DOI: 10.1111/fmii.12196

REVIEW ARTICLE

FINANCIAL MARKETS, INSTITUTIONS & INSTRUMENTS
NEW YORK UNIVERSITY SALOMON CENTER
WILEY

The effects of stress testing on US banks' off-balance sheet activities

Giovanni Calice[1] | Francesco Savoia[2]

[1]Bangor Business School, Bangor University, Bangor, UK

[2]Department of Management, University of Bologna, Bologna, Italy

Correspondence
Giovanni Calice, Bangor Business School, Bangor University, Bangor, UK.
Email: G.Calice@bangor.ac.uk

Abstract

This paper investigates the effects of the new post-financial crisis regulatory regime – risk-based capital ratios (RBC) and stress tests – on banks' off-balance sheet activities (OBS). We use a panel of US bank holding companies over the period 2001–2018 to examine the relationship between banks' capital levels and OBS activities. Our major finding is that banks significantly reduced their OBS exposure following the introduction of the new capital regulatory framework requirements. In particular, we show that tighter regulatory RBC resulted in a reduction of OBS activities in well-capitalised banks. Conversely, we find that under-capitalised banks increased their OBS activities, which suggests the possibility of regulatory arbitrage.

KEYWORDS
Bank regulation, Banks, Basel III, Off-balance sheet activities, Stress tests

JEL CLASSIFICATION
G01, G18, G21, G24, G28

1 | INTRODUCTION

Prior to the 2007–2009 financial crisis, risk-based capital ratios (RBC), designed by the Basel Committee on Banking Supervision (BCBS), were the dominant tools for regulators to assess banks' capital adequacy. It is well-established that bank capital acts as a cushion to absorb losses. However, during the 2007–2009 financial crisis, such capital

adequacy ratios dramatically failed to absorb banks' losses (Ferri & Pesic, 2017), underscoring critical weaknesses and flaws in the regulatory framework.

Many scholars (see Acharya & Richardson, 2009; Ferri & Pesic, 2017; Huang, 2018) argue that the elusion of regulatory capital requirements (regulatory arbitrage) is a plausible explanation for the failure of the capital regulatory standards. Before the crisis, banks were able to place assets, such as securitized mortgages, in off-balance sheet (OBS) entities to mitigate their regulatory capital requirements. In practice, banks have been relying on OBS transactions to hinder RBC adequacy ratios. Moreover, banks became more reliant on the income streams generated from OBS activities.[1] Therefore the business model of banks has shifted from traditional financial intermediation activities (core banking) to disintermediation (non-core banking) (Demirgüç-Kunt & Huizinga, 2010; Lepetit et al., 2008; Stiroh, 2004).

After the 2007–2009 financial crisis, regulators took bold measures by tightening capital requirements to unprecedented levels. For example, the BCBS Committee raised the minimum capital requirements and re-defined the computation criteria of RBC ratios, namely Tier 1 capital, core-equity Tier 1 and total capital ratios. Furthermore, a leverage ratio that considers not only credit risk but also OBS risk exposure is now a standard measure of banks' solvency. In addition, the U.S. Federal Reserve System (Fed) conducts annual supervisory stress tests of the systemically important banks (SIBs). Hence, how banks respond to a well-identified increase in regulatory capital requirements has become a critical research question in the contemporary academic and policy debate. In this paper, we look at this issue by addressing the following question: how do stress tests and RBC requirements affect banks' OBS activities? This issue has significant implications for both banking institutions and financial regulators. Our approach involves a comparative study of OBS activities by differentiating between (i) periods during which banks are being scrutinized by the regulators and periods in which they are not, and (ii) banks taking part in supervisory stress tests and banks which do not.

Methodologically, we use panel data regression methods on a sample of 357 US BHCs over the period 2001–2018, subsequently the enactment of Basel III and the implementation of the stress tests, that is, after 2010. We use dummy variables for the post-regulatory change period and for stress-tested banks for two main purposes: (i) to establish the relationship between a more stringent regulation and banks' OBS activities and (ii) to distinguish between stress-tested and non-stress-tested OBS behaviour in response to tighter capital requirements. Additionally, we examine a set of interactions to disentangle the effects of RBC requirements and supervisory stress tests and the relationship between Tier 1 ratio and OBS activities for stress-tested banks relative to non-stress-tested banks. Our paper complements studies that examine the implications of the new regulatory regimes on banks' behaviour.[2]

Our analysis builds on a study by Acharya et al. (2018) who find that the Fed's stress tests do not affect banks' credit supply. However, they document that banks tend to extend lending to less-risky borrowers while tightening credit to riskier borrowers. Other studies show a moderate increase in credit supply and document that banks shift their loan portfolios between different types of borrowers (Calem et al., 2020; Eber & Minoiu, 2016). Therefore, these studies seem to contradict the notion that increased capital requirements cause credit supply to shrink. Moreover, Cornett et al. (2020) analyse banks' behaviour under stress testing and find that stress-tested banks tend to manipulate their capital ratios to improve their chances of passing the test. Bouwman et al. (2018) provide further evidence that banks alter their assets and loan sizes to avoid additional regulatory capital costs. However, to our knowledge, none of the existing studies focus on the importance of the new RBC requirements and stress tests for OBS activities. Hence, we fill this gap in the literature by assessing whether banks change their OBS activities in response to stress test exercises and, if so, whether the increase is larger in comparison to banks that are not subject to supervisory stress testing.

Our paper is also related to a body of literature emphasizing the role of financial innovation via OBS activities as a key factor for banks to comply with the regulatory environment (Pavel & Phillis, 1987; James, 1988; Baer & Pavel, 1988; Cheng et al., 2015; Koppenhaver & Stover, 1991). We argue that banks engage in OBS activities to artificially meet the regulatory capital requirements and successfully pass the stress tests. Yet, the manipulation of regulatory capital ratios may vary across banks. In fact, in normal times, well-capitalised banks will naturally meet regulatory requirements, whereas less-capitalised banks may increase their OBS exposure to artificially reduce their on-balance

sheet exposure of regulatory capital requirements.[3] However, none of these studies tease out how RBC and stress tests affect banks' OBS positions.

An important earlier paper in this area is Jagtiani et al. (1995). The study models OBS activities as financial innovations in a sample of US banks, concluding that the introduction of RBC requirements has inconsistent effects on OBS activities. However, the paper is silent about how banks under capital constraints behave in response to stricter capital requirements. This is a key issue because banks with below or near required capital are expected to react differently than well-capitalised banks. Our study nonetheless differs in an important direction: we examine the behaviour of less-capitalised relatively to well-capitalised BHCs. We anticipate a negative effect of additional regulatory capital pressure on OBS activities, allowing for the possibility of regulatory capital arbitrage behaviour of less-capitalised banks. Additionally, we study the effects of tightened capital requirements on banks' behaviour. All banks in our sample are subject to Basel III capital requirements but only systemically important BHCs take part in the stress test exercises.[4] This implies that larger BHCs are subject to stricter financial regulation. Therefore, we include an interaction term, that is, the product between the stress tests dummy and RBC requirements (Tier 1 ratio), to examine how the stricter regulation affects banks' behaviour with respect to their OBS activities. Hence, a major contribution of this study is the analysis of the impact of the new regulatory regime on OBS activities.

This study contributes to the banking and finance literature by investigating the relationship between tightened regulations and banks' motivation to engage in OBS activities, using a dataset with an extensive sample of banks. In addition, we extend the analysis to RBC requirements under the Basel III Accord, which is more stringent than the Basel I RBC requirements examined in previous studies. Moreover, the empirical assessment of stress tests – arguably the most sophisticated US regulatory framework – has been neglected by prior research. Our major finding is that the new regulatory framework has a strong impact on banks' OBS activities. Thus, we provide direct evidence on the impact of tightened regulation on (underregulated) OBS activities.

Another novelty of this study is that we examine the role of the new RBC requirements and stress tests in driving banks' innovation on a sample of US BHCs during 2009–2018. Hence, we highlight the effectiveness of the newly introduced capital adequacy rules in regulating banking activities. This is important because banks use OBS activities to create liquidity to meet the growing credit needs of firms during the business cycle. However, although this is clearlybeneficial for banks as financial intermediaries, it causes the build-up of fragilities in the banking system (Moreira & Savov, 2017).

A number of important empirical results emerge from our analysis. First, we provide compelling empirical evidence that higher capital requirements imposed on BHCs caused a reduction in their OBS exposure. However, undercapitalised banks increased their OBS exposure following the introduction of stricter capital requirements (2011–2018), revealing regulatory capital arbitrage behaviour for banks with capital constraints. Second, we document that inadequately capitalised large banks increased their OBS exposure in response to tighter capital requirements. Third, we show that supervisory stress tests enhance the role of RBC requirements and serve as a complementary tool to regulate banks' risk exposure. Therefore, our main findings highlight the effectiveness of post-crisis regulations of SIBs.

A natural interpretation of these findings is that the simple RBC capital adequacy ratios under Basel III are still prone to regulatory arbitrage. This mainly reflects unresolved asymmetric information problems between regulators and banks. However, when combined with more sophisticated monitoring procedures such as the stress tests exercises, banks' risks are better assessed and disciplined. Therefore, an important regulatory implication of our results is that the perimeter of the supervisory stress tests should be extended to all banks, regardless of their systemic relevance and interconnectedness.

The remainder of the paper is structured as follows. Section 2 discusses the related literature on OBS activities and the impact of post-crisis regulation on the banking system. Section 3 presents the data and the methodology. The main results are discussed in Section 4. Finally, Section 5 concludes.

2 | LITERATURE REVIEW

This section discusses the literature on OBS activities, and the new banking regulation, with a special emphasis on the role of stress testing and Basel III requirements for the US banking sector.

2.1 | OBS activities and regulatory arbitrage

Traditionally, OBS transactions are considered a risk management tool by which banks can enter new businesses without increasing shareholders' risk. For example, banks could hold a minority interest in other companies such as conduits and special investment vehicles (SIVs) that bear most of the risks instead of a parent holding bank. This financial structure enables banks to transfer risky investments out of their balance sheet. However, the extraordinary expansion of over-the-counter (OTC) derivatives and securitized asset markets has allowed banks to generate high levels of non-interest income. Banks have taken advantage of the securitization process and transferred a substantial amount of risky assets off their balance sheets to avoid costly regulatory capital. Consequently, banks were trapped in a spiral that caused an unsustainable build-up of fragility in the financial system during the 2007–2009 financial crisis. Acharya et al. (2013) show that regulatory arbitrage was an important motive for banks to set up OBS entities (conduits and SIVs). Moreover, banks set up their guarantees to reduce regulatory capital requirements costs. Altunbas et al. (2009) present evidence of a similar behaviour by European banks. In this study, we argue that banks are prone to riskier behaviour especially when constrained by tightened regulatory rules. Consequently, this may lead to greater financial fragility during downturns. In this sense, the scope of this study is to analyse how stress tests and RBC requirements (Basel III) affect US banks' OBS activities under the assumption that banks' traditional activities are welfare-enhancing while non-traditional activities are welfare-reducing.

A separate strand of the literature examines the impact of non-interest income on banks' risk and banking system resilience (e.g. Ashraf et al., 2016; Gallo et al., 1996; Litan, 1985; Rogers & Sinkey, 1999). This line of research finds that banks' expansion towards non-banking activities helps reduce, at least partially, their risks through income diversification. However, other studies show that this income diversification tends to increase banks' risk-taking (see, for example, Demirgüç-Kunt & Huizinga, 2010; Deyoung & Roland, 2001; Lepetit et al., 2008b; Stiroh, 2004; Stiroh & Rumble, 2006). Furthermore, Allen and Jagtiani (2000) show that the shift towards non-traditional activities increases both systemic and interest rate risks. DeYoung and Torna (2013) document that banks probability of failure could increase with certain types of (asset-based) non-traditional activities such as venture capital and investment banking, but the probability of failure decreases with pure fee-based non-traditional activities such as insurance sales and brokerage fees. Therefore, we can conclude that banks are strongly motivated to undertake riskier businesses to maintain optimal profitability margins.

The growth of OBS activities since the 1980s has attracted scholars' attention to examine the motivation behind banks' OBS activities. Relative to this literature, Baer and Pavel (1988) using a sample of 33 BHCs from 1979 to 1985 show that banks increase loan securitization and issuance of standby letters of credit in response to regulatory taxes. Pavel and Phillis (1987) argue that even though regulatory taxes have been a substantial motive for loan sales, the efficiency in loans' origination and the level of diversification in banks' loans portfolio have had a stronger impact. On the other hand, Benveniste and Berger (1987) argue that capital requirements are not a significant determinant of the banks' choice to engage in OBS activities. Moreover, Koppenhaver and Stover (1991) find that the bank's decision to engage in the process of issuing standby letters of credit is not bound by capital but is simultaneously determined. These studies share two important characteristics: first, they consider OBS activities as innovative avenues for banks to diversify their balance sheet activities; second, they offer no conclusive answer as to whether the regulatory capital requirements are the main driver of OBS activities in BHCs.

