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The Impact of Capital Requirements on Crises in the U.S. and E.U.

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To my parents Sami and Glyn...

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CEO of Jabbour Enterprises

Ravel Jabbour

Originality Declaration

I Ravel Jabbour declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institute of tertiary education. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is given in the bibliography.

Copyright Declaration

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Glossary

AIRB Advanced Internal Ratings Based Approach.

B&U Berger and Udell (1994).

BCBS Basel Committee on Banking Supervision.

BIS Bank for International Settlements.

BLC Bank Lending Channel.

BNWC Bank Net Worth Channel.

CR Capital Ratio.

FDIC Federal Deposit Insurance Corporation.

FED Federal Reserve System.

FIRB Foundation Internal Ratings Based Approach.

GDP Gross Domestic Product.

LR Leverage Ratio.

MSCI Morgan Stanley Capital International.

NPL Non-Performing Loans.

OCC Office of the Comptroller of the Currency.

RBC Risk-Based Capital.

RW Risk Weight.

RWA Risk-Weighted Assets.

SA Standardized Approach.

SIFI Systemically Important Financial Institution.

TBTF Credit Crunch Hypothesis.

TBTF Too Big To Fail.

Abstract

Basel capital requirements have attracted a lot of debate surrounding their adequacy as the Basel I and II regulations were shortly followed by the 1990-1991 and 2007-2009 crises. This creates an appropriate scene for comparative purposes with respect to the impact of these requirements: same country of origin (U.S.) and similar outcome (credit crunches). Hence, after providing a brief overview of these regulations in Chapter 2, the aim of Chapter 3 is to apply the methodology in Berger and Udell (1994) over the subprime crisis and investigate any Basel II related impact. We find inconclusive results with regard to the impact of regulatory capital on the crisis and argue that this could be due to overshadowing by other factors such as leverage and liquidity.

Chapter 4 looks at changes in co-movement patterns (correlation) between the leverage and capital ratios across the aforementioned crises. We find that the change in the impact of the latter ratio on subsequent crises lies in the changing dynamics between the two regulatory requirements. Therefore, we argue that changes in risk-weights categories introduced in the Basel framework can reverse the relationship between both ratios. This inherently changes the binding constraints on banks between the two crises. Our reasoning is based on a formula we develop linking the two ratios together which is derived from the sensitivity of the risk-based capital ratio to a change in one of its risk-weights.

Finally, in Chapter 5, we shift our attention to European countries in order to explore the factors that jointly determine returns, spillovers and contagion. While our findings point out that EU countries might have the incentive to reduce their capital ratios in order to achieve higher returns, nonetheless having a substantial amount of capital can shield them from the effects of spillovers. Hence, it is important to maintain sensible capital ratios to counterweight the aggravating effects of bilateral linkages such as trade and cross-border finance.

Chapter I:

Introduction

The Bank for International Settlements (BIS) is the world's oldest international financial organization. Established in 1930 by a consortium of European countries along with Japan, it soon became known under the name of the city it was headquartered in: Basel (Switzerland). Initially entrusted with the task of overseeing reparations which were imposed on Germany after World War I, ever since, the BIS has taken on many objectives as part of its role of "bank of central banks" for its sixty member countries. These include overseeing the implementation of the Bretton Woods agreement, managing cross-border capital flows in the aftermath of the oil and debt crises of the 1970s and 1980s, fostering monetary policy cooperation, as well as providing emergency financing to countries in need. As part of its functions, the BIS also provides an extensive repository of statistical data linked to the global financial system in addition to a wide array of research documentation related to its various areas of policy work.

Towards the end of the 1980s, the BIS took charge of regulating the capital adequacy of financial institutions in order to put in place a global safety net and maintain a "level playing field". This task was assigned to the Basel Committee on Banking Supervision (BCBS) which introduced the concept of capital requirements. The latter would then have to be enforced by all member countries, albeit with some national discretion.

At the heart of these requirements lies the capital ratio which governs the amount of capital banks are required to hold to cover their unexpected losses[1]. This breakthrough was seen as an improvement over the leverage ratio which had already been implemented

[1]Expected losses having already been accounted for by reserve requirements.

in other countries. As such, the capital ratio, despite going through many changes, has always been the centerpiece of all Basel risk-based capital regulations (I, II, III).

Initially, the capital ratio initiative was praised as it re-assured the markets that banks were taking sufficient precautionary measures in regard to any risky behavior on their part. However, in light of the credit crises that affected financial markets, in particular those in the U.S., in the aftermath of the Basel I, the praise surrounding the impact of regulatory standards soon shifted to controversy (Syron (1991), Bernanke and Lown (1991) and Hall (1993)).

As a result, the question of whether the BIS objective can in reality be attained through enforcing capital requirements became a widespread subject of debate and continues unabated today. However, most of the Basel criticism was focused on the 1990-1991 credit crunch. Hence, based on the study conducted by Berger and Udell (1994), we complement the literature by exploring the hypothesis of whether capital cushions have affected the banks' lending during the 2007-2009 subprime crisis. Using a bank panel dataset obtained from the FDIC covering the period 2004-2009, we observe that capital requirements were indirectly implicated in the crisis while other factors such as leverage and liquidity played a bigger role by exploiting Basel regulatory loopholes. These results have direct policy implications with regard to Basel III which sought to capitalize on the shortcoming of its predecessors.

Still, one notable difference between both credit crunches was that banks were considerably overcapitalized prior to the onset of the 2007-2009 subprime crisis compared to those which had undergone the 1990-1991 recession (Milne (2002) and Chami and Cosimano (2010)). This raises the question that, if capital requirements were achieved prior to the subprime crisis, how could the Basel framework be blamed again for having accelerated if not caused another credit crunch? The answer to this puzzle seems to lie in the relationship between the capital ratio and the leverage ratio which is governed by risk-weights categories determined by the Basel regulation. However, we show that changes to risk-weight categories which affect the correlation pattern between both ratios are not reflected in the subprime crisis. This refutes the hypothesis that they were behind the changes to the binding constraint on banks. As a matter of fact, we demonstrate that these dynamics are governed by a formula linking the two ratios together which derives from the sensitivity of the risk-based capital ratio to a change in its risk-weight(s). One implication of our work regarding the Basel III regulation consists in validating the newly established capital increments in a mathematical rather than heuristical approach.

Our analysis has so far focused purely on U.S. financial markets. In an attempt to broaden our perspective on the Basel regulation, we shift the focus towards a more macroeconomic outlook on crises in Europe. Worldwide shocks such as financial crises have a direct impact on banking stock returns. One characteristic the more recent crises have in common is their widespread nature as they propagate from one country to the other. The latter, known as spillover and contagion effects, has recently attracted a lot of research by the academic (Baele (2005) and Fratzscher (2012)) and policy (Chan-Lau et al. (2012a) and Poirson and Schmittman (2012)) research communities without any focus in relation the Basel II implementation in Europe (CRDIII). Using a panel of European countries covering the period 2003-2012, we explore the bilateral and regulatory factors that jointly determine banking returns and the transmission of external and internal shocks. This information should allow regulators to decide on adequate macro-preventive measures to protect countries from the harmful consequences of these shocks. Beyond trade and financial linkages which are the principal channels investigated by previous research, we find that bank-specific factors at the heart of the new Basel III regulation also play a role in channeling global shocks. While this finding is not new in itself (Berger and Bouwman (2013)), our main contribution is in showing that both returns and shock transmission are governed by different combinations of the same factors across various samples of the banking sector. This study therefore complements the work of the ECB (2011) and constitutes a forward-looking assessment of enhancements brought by the new Basel III regulation.

This dissertation is therefore structured as follows. In Chapter 2, we present an overview of capital requirements. In Chapter 3, we look at the Basel capital credit crunch hypothesis from a new perspective in light of the subprime crisis. In Chapter 4, we explore the Basel capital requirement puzzle related to the contrasting effects of these requirements by undertaking a study of changing interconnections between leverage and risk-based capital ratios. In Chapter 5, we investigate the determinants of European returns, spillovers and contagion whilst taking into account these ratios as well as bilateral country linkages. Finally, we conclude with our main contributions and suggestions for future research.

Chapter II:

Capital Requirements Overview

1 Risk-Based Capital (RBC) Requirements - Basel

i Basel I

The first Basel initiative was published in 1988 (BCBS (1988)) to set the minimum threshold for banks in terms of capital ratio requirements. These formed the basis for Pillar 1 of the regulation[1]. The components of the Tier 1 (T1CR) and Total (TCR) capital ratios, also known as the Cooke ratio(s) after their inventor, are capital (K) and risk-weighted assets[2] (RWA). The latter depends on the number of risk-weight categories (N), individual assets (w_i) and their respective risk-weights (w_i) as given by the formulae below.

$$RWA = \sum_{i=1}^{N} w_i A_i \tag{II.1}$$

$$T1CR = \frac{\text{Tier 1 K}}{RWA} >= 4\% \tag{II.2}$$

$$TCR = \frac{\text{Tier 1 K + Tier 2 K + Tier 3 K}}{RWA} >= 8\% \tag{II.3}$$

Capital K is divided into three categories: Tier 1 (mainly equity capital and disclosed reserves), Tier 2 (loan loss reserves, preferred stock, subordinated debt and hybrid in-

[1]The other two pillars were Market Discipline and Supervisory Review.

[2]It is common to add a Credit Risk Equivalent (CRE) component to account for off-balance sheet items using the concept of a credit conversion factor (CCF) in the RWA summation. However what is still missing nowadays from that definition is how to correct the CCFs to account for securitization's credit enhancement mechanism.

struments), Tier 3 (unsecured and subordinated assets with a maturity of two years). According to Van-Roy (2005), "the difference between Tier 1 and Tier 2 capital thus reflects the degree to which capital is explicit or permanent". In addition, the lower the Tier level of capital, the better it is at absorbing losses. It is therefore common for some authors such as Buehler et al. (2010) to use Total Common Equity, a subcomponent of Tier 1, as the core capital layer for solvency requirements.

Assets on and off banks' balance sheets are divided into four (credit) risk categories according to the Standardized Approach as can be seen in Table 1. The least risky assets (e.g. T-Bills) were allocated a 0% risk-weight while the more risky ones (e.g. commercial loans) were given a 100% risk-weight. The weighted sum of these assets (RWA) was used to set the minimum risk-based capital (RBC) threshold according to the formulae below:

Table 1:
Basel I RW categories

This table shows the RW categories attributed to the different assets according to the Basel Standardized Approach.

RW	**Asset**
0%	Cash
	Claims on central governments and central banks
	Other claims on OECD central governments and central banks
	Claims collateralised or guaranteed by OECD central-governments
20%	Cash items in process of collection
	Claims on banks and loans guaranteed by the OECD
	Some non-OECD banks and government deposits and securities
	General obligation municipal bonds
	Some mortgage-backed securities
50%	Loans fully secured by mortgage on residential property
100%	Claims on the private sector
	Claims on banks and governments incorporated outside the OECD
	Claims on commercial companies owned by the public sector
	Real-estate, premises, plant and equipment and other fixed assets
	Capital instruments issued by other banks (unless deducted from capital)
	All other assets

ii Basel II

Initially published in mid-2004 (BCBS (2004)), the second Basel II framework was updated in 2006 (BCBS (2006)). Although it widened the scope for minimum capital requirements in areas such as Market and Operational Risk, our focus here remains on Credit Risk. The Standardised Approach as devised above remained almost the same aside for a few changes in risk-weight allocation. Hence, the Cooke ratio was renamed as the McDonough ratio. In addition, new methods were configured for computing risk-weights for banks which relied on credit ratings. These methods became known as the foundation and advanced internal ratings based approaches (FIRB/AIRB).

In the words of Kupiec (2001), this multiplicity in methods lead to the finding that "capital requirements for low-quality, high-risk instruments are significantly lower under the standardised approach than under the foundation internal ratings based approach (FIRB), which means that banks using the standardised approach have an incentive to specialise in high-risk credits, therefore increasing the overall risk of the banking system". In other words, "the temptation of picking the model that gives the lowest capital charge is irresistible" according to Moosa (2010).

The notable changes to the RWs were in the area of fully secured residential mortgages which saw their RW decrease from 50% to 35% as shown in the figure below taken from Blundell-Wignall and Atkinson (2010).

Further updates were introduced into the regulation with no notable change for capital requirements. These changes became known as Basel II.5.

iii Basel III

Midway through the subprime crisis, as capital requirements revealed their incapacity to absorb the full-weight of the losses in the banking sector, OpRisk and Compliance revealed that "Basel II is dead, long live Basel III". This coincided with the BCBS's

Basel I and Basel II risk weights and commentary

Risk Weights Under Basel I and Basel II (Pillar I), %							
	BASEL I	BASEL II Simplified Standardised	BASEL II Standardised based on External Ratings		BASEL II Advanced: Internal Ratings Based (IRB) 2004-05 QIS 4 Avg % chg in portf. MRC	2004-05 QIS 4 Median % Chg in portf. MRC	
SECURITY							Basel II Advanced IRB
Most Government/central bank	0	0			0	0	Comes close to letting banks set their own
AAA to AA-			0				**Pillar 1** capital, with supervisory oversight.
A+ to A-			20				Risk weights depend on internal estimates
BBB+ to BBB-			50				of a loan's probability of default; loss-given-
BB+ to B- (& unrated)			100				default; exposure to loss. These are based
Below B-			150				on the banks' own complex risk models,
Other public (supervisors discretion)	0-50	0			0	0	relying on subjective inputs and often on
Claims on MDBs	20	0			-21.9	-29.7	unobservable (e.g. OTC illiquid securities)
Most OECD Banks & Securities firms	20	20	<90days	Other	-21.9	-29.7	prices.
AAA to AA-			20	20			**Pillar 2** provides for supervisory oversight.
A+ to A-			20	50			With stress testing, and guidance from
BBB+ to BBB- (& unrated)			20	50			supervisors, banks can be made to hold
BB+ to B-			50	100			capital for risks not adequately captured
Below B-			150	150			under Pillar 1.
Residential Mortgages-fully secured	50	35	35		-61.4	-72.7	**Pillar 3** is disclosure and market discipline
Retail Lending (consumer)	100	75	75		(-6.5 to -74.3)	(-35.2 to -78.6)	which relies on some notion of market
Corporate & Commercial RE	100	100			(-21.9 to-41.4)	(-29.7 to -52.5)	efficiency. Rational markets punish poor
AAA to AA-			20				risk managers.
A+ to A-			50				
BBB+ to BB- (& unrated)			100				
Below BB-			150				

Sources: BIS (1988) and BIS (final version June 2006); FDIC (2005); authors' commentary.

Figure 1: Change in RWs between Basel I and II

attempt to derive lessons of the shortcomings from the crisis in order to solidify the previous framework(s). The new framework, which became known as Basel III, was phased-in early 2013 but gave banks until 2019 for full implementation. In what concerns capital requirements, the new changes consisted in raising the Tier 1 capital ratio to 6% (Equation (II.2)). Also, while the minimum Total capital ratio will remain at 8% (Equation (II.3)), it will be supplemented with a new conservation (2.5%) and counter-cyclical buffers (0-2.5%), as well as a SIFI buffer (0-2.5%) for TBTF institutions. Tier 3 capital was scratched altogether while Tier 2 instruments (especially hybrids) received heavy scrutiny.

In addition to increasing risk-based capital ratios, the regulation introduced liquidity as well as leverage requirements. The latter is described in our next section.

2 The Leverage Requirement

Albeit outside the spectrum of the Basel regulation until Basel III, one cannot complete an overview of capital requirements without mentioning leverage. In fact, the three main U.S. banking regulators (OCC, FDIC and FED) operated a discretionary leverage ratio requirement based on (undisclosed) CAMEL[3] ratings of the banks. Based on their score, banks were assigned a different threshold. Note that the leverage ratio is not to be confused with the traditional corporate finance definition of Debt/Equity as both "capital" measures differ mainly in their denominator: the leverage ratio uses Unweighted assets (UWA) whereas the capital ratio uses risk-weighted-assets (RWA) in relation to capital (numerator).

$$LR = \frac{\text{Tier 1 K}}{UWA} >= 3, 4, 5\% \tag{II.4}$$

As indicated by Blum (2008), the leverage ratio can sometimes be regarded as an "old-fashioned, blunt instrument" because it does not discriminate between various risk profiles. Nonetheless, it gained importance after the subprime crisis as banks reached critical leverage levels which resulted in a wave of deleveraging after the crisis was over.

