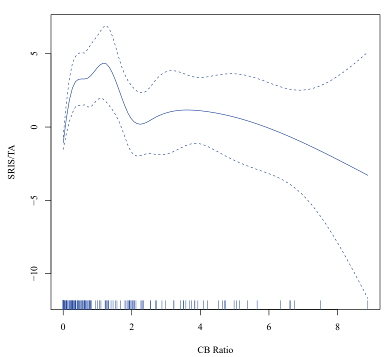
(a) CBs and LRMES - Model 1



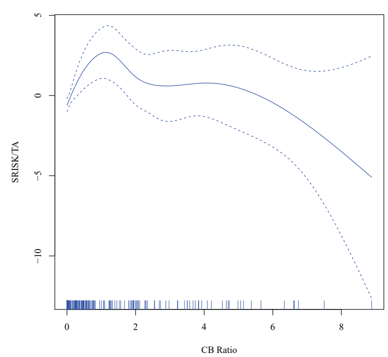
(b) CBS and LRMES - Model 2



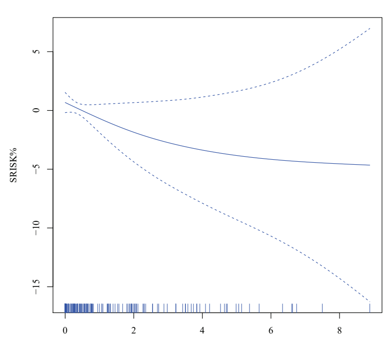
(c) CBs and SRI - Model 3



(d) CBs and SRI - Model 4



(e) CBs and SRISK% - Model 5



(f) CBs and SRISK% - Model 6