Our study contributes to the literature in several ways. First, we rely on the total OBS exposure measure as a percentage of total assets for non-traditional (unregulated) banking activities. This allows us to avoid inconclusive results

obtained in previous papers by examining individual OBS transactions.[5] Second, we use specific dummy variables to control for the stricter regulatory environment over the period 2011–2018 and to account for the participation of some banks to the stress testing process. Hence, we conduct the analysis by discriminating between well-capitalised and under-capitalised banks and differentiating between stress-tested and non-stress-tested banks. Third, our work also adds to the literature by examining the impact of RBC requirements, introduced in late 2010, on banks' non-traditional activities. Additionally, we examine the effects of the domestic regulatory framework (stress tests), which is considered to be the most comprehensive banking regulatory regime in the United States. Our sample of 357 BHCs is a considerably larger sample relative to previous studies and thereby augments the robustness of the analysis. In the next sub-section, we provide background on the recent major regulations imposed on banks and their implications on various dimensions of banks' businesses.

2.2 | Banks adoption of post-crises regulations

In the post-financial crisis period of 2007–2009, policymakers and regulators issued reinforced tools that have increased banks' capital requirements, especially SIBs. In 2011, the Dodd–Frank Act introduced the Comprehensive Capital Analysis and Review (CCAR) stress test conducted annually for large banks and bank holding companies (BHCs), followed in 2013 by the Dodd–Frank Act stress test (DFAST). In addition, on a global scale, in December 2010, the BCBS introduced new RBC requirements (Basel III requirements), including the refined capital ratios to address the shortcomings of Basel I and Basel II. Notably, the Basel Committee set out a special treatment of OBS items in the leverage ratio establishing that the exposure to OBS items is calculated via Basel II standards for credit risk and included in the denominator (total exposure) of the leverage ratio.

In this paper, we aim to address the build-up of excessive risk-taking in banks' OBS, which became particularly critical during the GFC. Specifically, we are interested in examining whether and how the new Basel III capital ratios and stress tests have affected banks' OBS activities. We build our analysis on the literature investigating the effects of stress testing and Basel III Accord on various banking aspects. Relative to this literature, the main novelty and contribution of our work is the impact of the new regulation on banks' OBS activities.

Bouwman et al. (2018) suggest that banks with assets near the threshold required for stress testing tend to alter their asset growth to avoid the new regulatory costs (unless the benefit of the asset growth weighs in more significantly than the new regulatory costs). Acharya et al. (2018) approach the issue from another angle and examine how stress tests impact banks' credit supply relying upon: (i) the risk management hypothesis, that states that stress-tested banks reduce their lending to risky borrowers; and (ii) the moral hazard hypothesis, which postulates that banks extend lending to risky borrowers to earn higher spreads. They provide evidence support the risk management hypothesis. A detailed analysis from Gambetta et al. (2017) show that the efficient risk management, large loan portfolios and higher levels of profitability allow banks to reduce the impact of stress tests.

Another stream of the literature explores the impact of the stress test results disclosure on the market. Morgan et al. (2014) is one of the early studies that explore the Supervisory Capital Assessment Program (SCAP), and provides evidence of a significant relationship between bank abnormal stock returns and the announcement of the results. Georgescu et al. (2017) show that the publication of the stress test results had a significant impact on market participants, as evidenced by the reactions of the banks' stocks prices of. More recently, Ahnert et al. (2018) investigate the impact of the US and EU stress tests on bank's equity and credit default swaps (CDS). They find that the banks that passed the tests had positive abnormal returns and lower CDS spreads. On the contrary, banks that failed the tests experienced stronger negative abnormal returns and larger CDS spreads.

Using an event study approach, Fernandes et al. (2017) investigate the impact of the US stress tests on banks' behaviour and the market. In line with the existing literature, they show that a significant stock market reaction for both stress-tested and non stress-tested banks follows the stress test announcements and results release dates. However, Flannery et al. (2017) propose alternative measures to study the market reaction to the stress test results

disclosure: one is the absolute cumulative abnormal stock return, and the other is the abnormal stock trading volume.

A recent evaluation of the cyclical macroprudential tools used by regulators of Elliott et al. (2013) shows that tighter regulatory requirements had more pronounced effects on credit levels. Shapiro and Zeng (2020) argue that the stricter stress tests are, the less banks lend to riskier borrowers. Correspondingly, the more lenient the stress tests are, the more banks would lend to riskier borrowers. In that sense, the relationship between stress tests and bank lending equilibria is 'self-fulfilling' and the stress tests can create a feedback loop effect.

The evidence presented in Cornett et al. (2020) indicates that banks' capital ratios significantly increased while collecting data for the CCAR and DFAST stress tests, and that stress-tested banks reduced their dividend payouts compared to non-stress-tested banks. Thus, these results are consistent with the intended purpose of the stress testing exercises. However, the study also reveals that stress-tested banks reversed such behaviour in other quarters, indicating that they may effectively adjust their policies to pass the stress test. Along the same line, Eber and Minoiu (2016) present evidence that banks tend to reduce their assets credit risk exposure in response to tighter regulatory requirements.

Calem et al. (2020) analyse how macroprudential policies affect credit supply, focusing on the impact of the stress tests on residential mortgages in the United States using micro-level data. Their findings indicate that the 2011 stress test had a significant negative effect on jumbo mortgage origination volumes, but the 2012 stress test had no significant impact. This suggests that banks adjusted their capital position after the start of the stress testing exercises to simply pass the tests.

A parallel, but still scarce strand of the literature, seeks to understand the implications of the Basel III Accord on banks' behaviour.[6] After the global financial crisis – that uncovered serious shortcomings of the Basel II Accord, specifically of the RBC requirements – the Committee introduced the Basel III Accord with more restrictive measures of liquidity (LCR and NSFR) and higher RBC levels.

Naceur et al. (2018) examine the impact of the Basel III requirements on lending for US and European banks and document that capital ratios had a negative impact on European banks' retail lending. Moreover, they show that large US banks only increased their leverage ratios when granting riskier loans. King (2013) explores several possible banks' strategies to meet the new NSFR rule over a sample of 15 banks in 15 countries in a cost-efficient manner. He reports a potential decline of 40% in interest margins compared to 2009. We follow Naceur et al. (2018) and employ the Basel III RBC ratios in our analysis. Yet, we go one step forward and analyse whether and how banks' OBS activities respond to RBC requirements under Basel III. In addition, we include the interaction term that accounts for the relationship between the RBC requirements (Tier 1 ratio) and the stress test dummy that takes a value of one for banks involved in this process, that is, being tested, and zero otherwise. As banks were given a period of nearly 3 years to meet the new requirements,[7] it is important to examine the long-term effect of stricter capital requirements on OBS activities

Another paper close to our analysis is by Mohanty et al. (2018), who examine the effects of the Dodd–Frank Act and Basel III regulation on global SIBs. They find a significant increase in all of their banks' risk measures over the periods post the European debt crisis and post theglobal financial crisis. Hence, their evidence seems to contradict the belief that the post-crisis regulation would negatively impact banks' risk measures.

The introduction of Basel III RBC and of the stress tests in response to the financial crisis of 2007–2008 was aimed at improving the banking system's resilience against future shocks. Regulators aimed to achieve this goal by mandating banks to hold substantial higher amounts of capital (Basel III) compared to the previous Basel I and Basel II requirements and for some banks to undergo rigorous stress tests to assess their future capital positions under severe stress scenarios.[8] As a result of these stricter regulations, banks expanded their OBS activities to appear compliant with regulatory requirements. However, this approach lead to a transfer of risks from heavily regulated on-balance sheet transactions to more lightly regulated or unregulated OBS transactions.

To our knowledge, no prior study has investigated the impact of the new regulatory frameworks on banks' OBS activities. Previous research (Bouwman et al., 2018; Cornett et al., 2020) has emphaisized the role of banks in manipulating their balance sheets and assets/loans growth to avoid regulation, but has neglected however OBS activities.

This study aims to fill this gap by addressing the following key question: what are the implications of RBC requirements and stress tests on banks' OBS activities?

Regulators aim to enhance the viability of the banking system by requiring banks to maintain adequate capital ratios, that is, the Tier 1 capital. Banks are expected to increase their capital in the short term through retained earnings or new equity issuance. However, they might artificially deflate the regulatory exposure measure as appears in the denominator, that is, the risk-weighted assets. The 2008–2009 financial crisis offered banks unprecedented opportunities to reduce their exposure to regulatory measures by providing loan securitizations and other instruments of financial innovation (OBS activities). Therefore, we examine how Basel III and stress tests influence banks' OBS activities from this viewpoint. Additionally, this study presents evidence of the extent of the regulatory pressure of RBC requirements, distinguishing the behaviour of US BHCs based on their size.

3 | DATA AND METHODOLOGY

This section presents the data and methodology to address our main research question. We examine the US banking sector, focusing on BHCs. Next, we describe data and relative sources, define the variables used in the estimations and present the empirical model.

3.1 | Data

We use a sample of 357 US BHCs from 2001 to 2018, including the banks that have undergone the stress tests exercises: 38 stress tested and 319 non-stress tested. The BHCs variables and macroeconomic data are from the Orbis BankFocus and Datastream. We focus on currently active banks since our goal is to examine the effects of post-crisis regulation on banks' OBS behaviour.[9]

We collect the list of stress-tested banks from the CCAR results report published[10] at the end of each stress test round.[11] The sample period spans over 18 annual periods allowing us to fully capture long-term changes in OBS activitiess. This approach is emphasised in the seminal paper by Berger and Udell (1994) who examine the effects of capital requirements on lending behaviour. Therefore, this extended sample period enables us to capture and compare the key drivers of OBS activities across different sub-periods. Lax regulations characterize the first period, 2001–2010 (Acharya & Richardson, 2009). The second period, 2011–2018, encompasses tighter regulations, that is, after Basel III and the introduction of the stress test exercises in late 2010.

Figure 1 plots the OBS exposure to total assets ratio for our sample of 357 BHCs from 2001 to 2018. The graph displays an upward trend in the ratio during the economic growth period between 2001 and 2007. Then it shows a sharp decline with the collapse of the securitized assets market (OBS activity) in late 2007. More importantly, the OBS ratio decreased after 2009 with the end of the crisis period, followed by an upward trend from 2012 onward, one year after the CCAR and two years after the introduction of the Basel III Accord, in line with the market recovery.

This graphical evidence does not capture the effects of the post-crisis regulations, but underlines the importance of our empirical analysis to understand the relationship between the new regulatory capital requirements and non-core banking activities.

3.2 | Description of the variables

In this section, we provide detailed definitions of the variables used in the model to estimate the determinants of OBS activities. The *dependent variable* is a proxy for the bank's OBS activities. The ratio of total OBS items to total exposure (total assets plus total OBS items) is denoted by *OBS* for bank *i* at time *t*. The ratio captures the bank's OBS exposure

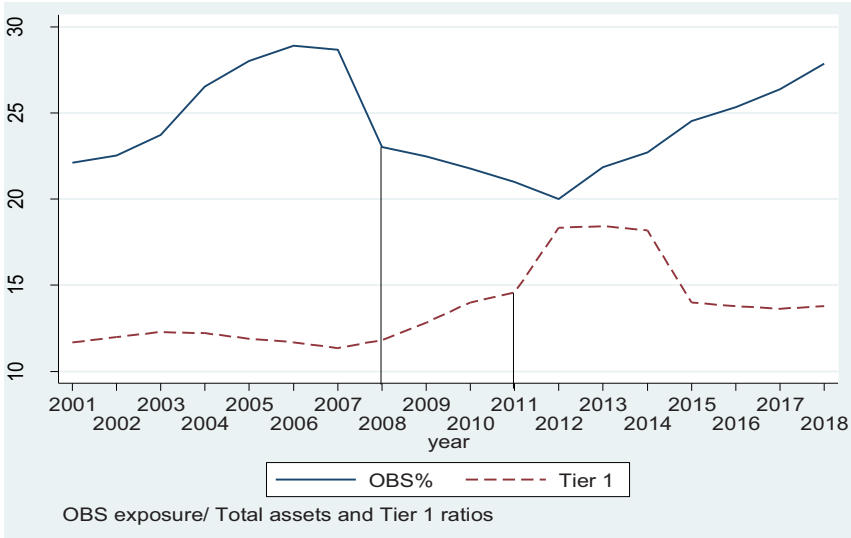

FIGURE 1 Trends in OBS exposure relative to bank size and Tier 1 ratio. [Color figure can be viewed at wileyonlinelibrary.com]

relative to the bank's total assets exposure.[12] For example, a higher OBS ratio means that banks engage more extensively in non-traditional activities (OBS) than traditional activities (deposits acceptance and loans granting). A plausible interpretation is that when expanding their business lines banks prefer to increase their OBS activities relative to on-balance sheet activities. The OBS exposure is obtained from the BankFocus database. The OBS definition used in this study encompasses the sum of guarantees, acceptances and documentary credits, committed credit facilities, managed securitized assets, other contingent liabilities and other exposures to securitization. The same definition is used by Duran and Lozano-Vivas (2013) to examine the association of OBS activities and default risk. In addition, Jagtiani et al. (1995) use a similar definition (sum of OBS items) to analyze the effects of Basel I regulatory framework on OBS items, and Jagtiani and Khanthavit (1996) to examine the impact of OBS on measures of bank cost efficiency.