As we will show later with regard to the effects of combining the capital ratio with the leverage ratio, the evidence is mixed. This suggests the need to dissociate the leverage ratio from the capital ratio in any impact study on solvency issues.

[3]The latter are used as a method of classifying banks based on their Capital Adequacy, Assets, Management Capability, Earnings, Liquidity, Sensitivity.

Chapter III:

The Risk-Based Capital Credit Crunch Hypothesis, a Dual Perspective

1 Introduction

Credit crunches have hit the U.S. banking sector almost immediately after the BIS regulatory standards came into existence. More precisely, the Basel I (BCBS (1988)) and II (BCBS (2004) and BCBS (2006)) regulations were followed, within a few years, by the 1990-1991 recession and the 2007-2009 crisis[1]. In line with Bernanke and Blinder (1992)'s observation that some policies take effect on the economy only six months after being introduced and do not completely adjust until after two years, in these circumstances, the obvious question to ask is whether there is a causal link between the regulations and the subsequent economic downturns. In answering that question, we choose to focus on one common factor behind these regulations: risk-based capital.

Research regarding the effects of capital has been shaped by the dual perspectives of risk and growth. The study of risk and capital was first pioneered by Koehn and Santomero (1980) and Kim and Santomero (1988), followed by Gennotte and Pyle (1991), Blum (1999) and Montgomery (2005). This stream of literature advocates that banks become less risk averse when compensating for the utility loss due to increases in capital. In contrast, Furlong and Keely (1987) and Furlong and Keely (1989) showed that stricter

[1]The first period was the "second most shallow" recession according to Greenspan et al. (2010). In contrast, the second period was the worst crisis since the Great Depression; and hence conveniently dubbed the "Great Recession".

capital requirements result in a decrease in total bank risk. This idea was later expanded by many authors, including Keely and Furlong (1990), Shrieves and Dahl (1992), Calem and Rob (1999) and Blum (2008). Together, these two literature strands highlight the lack of consensus regarding the impact of capital requirements which still prevails in current discussions between regulators and practitioners.

From a growth standpoint, the majority of authors blamed Basel I for being implicated in the 1990-1991 downturn. Syron (1991) was the first to associate the recession, or "credit crunch", with a "capital crunch". Bernanke and Lown (1991) agreed; asserting that, rather than raise capital, banks post-Basel I tried to meet the requirements by decreasing their assets (lending) in order to reduce the risk-weighted assets component of their capital ratios. More often than not, the latter is seen as the easier way out in order to maintain a target capital ratio with minor changes (Hyun and Rhee (2011)). Similarly, Moore (1992) and Baer and McElravey (1993) find that the reduction in lending arising from the higher proportion of constrained banks as a result of the new capital requirements was at its highest during the recession. Hall (1993) corroborates these findings by concluding that the Basel I regulation is inevitably linked to the crunch.

Much less has been said regarding the Basel II relation to the subprime crisis which is why we focus exclusively on this period. This crisis is more controversial than the 1990-1991 recession for many reasons. First, the regulation was technically not enforced by the time the crisis unfolded. To address this matter, we argue that regulatory effects arise well before full implementation. Second, capital ratios were non-binding in the sense that over-capitalized banks had no trouble meeting the capital thresholds imposed by the new regulation. Berger et al. (2008) find that in 2006, average Tier 1 and Total capital ratios across U.S. bank holding companies was around 11.3% and 12.8%. Similarly, Chami and Cosimano (2010) find that in the early stages of the crisis, the top 25 banks in the U.S. had a Tier 1 capital ratio of 8.3% and a Total capital ratio of 11.4%[2]. In both

[2]Close estimates of 9.7% and 11.9% were obtained by Demirguc-Kunt et al. (2010) for each ratio

cases, the estimates were well beyond the 4% and 8% standards imposed by the Basel I regulation and maintained as part of Basel II. Hence, the effect of the new regulation can be thought to have been diluted by excess capital formation (Berger et al. (2008)) or non-existent due to the fixed capital thresholds. However, we argue that a more tacit regulatory change affecting the risk-weighting of residential loans played a key role during the subprime crisis.

In line with Peek and Rosengren (1995b)'s view that a shock to capital is not enough, on its own, to cause a crunch, the literature disregarded any direct Basel effect on the crisis and turned its attention towards other factors, namely leverage[3]. As evidenced by Bernanke and Lown (1991), the use of the leverage ratio began well before that of the capital ratio and captures the effect of capital attributed to national as opposed to international regulators[4]. When studies such as Gilbert (2006) revealed that up until mid-2005 only the two largest U.S. banks were above the 5% leverage requirement for well capitalized institutions, the issue of which solvency ratio was the binding capital constraint on banks became a main concern for policymakers. Comparing the works of Baer and McElravey (1993) and Peek and Rosengren (1994) with those of Kiema and Jokivuolle (2010), Blundell-Wignall and Atkinson (2010) and our work in Chapter 4, one can observe that the capital ratio assumed the role of binding requirement following Basel I while the leverage ratio seems to have taken over after Basel II. This implies that any study on capital effects should clearly differentiate between capital and leverage ratios.

Leverage, however, did not single-handedly affect financial markets during the subprime crisis. Liquidity also seems to have played an important role. According to Moosa (2010), holding a large proportion of illiquid assets can trigger a run on deposits and

using a sample of OECD countries.

[3]Leverage is not to be confused with the traditional corporate finance definition of Debt/Equity. In fact both "capital" measures differ mainly in their denominator: the leverage ratio uses Unweighted assets (UWA) whereas the capital ratio uses risk-weighted-assets (RWA) in relation to capital (numerator).

[4]The OCC, FDIC and FED are responsible for enforcing leverage rules on a discretionary basis on U.S. banks.

force asset sales which can destabilize even a well-capitalized bank. Chiuri et al. (2001) and Chiuri et al. (2002) focus on developing countries and point out that the reduction in poor quality lending resulting from a positive effect of capital requirements can be negated by the drying up of bank liquidity. This is a compelling result because it highlights a potential link between risk-based capital, liquidity and good quality lending which was has implications for the 2007-2009 crisis.

Overshadowed by these factors, the Basel capital regulation did not have its due contribution assessed with respect to the 2007-2009 crisis. More importantly, while the role of these factors has mostly been ascertained by ex-post bank market reviews, in this research, we aim to showcase in an empirical setting the combined effect on lending reduction of these factors alongside capital. This will allow us to pinpoint the factor that played the more important role during the crisis while uncovering any (residual) effect related to Basel II.

Our benchmark is the model by Berger and Udell (1994), henceforth B&U, which uses data from the FDIC Quarterly Consolidated Reports of Condition and Income (Call Reports). Despite its inability to account for quality rather than quantity effects of capital, one argument in favor of using the B&U model is the distinction it makes between the risk-based capital and the leverage effects. In its original form, B&U's Risk-Based Capital Credit Crunch Hypothesis (RBC CCH) explores whether during a credit crunch, risky banks, constrained by low capital ratios, tend to reduce lending more than others. In this paper, we introduce an adaptation of the RBC CCH for banks with high capital ratios, in order to investigate the relationship between capital ratios and the subprime crisis. Another argument for choosing B&U's model is its tractability. It allows us to introduce new crisis-specific hypotheses alongside leverage, liquidity and coercive risk-retrenchment. These hypotheses, if valid for the crisis, add support to the Basel III recommendations[5] especially regarding the coexistence of capital, leverage and

[5]These include a rise in capital ratios supplemented by additional capital protection layers such as a

liquidity ratios.

Our research features closely-connected aspects with the work of Beatty and Liao (2011) who looked at the impact of Basel I on the dotcom and subprime crises using a similar empirical methodology. Focusing on loan loss provisions (the "pro-cyclical provisioning hypothesis"), they find evidence that well-capitalized banks are more likely to lend especially during recessions . We argue that while this could have held for the dotcom crisis, Basel I was too far back to affect the subprime crisis having been superseded by Basel II. Moreover their results do not differentiate between capital and leverage ratio effects which we seek to overcome in our study. On the other hand, Berger and Bouwman (2013) use bank data spanning from 1984-2009 in order to assess the differential impact of capital during normal times as well as during five different crises. Two of the latter are the ones alluded to for the purposes of this study. Their work can be seen as complementary to ours as it focuses on the risk perspective with regard to capital ratios, abstracting from any growth-related analysis. As such, their results support the fact that capital improves banks' survival rates during all crises regardless of size. However, their work does not emphasize the relationship between the Basel regulations and financial crises as they incorporate other (unrelated) market and dummy crises.

This research is thereby structured as follows. In section 2 we provide the justification for a possible causal link between Basel II and the subprime crisis. In section 3 we present the main hypotheses. Section 4 describes the data and empirical framework. We then run the model and elaborate on its findings in section 5. Section 6 presents the results of our robustness tests. Finally, we conclude with the main contributions and policy implications along with possible extensions for future work.

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conservation buffer (2.5%), a countercyclical buffer (0-2.5%) and a SIFI buffer (1-2.5%). Tier 3 capital has been removed while Tier 2 instruments (especially hybrids) have come under heavier scrutiny.

2 Motivation

i The Basel II regulation and the subprime crisis

In order to support the link between Basel II and the subprime crisis we start by revisiting the roll-out of Basel I in the U.S: according to various accounts (Woo (2003), Blasko and Sinkey (2006), Flannery and Rangan (2008) and Beatty and Liao (2011)) the first set of regulations was adopted in 1988, full set by 1989, beginning of phase-in around 1991, yet only fully implemented in 1992 (i.e. post-crunch). In comparison, the Basel II framework was released in June 2004; but the final guidance which took effect in April 2008 only dealt with advanced features such as the Internal Ratings Based Approach (FIRB/AIRB). At that time, the G20 full implementation of Basel II was scheduled for 2011, a year after Basel III was endorsed. Hence, while regulators argue that Basel II was not fully implemented by the time the subprime crisis took place, the claim we make here is that one cannot automatically cast out any linkage between Basel II and the subprime crisis simply based on effective implementation dates. The reasons are:

First, unless there is doubt that guidelines will change or there is some particular gain from delaying the implementation process, known as regulatory arbitrage (Jones (2000)), banks have interest in phasing-in the regulations as soon as possible as this sends a positive signal to the market and creates a competitive advantage. The findings in support of the speed at which banks respond to new capital regulations are plentiful[6]. Hall (1993) explains that banks had already reacted as early as 1987 after gaining insight into the Basel I guidelines with the joint US/UK agreement. This was confirmed by Hancock and Wilcox (1994) who made the assumption that even before the 1990-1991

[6] The bi-annual Financial Stability Institute (FSI) survey on the "Implementation of the New Capital Adequacy Framework" showed that out of the 106 countries that were on course to implement Basel II prior to 2008, 66 had implemented the Standardized Approach, 46 FIRB, 43 AIRB. On the other hand, U.S. regulators have assured the BCBS of being on course to implement the more sizeable changes of Basel III ahead of the 2019 deadline despite delays caused by the simultaneous introduction of the Dodd-Franck Act.

crunch, banks behaved as if the 8% threshold for the total capital ratio was already in place. In parallel, a survey by the Federal Reserve Board showed a shift in lending patterns had occurred in 1989 according to Shrieves and Dahl (1995); to the extent that, Montgomery (2005) spotted that even coefficients on the leverage ratio in Japan, which were insignificant before Basel I, turned significant almost immediately after the regulation was established. Note that this behavior also applies to non-capital constrained banks as Van Den Heuvel (2009) showed that banks optimally reduce their lending even if capital requirements are not binding in order not to risk violating the standards in the future. In sum, the surveyed authors, as well as many others such as Avery and Berger (1991) and Shrieves and Dahl (1992), are proponents of a causal effect between Basel I and the subsequent crunch irrespective of the final phasing-in of the regulation.

Second, despite the fact that U.S. regulators mandated the use of Basel II only for core banks, the non-core ones which had the necessary qualifications were given the right to switch to the new regulation early on (Herring (2007)). Moreover, because of the competitive disadvantage that would be caused to U.S. banks from not applying the risk-weight reduction on residential mortgages, the regulators agreed to implement a "transition period to the unconstrained use of the Basel II risk-weights" which fell under the Advanced Notice of Proposed Rulemaking[7] (FDIC (2005)). As such, Blundell-Wignall and Atkinson (2009) argue that banks did not wait for the formal application of Basel II in order to take advantage of the return incentive from the risk-weight reduction. The same authors (Blundell-Wignall and Atkinson (2010)) go a step further to conjecture a possible link to the crisis which we develop in the next section.

ii The Critical Change in Basel II

In light of the fact that regulatory capital targets remained unchanged between Basel I and II, one plausible question to ask is which changes could have had an impact on the

[7]The latter became informally known as Basel 1A.

subprime crisis.

As noted by Watanabe (2007), Basel I set the risk-weight on residential mortgages to half the level of other loans with comparable borrower creditworthiness and quality. The reason stated by Blundell-Wignall and Atkinson (2010) is that collateral plays a big part in deciding the risk-weights for assets which explains why mortgages could be considered safer than commercial and industrial loans. Hence, under Basel II, the second round lowering from 50% down to 35% was due to the sense of security provided by the housing boom as the collateral in mortgages further lowered their perceived risk.

Blasko and Sinkey (2006) find that after Basel I, the sizable increase real-estate lending banks (64% between 1989-1996) was linked to the banks' willingness to take advantage of the risk-weight on these assets. There is no reason to believe that under the new regulation, a similar change would have caused banks to behave differently; especially as this placed mortgages in a category closer to T-Bills than risky loans[8]. As such, banks could economize on capital and, at the same time, generate high profits in a bullish housing market. However, when the business cycle reverted after the bubble burst, the housing collateral became over-valued while the risk-weighting remained unchanged. As a result, whereas previous rounds of risk-weight lowering were upheld by the market (Avery and Berger (1991)), this one lead to more criticism of Basel II due to the static nature of risk-weights.

Another potentially important change was the credit enhancement due to securitization in the form of Residential Mortgage-Backed-Securities (RMBS). This change effectively set the risk-weight for RMBSs to 20%, lower than that of its individual loan components. Note that both changes directly impact the users of the Standardized Approach. However, regardless if they chose to implement the latter or either of the IRB methods, according to Blundell-Wignall and Atkinson (2010), banks could always be

[8]Without accounting for differences in interest rate risk as market risk was a totally novel addition to Basel II that could not be assumed to have been taken into account as fast as changes to risk-weights. The latter relates to the magnitude of the changes which became clear after the update in 2006.

relied on to try to game the regulatory system in order to save on capital especially at a time where the regulation was not fully enforced. In other words, banks will not apply a different credit risk method unless it outperforms the current one in terms of capital reduction. As such, any incentive arising from the decrease in risk-weights will have been factored in one approach or the other.

iii The Basel II Effect on Loan Growth: a Dual Perspective

Having shown which Basel II changes could have had an impact leading to the crisis, we now present the mechanism through which the effects could have been channeled.

After the advantage stemming from the Basel I risk-weight setting on mortgages had been consumed, capital ratios then declined towards the end of the 1990s as reported in Milne (2002), before rising again as per Berger et al. (2008). Meanwhile, an important change in bank behavior took place as Flannery and Rangan (2008) detected that the relationship between capital and risk reverted from being negative in the years following Basel I to positive after 1998. This indicates that over-capitalization was an excuse by banks to take on additional risk despite the restriction on lending imposed by high capital buffers according to Berger et al. (2008). This moral hazard leads to a deterioration in borrower screening on behalf of the banks (Keys et al. (2010)).

Yoshikawa et al. (1994) argue that a credit crunch can be induced by a demand rather than a supply shift. On that note, Baba (1995) shows that in a disequilibrium framework, the weaker effect between demand and supply determines the actual size of lending. More precisely, according to Kishan and Opiela (2000), the credit channel is formed by the borrower net worth (BNWC or demand) channel and the bank lending (BLC or supply) channel. Normally during a crisis, the demand-side effect is due to deposit draining; however, for this crisis we look at a different source. Since the banks admittedly relaxed the creditworthiness criteria for their loans, they could be seen as partly if not fully responsible for the loan quality deterioration which eventually caused them to cut down on lending. In other words, the supply channel was affected by an endogenous effect linked to the mortgage buyers which constitute the demand side. As such, the BNWC would have contributed to the change in loan supply unlike the 1990-1991 crunch where the reduction in supply was mostly exogenous and independent of the borrower pool.