These earlier studies focus on the output characteristics of OBS items and investigate the effects of RBC requirements on various types of OBS instruments such as loan sales, standby letters of credit and securitization. However, it is conceivable that some of the OBS activities can be considered as inputs and used merely for hedging or funding in the case of contingent liabilities (bankers acceptances) and loan sales, respectively. Although the total OBS exposure definition imposes a limitation to pinpoint, which OBS activities impacted the most, the definition serves the objectives of this study. Moreover, other studies assume that banks face a choice to shift transactions between assets and OBS items, whereas this study assumes that the shifts occur between balance sheet liabilities and assets on the one hand, and OBS on the other.

We use several variables to examine the effect of stricter capital requirements on OBS activities. In our model, we employ the Tier 1 regulatory capital ratio denoted by *Tier1* to proxy for increased capital ratio requirements in the spirit of Basel III[13], a dummy variable to represent BHCs taking part of the stress test denoted by *STB* (1 if the bank is within the stress test group and 0 otherwise), and a dummy variable for the post-regulation period denoted by *AR* (1 for the years 2011–2018 and 0 otherwise). As the main objective of this study is to examine the effects of global banks' regulatory supervision (Basel Accords) and domestic banks' monitoring tools (US stress tests), we employ a vector of interactions to disentangle the implications of the different regulatory frameworks.

Our model also employs bank-specific control variables that have been documented in the literature as drivers of banks' OBS activities. We conjecture that the control variables that may affect OBS activities are the following: size

TABLE 1 Variables and sources.

Variables	Description	Source
Dependent		
OBS	Nominal amount of total off-balance sheet items divided by total assets plus off-balance sheet items	BankFocus
Main independent		
Tier1	The ratio of Tier1 capital to risk-weighted assets	BankFocus
AR	After regulation: dummy variable that takes the value of 1 for the period 2011–2018; 0, otherwise	
STB	Stress tested bank: dummy variable that takes the value of 1 if the bank takes part in the stress testing process; 0, otherwise	Federal Reserve Board (2018)
Bank-specific control variables		
Assets	The natural logarithm of total assets	BankFocus
ROA	The ratio of net income to average total assets ROAA (proxy for banks' profitability).	BankFocus
LLR	The ratio of loan loss reserves to total loans (proxy for loans quality; a higher LLR ratio indicates lower loans quality.)	BankFocus
FrnD	The ratio of foreign deposits to total deposits (proxy for international access)	BankFocus
LoanAsset	The ratio of total loans to total assets (proxy for diversification)	BankFocus
Macroeconomic control variables		
GDP	Annual rate of GDP growth (proxy for economic activity)	DataStream
TermSpread	The difference between 10-year bond and federal fund rate	DataStream

denoted by *Assets*, which is the natural log of total assets, as larger banks typically engage more significantly in OBS activities. This is due to their access to financial markets domestically and internationally; profitability is proxied by the return on average assets ratio (ROAA) denoted by *ROA*. The intuition is that banks with high ROA might have stronger incentives to scale up their OBS activities. Notice that we use the loan loss reserve to total loans ratio, *LLR*, to account for the bank's outlook of the loan portfolio (Bostandzic & Weiß, 2018; Farruggio & Uhde, 2015). Banks with higher loan loss reserves ratios have a low loan portfolio quality. A plausible explanation for the increase of OBS activities is the perception of an excessive build-up of risks in their on-balance sheet activities. Total foreign deposits to total deposits are widely used in the literature to proxy for banks' access to international capital markets and are denoted by *FrnD*. We also use the loans-to-assets ratio, denoted by *LoanAsset*, to control for BHC's revenues reliance on interest income versus fee income. It is conceivable that banks with a vast international presence will report higher levels of OBS exposure relative to domestic-focused BHCs.

The analysis includes the year-on-year change in the real gross domestic product (*GDP*) and the US interest rate spread *TermSpread* (10-year bond less federal fund rate) to control for the impact of the state of the economy on bank's OBS exposure and for interest rate risk. Note that normally in booming (contractionary) economic periods the demand for credit and liquidity rises (decreases) and bank's on-balance and OBS exposure increase (decreases). Table 1 summarises and describes the main variables.

In Table 2, we present the descriptive statistics for all the variables included in our estimations. The dependent variable *OBS* exposure ratio in our sample has an average value of 17.2% with 5147 observations. The main independent variable *Tier1* ratio has an average value of 13.8% with 4740 observations. Interestingly, the average Tier 1 ratio in the sample is significantly higher than the minimum required level of 6% (8.5% with the conservation buffer and 11%

TABLE 2 Descriptive statistics.

Variable	Observations	Mean	Std.Dev.	Min	Max
OBS	5147	17.159	10.632	0	84.167
Tier1	5042	13.845	26.823	−13.7[32]	1154
AR	6426	0.444	0.497	0	1
STB	6426	0.106	0.308	0	1
Assets	5149	15.398	1.611	12.014	21.688
ROA	5146	1.006	1.346	−15.43	24.65
LLR	5143	1.504	1.376	0	23.101
FrnD	4647	2.1	9.558	0	100
LoanAsset	5145	65.269	15.14	0	96.211
GDP	6426	1.978	1.407	−2.5	3.8
TermSpread	6426	1.843	1.026	−0.39	3.097

Note: See Table 1.

TABLE 3 Summary statistics: OBS and capital level (tested vs. non-tested banks).

Variable	Observations	Mean	Std.Dev.	Min	Max
Non-STBanks 2001–2010					
OBS	2293	15.31	7.79	0.12	76.2
Tier1	2293	12.47	4.87	0.66	75.47
STBanks 2001–2010					
OBS	236	36.22	16.35	7.96	84.17
Tier1	236	9.55	4.32	−13.7	20.48
Non-STBanks 2011–2018					
OBS	2354	15.06	7.62	0	79.64
Tier1	2249	15.69	39.71	−4.99	1154
STBanks 2011–2018					
OBS	264	34.86	14.66	5.82	69.93
Tier1	264	13.89	4.86	−6.37	64.39

Note: OBS activities and Tier 1 capital ratio over the periods: 2001–2009 and 2010–2018. Banks taking part in the stress test (STBanks) are compared to banks not taking part in the stress test (non-STBanks). All the values are expressed in percentages.

with the countercyclical buffer), indicating that banks build capital buffers well above the minimum requirements (well ì-capitalised). Table 3 provides more details on the OBS and Tier1 ratios.

The *bank-specific and macroeconomic control variables* in the sample have an average size *Assets*, in terms of consolidated assets, of $4.62 billion. The average bank's return on assets *ROA* is about 1% (standard value for US BHCs). The ratio of the loan loss reserve to total loans *LLR* has an average value of 1.5% indicating that our sample of BHCs has relatively high loans quality. However, the maximum and minimum values of LLR display a gap of 22%, meaning that there are banks with relatively very low loan quality. We discuss the implications of these values in the Results section. The foreign deposits to total deposits ratio *FrnD* has a mean value of 2.1%. This ratio indicates that our sample of banks is not dependent on international deposits relative to domestic deposits. However, the minimum and maximum values of the foreign deposits range from 0 to 100% suggesting that our sample of banks is heterogeneous in their international

presence. Furthermore, notice that the total loans to total asset ratio *LoanAsset* has a mean value of 65% signalling that US BHCs generate their income mainly by granting loans (traditional activities). Finally, for the set of macroeconomic variables, the *GDP* has an average of 2%, with the highest value of 3.8% and the lowest a negative growth of 2.5%; the *TermSpread* mean value is 1.84% with the highest value of 3.097 and the lowest at −0.39% during our sample period.

Table 3 provides the statistics for the OBS activities and the capital levels for the group of stress-tested versus non-stress-tested banks, before and after 2010. The Tier1 ratio for STBanks (9.06%) is lower than for the non-STBanks (12.27%). However, this gap becomes smaller (2.04%) after 2010. This is suggestive that stress-tested banks had to increase their capital ratios to a much higher level than before the first round of the stress tests. Hence, these findings elucidate on how stricter capital requirements affect banks' behaviour with respect to their OBS activities. More specifically, they show that banks reduce their OBS activities in response to higher capital requirements.

3.3 | Model specification

We now turn our analysis to the implications of RBC and stress test exercises on US banks. We focus on the new regulatory regime to examine three main aspects: (i) whether it has an impact on banks' OBS activities; (ii) whether banks artificially comply with regulatory requirements by shifting risk exposures (assets and liabilities) off-balance sheet, thereby conducting regulatory arbitrage practices; (iii) whether RBC and stress testing frameworks are complementary tools and thus self-reinforcing. To conduct our analysis, we regress the OBS exposure on the Tier 1 capital ratio[14] and the stress test dummy. Likewise, we test the effects of the control variables (see Section 3.2) to evaluate banks' specific characteristics that may affect OBS activities. A set of macroeconomic variables is also considered to control for demand and market fluctuations effects. We use panel data regressions to estimate the impact of RBC requirements under Basel III and stress tests on OBS activities. Our simple model is specified as follows:

$$OBS_{i,t} = \alpha + \beta_1 Tier1_{i,t-1} + \beta_2 AR_t + \beta_3 STB_t + \beta_4 Interaction_{i,t} + \gamma Bank_{i,t-1} + \delta Macro_{t-1} + \mathcal{E}_{i,t} \quad (1)$$

where *i* and *t* represent bank *i* and year *t*, respectively. *OBS* is the off-balance sheet exposure ratio, calculated as the nominal value of OBS divided by the total assets plus the nominal value of OBS activities; the *Tier1* is the Tier 1 capital ratio under the Basel III definition calculated as total Tier 1 capital divided by total RWA; *AR* is a dummy variable that takes the value of one for the period 2011–2018, and 0 otherwise; and *STB* is a dummy variable that takes the value of one across the entire period (2001–2018) if banks took part in any stress test, and 0 otherwise.

We disentangle the effects of the post-crisis regulation on banks' OBS behaviour and employ the following set of interaction terms ($Interaction_{i,t}$): first, the *Tier1*AR* is an interaction term between the *Tier1* capital ratio and after regulations dummy *AR* and measures the effects of an increase in the required Tier 1 capital on banks' OBS exposure following the implementation of the stress tests and Basel III RBC requirements. This is important to establish whether stricter supervision and prudential standards influence banks' OBS exposure. Second, to distinguish the effect of the Tier 1 capital ratio on the OBS exposure between stress-tested and non-stress-tested banks, we use the *Tier1*STB* which measures the interaction between the Tier 1 capital ratio and the stress test bank dummy *STB*. Third, *AR*STB* is an interaction term between the after-regulation dummy *AR* and the stress test dummy *STB*.[15] It captures the effects of the post-regulation period on the stress-tested banks. Finally, *Tier1*STB*AR* is a triple interaction term between the Tier capital ratio, the stress-tested bank dummy STB and the after-regulation dummy AR. This interaction measures the effects of the post-financial crisis regulation on banks' OBS exposure for the stress-tested banks, which allows us to validate the effects of the new requirements on banks' OBS activities.

$Bank_{i,t}$ is a vector of *bank-specific variables* widely used in the literature as discussed in Section 3.2. We control for bank size, profitability, loans portfolio quality, foreign deposits and the loan-to-asset ratio. As a proxy for economic

activity, we include the vector $(Macro)_{i,t}$ which comprises real *GDP* growth and the *Term Spread* (10-year US government bond minus the federal fund rate).

4 | EMPIRICAL ANALYSIS

In the first part of this section, we present anddiscuss the main empirical results from the estimation of the model specified above. Then we provide an additional set of results to test for the robustness of our main findings.

4.1 | Main results

As we use in our analysis panel data techniques, we start by conducting conventional panel data tests to assess whether the unobserved individual effects are fixed or random. We report the results at the bottom of Table 4. We can clearly see that the estimated effects are fixed when STB is not included (columns 1–3), but random when it is added to the model (columns 4–6).[16] Nevertheless, despite different estimators being used in those cases, the main findings remain almost unchanged.[17] Additionally, we also account for possible simultaneity problems and heteroscedasticity by using lags (for most of the right-hand side variables) and robust standard errors (clustered by bank), respectively.[18]

In each set of results displayed in Table 4, we present the first set of estimations for the entire sample period 2001–2018 and then compare it with the pre- and post-regulation periods (i.e. 2001–2010 and 2011–2018). A number of important findings emerge from our analysis. First, the coefficient of *Tier1* is statistically insignificant across all the estimations, except in the pre-regulation period. In fact, it has a significant negative impact on banking OBS activities exposure. Because the level of the Tier 1 ratio has no significant impact on banks' OBS exposure, in particular after 2010, the new RBC requirements had virtually no effect on banks' OBS activities.[19] We would expect that a more refined definition of RBC measures would serve as an effective instrument to discipline banks' risky activities. However, strikingly, our findings point to a divergent pattern and thus go against the BCBS primaryobjective of enhancing financial stability.

As discussed by Jones (2000), one way by which banks can avoid higher capital requirements is to engage in OBS activities. Earlier work by Baer and Pavel (1988) and Jagtiani et al. (1995), Pavel and Phillis (1987) also address the issue of regulatory arbitrage through OBS activities. For example, using loan sales and securitization – both of which are common OBS activities – banks can free-up capital by transferring their riskier loan portfolios, which are penalized by capital taxes, to OBS entities. Therefore, banks are able to artificially comply with regulatory capital requirements (RBC).

Importantly, we can see that the 'after regulation' dummy (*AR*) has a highly significant negative coefficient, which lends support to the hypothesis that banks lowered their exposure to OBS activities during the period 2011–2018. It is reasonable to conjecture that banks are somehow disincentivized from engaging in non-core banking activities in a stricter regulatory environment. However, this may not be entirely true as tighter capital regulation can also prompt banks to engage more extensively in less regulated OBS activities to circumvent the constraints imposed by those rules. In fact, the level of capital does not seem to reflect the reduction in OBS activities. Nevertheless, there seems to be at work an underlying dynamic after the crisis that has somewhat limited banks' engagement in OBS activities. For example, the collapse of the securitized market during the 2007–2009 financial crisis might have prevented banks from holding high levels of OBS activities. Moreover, other factors that can explain the decrease in the overall OBS exposure might be the newly introduced Basel III liquidity ratios (liquidity coverage and net stable funding ratios), and several provisions under the Dodd–Frank Act.[20] In addition, stress test exercises might also have contributed to this trend. Hence, we need to explore more in-depth the role of financial regulation to identify the dynamics of OBS activities.

TABLE 4 Baseline estimations.

	(1) 2001–2018	(2) 2001–2010	(3) 2011–2018	(4) 2001–2018	(5) 2001–2010	(6) 2011–2018
Main						
Tier1	−0.001	−0.073*	−0.000	−0.002	−0.099**	−0.000
	(−1.200)	(−1.873)	(−0.461)	(−1.343)	(−2.567)	(−1.615)
AR	−1.269***			−1.391***		
	(−4.170)			(−4.664)		
STB				17.310***	19.676***	14.893***
				(5.917)	(5.790)	(5.057)
Controllers						
Assets	0.969***	0.473	0.708	1.165***	0.757**	1.286***
	(2.936)	(1.297)	(1.470)	(3.855)	(2.376)	(3.207)
ROA	0.476***	0.588***	0.287**	0.502***	0.655***	0.342***
	(5.656)	(6.449)	(2.369)	(5.796)	(6.308)	(2.795)
LLR	−0.426***	−0.250	−0.426***	−0.370***	−0.058	−0.347***
	(−3.440)	(−1.160)	(−3.056)	(−3.011)	(−0.308)	(−2.662)
FrnD	0.045	−0.015	0.037	0.066*	0.014	0.172***
	(1.621)	(−0.672)	(0.557)	(1.891)	(0.616)	(3.475)
LoanAsset	0.127***	0.075***	0.114***	0.124***	0.077***	0.105***
	(8.926)	(3.820)	(5.375)	(9.209)	(4.234)	(5.462)
GDP	0.625***	0.626***	0.343***	0.637***	0.650***	0.321***
	(12.743)	(11.783)	(3.352)	(13.017)	(12.481)	(3.076)
TermSpread	0.152**	0.231***	−0.898***	0.159**	0.244***	−0.819***
	(2.439)	(4.073)	(−5.054)	(2.565)	(4.170)	(−4.714)
Cons	−6.354	4.702	0.721	−11.311**	−1.763	−10.377
	(−1.290)	(0.845)	(0.092)	(−2.544)	(−0.362)	(−1.614)
Obs.	4217	2218	1999	4217	2218	1999
R-squared	0.193	0.244	0.168	0.192	0.242	0.161
Interaction	No	No	No	No	No	No
Estimator	Fixed	Fixed	Fixed	Random	Random	Random
Hausman test	0.000	0.000	0.000	0.000	0.000	0.000
Breusch–Pagan test				0.000	0.000	0.000
F-test	0.000	0.000	0.000			

Note: The columns show the estimations for the entire sample period 2001–2018 and before (2001–2010) and after (2011–2018) regulations. The significance levels are defined as follows: 10% (*), 5% (**) and 1% (***). All the estimations are conducted with robust standard errors (clustered by bank) to control for autocorrelation and heteroskedasticity. In all the estimations, the right-hand side variables are lagged 1 year to account for simultaneity/reverse causality issues.

With this goal in mind, we begin by adding the dummy *STB* to our estimated model (columns 4–6) to account for the role of stress testing. The results show a higher level of OBS exposure for banks that have undergone the tests. This indicates that stress-tested banks tend to have generally alarger exposure to OBS activities than non-stress-tested banks.[21] Nevertheless, we can also observe that despite this being the case before and after the introduction of the new regulation, the magnitude of the estimated difference decreases from the period 2001–2010 (19.7) to the period 2011–2018 (14.9). Hence, this finding underscores that OBS activities by stress-tested banks may have decreased after the 2007–2009 financial crisis. However, *AR* and *STB* do not seem per se to fully explain the implications of stricter capital requirements, that is, either RBC requirements or stress tests.

Before we proceed with our additional tests, it is important to briefly discuss the impact of the control variables. Overall, the results stillhold across different estimations. Indeed, the coefficients show that the OBS exposure ratio is positively related to the bank-specific characteristics: bank size,[22] profitability and business model. However, the OBS exposure is negatively impacted by loans quality. The negative sign of *LLR* means that banks with low loans quality have low OBS exposure. Note that the results are consistent with several studies that examine the drivers of OBS behaviour of banks (Benveniste & Berger, 1987; Koppenhaver & Stover, 1991; Pavel & Phillis, 1987; Jagtiani et al., 1995).

As expected, the positive sign of bank's size implies that larger banks have a higher OBS exposure. A plausible explanation for this is that larger banks have the capacity to enter in large size transactions associated with OBS items that typically serve large institutional investors needs. Similarly, the return on assets exhibits a significant positive coefficient, suggesting that profitable banks have a higher OBS exposure. Note that banks are motivated to move business outside their balance sheets to earn extra fees income, in addition to margins spreads, from the provision of underwriting services associated with OBS activities such as guarantees (Wall, 2014). The ratio of banks' loans to total assets also exhibits a significant positive effect on banks OBS exposure. One would expect that banks with higher loan-to-assets ratios are more focused on lending activities relative to non-traditional activities. Likewise, however, higher loan-to-assets ratios can provide banks with additional loans to securitise and transfer them off their balance sheet. Hence, the positive sign. Unsurprisingly, banks focused on traditional lending rather than market-based operations are more prone to borrowers' default risk, accumulating higher levels of loan loss reserves.[23] As an additional test, it is worth noting that the fee income ratio as an alternative proxy for lending versus other activities is not a significant predictor of OBS activities (Table A2 in the Appendix). Concerning the liquidity requirement characterising the post-DFA period, we also examine the stress-tested banks' behaviour following the evidence in Baker et al. (2017). It turns out that using the liquid assets ratio in alternative to the ratio of foreign versus domestic deposits, the results remain unchanged (Table A1 in the Appendix). Finally, GDP growth and the interest rate spread have a significant positive impact on banks' OBS exposure. As expected, banks tend to increase both on- and OBS activities to meet increasing demand.[24] Hence, as economic activity boosts the demand for loans, the transactions of specialised OBS instruments such as standby letters of credit, guarantees, credit commitments increase too. Thus, an increase in economic activity, as proxied by the Term Spread and real GDP growth, drives the outstanding value of OBS activities up.[25]

Table 5 presents the results when a set of interactions between *Tier1*, *AR* and *STB* are introduced to assess the implications of tighter capital requirements on banks' OBS exposure. Those interactions allow us to disentangle the effects of RBC requirements and stress tests on banks' OBS activities.

The results reported in column (1) account for the interaction between the Tier 1 capital ratio and the after-regulation period, that is, the *Tier1*AR*. This interaction is meant to evaluate whether an increase in the required Tier 1 capital ratio, under the new Basel III framework influences banks' OBS activities. The results suggest that an increase in the required Tier 1 ratio (stricter capital adequacy requirements) after 2010 has no significant impact on the banks OBS exposure ratio. Moreover, the coefficient on *AR* remains significantly negative, confirming that OBS activities are lower during that period, despite changes in the capital ratio requirements have no significant additional impact. Notably, this finding is in sharp contrast with the regulatory capital arbitrage hypothesis (Jones, 2000), which predicts that banks do increase their OBS activities to avoid costly capital requirements.

Next, we investigate if this finding holds also for the stress-tested banks. Column (2) reports the interaction between the Tier 1 ratio and the stress-tested banks dummy, that is, *Tier1*STB*. The significant negative coefficient

TABLE 5 Impact of post-crises regulation on OBS exposure for stress-tested BHCs.

	(1)	(2)	(3)	(4)
Main				
Tier1	−0.044	−0.001	−0.001	−0.046
	(−1.566)	(−1.194)	(−1.227)	(−1.584)
AR	−1.796***	−1.178***	−1.090***	−1.646***
	(−3.681)	(−3.896)	(−3.564)	(−3.244)
Tier1*AR	0.043			0.046
	(1.521)			(1.547)
Tier1*STB		−0.210**		0.237
		(−2.129)		(1.286)
STB*AR			−1.586	5.209*
			(−1.607)	(1.817)
Tier1*STB*AR				−0.579**
				(−2.215)
Controllers				
Assets	0.965***	0.927***	0.936***	0.912***
	(2.927)	(2.797)	(2.840)	(2.753)
ROA	0.503***	0.468***	0.472***	0.498***
	(5.938)	(5.650)	(5.760)	(5.984)
LLR	−0.397***	−0.444***	−0.456***	−0.451***
	(−3.152)	(−3.674)	(−3.714)	(−3.553)
FrnD	0.043	0.026	0.030	0.019
	(1.567)	(1.057)	(1.296)	(0.857)
LoanAsset	0.125***	0.125***	0.126***	0.122***
	(8.728)	(8.677)	(8.765)	(8.454)
GDP	0.621***	0.616***	0.624***	0.625***
	(12.717)	(12.615)	(12.727)	(12.505)
TermSpread	0.155**	0.150**	0.149**	0.141**
	(2.492)	(2.418)	(2.386)	(2.254)
Cons	−5.669	−5.260	−5.674	−4.691
	(−1.146)	(−1.059)	(−1.154)	(−0.940)
Obs.	4217	4217	4217	4217
R-squared	0.194	0.196	0.197	0.204
Interaction	Double	Double	Double	Triple
Estimator	Fixed	Fixed	Fixed	Fixed
Hausman test	0.000	0.000	0.000	0.000
F-test	0.000	0.000	0.000	0.000

Note: Tier1*AR is the interaction term between Tier1 and AR, Tier1*STB is the interaction term between Tier1 and STB, and Tier1*STB*AR is the triple interaction between Tier1, STB and AR. Significance levels are defined as follows: 10% (*), 5% (**) and 1% (***). All the estimations are conducted with robust standard errors (clustered by bank) to control for autocorrelation and heteroskedasticity. In all the estimations, the right-hand side variables are lagged 1 year to account for simultaneity/reverse causality issues.

on *Tier1*STB* indicates that stress-tested banks with a lower (higher) Tier 1 ratio tend to increasingly rely (decreasingly) on OBS activities. Note that this negative effect is in line with the descriptive evidence.[26] Hence, this finding may suggest that higher capital ratio requirements have led some stress-tested banks to rely more heavily on OBS activities to comply with the tighter prudential ruless.