Bridging both capital and credit perspectives together, one can regard the 1990-1991 crunch as an example of a decrease in bank (supply) riskiness, owing to a flight to quality to decrease risk-weighted assets in order to meet capital requirements. This resulted in a direct adverse effect on growth. We postulate that the impact (if any) of capital ratios on the subprime crisis happened in two phases as follows. Hiding behind inflated capital buffers, banks increased their risk-taking (moral hazard) while taking advantage of the reduction in risk-weight. Then, as loan write-off occurred, this caused a decrease in capital which lead to a subsequent slowdown in lending growth to maintain the banks as much above regulatory requirements. In sum, while the main component of the capital ratio related to the the 1990-1991 crunch was its denominator (risk-weighted assets), the numerator (capital) seems to have played the key role in the 2007-2009 crunch. In both cases, however, the effect would be captured by the same instrument, capital ratios.

If the latter is confirmed, this study will have illustrated a dual perspective for the impact of capital ratios on lending growth between both crises, thereby extending B&U's risk-based capital credit crunch hypothesis (RBC CCH) to encompass highly capitalized banks.

3 Credit Crunch Hypotheses

In this section, we present the hypotheses we investigate as part of our model.

H1: Risk-Based Capital Credit Crunch Hypothesis (RBC CCH)

According to B&U, the RBC CCH can be stated as follows: when banks are subjected to a regulatory change which increases capital requirements, one should expect a uniform[9] movement by all constituent assets into (out of) the low (high) risk-weight categories. As credit is normally in the upper risk-weight categories, the RBC CCH, if true, would predict a fall in lending growth. Note that this hypothesis cannot support any quality effect of capital and the focus is purely on level (quantity) effects.

Although the RBC CCH tested by B&U focused on the lending behavior of banks constrained by low capital ratios, the authors foresaw that even if the hypothesis was rejected for the 1990-1991 crunch, its importance could become instrumental in the future with the advent of additional types of risk. This would agree with the creation of the new risk-weight category for mortgage lending and is in line with the statement by Barajas et al. (2004) that the enhancement of the risk-weight scheme for credit risk valuation under Basel II should make loans more sensitive to new risk factors. In accordance with the dual perspective on capital illustrated in the previous section, these arguments have fueled our incentive to explore the RBC CCH from a different angle, that of banks which entered the crisis with high capital ratios.

H2: Leverage Credit Crunch Hypothesis

Assets in the leverage ratio are un-weighted and therefore not adjusted for any of the bank's risks in contrast to the capital ratio. It is argued that during the subprime crisis, risk-based capital requirements had a counter-beneficial effect due to, in some part, leverage. The latter can arise as the proportion of assets with low-weight (as in mortgages) increases. At this point, the capital ratio can remain in line with regulatory targets as the leverage ratio decreases (Chapter 4). This indicates a desire on the part of banks to maximize profit and a call for excessive risk-taking (Moosa (2010)).

[9] The validity of the uniformity assumption is debated in Appendix A.

Arguments in support of this detrimental effect have existed since the 1990-1991 crunch. Hall (1993) warned that higher Tier 1 capital ratios translated into more cumulative losses for dangerously leveraged banks. In that respect, the banks' preliminary increase in capital ratios is seen as an excuse in order to obtain a lower "technical" leverage ratio requirement from the regulators. This lead the author to assert that a country and/or sector specific leverage ratio can be harmful to risk-based capital. Moreover, despite earlier claims by Estrella et al. (2000) that risk-based capital has no predictive power over downturns, Buehler et al. (2010) affirm that the leverage ratio's predictive power for distress becomes non-existent when combined with the capital ratio. Finally, Blundell-Wignall and Atkinson (2010) highlight that seeking to achieve a certain imposed leverage ratio can push banks to arbitrage the weights to ensure their capital ratio barely goes beyond its specified target. This creates distortionary effects such as shifting banks towards low risk-weighted assets which materializes in a cutdown on lending.

In contrast, Avery and Berger (1991) downplayed the negative effect of leverage under the premise that its role is not to focus on off-balance sheet items. Similarly, Blum (2008) found empirical evidence that the two capital measures have a synergetic effect when combined together as leverage can compensate for deficiencies in risk-based capital requirements; thus insuring that banks will hold the first-best level of capital.

In light of the above, we undertake an investigation of the role of leverage in order to gauge whether the subprime crisis was in some way a repeat of the previous crunch. Our findings will therefore assess the Basel III advocacy of a combination of both capital measures in spite of the warnings expressed by some authors in the literature.

H3: Voluntary VS Coercive Risk-Retrenchment Credit Crunch Hypothesis

One of B&U's non-regulatory supply-driven hypotheses looked at the impact of Non-Performing Loans (NPLs). According to their Voluntary Risk-Retrenchment CCH, banks voluntarily reduced their risk-seeking activity leading to a reduction in risky lending (supply-side). Testing for such a hypothesis during the subprime crisis would seem misplaced as it entails that banks did so willingly. However, our argument stemming from the discussion of the dual perspective on capital would imply that this cut-down can also be coerced. This arises when banks are obliged to respond to (the induced) losses coming their way from their borrowers (demand-side). This change in perspective reflects the shift from a BLC to a BNWC channel as per Kishan and Opiela (2000) which changes the hypothesis from *Voluntary* to *Coercive*.

H4: Liquidity Credit Crunch Hypothesis

Loutskina and Strahan (2009) highlighted the fact that a bank's willingness to supply credit can also be driven by funding and asset liquidity conditions. In fact, as stated in Demirguc-Kunt et al. (2010), the liquidity inherent to residential mortgage backed securities holdings rapidly deteriorated once the crisis unfolded. Our aim is to validate this hypothesis in order to evaluate in hindsight, the appropriateness of introducing liquidity requirements to the framework.

4 Methodology

i Data and Sample Selection

Our data is culled primarily from a single source based on required bank filings, the FDIC Call Reports, over the period 2004Q3-2009Q2. Our final dataset comprises of almost 10,000 banks and more than 100,000 bank-quarter data points. In comparison, B&U's sample size consisted of more than 600,000 observations as they used a much longer control period than the rest of the literature dating back thirteen years prior to the 1990-1991 crunch[10]. However, when they reduce the control period to two years

[10] One reason is because they use a pre-1985 flag related to data availability which is not related to our case.

prior to the crunch, this does not affect their findings. In contrast, Hancock and Wilcox (1993), Peek and Rosengren (1995a) do not include any control period in their models.

In our setup, we establish the control and crunch periods in the following manner. We use the the third quarter of 2004, which immediately followed the Basel II declaration, as the start of the control period. This allows three years (including the second revision in 2006) for changes in bank behavior to take place[11]. As for the beginning of the crunch, our choice of the third quarter of 2007, which coincides with the widening of the U.S. TED spread, agrees with that of Berger and Bouwman (2013), Moosa (2010) and Gambacorta and Marques-Ibanez (2011). Finally, based on U.S. GDP, the second quarter of 2009 was the last one in which growth was negative. In contrast with the more conservative approach in Demirguc-Kunt et al. (2010)[12], this leads us to concur with King (2012) on the end of the crisis.

ii Variables Definition

Our first set of variables is taken from B&U to form our baseline model[13]. Additional variables, which constitute our enhanced model, are separated from the previous ones by a dashed line as can be seen in Table 2. This table also describes control and crunch period means for all variables[14].

[11] As argued earlier, actual implementation dates do not matter as B&U ended their control period a year before the beginning of phasing-in of the Basel I regulation, i.e. mid-way through the crunch.

[12] These authors chose the first quarter of 2009 as the crunch end.

[13] We have discarded B&U's SHARE variable due to multi-collinearity. Similarly, we removed the CRRAT variable as this was used for testing the loan examination hypothesis which we deem irrelevant for our analysis. Moreover, one striking feature we observed in B&U's model is the systematic opposite and inconsistent signs between T1RAT and TOTRAT in all the regressions. This is a permanent feature of the model whether the coefficients are significant or not and went unnoticed under B&U. This property, which arises due to the high correlation with T1RAT, makes it difficult to compare with the effects of capital reported elsewhere (Beatty and Liao (2011)). For this purpose we remove it from our model.

[14] Note that despite cleaning the data using B&U's filtering process (see empirical section), outliers are still bound to arise due to the size of the sample. Even after removing some of them, the mean of the variables remained almost unchanged with a noticeable decrease in standard deviation. Given that we would have to devise an ad hoc cleaning mechanism for each variable which does not appear to influence our results, we maintain the standard deviations as per our original sample in order to preserve the comparative aspect of our work with that of B&U.

Table 2:
Variable Definition and Sample Means

The values listed below are the means of the variables used in both the baseline and enhanced iterations of our model. Standard errors reported in between brackets correspond to the sample's standard deviation divided by the square root of the sample size. The Control period corresponds to 2004Q3-2007Q2 whereas the Crisis period corresponds to 2007Q3-2009Q2. Panel A groups all LHS variables in Equation (III.1) while the rest are the RHS variables. Note that capital and leverage ratios are preceded by a negative sign in order to interpret them as RISK factors. NPLs are defined as loans with 90 days or more past due and non-accrual. All RISK factors are also included as square ($1/2RISK^2$) and interaction ($CRUNCH \times RISK$ and $1/2CRUNCH \times RISK^2$) terms as per our model. The squares of RF3MO, SLOPE+ and SLOPE- are also included. Growth rates are scaled by the GNP deflator and measured in continuous-time as $\dot{Y_{it}} \equiv lnY_{it} - lnY_{it-1}$ for bank i at quarter t. Observations in the fourth quarter constitute the base group for seasonality variables in Panel F while banks with less than $100 million in total assets are in the base group in Panel H. Finally, banks that are Federal Reserve-regulated form the base group in Panel I.

Symbol	Definition	Control	Crisis
	A. Endogenous Asset Growth Rates		
CRLN	Real quarterly growth rate of commercial real estate loans	0.027	0.031
		(0.574)	(0.616)
CILN	Real quarterly growth rate of commercial and industrial loans	0.020)	0.014
		(0.646)	(0.681)
INLN	Real quarterly growth rate of installment loans	-0.008	-0.003
		(0.824)	(0.342)
RB100	Real quarterly growth rate of assets in RW 100% category	(0.019	0.015
		(0.082)	(0.083)
USTRA	Real quarterly growth rate of U.S. Treasuries&Agency obligations	-0.011	-0.208
		(0.410)	(0.294)
RB0	Real quarterly growth rate of assets in RW 0% category	-0.021	0.014
		(0.215)	(0.238)
USTA	Real quarterly growth rate of U.S. Agency obligations	0.089	-0.130
		(0.071)	(0.279)

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Table 2: (continued)

Symbol	Definition	Control	Crisis
USTREAS	Real quarterly growth rate of U.S. Treasuries	-0.091	-0.071
		(0.695)	(0.960)
CURR	Real quarterly growth rate of currency and coin	-0.009	0.008
		(0.488)	(0.417)
RSLN	Real quarterly growth rate of residential real estate loans	0.011	0.028
		(0.286)	(0.336)
TLRE	Real quarterly growth rate of total real estate loans	0.019	0.019
		(0.205)	(0.234)
TLN	Real quarterly growth rate of total loans	0.017	0.016
		(0.169)	(0.151)
RMBS	Real quarterly growth rate of RMBS	-0.017	0.075
		(0.071)	(0.412)
FGNMA	Real quarterly growth rate of RMBS guaranteed by FNMA/FHLMC/GNMA	-0.020	0.069
		(0.162)	(0.484)
RB20	Real quarterly growth rate of assets in RW 20% category	0.000	0.002
		(0.331)	(0.343)
RB50	Real quarterly growth rate of assets in RW 50% category	0.008	0.041
		(0.825)	(0.398)
	B. Credit Crunch Dummy Variable		
CRUNCH	Dummy variable equals one for crunch periods	0.000	1.000
		(0.000)	(0.000)
	C. Bank Perceived Risk Variables (RISK)		
	(Each averaged over the four previous quarters)		
T1RAT	Negative of the ratio of Tier 1 capital to RWA	-0.216	-0.207
		(0.951)	(0.887)
TOTRAT	Negative of the ratio of Total capital to RWA	-0.227	-0.218
		(0.951)	(0.886)

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Table 2: (continued)

Symbol	Definition	Control	Crisis
LEVRAT	Negative of the ratio of Tier 1 capital to UWA	-0.118	-0.118
		(0.096)	(0.097)
NPFRAT1	Ratio of non-performing loans (NPLs) to UWA	0.005	0.012
		(0.008)	(0.019)
- - - - - -	- - - - - - - - - - - - - - - - - - - -	- - - -	- - - -
LIQRAT	Negative of the ratio of liquid assets to UWA	-0.116	-0.098
		(0.067)	(0.066)
T2RAT	Negative of the ratio of Tier 2 capital to total RWA	-0.011	-0.011
		(0.006)	(0.005)
NPFRAT2	Ratio of nonperforming residential loans to UWA	0.005	0.013
		(0.008)	(0.023)
NPFRAT3	Ratio of nonperforming assets to UWA	0.007	0.015
		(0.009)	(0.024)
	D. Macroeconomic and Regional Variables (Each lagged one quarter)		
GNPGROW	Real growth rate of GNP (%)	1.403	0.188
		(0.432)	(1.421)
UNEMP	National unemployment rate (%)	4.967	5.675
		(0.386)	(1.208)
STGROW	Real state income growth (%)	0.007	-0.001
		(0.010)	(0.017)
STUNEMP	State unemployment rate (%)	4.760	5.914
		(0.912)	(0.935)
NE	Dummy variable, equals 1 for New England states	0.042	0.038
		(0.200)	(0.191)
BAAAAA	Difference in yields between Moody's BAA and AAA rated LT bonds	0.853	1.706
		(0.097)	(0.877)

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Table 2: (continued)

Symbol	Definition	Control	Crisis
RF3MO	Interest rate on three-month Treasury securities	3.815	1.730
		(1.231)	(1.466)
SW	Dummy variable, equals 1 for South-West states	0.040	0.045
		(0.197)	(0.206)
	E. Time and Seasonal Variables		
TIME	Time trend, starts at 1 in 2004:Q3 and incremented by 1 each quarter	6.500	16.500
		(3.450)	(2.291)
SEAS1	Dummy, equals 1 for the first quarter of the year	0.250	0.250
		(0.433)	(0.433)
SEAS2	Dummy, equals 1 for the second quarter of the year	0.250	0.250
		(0.433)	(0.433)
SEAS3	Dummy, equals 1 for the third quarter of the year	0.250	0.250
		(0.433)	(0.433)
	F. Term Structure Slope Variables (Each lagged one quarter)		
SLOPE+	Slope of the term structure if it is (+). Calculated as the 20YR Treasury rate less RF3MO, divided by the duration of a 20YR Treasury (x10 to adjust units). Set to 0 if the slope is (−).	0.923	2.066
		(0.984)	(0.853)
SLOPE-	Same as SLOPE+ except that is set to 0 if the slope is is positive rather than negative.	-0.029	-0.000
		(0.065)	(0.000)
	G. Bank Size and Competition Variables		
MEDIUM	Dummy variable, equals 1 if \$100 million $\leq$ UWA $<$ \$1 billion	0.499	0.535
		(0.500)	(0.499)
LARGE1	Dummy variable, equals 1 if \$1 billion $\leq$ UWA $<$ \$10 billion	0.056	0.063

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Table 2: (continued)

Symbol	Definition	Control	Crisis
		(0.230)	(0.243)
LARGE2	Dummy variable, equals 1 if UWA $\geq$ \$10 billion	0.012	0.012
		(0.108)	(0.107)
HERF	Herfindahl index of local market concentration	0.125	0.127
		(0.138)	(0.144)
	H. Primary Federal Regulator Identity Variables		
OCC	Dummy, equals 1 if bank is OCC-regulated	0.215	0.197
		(0.411)	(0.398)
FDIC	Dummy, equals 1 if bank is FDIC-regulated	0.582	0.601
		(0.493)	(0.490)
OTS	Dummy, equals 1 if bank is OTS-regulated	0.099	0.098
		(0.299)	(0.297)

a Dependent Variables

Panel A focuses on our dependent variable, growth, in each of the four risk-weight classes (RB0, RB20, RB50 and RB100). Note that banks still reported mortgage assets in either RB20 or RB50 according to credit risk[15]. In fact, both categories grew during the crisis; as did the safest risk-weight category RB0. This re-enforces the perception that compared to RB100, the latter categories were considered "safe". However, the notable difference is that RB20, which contains mortgages guaranteed by GSEs, grew at a slower pace than the others. We attribute this to the heterogeneity of the array of assets in RB20 which brings out the possibility that there could be an imbalance in these assets' risk assessment. We suffice with exposing some characteristics of this imbalance since measuring it would require a different analysis similar to that in Avery and Berger (1991) to check if the risk-weights are truly aligned with the inherent risk of each asset belonging to that category.