Note that regulatory arbitrage behaviour may also materialize in this process. Thus, we further examine this hypothesis by introducing the triple interaction term *Tier1*STB*AR* to assess the combined effect of tighter capital requirements (RBC requirements under Basel III and stress tests) over the period 2011–2018.[27]

The results reported in column (4) show a significant negative coefficient on this triple interaction, suggesting that in the period after 2010, the OBS activities of stress-tested banks decrease, on average, by 0.6 p.p. when Tier1 increases by 1 p.p. (relatively to non-stress tested and the pre-regulation period). It appears that strenghtened capital regulation (stress tests and RBC requirements) has been effective in reducing OBS activities. However, the negative sign also indicates that undercapitalised banks (with a low Tier 1 ratio) are more prone to take on additional OBS exposure. This might suggest that banks are collectivelly willing toto hold a larger total quantity of OBSassets to artificially meet higher capital requirements. Hence, this is direct evidence of regulatory capital arbitrage for undercapitalised banks. This result is also confirmed by the significant negative sign of *LLR* on the OBS exposure. Banks can reduce their on-balance sheet risk (improve loans quality) by transferring (securitizing) those loans to their OBS entities to circumvent the RBC requirements. Importantly, these results are also consistent with a strand of theoretical and empirical research on regulatory arbitrage channels (see, Bensalah & Fedhila, 2016; Calomiris & Mason, 2004; Farruggio & Uhde, 2015; Jones, 2000; Uzun & Webb, 2007).

Furthermore, we can observe that the volume of OBS activities is lower after 2010 (see the coefficient on *AR*), but it is still higher for STB than other banks during that period (see the coefficient on *STB*AR*). In addition, as discussed above, over the period 2011 - 2018,OBS activities significantly decline for those stress-tested banks with a higher Tier 1 capital ratio (see the coefficient on the *Tier1*STB*AR*). Note that these findings are also in line with the raw data from the summary statistics. In particular, they uncover two important behavioural trends. First, each individual US BHCs significantly raised the capital adequacy ratios, well above the minimum requirements. Interestingly, notice that this capital increase is proportionally much stronger for the large systemically important BHCs. Second, the level of OBS activities (non-core banking) markedly decreased only for the group of the largest banks.

To sum up, our empirical evidence suggests that RBC requirements standalone have no noticeable impact on banks' OBS activities. However, when combined with stress testing exercises, they are an effective prudential policy tool for supervisory authorities to oversee banks OBS activities. Consequently, SIBs with low regulatory capital ratios may increase their OBS exposure in response to tighter regulatory capital requirements. This is also evident from the results on the interaction *Tier1*STB*AR*.

Moreover, regulatory capital arbitrage seems to be at work only in capital-constrained stress-tested banks. Jones (2000) argues that when regulators impose stricter capital standards, banks free up capital by engaging extensively in OBS activities. This process is labelled regulatory capital arbitrage (RCA). This has also important economic and policy implications that need to be addressed. The RCA process arises when there is information asymmetry between regulators and banks. If the RBC measures do not accurately price in the risk of an asset, then an arbitrage opportunity might occur and banks would then increase their exposure to such asset eluding the commensurate taxation rate. Therefore, this would, in turn, lessen the effectiveness of RBC capital requirements.

The results of the stress test exercises underscore the under-capitalised banks that might be riskier from a financial stability perspective. Therefore, banks are motivated to shift risk from on-balance sheet – that are penalized by regulatory capital requirements – to OBS activities. This is also confirmed by the significant negative coefficient on *LLR*, which suggests moral hazard behaviour. In this sense, these results corroborate Acharya et al. (2018) work on the effects of stress testing on credit supply. They show that the US stress tests prompt banks to increase their loans portfolio quality and their capital ratios. However, their analysis is limited to the transfer of risk exposure within a bank's balance sheet. Consequently, we go one step further and evaluate the effect of loans quality on OBS activities. Our results show

that under-capitalised banks increase their OBS activities (e.g. loan sales, securitization, standby letters of credit, and guarantees). Hence, this leads to the transfer of risk off their balance sheet. Thus, an important policy implication of our findings is thatbanking stress testing programmes actually enhance the effectiveness of Basel III capital requirements. As discussed earlier, standalone RBC requirements (under Basel III) are insufficient to discipline OBS activities. However, when combined with stress tests, capital adequacy ratios are effective in *regulating* underregulated OBS activities.

Another implication of our results is that the financial crisis of 2007–2009 has dramatically undermined the credibility of the RBC framework. Indeed, the Basel capital standards have failed to mitigate the tendency of banks to artificially comply with capital requirements by actively engaging in OBS activities, as discussed in Jones (2000) and Acharya et al. (2013). Nevertheless, the US stress tests have been successful in helping restore banks because they could also evaluate OBS activities (Wall, 2014). While RBC requirements remain inadequate in disciplining banks' OBS activities, when combined with stress tests they create the incentive for well-capitalized banks to decrease their OBS exposure. On the contrary, banks with insufficient capital increase their OBS activities. A natural interpretation of these findings is that the US stress tests are an adequate supervisory tool that could be also extended to other US banks.

It is worth emphasizing that another important issue is the solvency of OBS positions. In fact, a bank's capital position might appear sound under Basel III capital requirements although in practice the bank's OBS portfolio is not. According to Moreira and Savov (2017), banks must meet liquidity and credit demands during periods of economic growth. At the same time, they also hold an increasingly sizeable share of OBS activities thereby contributing to the build-up of fragility in the financial system.

4.2 | Robustness checks

In this section, we perform a set of robustness checks. First, to remove the effects of potential outliers, we use the winsorised variable Tier1 (wTier1), excluding values below the 1st percentile and above the 99th percentile. Then, we use *wTier1* in the interaction (Table 6). Second, we provide the estimated effects of stress tests using an alternative measure, replacing the dummy variable *STB* with *STyear* which takes the value of 1 if the bank takes part in the stress test in a given year, and 0 otherwise (Table 7).[28] It is worth noting that the FED requires all participating banks to submit their capital plans during the first quarter of the year. Then, it reviews and issues the approval or revision by the beginning of the second quarter (see Federal Reserve Board, 2011). Therefore, we assume that any adjustments in banks' OBS exposure occur during the stress-tested year.[29] Typically, banks are informed that they will be subject to the stress test early in the year. Furthermore, the FED must notify banks of any objections to their capital plans by the end of the first quarter and accordingly, banks will have to re-submit the revised capital plans to the FED. Thus, in the context of our study, it is important to check whether our results still hold after controlling for such regulatory provisions.

The results reported in Table 6 resemble those displayed in Table 5. Specifically, the triple interaction *wTier1*STB*AR* shows a similar effect. This confirms the argument that large banks that are less capitalised tend to increase their OBS exposure in response to tighter capital requirements, which is consistent with the regulatory capital arbitrage hypothesis.

We also observe that *STB*AR* has a more significant positive effect. This demonstrates that stress-tested banks have higher levels of OBS exposure compared to non-stress-tested banks. Notice that this result aligns with the findings reported in Table 3, where we can observe that the non-stress tested banks have an OBS ratio mean value of 15% and the stress-tested banks exhibit a mean OBS ratio of 34.8% over the period 2011–2018. This is also in line with the results provided in Table 5 which shows that the Tier 1 ratio has a significant negative effect on OBS exposure, especially for the group of SIBs (the effect is more pronounced after 2011, i.e. when Basel III and the stress tests have been enforced).

TABLE 6 Robustness check: Dealing with potential outliers.

	(1)	(2)	(3)	(4)
Main				
wTier1	−0.080*	−0.055	−0.068	−0.073*
	(−1.931)	(−1.300)	(−1.633)	(−1.760)
AR	−1.174	−1.054***	−0.942***	−1.260
	(−1.523)	(−3.534)	(−3.112)	(−1.616)
STB				
*wTier1*AR*	0.006			0.025
	(0.125)			(0.486)
*wTier1*STB*		−0.222*		0.488**
		(−1.662)		(2.292)
*STB*AR*			−1.499	7.818**
			(−1.517)	(2.562)
*wTier1*STB*AR*				−0.836***
				(−3.070)
Controllers				
Assets	0.879***	0.870***	0.856***	0.833**
	(2.652)	(2.636)	(2.591)	(2.510)
ROA	0.500***	0.485***	0.493***	0.491***
	(5.761)	(5.743)	(5.878)	(6.056)
LLR	−0.402***	−0.426***	−0.434***	−0.476***
	(−3.250)	(−3.578)	(−3.570)	(−3.909)
FrnD	0.040	0.025	0.027	0.016
	(1.516)	(1.015)	(1.171)	(0.742)
LoanAsset	0.118***	0.118***	0.118***	0.118***
	(7.355)	(7.219)	(7.206)	(7.271)
GDP	0.611***	0.607***	0.612***	0.626***
	(12.806)	(12.723)	(12.769)	(12.695)
TermSpread	0.153**	0.152**	0.150**	0.135**
	(2.436)	(2.464)	(2.409)	(2.153)
Cons	−3.472	−3.313	−3.148	−3.139
	(−0.674)	(−0.643)	(−0.611)	(−0.607)
Obs.	4217	4217	4217	4217
R-squared	0.195	0.198	0.199	0.207
Interaction	Double	Double	Double	Triple
Estimator	Fixed	Fixed	Fixed	Fixed
Hausman test	0.000	0.000	0.000	0.000
F-test	0.000	0.000	0.000	0.000

Note: The table reproduces the baseline estimations replacing the variable Tier1 ratio with winsorised, at the 1st and 99th percentiles, values of the Tier1 ratio (wTier 1). wTier1*AR is the interaction between wTier1 and AR, wTier1*STB is the interaction between wTier1 and STB and wTier1*STB*AR is the triple interaction between wTier1, STB and AR. Significance levels are defined as follows: 10% (*), 5% (**) and 1% (***). All the estimations are conducted with robust standard errors (clustered by bank) to control for autocorrelation and heteroskedasticity. In all the estimations, the right-hand side variables are lagged 1 year to account for simultaneity/reverse causality issues.

TABLE 7 Robustness check: using STyear dummy.

	(1) AllBanks	(2) STBanks	(3) STBanks
Main			
Tier1	−0.001	−0.122	0.246
	(−1.107)	(−0.952)	(1.589)
STyear	3.771*	−0.723	5.209**
	(1.950)	(−0.738)	(1.977)
*Tier1*STyear*	−0.452***		−0.506**
	(−3.276)		(−2.525)
Controllers			
Assets	0.177	−1.502	−0.960
	(0.628)	(−1.358)	(−0.854)
ROA	0.463***	0.081	0.544
	(5.847)	(0.261)	(1.456)
LLR	−0.597***	−0.072	−0.173
	(−4.739)	(−0.206)	(−0.369)
FrnD	0.031	0.079	0.207***
	(1.469)	(1.064)	(2.956)
LoanAsset	0.130***	0.165*	0.078
	(8.941)	(1.879)	(1.009)
GDP	0.522***	0.627***	0.599***
	(14.251)	(3.943)	(3.307)
TermSpread	0.032	0.064	−0.051
	(0.589)	(0.253)	(−0.172)
Cons	5.899	55.465**	44.191*
	(1.367)	(2.595)	(1.907)
Obs.	4217	447	447
R-squared	0.195	0.215	0.248
Interaction	Double	No	Double
Estimator	Fixed	Fixed	Random
Hausman test	0.000	0.000	1.000
Breusch-Pagan test			0.000
F test	0.000	0.000	

Note: STyear denotes the stress test year and Tier1*STyear denotes the interaction between the Tier 1 ratio and the stress test year. Column 1 reports the estimations for all the banks; columns 2 and 3 show the estimations for stress-tested banks subsample (STBanks). The significance levels are defined as follows: 10 (*), 5 (**) and 1% (***). All the estimations are conducted with robust standard errors (clustered by bank) to control for autocorrelation and heteroskedasticity. In all the estimations, the right-hand side variables are the lagged 1 year to account for simultaneity/reverse causality issues.

As mentioned above, in the regressions results reported in Table 7, the *STB* dummy is replaced by the *STyear* dummy. We report the regression results for the entire sample of banks in column 1, the stress-tested banks only in column 2 and the stress-tested banks with an interaction term in column 3. The aim here is to analyse the effects in the year in which the stress tests have been implemented and, at the same time, the role that regulatory capital requirements play in driving OBS activities. To do so, we estimate the effects from the interaction between the RBC requirement variable, *Tier1*, and the stress test year dummy, *STyear* (i.e. *Tier1*STyear*).

Notably, the results align with the evidence provided in Section 4.1. They are also consistent with the results reported in Tables 4 and 5. In fact, we can see that the main variable, *Tier 1*, is statistically insignificant in all the estimations, which means that the level of regulatory capital that banks hold, by itself, is a negligible determinant of OBS activities. However, the results indicate that the OBS activities increase in the years in which banks have undergone the stress testing exercises, especially when we allow for the interaction between *Tier1* and *STyear*. This effect is stronger when we restrict the analysis to the stress-tested banks only. Nevertheless, the most striking finding is that well-capitalised banks have low exposure to OBS activities, even in the stress-testing years.

Overall, these results reinforce our major finding that the stress test framework adds regulatory pressure on banks to comply with Basel III capital requirements and hold adequate capital against their credit risk exposures. Hence, this behaviour aligns with the regulator's intended goal. However, concurrently, undercapitalised banks have strong incentives to transfer risks off their balance sheet in the years of the stress test exercises to artificially meet prudential capital requirements. Therefore, this result uncovers regulatory capital arbitrage.

Finally, it is worth noting that procyclical regulations such as the Basel Accords (I, II and III) and the stress tests might be counterproductive. On the one hand, we observe that banks' capital levels tend to increase, implying that their solvency will increase in times of crisis. On the other hand, the same regulatory pressure leads banks with high solvency risks to artificially deflate their risks by transferring out of regulators' radar (RBC ratios) onto OBS activities.

4.3 | Alternative OBS measures

As additional robustness check, we utilize alternative OBS measures, including the OBS risk exposures, the exclusion of mortgage securitization and loan commitments from the overall measure of OBS, and finally the ratio of OBS exposures to the banks risk-weighted assets.

Concerning the OBS risk exposures, we replicate the baseline estimations by measuring OBS activities using the suggested conversion ratios of the Basel rules.[30] Table 8 reports the new baseline estimations for the entire period and the pre-and post-regulation periods with fixed and random effects. Importantly, considering all our main variables of interest, we find that our main results continue to hold. We can see that the Tier 1 ratio has no significant impact on the estimated OBS exposures (except in the pre-regulation period), while the 'after-regulation' dummy (AR) has a highly significant negative coefficient, supporting the hypothesis that banks lowered their exposure to OBS activities during the period 2011–2018. Finally, the stress-test dummy (STB) indicates a higher level of OBS exposure for banks that have undergone the tests. Unsurprisingly, the magnitude of the coefficients is lower compared to our previous estimates.

Following our baseline analysis, we have also rerun the estimations introducing the interactions between *Tier 1*, *AR* and *STB* to shed additional light on the impact of tighter capital rules on banks OBS exposure (Table 9). Again, importantly, the results corroborate the evidence presented previously. It is worth noting that the magnitude of the interactions *STB*AR* and *Tier1*STB*AR* decrease significantly, from 5.209 to 0.781 and from −0.579 to −0.087, respectively (column 4).

Table 10 reports the empirical estimates with alternative OBS measures for the 2001–2018 period. What is noteworthy here is that a large part of outstanding OBS exposure islinked to banks' securitizationactivities. As such, we exclude mortgage securitization from the overall OBS measureì(columns 1 and 2).[31]The results for the full sample period align well with the main results (the coefficients of Tier 1 and the after-regulation dummy *AR* are statistically

TABLE 8 OBS risk exposures (baseline estimations).

	(1)	(2)	(3)	(4)	(5)	(6)
	2001–2018	2001–2010	2011–2018	2001–2018	2001–2010	2011–2018
Tier1	−0.000	−0.011*	−0.000	−0.000	−0.015**	−0.000
	(−1.200)	(−1.873)	(−0.461)	(−1.343)	(−2.567)	(−1.614)
AR	−0.190***			−0.209***		
	(−4.170)			(−4.664)		
STB				2.596***	2.951***	2.234***
				(5.917)	(5.790)	(5.057)
Assets	0.145***	0.071	0.106	0.175***	0.114**	0.193***
	(2.936)	(1.297)	(1.470)	(3.855)	(2.376)	(3.207)
ROA	0.071***	0.088***	0.043**	0.075***	0.098***	0.051***
	(5.657)	(6.449)	(2.369)	(5.796)	(6.308)	(2.795)
LLR	−0.064***	−0.037	−0.064***	−0.055***	−0.009	−0.052***
	(−3.439)	(−1.159)	(−3.056)	(−3.011)	(−0.307)	(−2.662)
FrnD	0.007	−0.002	0.006	0.010*	0.002	0.026***
	(1.621)	(−0.672)	(0.557)	(1.891)	(0.616)	(3.476)
LoanAsset	0.019***	0.011***	0.017***	0.019***	0.012***	0.016***
	(8.926)	(3.820)	(5.375)	(9.209)	(4.234)	(5.463)
GDP	0.094***	0.094***	0.052***	0.096***	0.097***	0.048***
	(12.743)	(11.784)	(3.352)	(13.018)	(12.481)	(3.076)
TermSpread	0.023**	0.035***	−0.135***	0.024**	0.037***	−0.123***
	(2.440)	(4.073)	(−5.054)	(2.565)	(4.170)	(−4.713)
Cons	−0.953	0.705	0.108	−1.697**	−0.264	−1.557
	(−1.290)	(0.845)	(0.092)	(−2.544)	(−0.362)	(−1.614)
Obs	4217	2218	1999	4217	2218	1999
R-squared	0.193	0.244	0.168	0.192	0.242	0.161
Interaction	No	No	No	No	No	No
Estimator	Fixed	Fixed	Fixed	Random	Random	Random

Note: Significance levels are defined as follows: 10 (*), 5 (**) and 1% (***).

insignificant) further suggesting that banks lowered their exposure to OBS activities during the period 2011–2018. More interestingly, the stress-test dummy *STB* indicates a lower level of OBS exposure for banks that have undergone the tests. This suggests that the vast engagement of stress-tested banks in OBS activities can be mostly explained by the mortgage securitization market.

In addition, regarding the OBS exposure in relation to potential regulatory capital arbitrage, we have employed a new measure excluding loan commitments (columns 3 and 4). In this case, the coefficient of Tier 1 turns out significant at 1% (column 4), while the after-regulation dummy *AR* is in line with our previous findings. However, excluding this asset, we observe that the stress-test dummy *STB* indicates a lower level of OBS exposure for banks that have undergone the tests. Finally, adding a new measure calculated as the ratio of OBS exposures to the bank's risk-weighted assets (columns 5 and 6), the results fully align again with our previous estimations based on the OBS exposure.

TABLE 9 OBS risk exposures: Impact of post-crisis regulations for stress-tested banks.

	(1) 2001–2018	(2) 2001–2018	(3) 2001–2018	(4) 2001–2018
Tier1	−0.007	−0.000	−0.000	−0.007
	(−1.566)	(−1.194)	(−1.227)	(−1.584)
AR	−0.269***	−0.177***	−0.164***	−0.247***
	(−3.680)	(−3.896)	(−3.564)	(−3.244)
*Tier1*AR*	0.006			0.007
	(1.521)			(1.547)
*Tier1*STB*		−0.032**		0.036
		(−2.128)		(1.287)
*STB*AR*			−0.238	0.781*
			(−1.607)	(1.818)
*Tier1*STB*AR*				−0.087**
				(−2.215)
Assets	0.145***	0.139***	0.140***	0.137***
	(2.927)	(2.797)	(2.840)	(2.753)
ROA	0.075***	0.070***	0.071***	0.075***
	(5.938)	(5.650)	(5.760)	(5.984)
LLR	−0.059***	−0.067***	−0.068***	−0.068***
	(−3.151)	(−3.674)	(−3.713)	(−3.553)
FrnD	0.006	0.004	0.005	0.003
	(1.567)	(1.057)	(1.296)	(0.857)
LoanAsset	0.019***	0.019***	0.019***	0.018***
	(8.729)	(8.677)	(8.766)	(8.455)
GDP	0.093***	0.092***	0.094***	0.094***
	(12.718)	(12.615)	(12.727)	(12.505)
TermSpread	0.023**	0.022**	0.022**	0.021**
	(2.492)	(2.419)	(2.387)	(2.255)
Cons	−0.850	−0.789	−0.851	−0.704
	(−1.146)	(−1.059)	(−1.154)	(−0.940)
Obs	4217	4217	4217	4217
R-squared	0.194	0.196	0.197	0.204
Interaction	Double	Double	Double	Triple
Estimator	Fixed	Fixed	Fixed	Fixed

Note: Significance levels are defined as follows: 10 (*), 5 (**) and 1% (***).

5 | CONCLUSION

This paper examines the effects of the new RBC requirements and the FED's stress test exercises on banks' OBS behaviour. When banks are forced to comply with higher regulatory capital requirements, they either naturally raise their capital levels or may attempt to artificially free up capital by transferring more taxed on-balance sheet assets

TABLE 10 Alternative OBS measures (2001–2018).

	(1) Excluding mortgage securitization	(2) Excluding mortgage securitization	(3) Excluding Loan commitments	(4) Excluding loan commitments	(5) OBS exp/RWA	(6) OBS exp/RWA
Tier1	0.001	0.000	0.001	0.001***	−0.003**	−0.003**
	(0.578)	(0.350)	(1.374)	(3.193)	(−2.396)	(−2.445)
AR	−3.733***	−2.097***	−5.293***	−4.321***	−0.620***	−0.694***
	(−25.789)	(−36.804)	(−88.598)	(−185.648)	(−5.391)	(−5.759)
STB		−0.809***		−0.427***		3.179***
		(−4.767)		(−5.433)		(3.767)
Assets	2.280***	0.324***	1.690***	0.127***	0.080	0.198*
	(14.480)	(8.832)	(17.205)	(7.349)	(0.681)	(1.823)
ROA	0.023	0.167***	0.052**	0.026**	−0.001	0.022
	(0.595)	(4.123)	(2.049)	(2.205)	(−0.041)	(0.780)
LLR	−0.489***	−0.228***	0.019	−0.035***	−0.070	−0.025
	(−4.102)	(−3.916)	(0.365)	(−2.642)	(−1.078)	(−0.420)
FrnD	−0.034**	−0.005	−0.024***	−0.005*	0.033	0.042
	(−2.099)	(−1.379)	(−3.142)	(−1.785)	(1.152)	(1.400)
LoanAsset	0.015*	0.015***	−0.003	0.003**	0.028***	0.028***
	(1.764)	(4.965)	(−0.748)	(2.165)	(6.145)	(7.155)
GDP	1.264***	1.116***	1.312***	1.192***	0.151***	0.159***
	(77.625)	(105.664)	(146.452)	(207.896)	(5.578)	(5.892)
TermSpread	−0.028	−0.305***	0.192***	0.079***	−0.013	−0.007
	(−1.079)	(−15.618)	(16.531)	(12.763)	(−0.551)	(−0.314)
Cons	−11.372***	18.189***	−2.660*	20.888***	−0.795	−3.054*
	(−4.702)	(28.381)	(−1.731)	(71.364)	(−0.438)	(−1.861)
Obs	3636	3636	2806	2806	4216	4216
R-squared	0.599	0.534	0.799	0.776	0.096	0.095
Interaction	No	No	No	No	No	No
Estimator	Fixed	Random	Fixed	Random	Fixed	Random

Note: Significance levels are defined as follows: 10 (*), 5 (**) and 1% (***).

to less taxed OBS assets (regulatory arbitrage). In this paper, we present evidence on the impact of tightened regulatory requirements on non-core banking activities (OBS) for US banks, emphasising the role of stress tests and RBC requirements under Basel III.

Methodologically, our analysis relies on panel data techniques using a sample of BHCs during the 2001–2018 period. We account for the restrictive regulations imposed after 2011 and for stress-tested banks with two main purposes: (i) to establish the relationship between a more stringent regulation and banks' OBS activities; and (ii) to investigate the response of stress-tested and non-stress-tested banks to tighter capital requirements of their OBS activities. Additionally, we examine a set of interactions to disentangle the implications of RBC requirements and of the supervisory stress tests.

Our baseline results demonstrate that, in general, the new regulatory framework encouraged banks to switch away from OBS activities. Furthermore, we do not find evidence that the RBC Tier1 ratio directly affects OBS activities. Additionally, stress-tested banks tend to rely more extensively on OBS activities. We also provide robust evidence that the RBC Tier1 ratio remains insignificant in determining OBS behaviour for non-stress-tested banks. However, it has a significant negative impact on stress-tested banks' OBS behaviour in the new regulatory period.

These findings suggest that the new prudential capital regulatory regime introduced after the 2007–2009 financial crisis caused SIBs to reduce non-core banking activities. Moreover, the impact of standalone RBC ratios, under the Basel III Accord, does not seem to act as an effective regulatory tool for banks' OBS activities. However, our results show that when combined with a more comprehensive capital monitoring framework (i.e. stress testing), RBC is an effective mechanisml to discipline OBS activities. Our intuition here is that the stress tests framework adds regulatory pressure on banks forcing them to hold adequate capital buffers against their risk exposures.

Our key insights are relevant to regulators and practitioners. In particular, we show that the tighter banking capital regulation in response to the global financial crisis can be counterproductive. On the one hand, they prompted banks to increase regulatory capital measures (lowering insolvency risk). On the other hand, however, those measures had an unintended effect on undercapitalized banks that increased their holdings of OBS activities to comply with capital requirements. This implies that regulators should be more vigilant in assessing the risk exposures ofweak banks.