We also explore the behavior of individual loan types which fall into these categories in order to monitor loan-specific movements. For instance, commercial and industrial loans (CILN) and installment/consumer loans (INLN) are placed under RB100 but behave in opposite ways. This supports our critique of B&U's uniformity assumption (Appendix A). In line with Hall (1993), the decrease in CILN loans can be indicative of a credit crunch; however the increase in commercial real-estate loans (CRLN) despite the related market turmoil is ambiguous[16].

Underlining the impact of securitization, RMBS grew at two and a half times the pace of RSLN. Together, these two categories accelerated far beyond the aggregate loan categories, TLRE and TLN[17]. This unexpected result in light of the crunch could be

[15]It appeared from our discussions with FDIC that the regulators did not setup a new 35% risk-weight category in their Call Reports before the Basel II regulations were formally in place in the U.S.

[16]B&U have tried to make sense of this upward trend on the basis of a change in accounting standards. Although this hypothesis could have been true at the time, there is no evidence of such changes taking place during the subprime crisis.

[17]Note that our estimate of growth in total lending (TLN) during the crisis is identical to that of

explained by banks continuing to take advantage of the favorable risk-weight treatment of such assets while lending only to creditworthy borrowers. Another reason could be a delay with regard to our choice of crunch period which might not be in line with the phase of removing toxic assets off banks' balance sheets (forebearance).

Nevertheless, Bernanke and Lown (1991) confirm that a similar incident had taken place as 1-4 family residential mortgages also grew rapidly during the 1990-1991 recession. Hall (1993) points to the first change in mortgage risk-weight under Basel I claiming that the 50% risk-weight attributed to these assets at the time was responsible for their 30% growth between 1988 and 1992. Our findings therefore validate a similar hypothesis, alluded to by Blundell-Wignall and Atkinson (2010), in that a 30% dip in risk-weight (down to 35%) was matched by a 150% increase in growth rate in RSLN. This is the first time such a finding is put forward as there has never been, to our knowledge, a similar two-phase real decrease in any other instrument category on which to calculate a similar measure. Hence, this underlines the convexity of the function relating the risk-weight of an asset to its growth rate and illustrates the impact a potential risk-weight mis-calculation can have on the growth rate of an asset type.

Finally, while RB0 increased during the market's flight to quality, US Treasuries and Agency Obligations (USTA) fell by an order of magnitude between both periods. This was despite the fact that treasuries account for the largest proportion of this category[18]. We take a look at this puzzle later in our analysis.

b Independent Variables

In Panel C, our RISK factors allow for the testing of our hypotheses. Compared with B&U's estimates, both Tier 1 and Total capital ratios (RBC CCH - H1), along with the leverage ratio (H2), increased from the levels they were at two decades ago. However,

Beatty and Liao (2011). However, their control period is much longer than ours and therefore we are unlikely to obtain similar pre-crisis results.

[18] Close to 40% during the first crisis according to B&U.

eroded by losses during the recent crisis, capital ratios fell[19] while leverage seems quite resilient to any change. The latter's less obvious behavior was also recognized by Hall (1993)[20] during the 1990-1991 crunch[21]. Nonetheless, the risk indicator in support of the coercive risk-retrenchment hypothesis (H3), the NPL ratio (NPFRAT1) went up[22] by almost the same amount as RSLN reflecting the impact of the mediocre screening of borrowers.

In order to test for the liquidity hypothesis (H4) we define LIQRAT as the ratio of Total Quality Liquid Assets (incorporated as a standalone variable in the FDIC database) to Unweighted Assets, pre-multiplied by a negative sign to mimic the logic behind the RISK variables. The fall in this variable during the crisis is evident as per 2. Note that this variable measures the asset liquidity component as opposed to the Basel III advocated measures, LCR and NSFR, which measure funding liquidity[23].

c Control Variables

In this section we complete our presentation by introducing our control variables.

Most macroeconomic indicators in Panel D reflect the negative repercussions of the crisis on the economy at both national and state levels. These were felt through a dip in GNP[24] (GNPGROW, Datastream) and income growth (STGROW, US Bureau of

[19] Our stimates are almost identical to those in Beatty and Liao (2011).

[20] Between 1990 and 1992, the average leverage ratio increased by less than a third of the growth in capital ratio.

[21] Note that our central estimates conceal the fact that leveraging and deleveraging occurred respectively within very small spans of time prior to and during the crunch; which is probably why no change is observed here. This also explains why deleveraging efforts continued years after the crunch.

[22] The ratio is in absolute terms smaller compared to the earlier crunch. The reason is because the asset base of banks in terms of unweighted assets increased on average by an order of magnitude between the two crises. This can also be seen in the changes in the number of MEDIUM and LARGE banks, mirrored to a certain extent by the increases in FDIC-regulated banks and the decrease in OCC-regulated banks. These changes reflect on our competition estimates, HHI which do not account for survivorship bias owing to the large amount of takeovers and failures that took place between these two periods.

[23] Since the first measure relies on a given bank's stress scenario while the second requires a highly granular categorization of assets which is not characteristic of the FDIC database, we are unable to factor these variables in our analysis.

[24] Although it is more common nowadays to use GDP, our choice of GNP is strictly in line with B&U. In our framework, both variables yield similar results.

Economic Analysis) alongside an increase in unemployment (STUNEMP, US Bureau of Labor Statistics) which spilled over to the corporate sector as signaled by the widening of the credit spread (BAA-AAA, FED). An interesting difference is that national unemployment fell during the 1990-1991 crunch according to B&U's estimates. However, according to Hancock and Wilcox (1994), such an outcome should not always be regarded as a sign of economic strength, as this might also be because of other factors such as the "discouraged worker" effect. In addition, we capture the level of nominal interest rates by (RF3MO, FED) which was slashed as a result of short-term aggressive monetary policy.

We also introduce a South West (SW) variable in Panel D to control for the demand component originating from the states of California, Nevada and Arizona. This should mimic B&U's New England dummy variable that accounted for the worse affected regional states during the 1990-1991 crunch. Similar controls were also used by Peek and Rosengren (1992, 1994, 1995a) and more recently Ghosh (2008)[25]. For details on how this variable was constructed see Appendix B.

Moreover, we include time and seasonal variables[26] in Panel E. These are supplemented in Panel F with interest rate variables such as SLOPE (bond durations are obtained from CRSP). Note that 30YR Treasuries were still discontinued at the start of our control period (Andelman (2005)). Therefore, duration and interest rates were not available for this maturity in order to calculate SLOPE variables. Instead of extrapolating from past or future values, we take a more solid approach by using the second closest maturity posted by the FED, the 20YR bond. We do the same for 10YR and 5YR Treasuries and our results are not sensitive to either specification. Note that, since bonds come in multiple issues, we compute duration as the average over all bonds issued in a certain year with a given maturity. The separation between positive and negative

[25]Mian and Sufi (2009) only look at ZIP code differences which does not capture regional effects.

[26]All seasonal variables are equal because by construction it happens that we have the same number of quarters belonging to each seasonal group.

slopes is designed to control for added demand and supply effects according to B&U. However, the interpretation of the SLOPE parameters is not straightforward. What matters during downturns with regards to the characteristic shape of the inverted term structure of interest rates is the negative slope which increases in absolute value as shown in Table 2.

Furthermore, we control for bank size and competition[27] in Panel G. Our state-level Herfindahl index, HHI, confirms the result in Wright and Quadrini (2009) that shows an increase in the index level at national level. This can also be understood as a decrease in competition or increase in market power over time.

Finally, the addition of the OTS variable in Panel H to the two regulatory dummy variables, OCC and FDIC, is designed to uncover any thrift-related effect as OTS-regulated banks, believed to have had an important role during the crunch. The variable does not show any drastic change probably due to the smaller proportion of these banks in the overall sample. Nonetheless, this compelled us to use an aggregate variable of U.S. Treasuries and Agency Obligations (USTRA) which comprises U.S. Treasuries (USTREAS) and Agency Obligations (USTA) instead of a standalone U.S. Treasuries variable. The reason, as stated by the FDIC, is that after the second quarter of 1996 these banks no longer reported Treasuries on a separate basis from other government obligations. As such, using the variable accounting for Treasuries only (USTREAS), which other banks submit as part of their Call Reports, would have resulted in missing values for all thrift filers.

iii Empirical Model

In this section, we elaborate on the RISK-factor methodology applied by B&U which constitutes our baseline model. Later, we rerun the baseline model adding our newly-introduced variables which we label as our enhanced model. Both models use Newey-

[27] HHI is computed from the in-sample dataset.

White robust estimators to account for serial correlation. As can be seen in equation (III.1) below, the log growth rate in each asset category (CILN, CRLN, INLN, RSLN, TLRE, TLN, RMBS, USTRA) and risk-weight-class (RB100, RB50, RB20, RB0), $\dot{Y}$, is regressed on a CRUNCH dummy variable, various RISK factors (Panel C), interaction terms denoted as CR_RISK, marginal contributions denoted as RISK^2 and CR_RISK^2, and a vector of macroeconomic and control variables X listed in Panels D through H in Table 2. The interaction terms are used to single out the effect of these RISK factors during the course of the crunch as opposed to the full length of the study period; while marginal terms bring out any non-linear effects.

Note that a negative sign is appended to the capital RISK categories in order to make them increasing in risk. In other words, a higher (in absolute value) capital ratio/leverage ratio is, in principal, less risky. Moreover, all RISK variables were computed as the lagged quarterly average over the previous year going back from the current date in order to remove any endogeneity.

$$\begin{aligned}\dot{Y}_{it} = \alpha + \beta CRUNCH_t + \sum_{j=1}^{5} \delta_j RISK_{ijt} + \frac{1}{2}\sum_{j=1}^{5} \phi_j RISK_{ijt}^2 \\ + \sum_{j=1}^{5} \gamma_j CR\_RISK_{ijt} + \frac{1}{2}\sum_{j=1}^{5} \theta_j CR\_RISK_{ijt}^2 \\ + \sum_{k} \lambda_k X_{ikt} + \epsilon_{it}\end{aligned} \tag{III.1}$$

While the normal selection process would be to conduct a Hausman test[28], having included quasi-time-independent variables such as SIZE and REGULATOR, we conjecture that a random-effects model would be more amenable than a fixed-effects one. Otherwise, the explanatory power in those variables would be absorbed by the intercept and would not have shown up as significant in both our model and in B&U's (Gam-

[28] The result in our case does not strongly favor one effects model over the other.

bacorta and Marques-Ibanez (2011)). In fact, Ediz et al. (1998) confirm having used a random-effects specification in similar cicumumstances while Nichols et al. (2011) opt for a fixed-effects regression which does not include any time-invariant regressors. Based on the latter, our choice of random-effects seems justified.

Finally, before running the models we cleanse the data in order to account for mergers, failures as well as data and estimation errors. Hence, we exclude observations for a particular bank when either the growth rate in total assets went beyond 25%[29] or that in the riskiest and/or safest risk-weight-category (RB100/RB0) exceeded 75% in absolute value for a designated quarter. This method also excludes non-"mature" banks as argued by Peek and Rosengren (1994).

5 Results and Discussion

i Baseline Model

Table 3 shows the results from running the baseline model on B&U's original set of variables. Due to the lower magnitude R^2s we obtain, we suspect that the dependent variables might not bare the same relationship to this crisis as they did during the 1990-1991 crunch. Our suspicion is accentuated by the fact that the CRUNCH variable is not relevant for any loan category. This requires the adjustments which we showcase in our enhanced model.

We find almost no impact of capital ratios on any of the loans both before and after the crisis. While this could be due to model mis-specification, bearing in mind that our sample consists in majority of small and medium banks[30], Beatty and Liao (2011) admit to the fact that any positive association between capital and lending disappears for this type of banks.

[29] Beatty and Liao (2011) use a less conservative estimate of 10%.

[30] LARGE banks take up 5% of the dataset with 66% of total assets. This is comparable with B&U's 2% estimate for LARGE banks.

In contrast, leverage had a significant impact on the riskiest risk-weight category (RB100), reflecting the cut-down in risky assets for banks with low leverage ratios. The weaker significance for individual loan categories can be explained by the fact that RB100 is larger than all individual risky loans and therefore holds a larger proportion of unweighted assets in the construction of the leverage ratio.

NPFRAT1 is highly negatively significant before the crisis. While this result is expected at all times, the lack of significance during the crisis despite the sizable increase in NPLs as reported in Table 2 could indicate that these categories were not the ones which formed the bulk of non-performing loans and therefore did not witness a contraction during the crisis. Note that by definition NPLs are only registered after 90 days which can undermine the effect of bad loans during the early stages of the crunch period. As expected, we note a positive effect on USTRA as the latter benefits from negative loan performance through flight to quality. As USTRA belongs to the category RB0, we would normally have expected the same positive effect on both. However, this is not the case as we provide further explanation in the following section.

In most cases, macroeconomic variables have the expected sign and are particularly significant for the safest categories USTR and RB0. Note that the signs on these categories normally contrast with those on RB100 reflecting a shift from risky to safe assets as expected during crisis times. Indeed, decreases in GNPGROW and STGROW encourage a flight to quality in opposite manner to unemployment UMEMP and STUNEMP as well as the risk aversion implied by the widening of the corporate spread BAAAAA. This agrees with similar results in Beatty and Liao (2011). Bearing in mind that risk-weight categories are not expected to cover for interest rate (market) risk, RF3MO is normally expected to be positively significant as an indicator of the return on these instruments as well as the cornerstone of monetary policy transmission. However, in line with the results in B&U this is not the case. This is perhaps because initial cuts to the interest rate where not endorsed by the market which only responded after further economic

Table 3:
Baseline RISK-factor model

The Table presents the results obtained from running the baseline version of the model on the LHS variables listed in the first row which are defined in Table 2. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: $* \; p < 0.05, ** \; p < 0.01, *** p < 0.001$.