We further show that the stress test framework significantly impacted SIBs with respect to their exposure to OBS activities. In addition, the new RBC requirementsare only economically significant for the group of the too-big-to-fail banks. This has an important policy implication for banking system regulators, suggesting that it would be appropriate the introduction of rules that should limit and potentially exclude OBS activities as a mitigating mechanism of prudential capital requirements. Importantly, this would facilitate the regulators' efforts to prevent the build-up of financial fragilities in the banking sector. It is important to stress that this study is not without limitations and leaves some questions open. First, in our analysis, we focus only on BHCs as they are subject to the stress tests, while different types of banks such as commercial, saving and cooperative banks might respond differently to stricter capital requirements. Therefore, future research might extend the analysis of OBS activities under stricter regulation to different types of banks and forms of regulation. For example, it would be fruitful to explore the implications of the new leverage and liquidity coverage ratios. Note that these measures were not available yet at the time of this study. The leverage ratio requires banks to hold 3% of capital against total exposures. As its denominator includes both on-balance and OBS risk exposures, as well as derivatives and trading exposures, it might provide further critical information on OBS activities. Hence, it diverges from other Basel III RBC ratios, which consider only the risk-weighted assets..

Second, it must be noted that our dependent variable, the volume of OBS activities, does not inherently measure risk. While we present evidence translating the OBS outstanding amount into equivalent on-balance sheet risk exposure, by assigning different weights on the various OBS activities, it would be desirable to further scrutinize the response of each component to stricter banking regulation.

Third, during our sample period, some modifications concerning the definition and level of the Tier 1 capital ratio have occurred, potentially distorting the interpretation of the findings. While we acknowledge the importance of using different measures of capital ratio as robustness test (e.g. the CET1), we were severely limited by data availability. We expect banks below or near the minimum required capital ratio to react differently from other well-capitalised banks. Investigating how the behaviour of banks changes around the CET1 threshold represents an interesting question for future research.

ACKNOWLEDGEMENTS

We would like to thank the Editor, Anthony Saunders. We are also grateful to an anonymous referee for the extensive comments and constructive suggestions that have greatly helped to improve the paper. We gratefully acknowledge that the final version of this article builds upon a preliminary study conducted by Sad Abu alim, as part of his doctoral studies, under the supervision of Giovanni Calice. The authors alone are responsible for any errors and for the views expressed in the paper.

DATA AVAILABILITY STATEMENT

The main data that support the findings of this study are available from the authors upon request.

ORCID

Giovanni Calice https://orcid.org/0000-0001-9161-4697
Francesco Savoia https://orcid.org/0000-0001-6405-3556

ENDNOTES

[1] Whether there is an income diversification benefit from relying more on non-interest income (a product of OBS activities) is an ongoing debate in the literature. Some studies view fees income generated from OBS activities as a tool to diversify profits and, therefore, reduce earnings volatility (e.g. Abedifar et al., 2018; Calmès & Théoret, 2010; Gueyié et al., 2019). Other papers show that there is a strong association between non-interest income and various types of bank's risk (e.g. Stiroh, 2004; Stiroh & Rumble, 2006).

[2] Examples of recent papers which examine various banking areas such as derivative markets (Haynes et al., 2018), liquidity (Duijm & Wierts, 2016), channels of adjustments in response to capital requirements (Cohen & Scatigna, 2016), market reaction (Sahin & de Haan, 2016), lending behaviour (Acharya et al., 2018), and stress testing effectiveness (Gambetta et al., 2017).

[3] The denominator of the regulatory capital ratio is the risk-weighted assets (RWA) under all Basel Accords except the recent leverage ratio under the Basel III Accord.

[4] From 2011, BHCs with $50 billion or more of consolidated assets are required to take part of the Comprehensive Capital Analysis and Review (CCAR).

[5] For instance, Benveniste & Berger (1987) examine securitization with recourse; loan sales are examined in Pavel & Phillis' (1987a,b) paper; and standby letters of credit are considered in Koppenhaver & Stover (1991).

[6] "…the proposals on bank capital and liquidity by the Basel Committee on Banking Supervision… are very significant. If the final form of the proposals, known as Basel III, is reasonably similar to the consultative version, we believe that the reforms are likely to trigger fundamental changes in business models and product pricing" Standard & Poor's (2010).

[7] The Basel III Accord was enacted in December 2010, immediately after the global financial crisis. The new measures were supposed to be implemented gradually from 2011 to 2014 but some measures had several extensions to 2015, 2019 and 2022.

[8] Failure to meet a certain threshold or to pass the stress test results in penalties. The minimum RBC ratios are: 3, 6 and 8% for the leverage ratio, the Tier 1 ratio and the total capital ratio, respectively.

[9] The main aim of the stress test exercises is to prevent systemically important banks from taking excessive portfolio risks and require them to hold larger cushion of capital against losses during adverse economic scenarios. In addition, Basel III refined the RBC ratios criteria and increased their minimum levels to foster banks' capital.

[10] The results of the Comprehensive Capital Analysis and Review CCAR and Dodd-Frank Act stress Tests DFAST are published on the FED website.

[11] There are two US stress tests: the CCAR and the DFAST. Both are very similar in the application. We follow Cornett et al. (2020) and examine the CCAR stress test because it started earlier than the DFAST stress test. Therefore,we can provide estimates for a longer period by focusing our analysis on the CCAR stress test. Moreover, examining the DFAST might lead to bias in our results because the majority of banks are the same for both stress tests. BHCs entered and left the stress test rounds during our sample period. The CCAR's first round in 2011 included 18 BHCs, and the CCAR latest round in 2018 included 35 BHCs.

[12] The OBS items in simple terms are assets and liabilities of a bank that are not recorded on their balance sheets. The Federal Deposit Insurance Corporation (FDIC) assigns the following classification to OBS items: OBS lending activities (letters of credit and loan commitments), transfers of financial assets (guarantees, securitization with and without recourse), contingent liabilities (bankers' acceptances, standby letters of credit issued by another depository institution; FDIC, 2002).

[13] Note that Basel III was endorsed in 2010 and the Accord's tighter requirements have been implemented by 2019. Hence, our sample period (2001–2018) allows us to compare the banks' OBS behaviour before (2001–2010) and after (2011 - 2018) the implementation of Basel III capital requirements.

[14] We also employ as a complementary estimation approach the total capital ratio under the Basel III Accord and obtain similar results (which are not reported). With regard to the new CET1 and leverage ratios, we were limited by data availability since banks were still implementing without reporting those two new measures during our analysis.

[15] A high OBS ratio is a characteristic of stress-tested banks. Hence, we expect the interaction *AR*STB* to have a significant positive sign.

[16] OLS is biased and inconsistent because of unobserved heterogeneity. Since we use robust standard errors in the FE estimator, in an additional check, we also employ the Sargan–Hansen test (not reported) to test for over identification in the RE estimator. This test confirms the Hausman test results that FE is preferred.

[17] In the next section, when the interactions are considered, we will see that the preferred estimatoris the FE.

[18] Some of the variables may be persistent due to the extended period of our study. Therefore, we use the standard errors clustered by bank to resolve this concern.

[19] Recall that the Basel III Committee introduced the new definition of capital along with the new minimum capital ratio requirements. The Basel III reforms include a revised calculation method of the risk-weighted assets in the denominator of the Tier1 ratio.

[20] For example, the FED can require BHCs of $50 billion of assets or more to sell or transfer off-balance sheet items to unaffiliated entities if the BHC is does not meet certain legal requirements. Furthermore, limits on short-term debts are expanded to off-balance sheet exposures. Finally, the inclusion of off-balance sheet activities in computing capital requirements.

[21] Under the Dodd–Frank Act, stress-tested banks are classified as systemically important banks or "too-big-to-fail" due to their large size and interconnectedness.

[22] The significant positive sign of the natural log of total assets in the OBS ratio indicates that larger size banks have higher OBS exposure than smaller size banks. This lends support to the results observed from the dummy stress test *STB* and confirms our preliminary remarks in Section 3.2.

[23] Another plausible explanation is that banks with larger core banking (lending) activities have a larger loans portfolio and, therefore, their main income is generated by the interest margins on those loans. This means that they lend to riskier borrowers to increase their margins. However, banks that have high OBS usage benefit from additional fees and commissions generated by those activities, which results in increasing margins.

[24] The results for the controllers reported in the estimations below are consistent with the ones reported in Table 4.

[25] In some specifications, we also control for local occupational variations and credit and housing market dynamics, including the unemployment rate and the house price index *(HPI)* at the state level. The results from this robustness check generally confirm our baseline findings (for brevity, the results are omitted in this version and are available upon request).

[26] Note that the stress tested banks sub-sample has an average OBS exposure ratio of 36.22% before 2011 and of 34.86% after 2011 while the Tier1 ratio increased from 9.55 to 13.89%.

[27] In column (3), we note that the coefficient on the interaction between the after regulation period and the stress-tested banks (*STB*AR*) is statistically insignificant. Therefore, this finding does not provide confirmation that the OBS exposure is higher for stress-tested banks in the post-regulation period.

[28] The authors acknowledge that the assignment (number of participating banks) of the banks to the stress test changed over time due to the refinement of the stress test routine. Hence, the data are collected manually from each of the stress test reports published on the FED's website. Accordingly, the dummy variable represents only those banks that took part in the stress test in the relevant year.

[29] Note that our measure of total OBS exposure denotes its value at the end of the year. Hence, the ratio incorporates these adjustments.

[30] Standby letters of credit, guarantees and securitization (100%); LT loan commitments (50%); commercial letters of credit (20%); financial derivatives (0%–15% depending on the type and residual maturity) and ST loan commitments (0%).

[31] Jagtiani et al. (2021) show that as of 2016, about 80% of FHA mortgage origination was in the non-bank sector.

[32] The negative Tier1 value in our sample belongs to Deutsche Bank (DB) USA corporation for the years 2002 through 2012. Another bank with a negative Tier 1 ratio is First NBC bank holding company but only for the year 2017. DB was going through a re-structuring process of its capital, especially, after the stricter US regulations (Braithwaite and Nasiripour (2012). The negative Tier 1 capital value is not a data or measurement error. For robustness, we check this issue and its impact on our results; first by excluding those banks with high Tier 1 values; second, by winsorising the Tier1 at the 1% and 99% levels. However, we find no significant impact on the results, as shown in Tables 4 and 5. Therefore, we keep the bank observations in the reported estimations.

REFERENCES

Abedifar, P., Molyneux, P., & Tarazi, A. (2018). Non-interest income and bank lending. *Journal of Banking & Finance*, Elsevier B.V., *87*, 411–426. https://doi.org/10.1016/j.jbankfin.2017.11.003<./bib>

Acharya, V. V., Berger, A. N., & Roman, R. A. (2018). Lending implications of U.S. bank stress tests: Costs or benefits? *Journal of Financial Intermediation*, *34*, 58–90. https://doi.org/10.1016/j.jfi.2018.01.004

Acharya, V. V., & Richardson, M. (2009). Causes of financial crises. *Critical Review*, *21*(2–3), 195–210. https://doi.org/10.1080/08913810902952903

Acharya, V. V., Schnabl, P., & Suarez, G. (2013). Securitization without risk transfer. *Journal of Financial Economics*, Elsevier, *107*(3), 515–536. https://doi.org/10.1016/j.jfineco.2012.09.004

Ahnert, L., Vogt, P., Vonhoff, V., & Weigert, F. (2018). The impact of regulatory stress testing on bank's equity and CDS performance. SSRN. https://doi.org/10.2139/ssrn.3179540

Allen, L., & Jagtiani, J. (2000). The risk effects of combining banking, securities, and insurance activities. *Journal of Economics and Business*, Elsevier, *52*(6), 485–497. https://doi.org/10.1016/s0148-6195(00)00033-3

Altunbas, Y., Gambacorta, L., & Marques-Ibanez, D. (2009). Securitisation and the bank lending channel. *European Economic Review*, Elsevier, *53*(8), 996–1009. https://doi.org/10.1016/j.euroecorev.2009.03.004

Ashraf, D., Ramady, M., & Albinali, K. (2016). Financial fragility of banks, ownership structure and income diversification: Empirical evidence from the GCC region. *Research in International Business and Finance*, Elsevier Ltd, *38*, 56–68. https://doi.org/10.1016/j.ribaf.2016.03.010

Baer, H. L., & Pavel, C. A. (1988). Does regulations drive innovation? *Economic Perspectives*, (Mar, No V.12 15), *12*, 3–15.

Baker, C., Cummings, C., & Jagtiani, J. (2017). The impacts of financial regulations: Solvency and liquidity in the post-crisis period. *Journal of Financial Regulation and Compliance*, *25*(3), 253–270.

Bensalah, N., & Fedhila, H. (2016). What explains the recourse of US commercial banks to securitization? *Review of Accounting and Finance*, Emerald Group Publishing Ltd., *15*(3), 317–328. https://doi.org/10.1108/RAF-03-2014-0033

Benveniste, L. M., & Berger, A. N. (1987). Securitization with recourse. *Journal of Banking & Finance*, *11*(3), 403–424. https://doi.org/10.1016/0378-4266(87)90041-0

Berger, A. N., & Udell, G. F. (1994). Did risk-based capital allocate bank credit and cause a "credit crunch" in the United States? *Journal of Money, Credit and Banking*, *26*(3), 585. https://doi.org/10.2307/2077994

Federal Reserve Board. (2018). *Comprehensive capital analysis and review 2018: Assessment framework and results.* Federal Reserve Board, June(June). federalreserve.gov/publications/files/2018-ccar-assessment-framework-results-20180628.pdf

Bostandzic, D., & Weiß, G. N. F. (2018). Why do some banks contribute more to global systemic risk? *Journal of Financial Intermediation*, Elsevier, *35*, 17–40. https://doi.org/10.1016/j.jfi.2018.03.003

Bouwman, C. H. S., Hu, S. (Sophia), & Johnson, S. A. (2018). Differential bank behaviors around the Dodd–Frank Act size thresholds. *Journal of Financial Intermediation*, Elsevier, *34*, 47–57. https://doi.org/10.1016/j.jfi.2018.01.005

Calem, P. S., Correa, R., & Lee, S. J. (2020). Prudential policies and their impact on credit in the United States. *Journal of Financial Intermediation*, *42*, 100826.

Calmès, C., & Théoret, R. (2010). The impact of off-balance-sheet activities on banks returns: An application of the ARCH-M to Canadian data. *Journal of Banking & Finance*, Elsevier B.V., *34*(7), 1719–1728. https://doi.org/10.1016/j.jbankfin.2010.03.017

Calomiris, C. W., & Mason, J. R. (2004). Credit card securitization and regulatory arbitrage. *Journal of Financial Services Research*, *26*(1), 5–27. https://doi.org/10.1023/B:FINA.0000029655.42748.d1

Cheng, A. C. S., Fung, M. K., Hu, K. P., & Cheng, L. T. W. (2015). Interest rate deregulation and banks' off-balance-sheet activities: A Hong Kong perspective. *Applied Economics*, Routledge, *47*(47), 5088–5102. https://doi.org/10.1080/00036846.2015.1042144

Cohen, B. H., & Scatigna, M. (2016). Banks and capital requirements: Channels of adjustment. *Journal of Banking and Finance*, Elsevier B.V., *69*, S56–S69. https://doi.org/10.1016/j.jbankfin.2015.09.022

Cornett, M. M., Minnick, K., Schorno, P. J., & Tehranian, H. (2020). An examination of bank behavior around Federal Reserve stress tests. *Journal of Financial Intermediation*, *41*, 100789.

Demirgüç-Kunt, A., & Huizinga, H. (2010). Bank activity and funding strategies: The impact on risk and returns. *Journal of Financial Economics*, *98*(3), 626–650. https://doi.org/10.1016/j.jfineco.2010.06.004

Deyoung, R., & Roland, K. P. (2001). Product mix and earnings volatility at commercial banks: Evidence from a degree of total leverage model. *Journal of Financial Intermediation*, Academic Press, *10*(1), 54–84. https://doi.org/10.1006/jfin.2000.0305

DeYoung, R., & Torna, G. (2013). Nontraditional banking activities and bank failures during the financial crisis. *Journal of Financial Intermediation*, Elsevier Inc., *22*(3), 397–421. https://doi.org/10.1016/j.jfi.2013.01.001

Duijm, P., & Wierts, P. (2016). The effects of liquidity regulation on bank assets and liabilities. *International Journal of Central Banking*, *12*(2), 385–411. https://www.ijcb.org/journal/ijcb16q2a9.pdf

Duran, M. A., & Lozano-Vivas, A. (2013). Off-balance-sheet activity under adverse selection: The European experience. *Journal of Economic Behavior & Organization*, Elsevier B.V., *85*, 176–190. https://doi.org/10.1016/j.jebo.2012.04.008<./bib>

Eber, M., & Minoiu, C. (2016). How do banks adjust to stricter supervision? SSRN. https://doi.org/10.2139/ssrn.2662502

Elliott, D. J., Feldberg, G., & Lehnert, A. (2013). The History of Cyclical Macroprudential Policy in the United States.

Farruggio, C., & Uhde, A. (2015). Determinants of loan securitization in European banking. *Journal of Banking & Finance*, Elsevier B.V., *56*, 12–27. https://doi.org/10.1016/j.jbankfin.2015.01.015

FDIC. (2002). *Off-balance sheet activities.* https://www.fdic.gov/regulations/safety/manual/manual_examinations_full.pdf

FED. (2011). *Comprehensive capital analysis and review: Objectives and overview board of governors of the Federal Reserve System.* http://www.federalreserve.gov/boarddocs/srletters/2009/SR0904_Addendum.pdf

Fernandes, M., Igan, D., & Pinheiro, M. (2017). March madness in Wall Street: (What) does the market learn from stress tests? *Journal of Banking and Finance*, *112*, 105250. https://doi.org/10.1016/j.jbankfin.2017.11.005

Ferri, G., & Pesic, V. (2017). Bank regulatory arbitrage via risk weighted assets dispersion. *Journal of Financial Stability*, Elsevier B.V., *33*, 331–345. https://doi.org/10.1016/j.jfs.2016.10.006

Flannery, M., Hirtle, B., & Kovner, A. (2017). Evaluating the information in the federal reserve stress tests. *Journal of Financial Intermediation*, Elsevier Inc., *29*, 1–18. https://doi.org/10.1016/j.jfi.2016.08.001

Gallo, J. G., Apilado, V. P., & Kolari, J. W. (1996). Commercial bank mutual fund activities: Implications for bank risk and profitability. *Journal of Banking and Finance. North-Holland*, *20*(10), 1775–1791. https://doi.org/10.1016/S0378-4266(96)00024-6

Gambetta, N., García-Benau, M. A., & Zorio-Grima, A. (2017). Stress test impact and bank risk profile: Evidence from macro stress testing in Europe. *International Review of Economics and Finance*, 1–8. https://doi.org/10.1016/j.iref.2018.04.001

Georgescu, O.-M., Gross, M., Kapp, D., & Kok, C. (2017). *Do stress tests matter? Evidence from the 2014 and 2016 stress tests* [Working paper], ECB (May). https://doi.org/10.2866/622534

Gueyié, J.-P., Guidara, A., & Lai, V. S. (2019). 'Banks' non-traditional activities under regulatory changes: Impact on risk, performance and capital adequacy. *Applied Economics*, Routledge, *51*(29), 3184–3197. https://doi.org/10.1080/00036846.2019.1569197

Haynes, R., McPhail, L., & Zhu, H. (2018). *Assessing the impact of the Basel III leverage ratio on the competitive landscape of US derivatives markets: Evidence from options*. SSRN Electronic Journal, (April). https://doi.org/10.2139/ssrn.3378619

Huang, J. (2018). Banking and shadow banking. *Journal of Economic Theory*, Elsevier Inc., *178*, 124–152. https://doi.org/10.1016/j.jet.2018.09.003

Jagtiani, J., & Khanthavit, A. (1996). Scale and scope economies at large banks: Including off-balance sheet products and regulatory effects (1984–1991). *Journal of Banking & Finance*, *20*(7), 1271–1287.

Jagtiani, J., Lambie-Hanson, L., & Lambie-Hanson, T. (2021). Fintech lending and mortgage credit access. *The Journal of FinTech*, *1*, 1–50.

Jagtiani, J., Saunders, A., & Udell, G. (1995). The effect of bank capital requirements on bank off-balance sheet financial innovations. *Journal of Banking & Finance*, *19*(3–4), 647–658. https://doi.org/10.1016/0378-4266(94)00145-S

James, C. (1988). 'The use of loan sales and standby letters of credit by commercial banks'. *Journal of Monetary Economics*, *22*(3), pp. 395–422.

Jones, D. (2000). Emerging problems with the Basel Capital Accord: Regulatory capital arbitrage and related issues. *Journal of Banking & Finance*, *24*(1–2), 35–58. https://doi.org/10.1016/S0378-4266(99)00052-7

King, M. R. (2013). The Basel III Net Stable Funding Ratio and bank net interest margins. *Journal of Banking & Finance*, Elsevier B.V., *37*(11), 4144–4156. https://doi.org/10.1016/j.jbankfin.2013.07.017

Koppenhaver, G. D., & Stover, R. D. (1991). Standby letters of credit and large bank capital: An empirical analysis. *Journal of Banking & Finance*, *15*(2), 315–327. https://doi.org/10.1016/0378-4266(91)90070-3

Lepetit, L., Nys, E., Rous, P., & Tarazi, A. (2008). The expansion of services in European banking: Implications for loan pricing and interest margins. *Journal of Banking & Finance*, Elsevier B.V., *32*(11), 2325–2335. https://doi.org/10.1016/j.jbankfin.2007.09.025

Litan, R. E. (1985). Evaluating and controlling the risks of financial product deregulation. Yale Journal on Regulation, *3*, 1. https://heinonline.org/HOL/Page?handle=hein.journals/yjor3&id=7&div=&collection=

Mohanty, S. K., Akhigbe, A., Basheikh, A., & ur Rashid Khan, H. (2018). The Dodd-Frank Act and Basel III: Market-based risk implications for global systemically important banks (G-SIBs). *Journal of Multinational Financial Management*, Elsevier B.V., *47–48*, 91–109. https://doi.org/10.1016/j.mulfin.2018.10.002

Moreira, A., & Savov, A. (2017). The macroeconomics of shadow banking.', *The Journal of Finance*, *72*(6), 2381–2432. https://doi.org/10.1111/jofi.12540

Morgan, D. P., Peristiani, S., & Savino, V. (2014). The information value of the stress test. *Journal of Money, Credit and Banking*, *46*(7), 1479–1500. https://doi.org/10.1111/jmcb.12146

Naceur, S. B., Marton, K., & Roulet, C. (2018). Basel III and bank-lending: Evidence from the United States and Europe. *Journal of Financial Stability*, Elsevier B.V., *39*, 1–27. https://doi.org/10.1016/j.jfs.2018.08.002

Pavel, C., & Phillis, D. (1987). Why commercial banks sell loans: An empirical analysis. *Economic Perspectives*, *11*(3), 3–14.

Rogers, K., & Sinkey, J. F. (1999). An analysis of nontraditional activities at U.S. commercial banks. *Review of Financial Economics*, Elsevier Inc., *8*(1), 25–39. https://doi.org/10.1016/S1058-3300(99)00005-1

Sahin, C., & de Haan, J. (2016). Market reactions to the ECB's comprehensive assessment. *Economics Letters*, Elsevier B.V., *140*, 1–5. https://doi.org/10.1016/j.econlet.2015.12.011

Shapiro, J., & Zeng, J. (2020). *Stress testing and bank lending*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3432291

Standard & Poor's. (2010). 'Standard & Poor's Response To The Basel Committee's Proposals on Bank Capital and Liquidity', April 15, 2010.

Stiroh, K. J. (2004). Diversification in banking: Is noninterest income the answer? *Journal of Money, Credit, and Banking*, *36*(5), 853–882. https://doi.org/10.1353/mcb.2004.0076

Stiroh, K. J., & Rumble, A. (2006). The dark side of diversification: The case of US financial holding companies. *Journal of Banking & Finance*, North-Holland, *30*(8), 2131–2161. https://doi.org/10.1016/j.jbankfin.2005.04.030

Uzun, H., & Webb, E. (2007). Securitization and risk: Empirical evidence on US banks. *Journal of Risk Finance*, Emerald Group Publishing Ltd., *8*(1), 11–23. https://doi.org/10.1108/15265940710721046

Wall, L. D. (2014). The adoption of stress testing: Why the Basel capital measures were not enough. *Journal of Banking Regulation*, *15*(3–4), 266–276. https://doi.org/10.1057/jbr.2014.10

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Calice, G., & Savoia, F. (2024). The effects of stress testing on US banks' off-balance sheet activities. *Financial Markets, Institutions & Instruments*, *33*, 447–475. https://doi.org/10.1111/fmii.12196

AUTHOR BIOGRAPHIES

Giovanni Calice is a Professor of Banking and Economics at Bangor University Business School. He previously taught (as tenured faculty member) at the University of Birmingham, Loughborough University and the University of Southampton. Giovanni has written extensively on systemic risk and is a leading expert on credit derivatives markets. His work has been published in the world's leading academic journals in finance and economics. He is a regular speaker at numerous university and practitioner seminars and international conferences. He obtained his PhD in Economics from the University of Bath.

Francesco Savoia is a Postdoctoral Research Fellow at the University of Milan and a research affiliate at the Yunus Social Business Centre of the University of Bologna. His research interests lie primarily in empirical applications to regional development issues at the macro and micro levels, including economic inequality, technological change and financial development. He was a Visiting PhD Fellow at the JRC of the European Commission. Before joining the University of Milan, he was a Research Fellow at the University of Bologna, the University of Modena and Reggio-Emilia and the University of Naples Federico II. He also worked as a Policy Analyst at the Italian Ministry of Economic Development.