	CILN		CRLN		INLN		RB100		USTRA		RB0	
	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat
INTERCEPT	0.046	0.506	-0.037	-0.453	-0.095	-0.930	0.010	0.973	-0.426	-1.521	-0.220***	-6.702
CRUNCH	-0.036	-1.225	-0.041*	-1.680	-0.011	-0.339	-0.002	-0.430	-0.163**	-2.433	0.014*	1.768
T1RAT	0.476	0.356	-0.230	-0.587	-0.640	-1.546	-0.051	-0.563	0.266	0.294	-0.023	-0.151
TOTRAT	-0.467	-0.350	0.234	0.597	0.643	1.554	0.047	0.518	-0.262	-0.289	0.029	0.183
LEVRAT	-0.131	-0.913	0.010	0.136	-0.182*	-1.897	-0.106***	-5.617	-0.048	-0.247	-0.019	-0.763
NPFRAT1	-0.935**	-2.421	-1.254***	-3.651	-0.736*	-1.881	-1.180***	-12.628	1.771*	1.848	-0.275**	-2.064
CRRAT	-0.251***	-2.600	-0.324***	-6.141	-0.013	-0.219	0.069***	9.067	-0.041	-0.396	0.076***	5.425
SQ_T1RAT	3.244	0.864	0.046	0.087	0.577	0.637	0.055	0.224	0.309	0.263	0.260	0.737
SQ_TOTRAT	-3.244	-0.864	-0.046	-0.086	-0.577	-0.637	-0.055	-0.224	-0.309	-0.263	-0.259	-0.736
SQ_LEVRAT	-0.302	-1.155	-0.079	-0.593	-0.362**	-2.055	-0.229***	-5.429	0.081	0.205	0.065	1.253
SQ_NPFRAT1	6.477	0.607	16.943*	1.828	15.257	1.031	13.785***	2.860	-12.793	-0.513	8.409*	1.714
SQ_CRRAT	1.246***	2.672	0.884***	5.415	-0.182	-0.645	-0.174***	-5.793	0.696	1.605	-0.145***	-2.653
CR_T1RAT	-0.531	-0.359	1.430**	2.197	1.057*	1.682	-0.280*	-1.761	4.581**	1.997	0.022	0.078
CR_TOTRAT	0.523	0.354	-1.426**	-2.196	-1.060*	-1.687	0.285*	1.767	-4.579**	-1.993	-0.014	-0.048
CR_LEVRAT	-0.077	-0.401	-0.102	-0.698	-0.034	-0.209	-0.053*	-1.821	-1.185***	-3.070	0.126***	3.121

Table 3: (continued)

CR_NPFRAT1	0.356	0.736	0.300	0.628	-0.888	-1.556	0.304***	2.720	-1.796	-1.113	0.125	0.663
CR_CRRAT	0.206*	1.872	-0.050	-0.544	0.041	0.339	-0.041***	-4.112	-0.119	-0.475	0.018	0.769
SQ_CR_T1RAT	-4.021	-1.156	1.992	1.218	0.705	0.450	-0.085	-0.148	0.734	0.245	-0.233	-0.416
SQ_CR_TOTRAT	4.021	1.156	-1.992	-1.218	-0.705	-0.450	0.086	0.149	-0.734	-0.245	0.234	0.416
SQ_CR_LEVRAT	-0.097	-0.261	-0.160	-0.579	-0.091	-0.318	-0.066	-0.844	-1.967**	-2.553	0.201**	2.437
SQ_CR_NPFRAT1	-6.709	-0.600	-11.947	-1.158	-1.175	-0.072	-10.374*	-1.928	2.313	0.066	-7.908	-1.354
SQ_CR_CRRAT	-0.834	-1.612	0.137	0.494	0.057	0.095	0.100***	2.642	-1.144	-1.032	-0.120	-1.352
GNPGROW	0.016**	2.159	0.001	0.144	0.009	0.927	-0.000	-0.073	-0.106***	-5.085	-0.006**	-2.356
UNEMP	-0.012	-1.479	0.005	0.651	-0.001	-0.060	-0.000	-0.098	0.136***	4.859	0.028***	9.367
STGROW	0.016	0.116	-0.032	-0.176	-0.079	-0.384	-0.038*	-1.747	-1.833***	-3.581	-0.668***	-10.320
STUNEMP	-0.002*	-1.796	-0.000	-0.168	0.001	0.976	-0.001***	-5.897	0.008*	1.681	0.001	1.297
NE	0.018*	1.651	-0.019	-1.530	0.005	0.921	-0.006***	-4.394	-0.005	-0.252	-0.009***	-3.307
BAA-AAA	0.025	1.358	-0.001	-0.095	0.011	0.550	-0.001	-0.302	-0.230***	-4.543	-0.062***	-9.889
RF3MO	-0.008	-0.421	0.014	0.739	0.002	0.084	-0.003	-1.508	-0.055	-0.863	-0.033***	-4.277
SQ_RF3MO	0.004	0.676	-0.002	-0.393	0.004	0.467	0.001	1.504	0.038**	2.127	0.020***	8.784
TIME	-0.000	-0.012	0.003*	1.921	0.001	0.334	-0.000	-0.678	-0.010**	-2.081	0.005***	7.885
SEAS1	-0.001	-0.134	0.001	0.154	-0.010	-1.105	-0.005***	-6.394	-0.094***	-4.849	0.006**	2.055
SEAS2	0.015**	2.113	-0.002	-0.303	0.012	1.628	0.014***	16.726	-0.012	-0.717	-0.005**	-1.984
SEAS3	-0.009	-1.326	-0.007	-1.403	0.008	1.030	0.008***	10.488	0.004	0.240	-0.012***	-5.055
SLOPE+	0.011	0.263	0.019	0.602	0.019	0.453	0.003	0.738	0.099	1.088	0.101***	8.232
SLOPE-	-1.568	-1.626	0.701	0.965	1.547	1.079	0.738***	8.168	13.421***	6.037	-2.152***	-7.103
SQ_SLOPE+	0.001	0.052	-0.003	-0.252	-0.004	-0.197	-0.002	-1.049	-0.087**	-2.156	-0.044***	-8.231

Table 3: (continued)

SQ_SLOPE-	-17.703	-1.621	6.718	0.808	16.814	1.030	8.079***	7.885	147.248***	5.842	-25.448***	-7.412
MEDIUM	0.005	1.452	0.019***	6.977	-0.001	-0.362	0.005***	9.003	0.015*	1.649	0.000	0.433
LARGE_1	0.009	1.140	0.026***	3.673	-0.011*	-1.703	0.008***	6.981	-0.024	-1.063	-0.000	-0.123
LARGE_2	0.051	1.223	-0.078**	-2.234	-0.008	-0.743	0.014***	3.545	0.023	0.400	0.018***	2.940
HHI	0.040	0.980	0.033	0.765	-0.061**	-2.148	-0.005	-1.067	0.059	0.703	-0.004	-0.377
OCC	-0.021***	-4.533	-0.005	-1.000	-0.003	-0.756	-0.004***	-4.530	0.038***	3.194	0.002	1.329
FDIC	-0.014***	-2.966	0.006*	1.795	-0.001	-0.401	0.001*	1.945	0.033***	3.142	0.001	0.579
R^2	0.001		0.002		0.000		0.024		0.006		0.013	
Num Obs	119679		119679		119679		119679		119679		119679	

Table 4:
Baseline RISK-factor model (RB0/RB20 Breakdown)

The Table presents the results obtained from running the baseline version of the model on the LHS variables listed in the first row which are defined in Table 2. For the purpose of understanding the individual asset classes behavior within each risk-weight category, the first three dependent variables relate to RB0 while the last one is part of RB20. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: * $p < 0.05, **p < 0.01, ***p < 0.001$.

	USTA		USTREAS		CURR		FGNMA	
	Parms	t-stat	Parms	t-stat	Parms	t-stat		
INTERCEPT	0.354	0.911	-0.807***	-2.810	-0.513***	-4.786	-0.140	-0.813
CRUNCH	-0.023	-0.308	-0.124**	-2.242	0.008	0.269	-0.018	-0.460
T1RAT	0.010	0.955	0.014**	2.177	0.155***	3.002	0.007	1.219
LEVRAT	-0.037	-0.153	-0.092	-0.511	-0.236	-1.264	-0.136	-0.830
NPFRAT1	1.919	1.274	-0.513	-0.414	1.815	0.711	-2.206**	-2.420
SQ_T1RAT	0.000	0.929	0.000**	2.039	0.037*	1.942	0.000	1.338
SQ_LEVRAT	-0.115	-0.237	0.109	0.303	0.124	0.251	-0.268	-0.768
SQ_NPFRAT1	-8.559	-0.156	0.995	0.021	-143.018	-1.268	62.491*	1.937
CR_T1RAT	-0.018	-0.544	-0.033	-1.402	0.014	0.191	-0.023	-1.032
CR_LEVRAT	-1.272***	-2.668	0.010	0.031	-0.066	-0.267	-0.180	-0.663
CR_NPFRAT1	-4.411**	-1.992	2.178	1.341	-2.500	-0.903	1.127	0.876
SQ_CR_T1RAT	-0.001	-0.547	-0.001	-1.359	0.016	0.548	-0.001	-1.030

Table 4: (continued)

SQ_CR_LEVRAT	-2.137**	-2.073	-0.365	-0.532	-0.343	-0.739	-0.752	-1.206
SQ_CR_NPFRAT1	38.853	0.603	-27.462	-0.521	147.087	1.299	-68.346*	-1.957
GNPGROW	-0.027	-0.959	-0.083***	-3.849	0.012	1.104	0.009	0.656
UNEMP	0.077**	2.093	0.059**	2.236	0.061***	7.522	-0.062***	-3.836
STGROW	-2.273***	-3.355	0.788	1.590	-1.888***	-8.229	1.071***	2.623
STUNEMP	-0.014**	-2.338	0.021***	4.611	0.000	0.177	-0.000	-0.012
NE	-0.050*	-1.765	0.057**	2.432	-0.012*	-1.861	-0.040**	-2.259
BAAAAA	-0.125*	-1.796	-0.115**	-2.226	-0.089***	-3.612	0.042	1.348
RF3MO	-0.147*	-1.709	0.083	1.322	0.036*	1.729	0.085**	2.054
SQ_RF3MO	0.046*	1.822	0.001	0.049	0.010	1.433	-0.016	-1.278
TIME	-0.021***	-3.063	0.011**	2.204	0.008***	4.035	0.010***	3.081
SEAS1	-0.085***	-3.205	0.000	0.001	-0.066***	-4.562	0.039***	2.878
SEAS2	0.014	0.550	-0.025	-1.266	-0.061***	-5.352	-0.018	-1.472
SEAS3	0.004	0.194	-0.002	-0.088	-0.100***	-9.011	-0.032***	-2.853
SLOPE+	-0.064	-0.459	0.218**	1.980	0.105**	2.055	0.097	1.457
SLOPE-	7.475**	2.305	5.671**	2.268	-6.740***	-7.236	-3.517*	-1.881
SQ_SLOPE+	-0.028	-0.476	-0.080*	-1.698	-0.023	-0.971	-0.009	-0.321
SQ_SLOPE-	82.354**	2.251	61.292**	2.177	-79.801***	-7.445	-41.532**	-1.963
MEDIUM	0.045***	3.971	-0.037***	-4.500	-0.021	-0.438	0.013*	1.654
LARGE_1	0.077**	2.441	-0.124***	-4.462	-0.029	-0.596	-0.004	-0.291
LARGE_2	0.180**	1.967	-0.094	-1.080	-0.033	-0.663	-0.001	-0.046
HHIA	-0.090**	-2.081	0.062**	2.032	-0.005	-0.239	0.017	0.668

Table 4: (continued)

OCC	0.007	0.353	0.013	0.774	-0.004	-0.591	0.024**	2.222
FDIC	-0.035**	-1.976	0.048***	3.346	0.008	1.461	0.023**	2.433
R^2	0.003		0.001		0.022		0.003	
Num Obs	107404		107404		25424		119679	

stimulus (SQ_RF3MO). Also, as shown during the 1990 recession, all categories exhibit at least one sign reversal in seasonality indicating that lending patterns are not consistent throughout the year. It is, however, more difficult to assess the impact of the slope coefficients which remain inconsistent as per B&U.

Finally, MEDIUM, LARGE_1 and LARGE_2 were more inclined toward riskier lending (RB100) although competition (HHI) remained subdued probably because most banks engaged in similar risk-taking. Differences were still observed depending on regulator type (OCC/FDIC).

ii Granularity of the Risk-Weight Categories

In this section, we try to clarify a few "puzzles" in our previous results. For example, the sign on NE for the most significantly affected categories, RB100 and RB0, was the same despite their radically different risk profiles. TIME, on the other hand was mostly significant for USTRA and RB0 but with unexpectedly opposite signs, despite the similarity in risk profiles. Moreover, we highlighted earlier one clear anomaly related to the sign difference between USTRA and RB0 regarding NPFRAT1.

In order to shed light on this matter, we do a granular analysis on the underlying components of RB0. Our estimates in Table 2 show that the two largest elements of RB0, Treasuries (USTREAS) and Currency (CURR), did increase during the crisis due to a flight to quality. By deduction, aside from CDO tranches[31], the only remaining component responsible for decreasing the aggregate variable USTRA are the non-mortgage obligations issued by GSEs, USTA.

Thus, we run our baseline model on the main constituent elements of RBO with a breakdown of USTRA into USTA and USTREAS. The results are shown in Table 4. During the crisis, the leverage impact on USTRA stems uniquely from USTA. Similarly, the reported negative sign of the interest rates variable (RF3MO) and NE on RB0 in

[31] Unfortunately these cannot be isolated from the Call Reports.

Table 4 is due to USTA rather than USTREAS. In conclusion, it seems that USTA are distorting the results in RB0 and USTRA by behaving more like risky assets than would be expected from their low risk-weight allocation. We presume this is due to the change in market perception for these instruments following the stigma that enveloped the GSEs regarding their mortgage originations.

iii Enchanced Model

Our enhanced model applies to mortgage-related dependent variables and includes new explanatory variables particular to the crisis. Results are summarized in Table 5.

Despite their idiosyncratic nature, the new dependent variables in our model allow us to match B&U in terms of explanatory power[32]. We note the reversal in most coefficients between RB50 and RB20 in similar fashion to what was observed earlier for RB100 and RB0. However, given that RSLN behaved more like RB50, this is an indicator of where the true market perception of riskiness lied with regard to RSLN which the Basel regulators considered to be at an equal distance from the two middle risk-weight categories (35%).

As predicted by Beatty and Liao (2011), the CRUNCH term is negatively significant for individual loan categories and RB50 and to a lesser extent on RMBS and RB20. However the positive sign on CR_T1RAT and SQ_CR_T1RAT for RSLN and TLN indicates that banks with higher capital ratios were lending less during during crunch time. Notwithstanding this evidence, the fact that we do not observe a significantly opposite result before the crisis sheds some doubt on the RBC CCH.

We find the opposite significance for leverage during the crunch period (CR_L_LEVRAT) meaning that banks with low leverage ratios were lending less then their less risky peers. This result is line with Demirguc-Kunt et al. (2010). Note that this same negative effect

[32]The R^2 magnitude suggest that the B&U model is not adequate in terms of forecasting power due to some extent to the large number of observations. Despite the number of variables used, this implies the need to incorporate additional factors to account for cross-sectional differences between banks. The latter fall outside the realm of the Basel regulation and hence of this research.

Table 5:
Enhanced RISK-factor model

The Table presents the results obtained from running the enhanced version of the model on the LHS variables listed in the first row which are defined in Table 2. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: * $p < 0.05, **p < 0.01, ***p < 0.001$.

	RSLN		TLRE		TLN		RMBS		RB20		RB50	
	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat
INTERCEPT	0.044	1.535	-0.014	-0.523	0.036***	2.712	-0.232	-1.404	0.106**	2.138	-0.185*	-1.741
CRUNCH	-0.027***	-3.525	-0.023***	-2.877	-0.017***	-3.375	-0.004	-0.098	-0.002	-0.146	-0.045*	-1.812
T1RAT	0.004	1.611	-0.007	-0.670	0.003*	1.785	0.011	1.472	-0.012	-0.528	0.003	0.699
LEVRAT	-0.033	-0.659	-0.048	-1.106	-0.022	-0.870	-0.123	-0.732	0.000	0.006	0.141	1.468
NPFRAT1	-1.193***	-5.405	-1.321***	-6.175	-1.181***	-14.203	-1.719*	-1.914	0.343**	2.266	-1.422***	-3.268
LIQRAT	-0.019	-0.740	-0.079***	-4.333	-0.045***	-3.595	-0.190	-0.831	0.149***	4.393	-0.080	-1.385
SQ_T1RAT	0.000	1.373	-0.000	-0.683	0.000*	1.690	0.000	1.491	0.000	0.196	0.000	0.865
SQ_LEVRAT	-0.068	-0.621	-0.185	-1.410	-0.082	-1.644	-0.218	-0.597	0.036	0.381	0.201	1.192
SQ_NPFRAT1	28.398**	2.207	26.866*	1.882	16.177***	4.860	56.211*	1.757	-3.887	-0.863	6.785	0.525
SQ_LIQRAT	-0.202	-0.722	-0.656***	-3.276	-0.301*	-1.762	2.536	1.241	-0.160	-0.522	-0.431	-0.687
CR_T1RAT	0.010**	2.019	0.016	1.025	0.008*	1.878	0.003	0.225	0.010	0.258	0.055**	2.295
CR_LEVRAT	-0.165*	-1.826	-0.163*	-1.666	-0.112***	-3.993	0.144	0.555	-0.109	-0.713	-0.415**	-2.300
CR_NPFRAT1	0.708***	2.834	0.120	0.533	0.182**	2.014	1.264	0.993	-0.307	-1.415	-0.052	-0.084
CR_LIQRAT	-0.019	-0.381	-0.001	-0.020	-0.041**	-2.416	0.122	0.274	0.179**	2.209	-0.033	-0.232
SQ_CR_T1RAT	0.000**	2.112	0.000	1.024	0.000*	1.753	0.000	0.230	-0.000	-0.150	0.002**	2.292

Table 5: (continued)

SQ_CR_LEVRAT	-0.272*	-1.732	-0.209	-1.115	-0.116	-1.176	0.028	0.054	-0.124	-0.233	-0.342	-0.935
SQ_CR_NPFRAT1	-24.645*	-1.936	-20.237	-1.431	-11.761***	-3.322	-66.048*	-1.908	4.850	0.830	7.025	0.490
SQ_CR_LIQRAT	0.121	0.257	0.500	1.629	-0.220	-1.165	6.006	1.494	0.874	1.356	-0.834	-0.601
GNPGROW	0.001	0.371	0.001	0.949	0.002*	1.690	0.022*	1.682	0.012**	2.546	-0.001	-0.091
UNEMP	-0.009***	-3.108	0.000	0.023	-0.002	-1.332	-0.065***	-4.167	-0.011**	-2.500	0.005	0.449
STGROW	-0.094	-1.197	-0.163	-1.629	-0.135***	-4.013	1.199***	3.092	0.937***	10.116	-0.135	-0.412
STUNEMP	-0.001	-1.465	-0.002***	-3.405	-0.001***	-7.224	0.004	0.993	0.002***	2.746	-0.000	-0.058
NE	-0.002	-1.078	-0.011**	-2.570	-0.005***	-4.571	-0.026*	-1.662	-0.009***	-3.170	-0.006	-1.536
SW	0.015**	2.133	0.008	1.537	0.009***	5.555	0.008	0.376	-0.001	-0.294	0.009	0.500
BAAAAA	0.004	0.536	0.003	1.088	0.001	0.332	0.071**	2.447	0.048***	4.350	-0.002	-0.098
RF3MO	-0.011	-1.369	0.006	0.763	-0.003	-1.047	0.085**	2.199	-0.046***	-4.296	0.016	0.570
SQ_RF3MO	0.004	1.464	-0.001	-0.530	0.000	0.087	-0.016	-1.315	0.011***	3.654	0.004	0.458
TIME	0.001**	2.143	0.000	0.944	0.000	0.320	0.008***	2.733	-0.002**	-2.397	0.004*	1.692
SEAS1	0.001	0.314	-0.001	-0.400	-0.004***	-4.729	0.051***	4.018	0.008*	1.900	-0.001	-0.101
SEAS2	0.008***	3.838	0.006***	3.121	0.014***	11.435	-0.016	-1.354	-0.050***	-13.206	0.001	0.212
SEAS3	0.009***	4.377	0.008***	5.193	0.008***	8.873	-0.027***	-2.614	-0.014***	-3.999	0.009	1.149
SLOPE+	0.026**	2.029	0.010	1.336	-0.004	-0.767	0.097	1.574	0.028	1.571	0.081*	1.900
SLOPE1	-0.075	-0.340	0.267	1.535	0.581***	7.105	-4.599***	-2.787	-2.909***	-6.383	-2.218**	-2.223
SQ_SLOPE+	-0.010	-1.616	-0.001	-0.512	0.002	0.637	-0.007	-0.264	-0.029***	-4.068	-0.024	-1.182
SQ_SLOPE-	-1.227	-0.492	2.746	1.438	6.185***	6.954	-53.731***	-2.876	-31.655***	-6.213	-26.521**	-2.365
MEDIUM	0.005***	3.255	0.007***	4.877	0.007***	8.806	0.040***	4.592	0.001	0.611	0.007*	1.920
LARGE_1	0.001	0.239	0.005*	1.895	0.008***	7.576	0.039***	2.701	-0.000	-0.103	-0.003	-0.462

Table 5: (continued)

LARGE_2	-0.013	-1.327	-0.027	-1.565	0.006*	1.869	0.031	1.302	0.008	1.018	-0.006	-0.559
HHIA	-0.012	-1.293	-0.006	-0.783	0.005***	2.735	0.037	1.382	0.000	0.076	0.022	1.583
OCC	-0.007**	-2.100	-0.005**	-2.207	-0.003***	-4.038	-0.004	-0.352	0.003	1.440	0.003	0.633
FDIC	-0.000	-0.068	0.003	1.558	0.002**	1.981	0.001	0.085	0.003	1.452	0.012***	3.301
OTS	-0.010***	-3.041	-0.008***	-3.292	-0.004***	-3.503	-0.016	-0.975	-0.010***	-3.438	-0.001	-0.337
R^2	0.002		0.005		0.012		0.004		0.012		0.000	
Num Obs	119679		119679		119679		119679		119679		119679	

which was also present for RB100 in our baseline model (Table 3) is observed as well for RB50. Note that the leverage CCH has no explanatory power for RMBS as we recall from our previous discussion that a large proportion of those assets was off-balance-sheet.

While the negative effect of NPFRAT1 prior to the crisis is still observed for the new loan categories, the positive sign during the crisis indicates that banks with more NPLs were those which were lending more. This acute sign of risk-taking (predatory lending) is in stark contrast to the negative effect witnessed by B&U during the 1990 recession. Nonetheless, the negative sign on the marginal term (SQ_CR_NPFRAT1) is proof that upon reaching a certain level of NPLs, banks were eventually induced by a demand, or borrower-related, effect to cut down on their lending and RMBS holdings. This is the basis for our coercive risk-retrenchment CCH.

Liquidity has a strong negative effect on RSLN and TLN prior to the crisis but to a lesser extent during the crisis. This could seem surprising at first given that liquidity was recognized as the main concern until 2008Q3. However, given that the FDIC definition of liquid assets includes other types of RMBS securities which are found under RB20, the reverse effect was observed for this risk-weight category during the crisis. In other words, banks with lower liquidity levels were more likely to invest in RB20 instruments which relate mostly to securitized assets as a way to build up liquidity.

Macro and seasonality variables still play an important role in our enhanced model. Our new SW variable has the opposite sign compared to NE indicating that banks in the former region were lending more aggressively than their counterparts in NE which eventually translated into higher losses. Note that the sign on SW for this crisis is in line with what was obtained by B&U for NE during the 1990-1991 crunch. Moreover, MEDIUM banks seem to have benefited during the whole period. This is confirmed by the negative sign on OCC-regulated banks which are normally the larger ones. As expected, OTS-regulated banks also had to cut down on lending which underlines the additional role played by thrifts in the subprime crisis.

In sum, abstracting from any quality of capital effects, the results on the RBC CCH remain inconclusive. This could be due to overshadowing by other factors which exploited some of the weaknesses of capital ratios. First, the moral hazard or having strong capital ratios lead banks to take on more risk (leverage). Second, solvency is not the sole indicator of a bank's viability (liquidity). Together with the banks' own incentives to take advantage of matters which were outside of pillar 1 of the regulation (predatory behavior), these factors culminated in a coerced behavior by banks to cut down on lending.

6 Robustness

In order to validate the results we found above, we run a series of robustness tests on our enhanced model.

First, we ascertain whether the introduction of the FED's emergency programs and aggressive monetary policy to curb the impact of the crisis had any impact on our results. We rerun our model but taking into account only the quarters until 2008Q3, date of the TARP introduction. Our main findings remain unchanged as can be seen in Table 6. Nonetheless, we note the apparent significance of the CRUNCH variable on RMBS as well as the intensification of the liquidity effect (LIQRAT) on TLN as our crisis period is now in phase with the peek of the liquidity drought. However, we observe that the impact of interest rates (RF3MO) has decreased, highlighting the fact that the rescue program was only effective later during the crisis.

Second, our main results pointed out that RB20 behaved quite differently to RMBS. We assume this is again because of heterogeneity in the RB20 risk-weight class. To validate this assumption, we rerun the model only on the proportion of loans related to GSEs, FGNMA (Table 4). We see that the sign of NPFRAT1 on this sub-component of RB20 is indeed negative. To find the asset responsible for the unexpected sign, we would need a similar breakdown as we did before with RB0. Unfortunately, the assets in RB20 are too heterogeneous and the FDIC database is not granular enough to support such a breakdown. The discrepancy amongst various risk categories stresses again the subject of non-homogeneous behavior within risk-weight categories. This is at odds with the strict monotonicity assumption in the risk-weight scheme and has been referred to as one "regulatory loophole"[33] by Kamada and Nasu (2000).

Third, we test the dependence of our hypotheses on our choice of variables in Table 7. While our model does not account for the quality effect of capital ratios, we test to see if our results in relation to the RBC CCH would change depending on which layer of capital we investigate. Indeed, following the subprime crisis, due to the role played by hybrid securities, much more has been said about the impact of Tier 2 rather Tier 1 capital. Hence, we substitute T1RAT with T2RAT and TOTRAT and find that both add no quantity effect to the model. Similarly, with regards to the coercive risk-retrenchment hypothesis, since loans affecting NPFRAT1 can be sandwiched between non-performing assets and non-performing real-estate loans, we substitute this variable in our regression by NPFRAT2 and NPFRAT3 and reproduce the same highly significant pre-crisis effect as in our original model. This was expected as the growth rates in Table 2 are very similar; reflecting again the fact that real-estate loans were the dominant non-performing asset.

Fourth, we test that our results have not been diluted by the number of small banks in Table 8. Hence, we remove these banks from our sample and confirm that our most of the effects found relate to the larger banks. Indeed, the latter were reported as being the key players of the recent crisis unlike the 1990-1991 period where the smaller banks founded more difficult to meet the new regulatory constraints.

[33]This term is attributed to items which were considered missing from the Basel framework. These include the supervisory role of Credit Rating Agencies and Special Purpose Vehicles which were not formally bound by any jurisdiction under the Basel II agreement.

Table 6:
Enhanced RISK-factor model (Pre-TARP)

The Table presents the results obtained from running the enhanced version of the model on the LHS variables listed in the first row which are defined in Table 2. Data includes only goes until 2008Q3, with the launch of the TARP program. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: * $p < 0.05, **p < 0.01, ***p < 0.001$.

	RSLN		TLRE		TLN		RMBS		RB20		RB50	
	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat
INTERCEPT	-0.153	-0.671	-0.260	-1.456	0.055	0.387	-0.561	-0.525	0.817**	2.493	-2.344***	-2.884
CRUNCH	-0.024*	-1.757	-0.035***	-3.280	-0.010	-1.447	-0.196***	-2.884	-0.017	-0.717	-0.135***	-3.158
T1RAT	0.006	1.503	-0.010	-0.765	0.003*	1.749	0.010	1.321	-0.022	-0.696	0.004	0.838
LEVRAT	-0.177**	-2.487	0.037	0.889	-0.032	-1.148	0.003	0.021	0.002	0.016	0.059	0.530
NPFRAT1	-1.404***	-3.521	-0.841***	-9.326	-1.153***	-13.209	-1.499*	-1.878	0.455**	2.495	-1.685***	-3.305
LIQRAT	-0.025	-0.668	-0.074***	-4.782	-0.047***	-3.658	-0.195	-1.119	0.361***	7.092	-0.068	-0.971
SQ_T1RAT	0.000	1.320	-0.000	-0.744	0.000*	1.704	0.000	1.408	-0.000	-0.089	0.000	0.909
SQ_LEVRAT	-0.329**	-2.150	-0.037	-0.270	-0.104*	-1.891	0.036	0.120	0.041	0.154	0.046	0.232
SQ_NPFRAT1	41.990	1.632	9.019***	2.610	15.535***	4.503	63.169**	2.112	-6.360	-1.255	16.850	1.063
SQ_LIQRAT	0.037	0.102	-0.853***	-4.758	-0.264	-1.443	0.971	0.609	0.206	0.470	-0.096	-0.131
CR_T1RAT	0.018**	2.279	0.012	0.695	0.011*	1.705	0.013	0.753	0.030	0.474	0.034**	2.490
CR_LEVRAT	-0.198**	-2.185	-0.274***	-2.669	-0.087**	-2.474	-0.041	-0.118	-0.174	-0.800	-0.456**	-2.310
CR_NPFRAT1	0.785**	1.970	-0.336	-1.500	0.125	1.142	0.792	0.479	-0.383	-1.335	-0.203	-0.259
CR_LIQRAT	0.048	0.458	-0.047	-1.082	-0.050***	-2.756	0.006	0.010	0.469***	3.795	0.025	0.136

Table 6: (continued)

SQ_CR_T1RAT	0.001**	2.335	0.000	0.649	0.000	1.506	0.000	0.621	0.000	0.177	0.001**	2.526
SQ_CR_LEVRAT	-0.265*	-1.744	-0.443*	-1.811	-0.010	-0.062	-0.365	-0.551	-0.089	-0.103	-0.660*	-1.875
SQ_CR_NPFRAT1	-39.445*	-1.646	-3.682	-0.778	-11.947***	-2.610	-59.829*	-1.665	15.851*	1.946	-1.894	-0.103
SQ_CR_LIQRAT	0.452	0.537	-0.087	-0.217	-0.272	-1.309	6.686	1.257	3.304***	3.451	-0.313	-0.169
GNPGROW	-0.003	-0.707	0.001	0.241	-0.002	-0.811	0.070***	3.577	0.014**	2.057	0.021	1.503
UNEMP	0.013	0.455	0.029	1.208	-0.005	-0.252	-0.016	-0.119	-0.117***	-2.896	0.260**	2.473
STGROW	0.110	1.016	-0.031	-0.214	-0.061*	-1.655	0.984**	2.143	0.784***	6.642	0.134	0.287
STUNEMP	-0.000	-0.064	-0.002***	-2.722	-0.002***	-4.666	0.010***	2.774	0.003***	3.433	-0.001	-0.635
NE	0.000	0.141	-0.010**	-2.518	-0.005***	-4.008	-0.027*	-1.788	-0.010**	-2.485	-0.006	-1.616
SW	0.006	0.840	0.010	1.459	0.010***	5.474	-0.007	-0.341	-0.003	-0.653	-0.019	-1.146
BAAAAA	-0.017	-1.401	0.002	0.235	-0.010**	-2.423	0.038	0.629	0.012	0.640	0.021	0.451
RF3MO	0.019	0.636	0.036*	1.685	0.005	0.328	0.018	0.150	-0.048	-1.202	0.202**	2.186
SQ_RF3MO	-0.001	-0.161	-0.005	-1.020	-0.002	-0.600	0.001	0.025	-0.001	-0.102	-0.016	-0.748
TIME	0.002	0.896	0.002	1.115	-0.000	-0.276	0.030**	2.550	-0.004	-0.994	0.026***	2.906
SEAS1	0.000	0.090	-0.001	-0.380	-0.005***	-4.034	0.050***	3.152	0.014***	2.729	-0.004	-0.368
SEAS2	0.011***	3.343	0.007***	2.627	0.016***	8.577	-0.055***	-3.159	-0.046***	-7.491	-0.013	-0.867
SEAS3	0.009*	1.710	0.010**	2.531	0.006**	2.073	0.020	0.966	-0.010*	-1.747	0.042***	2.645
SLOPE+	0.034*	1.687	0.028*	1.852	-0.010	-0.881	0.180*	1.707	-0.027	-0.776	0.252***	3.009
SLOPE-	0.108	0.374	0.380*	1.805	0.677***	7.146	-6.926***	-3.565	-3.992***	-7.391	-2.054*	-1.646
SQ_SLOPE+	-0.007	-0.824	-0.003	-0.454	0.006	1.183	-0.052	-1.331	-0.006	-0.565	-0.055*	-1.744
SQ_SLOPE-	1.021	0.315	4.362*	1.892	7.220***	6.597	-79.662***	-3.595	-44.755***	-7.348	-21.891	-1.561
MEDIUM	0.005***	2.640	0.007***	7.848	0.008***	8.417	0.030***	3.876	0.000	0.239	0.015***	3.202

Table 6: (continued)

LARGE_1	0.003	0.514	0.006***	2.594	0.009***	7.329	0.021	1.516	-0.001	-0.155	0.006	0.590
LARGE_2	-0.012	-1.041	-0.032	-1.499	0.008**	2.351	0.009	0.302	0.007	0.675	0.012	1.061
HHIA	-0.020	-1.498	-0.005	-0.699	0.003	1.630	0.030	1.257	0.003	0.483	0.003	0.231
OCC	-0.012*	-1.896	-0.005*	-1.756	-0.004***	-3.903	-0.008	-0.698	0.004	1.393	-0.001	-0.135
FDIC	-0.004	-0.693	0.001	0.362	0.002*	1.848	-0.007	-0.708	0.001	0.444	0.009**	2.202
OTS	-0.011*	-1.895	-0.008***	-2.982	-0.003***	-2.910	-0.021	-1.517	-0.021***	-4.426	0.000	0.074
R^2	0.002		0.003		0.011		0.005		0.015		0.001	
Num Obs	99755		99755		99755		99755		99755		99755	

Table 7:
Enhanced RISK-factor model (Robustness)

The Table presents the results obtained from running the enhanced version of the model on the LHS variables listed in the first row which are defined in Table 2. We replace T1RAT and NPFRAT1 by TOTRAT and NPFRAT2, respectively. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: * $p < 0.05, **p < 0.01, ***p < 0.001$.

	RSLN		TLRE		TLN		RMBS		RB20		RB50	
	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat
INTERCEPT	0.043	1.518	-0.016	-0.571	0.035***	2.678	-0.233	-1.407	0.106**	2.132	-0.185*	-1.740
CRUNCH	-0.027***	-3.577	-0.022***	-2.875	-0.018***	-3.460	-0.006	-0.155	-0.001	-0.096	-0.046*	-1.824
TOTRAT	0.004	1.581	-0.007	-0.683	0.002*	1.756	0.011	1.468	-0.012	-0.518	0.003	0.643
LEVRAT	-0.030	-0.589	-0.044	-1.024	-0.017	-0.656	-0.118	-0.702	-0.001	-0.019	0.150	1.561
NPFRAT2	-0.935***	-7.485	-1.093***	-12.395	-1.056***	-14.090	-1.136	-1.294	0.300**	2.251	-1.016**	-2.175
LIQRAT	-0.017	-0.650	-0.076***	-4.153	-0.041***	-3.289	-0.186	-0.813	0.148***	4.353	-0.070	-1.220
SQ_TOTRAT	0.000	1.333	-0.000	-0.697	0.000*	1.665	0.000	1.492	0.000	0.210	0.000	0.811
SQ_LEVRAT	-0.059	-0.538	-0.174	-1.337	-0.070	-1.381	-0.201	-0.552	0.033	0.355	0.225	1.332
SQ_NPFRAT2	9.685***	3.282	10.211***	4.217	10.673***	4.106	39.670	1.297	-1.368	-0.442	10.100	1.211
SQ_LIQRAT	-0.188	-0.669	-0.630***	-3.136	-0.273	-1.592	2.573	1.261	-0.164	-0.535	-0.341	-0.542
CR_TOTRAT	0.011**	2.060	0.016	1.047	0.007*	1.870	0.002	0.116	0.010	0.256	0.054**	2.286
CR_LEVRAT	-0.166*	-1.847	-0.159	-1.630	-0.112***	-3.945	0.140	0.539	-0.106	-0.700	-0.421**	-2.333
CR_NPFRAT2	0.506***	2.959	-0.029	-0.248	0.229***	2.834	1.478	1.238	-0.389**	-1.978	0.010	0.017
CR_LIQRAT	-0.020	-0.412	-0.002	-0.085	-0.042**	-2.479	0.122	0.274	0.179**	2.209	-0.033	-0.238

Table 7: (continued)

SQ_CR_TOTRAT	0.000**	2.149	0.000	1.047	0.000*	1.740	0.000	0.116	-0.000	-0.153	0.002**	2.281
SQ_CR_LEVRAT	-0.273*	-1.751	-0.201	-1.074	-0.115	-1.159	0.015	0.029	-0.122	-0.230	-0.357	-0.975
SQ_CR_NPFRAT2	-6.284*	-1.838	-3.932	-1.506	-6.997***	-2.581	-56.363*	-1.714	3.863	0.995	0.627	0.068
SQ_CR_LIQRAT	0.116	0.249	0.462	1.524	-0.226	-1.196	6.109	1.519	0.848	1.322	-0.807	-0.582
GNPGROW	0.001	0.373	0.002	0.963	0.002*	1.693	0.022*	1.678	0.012**	2.550	-0.001	-0.091
UNEMP	-0.009***	-3.146	-0.000	-0.096	-0.002	-1.453	-0.065***	-4.167	-0.011**	-2.488	0.004	0.419
STGROW	-0.093	-1.176	-0.162	-1.619	-0.134***	-3.991	1.204***	3.104	0.936***	10.109	-0.130	-0.398
STUNEMP	-0.001	-1.230	-0.002***	-2.818	-0.001***	-5.954	0.003	0.879	0.002***	2.707	0.000	0.037
NE	-0.002	-0.901	-0.010**	-2.497	-0.005***	-4.304	-0.025	-1.571	-0.009***	-3.215	-0.005	-1.195
SW	0.015**	2.178	0.008	1.510	0.009***	5.316	0.009	0.417	-0.001	-0.296	0.009	0.507
BAAAAA	0.004	0.529	0.003	1.061	0.001	0.278	0.071**	2.444	0.048***	4.354	-0.002	-0.108
RF3MO	-0.011	-1.385	0.006	0.736	-0.003	-1.099	0.085**	2.194	-0.046***	-4.299	0.016	0.557
SQ_RF3MO	0.004	1.472	-0.001	-0.519	0.000	0.100	-0.016	-1.308	0.011***	3.653	0.004	0.466
TIME	0.001**	2.196	0.000	1.025	0.000	0.363	0.008***	2.705	-0.002**	-2.379	0.004*	1.680
SEAS1	0.001	0.321	-0.000	-0.368	-0.004***	-4.685	0.051***	4.013	0.008*	1.900	-0.001	-0.095
SEAS2	0.008***	3.854	0.006***	3.147	0.014***	11.468	-0.016	-1.356	-0.050***	-13.209	0.002	0.216
SEAS3	0.009***	4.379	0.008***	5.210	0.008***	8.870	-0.027***	-2.613	-0.014***	-3.997	0.009	1.150
SLOPE20P	0.026**	2.020	0.010	1.302	-0.004	-0.809	0.098	1.578	0.028	1.570	0.081*	1.894
SLOPE20M	-0.077	-0.349	0.263	1.509	0.577***	7.054	-4.596***	-2.784	-2.909***	-6.385	-2.229**	-2.233
SQ_SLOPE20P	-0.010	-1.617	-0.001	-0.494	0.002	0.647	-0.008	-0.275	-0.029***	-4.064	-0.024	-1.188
SQ_SLOPE20M	-1.248	-0.499	2.701	1.413	6.143***	6.902	-53.685***	-2.873	-31.658***	-6.214	-26.640**	-2.375
MEDIUM	0.005***	3.524	0.007***	5.263	0.007***	9.462	0.041***	4.698	0.001	0.506	0.008**	2.265

Table 7: (continued)

LARGE_1	0.001	0.228	0.005*	1.868	0.008***	7.699	0.039***	2.755	-0.000	-0.122	-0.002	-0.349
LARGE_2	-0.014	-1.394	-0.028*	-1.647	0.004	1.399	0.030	1.287	0.008	1.032	-0.007	-0.642
HHIA	-0.012	-1.293	-0.006	-0.746	0.005***	2.807	0.036	1.368	0.000	0.089	0.022	1.559
OCC	-0.007**	-2.146	-0.005**	-2.337	-0.004***	-4.333	-0.005	-0.363	0.003	1.458	0.002	0.514
FDIC	-0.000	-0.103	0.002	1.457	0.001*	1.717	0.001	0.065	0.003	1.478	0.012***	3.158
OTS	-0.010***	-2.818	-0.007***	-2.872	-0.003***	-2.701	-0.015	-0.941	-0.010***	-3.512	-0.001	-0.152
R^2	0.002		0.004		0.012		0.004		0.012		0.000	
Num Obs	119679		119679		119679		119679		119679		119679	

Table 8:
Enhanced RISK-factor model (NoSmall)

The Table presents the results obtained from running the enhanced version of the model on the LHS variables listed in the first row which are defined in Table 2. We remove the small banks from our sample in order to check if there is any size effect. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: $* \ p < 0.05, ** \ p < 0.01, *** p < 0.001$.

	RSLN		TLRE		TLN		RMBS		RB20		RB50	
	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat
INTERCEPT	0.070**	2.055	0.058***	4.366	0.057***	3.834	-0.033	-0.159	0.127**	2.503	-0.241**	-2.238
CRUNCH	-0.026***	-3.626	-0.022**	-2.493	-0.023**	-2.051	-0.010	-0.200	-0.006	-0.523	-0.041	-1.501
T1RAT	0.023	1.365	0.066***	3.512	0.044	1.025	0.275***	2.594	0.172***	5.709	0.084	0.887
LEVRAT	0.055	1.014	-0.074	-1.074	-0.011	-0.079	-0.208	-0.622	-0.397***	-4.728	-0.222	-0.770
NPFRAT1	-1.075***	-6.934	-1.354***	-10.746	-1.647***	-15.230	-1.463	-1.079	0.374**	1.968	-1.459*	-1.851
LIQRAT	-0.024	-1.038	-0.055**	-2.191	-0.013	-0.737	-0.122	-0.487	0.304***	6.500	0.127	1.256
SQ_T1RAT	0.008	1.537	0.023***	3.367	0.010	0.612	0.084**	2.281	0.057***	6.019	0.060	1.636
SQ_LEVRAT	0.083	0.820	-0.168	-1.065	0.018	0.050	0.251	0.346	-0.321*	-1.757	-1.404	-0.876
SQ_NPFRAT1	14.421***	3.342	14.788***	4.641	21.929***	4.577	72.152	1.231	-2.085	-0.429	15.476	1.047
SQ_LIQRAT	-0.344	-1.261	-0.595*	-1.832	0.170	0.568	3.612	1.460	1.213***	2.860	1.564	1.404
CR_T1RAT	0.128***	3.311	0.039	0.597	0.026	0.547	-0.168	-1.099	0.053	0.524	0.259**	2.368
CR_LEVRAT	-0.378***	-3.614	-0.289	-1.376	-0.224	-1.394	0.457	0.941	-0.216	-1.101	-0.551	-1.362
CR_NPFRAT1	0.694**	2.051	-0.118	-0.535	0.400***	3.515	1.199	0.657	-0.456	-1.551	0.325	0.392
CR_LIQRAT	0.047	0.787	0.012	0.318	-0.035	-1.275	0.036	0.059	0.191*	1.738	0.087	0.546

Table 8: (continued)

SQ_CR_T1RAT	0.041***	2.950	0.007	0.357	0.008	0.424	-0.053	-1.010	-0.015	-0.638	0.042	0.823
SQ_CR_LEVRAT	-0.477**	-2.124	-0.344	-1.308	-0.668	-1.373	0.259	0.258	0.459	0.477	0.608	0.411
SQ_CR_NPFRAT1	-9.696*	-1.716	-4.347	-1.044	-13.803***	-2.772	-86.813	-1.393	4.802	0.667	-4.484	-0.279
SQ_CR_LIQRAT	0.929*	1.689	0.632*	1.676	-0.181	-0.524	3.585	0.610	0.223	0.238	2.277	1.258
GNPGROW	0.001	0.527	0.003**	2.137	0.002	1.444	0.047***	2.811	0.013***	3.225	0.007	0.851
UNEMP	-0.011**	-2.542	-0.002*	-1.790	-0.002	-1.644	-0.081***	-4.300	-0.009	-1.626	0.012	1.221
STGROW	-0.050	-0.379	-0.073	-0.884	-0.070	-1.574	0.968*	1.828	0.625***	5.911	-0.801	-1.439
STUNEMP	-0.002**	-2.012	-0.001**	-2.550	-0.001***	-5.541	0.006	1.238	0.002**	2.541	0.001	0.339
NE	-0.001	-0.709	-0.011**	-2.291	-0.005***	-3.571	-0.013	-0.788	-0.006**	-2.253	-0.009**	-2.022
SW	0.009**	2.041	0.007	1.571	0.005***	3.386	-0.009	-0.425	-0.008*	-1.812	0.004	0.143
BAAAAA	0.006	0.801	0.001	0.539	0.001	0.280	0.111***	3.041	0.042***	4.346	-0.003	-0.142
RF3MO	-0.016**	-2.404	-0.012***	-2.682	-0.005	-1.142	0.070	1.404	-0.041***	-3.615	0.042	1.317
SQ_RF3MO	0.006*	1.905	0.003*	1.801	0.000	0.278	-0.020	-1.284	0.006*	1.884	-0.006	-0.624
TIME	0.001	1.159	-0.001	-1.392	0.000	0.137	0.008**	2.159	-0.002***	-2.730	0.004*	1.952
SEAS1	-0.001	-0.279	-0.001	-0.365	-0.002**	-2.486	0.046***	2.772	0.020***	4.989	0.012	1.318
SEAS2	0.005*	1.803	0.006***	3.112	0.010***	7.111	-0.015	-1.008	-0.029***	-8.188	0.002	0.323
SEAS3	0.006***	3.152	0.008***	4.253	0.006***	5.620	-0.023*	-1.691	0.001	0.364	0.011	1.367
SLOPE20P	0.033*	1.695	0.003	0.255	-0.005	-0.861	0.041	0.510	-0.007	-0.423	0.041	0.979
SLOPE20M	-0.031	-0.103	0.334*	1.786	0.326***	2.941	-7.250***	-3.352	-2.707***	-5.997	-1.934*	-1.933
SQ_SLOPE20P	-0.014	-1.475	-0.003	-0.638	0.002	0.577	0.010	0.294	-0.015**	-2.077	-0.004	-0.205
SQ_SLOPE20M	-0.736	-0.216	3.404	1.617	3.252***	2.780	-84.035***	-3.437	-29.589***	-5.765	-23.427**	-2.068
HHIA	-0.011	-1.337	-0.004	-0.657	0.003	1.495	0.039	1.189	-0.003	-0.582	0.022	0.924

Table 8: (continued)

OCC	-0.003*	-1.687	-0.001	-0.327	-0.003***	-2.658	-0.013	-0.929	0.002	0.710	0.007	1.173
FDIC	0.002	1.363	0.004	1.602	0.002**	2.210	-0.003	-0.196	0.002	0.891	0.017***	2.747
OTS	-0.005***	-3.274	-0.003	-1.297	-0.002	-1.095	-0.017	-0.869	0.000	0.005	0.010	1.076
R^2	0.003		0.007		0.011		0.003		0.016		0.001	
Num Obs	66334		66334		66334		66334		66334		66334	

Table 9:
Enhanced RISK-factor model (NoFilter)

The Table presents the results obtained from running the enhanced version of the model on the LHS variables listed in the first row which are defined in Table 2. We remove the filtering procedure from our empirical setup to include all banks in our sample. All RISK variables are lagged and averaged over the previous four quarters. Risk factors pre-multiplied by the CRUNCH dummy variable are denoted as CR_RISK while marginal contributions computed as the square of RISK variables are denoted as SQ_RISK. The combination of both is refered to as SQ_CR_RISK. Statistical significance is set as follows: $* \ p < 0.05, ** \ p < 0.01, *** p < 0.001$.

	RSLN		TLRE		TLN		RMBS		RB20		RB50	
	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat	Parms	t-stat
INTERCEPT	0.021	0.580	-0.035	-0.983	0.025	0.935	-0.061	-0.386	0.059	0.782	-0.047	-0.340
CRUNCH	-0.044***	-3.964	-0.036***	-4.569	-0.029***	-3.529	-0.075**	-2.040	-0.003	-0.249	-0.091***	-2.929
T1RAT	-0.002	-0.466	-0.003	-0.558	0.003	0.328	0.017	1.395	-0.001	-0.037	-0.011	-0.649
LEVRAT	-0.127***	-4.561	-0.132***	-5.581	-0.123***	-4.458	-0.209***	-3.694	-0.063	-1.517	-0.079	-0.563
NPFRAT1	-1.172***	-5.109	-1.371***	-6.032	-1.836***	-10.402	-0.969	-1.090	0.180	0.758	-1.631***	-3.175
LIQRAT	-0.052	-0.866	-0.138**	-2.505	-0.154***	-2.750	-0.135	-0.789	0.135**	2.316	-0.106	-1.111
SQ_T1RAT	-0.000	-0.738	-0.000	-0.792	0.000	0.233	0.000	1.255	0.001	0.667	-0.000	-0.729
SQ_LEVRAT	-0.005***	-4.615	-0.005***	-5.709	-0.005***	-4.552	-0.008***	-3.769	-0.003**	-2.021	-0.003	-0.579
SQ_NPFRAT1	19.242***	3.594	19.745***	3.546	19.226***	3.958	33.685	1.216	-0.990	-0.184	15.694	1.193
SQ_LIQRAT	0.281	0.527	-0.316	-0.692	0.388	0.853	2.149	1.387	-0.554	-1.107	0.394	0.422
CR_T1RAT	0.019	0.749	0.016**	2.077	0.010	0.683	0.075***	3.011	0.003	0.145	0.044	1.495
CR_LEVRAT	-0.260***	-2.749	-0.177***	-4.252	-0.200***	-3.393	-0.345**	-2.536	-0.086	-1.172	-0.669***	-3.080
CR_NPFRAT1	0.437	1.454	-0.121	-0.401	0.378	1.562	-0.033	-0.029	-0.637**	-2.135	-0.430	-0.658
CR_LIQRAT	-0.159*	-1.958	-0.060	-1.058	-0.064	-1.204	-0.019	-0.050	0.211**	2.106	-0.159	-0.924

Table 9: (continued)

SQ_CR_T1RAT	0.001	0.644	0.000*	1.859	0.000	0.594	0.003***	3.091	-0.000	-0.443	0.001	1.394
SQ_CR_LEVRAT	-0.108***	-3.098	-0.107***	-5.498	-0.108***	-4.910	-0.294***	-4.289	-0.067**	-2.530	-0.572**	-2.047
SQ_CR_NPFRAT1	-19.776***	-2.965	-16.237**	-2.361	-15.831***	-3.526	-26.442	-0.897	-5.068	-0.767	-3.348	-0.249
SQ_CR_LIQRAT	-1.365*	-1.783	-0.052	-0.092	-0.710	-1.375	5.421	1.536	0.439	0.509	-1.056	-0.614
GNPGROW	0.000	0.035	0.001	0.320	0.006**	2.138	0.031**	2.266	0.011*	1.796	0.006	0.528
UNEMP	-0.008**	-2.424	0.002	1.135	-0.003	-1.508	-0.061***	-4.308	-0.010*	-1.735	-0.012	-0.975
STGROW	-0.013	-0.150	-0.038	-0.419	-0.089	-1.416	1.195***	3.147	1.132***	7.174	-0.011	-0.031
STUNEMP	-0.002**	-2.077	-0.002**	-2.575	-0.002***	-3.446	0.004	1.185	-0.001	-0.763	0.001	0.543
NE	-0.011***	-2.999	-0.013***	-3.493	-0.010**	-2.177	-0.044***	-3.217	-0.016***	-6.006	-0.026***	-4.369
SW	0.015**	2.056	0.004	0.689	-0.009	-0.916	0.035**	1.992	-0.002	-0.410	0.056***	3.006
BAAAAA	0.002	0.256	-0.004	-0.792	0.007	1.318	0.022	0.740	0.050***	3.841	0.016	0.611
RF3MO	-0.007	-0.590	0.003	0.291	-0.007	-0.809	-0.000	-0.005	-0.033*	-1.896	-0.006	-0.194
SQ_RF3MO	0.002	0.472	-0.001	-0.313	-0.001	-0.452	0.004	0.322	0.009*	1.820	0.004	0.387
TIME	0.001*	1.675	0.001*	1.675	0.000	0.077	0.013***	4.191	-0.001	-0.925	0.003	1.353
SEAS1	0.005	1.250	0.003	1.043	0.000	0.147	0.046***	3.647	0.013**	2.233	0.010	0.957
SEAS2	0.007**	2.005	0.003	1.217	0.014***	5.532	-0.038***	-3.397	-0.048***	-8.177	0.006	0.636
SEAS3	0.008***	2.746	0.009***	4.234	0.013***	6.288	-0.029***	-2.641	-0.008*	-1.659	0.011	1.249
SLOPE+	0.013	0.851	0.008	0.615	-0.016	-1.249	0.098	1.546	0.039	1.337	0.036	0.656
SLOPE-	-0.178	-0.297	-0.125	-0.252	0.274	0.747	-5.427***	-3.351	-3.301***	-5.928	-2.161*	-1.648
SQ_SLOPE+	-0.003	-0.449	-0.001	-0.164	0.005	0.893	-0.021	-0.746	-0.031***	-2.604	-0.011	-0.447
SQ_SLOPE-	-2.808	-0.414	-1.711	-0.309	3.040	0.730	-63.549***	-3.465	-36.561***	-5.827	-26.915*	-1.811
MEDIUM	0.017***	5.754	0.020***	6.913	0.025***	5.673	0.052***	7.435	0.002	1.057	0.016**	2.479

Table 9: (continued)

LARGE_1	0.044***	4.752	0.046***	4.361	0.066***	4.567	0.063***	5.242	0.004	1.157	0.037***	3.192
LARGE_2	0.027	1.172	0.046**	2.172	0.042**	2.312	0.033	1.319	0.024**	2.271	-0.006	-0.249
HHIA	-0.005	-0.487	0.001	0.119	0.005	0.566	0.030	1.461	0.004	0.601	0.026	1.483
OCC	-0.009***	-2.604	-0.012***	-3.362	-0.009*	-1.899	-0.012	-1.240	0.005**	2.051	-0.012*	-1.883
FDIC	0.006*	1.774	0.005	1.434	0.006	1.098	0.004	0.484	0.005**	2.128	0.011*	1.922
OTS	-0.016***	-3.083	-0.016***	-2.921	-0.008	-1.081	-0.020*	-1.779	-0.011***	-2.961	-0.011	-1.437
R^2	0.003		0.006		0.006		0.003		0.005		0.001	
Num Obs	170668		170668		170668		170668		170668		170668	

Fifth, we remove the cleansing filter from our empirical setup and rerun our model on the new dataset which includes all possible banks which includes some with peculiar ratios. Results in Table 9 show that even before the crisis there was a strengthening of the liquidity, coercive risk-retrenchment and particularly the leverage hypothesis through an increase in significance of the related variables up to the 1% level. Similarly, the CRUNCH effect becomes more obvious for the RMBS category as the filtering procedure adopted by B&U was seemingly too conservative.

7 Conclusion

Regardless if one agrees with the blame directed at the Basel regulation for failing to achieve its safety goal, what can factually be stated is that, in retrospect, the regulation certainly did not prevent any crises, at least in the U.S. While the 1990-1991 recession was established as a "capital crunch", our research question asks whether this could have also been the case for the 2007-2009 subprime crisis. Given that the Basel II capital requirements did relatively little to alleviate the heavy losses that ensued during the recent crisis, the broader question becomes how adequate was the "capital adequacy" requirement - pillar one of the three Basel pillars - in light of the subprime crisis?

Based on B&U's model for the 1990-1991 crunch, we argue that under Basel II, the lowering of the risk-weight on residential mortgages could have pushed banks toward further lending in this asset category in order to maintain high capital ratios. The latter became an incentive for banks to increase their risk-taking (moral hazard). Combined with dangerous levels of leverage and a dry-up in liquidity, this meant that banks could not measure up to the resulting wave of defaults. Hence, having reached excessive levels of non-performing loans, this *coerced* banks to cut down on their lending. While our results only reveal the validity of our RBC CCH during the crisis, leverage appears to have been the dominant factor with liquidity in second position.

As such, the inclusion of the leverage and liquidity ratios as part of the Basel III framework provided an implicit answer as to the effect of the regulation on the crisis by pointing out the related factors as "regulatory loopholes". We find that a plain asset liquidity measure such as liquid assets to total assets (LIQRAT) variable would be a good complement to the recently advocated funding liquidity measures, LCR and NSFR. However, the hindsight of having worked with a proven-to-be-faulty tandem of capital and leverage ratios, as in the case of the U.S., should push the regulators to rethink their Basel III strategy of implementing the second ratio as a "backstop" measure as this could repudiate the value of having simple risk-based capital guidelines. Finally, while we do not measure the effect of quality of capital, increasing the quantity levels of capital could deter banks from building comfortable capital cushions which induced them into moral hazard.

Note that some seemingly odd features of the risk-weighting scheme which were revealed by our analysis, such as the opposite signs on USTR/USTRA, allowed us to unveil further characteristics of the crunch such as the role of GSEs. In particular, we witness certain differences in growth-related behavior between an instrument (e.g. USTREAS/USTA/FGNMA) and its corresponding risk-weight class (RB0/RB20). This hints to the breakdown of strict monotonicity in the risk-weighting scheme as the riskiness of a particular instrument and its belonging to a certain risk-weight class appear to be dependent on the business cycle. Potentially, this could lead towards the concept of having dynamic versus static risk-weights. Also, by definition, capital ratios are sensitive to changes in risk-weight. Unfortunately, aside from two historical data points where changes have occurred to a single asset class (residential mortgages), the characteristics of this sensitivity remain virtually unknown. This matter is addressed from a mathematical viewpoint in Chapter 4.

In sum, our findings agree with B&U's claim on the effectiveness of the Basel regulation(s) in changing the banks' behavior in one way or another. No matter how the scenario differs between credit crunches in terms of supply/demand triggers, direct/indirect effects, regions NE/SW and players FDIC/OTS, the essence of capital adequacy will always be to delay rather than completely absorb shocks; that is, if used properly in conjunction with the remaining pillars 2 and 3 guidelines. So far, the Basel regulations have preceded, if not lead to, these credit crunches. Nowadays, this logic has been reversed as we observe the impact of the subprime crisis on regulatory guidelines such as Basel II.5 and III. Except for the combination of capital and leverage ratios which could be distortionary, our overall assessment is that the measures taken are heading in the right direction. However, noting that the basis for computing the required capital ratios in all four regulatory frameworks still hinges on static risk-weights, it is time for the Basel regulators to re-evaluate their perception that "the benefits of a risk-sensitive capital framework outweigh [any] potential concern".

Chapter IV:

The Basel Capital Requirement Puzzle: A Study of Changing Interconnections between Leverage and Risk-Based Capital Ratios

1 Introduction

The Basel Committee on Banking Supervision (BCBS) has been widely criticized for not meeting its bank safety objective after the U.S. witnessed two credit crunches in a span of less than twenty years. Indeed, after the introduction of Basel I (BCBS (1988)), banks struggled to meet the newly established risk-based capital requirements and hence shifted their portfolio composition towards safer assets to boost their capital ratios (CRs). This resulted in a lending contraction during the 1990-1991 recession, hereafter referred to as the first crunch.

In contrast, since the Basel II framework was released (BCBS (2004) and BCBS (2006)), it seems that banks willingly increased their CRs beyond the target thresholds. Indeed, according to Chami and Cosimano (2010), in the early stages of the subprime crisis, the top 25 banks in the U.S. and Europe had a Tier 1 capital ratio of 8.3% and 8.1% while the Total capital ratio was 11.4% and 11.6%, respectively. Due to the distortionary incentives created by holding such high capital buffers (or moral hazard as indicated by Brinkmann and Horvitz (1995)), banks reached dangerous leverage ratios[1] (LR) judging by the standards set by the main U.S. regulators (OCC, FDIC and FED) for well-capitalized institutions. Indeed, Gilbert (2006) states that up until mid-2005 only the two largest U.S. banks did not fall below the 5% leverage requirement.

Once defaults began their domino effect which triggered the second credit crunch in 2007-2009, the blame was directed at the regulators for having incentivized banks to take on excessive risk prior to the crisis. Aside from new capital definitions, if the regulatory target thresholds were maintained at the pre-established 4% and 8% levels for Tier 1 and Total CR, the only regulatory change that could have affected these ratios exogenously would have been the introduction of new risk-weight categories. The latter is reported to have shifted the portfolio risk appetite of banks between asset classes, namely with regard to residential mortgages (Blasko and Sinkey (2006) and Cathcart et al. (2013)).

Since their introduction under the Basel framework, the effects of capital requirements have been investigated from two different perspectives. The first is related to the impact on lending growth (Bernanke and Lown (1991); Peek and Rosengren (1992, 1994, 1995a,b); Barajas et al. (2004); Cathcart et al. (2013)) whereas the second focuses on risk incentives (Koehn and Santomero (1980); Furlong and Keely (1987); Kim and Santomero (1988); Furlong and Keely (1989); Keely and Furlong (1990); Gennotte and Pyle (1991); Shrieves and Dahl (1992); Calem and Rob (1999); Blum (1999); Montgomery (2005); Berger and Bouwman (2013))[2]. Opinions remain mixed as to the effect capital can have in each case[3]. Moreover, due to the partial implementation of Basel II in the U.S. prior to the second crunch, this makes the puzzle of finding a relationship between

[1]Leverage is not to be confused with the traditional corporate finance definition as the ratio of debt to equity. In the regulatory context it is defined as the ratio of equity to assets (see section 2). In that sense, high leverage is considered to be a good sign.

[2]Note that all but the last citations in each literature perspective relate to the first crunch which underlines the greater attention attributed to the Basel regulation following this period.

[3]Though some studies have shown that capital can relate to other bank-specific features such as size. In this case, the perception seems to be that larger banks have smaller CRs (Hall (1993), Estrella et al. (2000), Gilbert (2006) and Demirguc-Kunt et al. (2010)). Still, this finding can depend on the choice of capital measure: Tier 1 VS Total (Demirguc-Kunt et al. (2010)).

the regulation and the crisis more difficult.

Resolving this puzzle could potentially benefit from a different approach. In fact, our literature survey revealed that authors alternate between the use of the CR or LR in their studies. However, the two ratios are not entirely independent as the interaction between both can lead to some interesting findings and a new perspective on relating the abovementioned crunches to the effects of capital requirements. In this paper, we complement the existing literature by exploring a three-step procedure whereby a bank's binding constraint can be affected by changes in the correlation pattern of LR and CR, which in turn is explained by the sensitivity of the latter to alterations in its risk-weights.

Firstly, in order to showcase the shifts in banks' binding constraints between the two crunches, we conduct a bank failure analysis in relation to the CR and LR requirements. While one might consider bank failure as being the adverse consequence of excessive risk-taking, not all failures can be attributed to banks' risky behavior with regard to capital adequacy[4]. Since the existing literature investigated the causal linkages to the subprime crisis outside the realm of risk-based capital requirements (leverage, liquidity, securitization), our study re-emphasizes the effects of these requirements on failures in an aim to fill the gap.

Secondly, we investigate reversals in correlation patterns between LR and CR. We show that these patterns are related to economic fundamentals such as lending and GDP which allows us to pinpoint the loan category mostly correlated with the second crunch. Also, in this context, it is common for some authors to confuse correlation for causality, an opinion shared with Furfine (2000). We therefore assess any implied causality using Granger tests.

Thirdly, we derive a partial differential equation (PDE) related to the sensitivity of the CR which combines the two capital requirements. The closed-form solution of this equation can assist policy-makers in setting adequate rather than heuristic targets for the

[4]Operational risk, for instance, has been at the helm of many investigations: fraud (Daiwa, Sumitomo), rogue trading (Barings Bank).

CR and LR. This can also shed light on the controversy highlighted by various authors (Hall (1993); Thakor (1996); Blum (2008); Buehler et al. (2010); Blundell-Wignall and Atkinson (2010); Kiema and Jokivuolle (2010)) regarding the effects of combining the two capital measures together under a single framework. In turn, this has implications on the Basel III regulation which seeks to incorporate the LR as a "backstop" measure alongside the CR.

In order to validate our three-step procedure we proceed as follows. In section 2, we describe our dataset. In section 3, we illustrate the impact of the CR and LR requirements on bank failures for the second crunch period. In section 4, we explore the changes in correlation patterns between the two ratios. Finally, in section 5, we explain the correlation reversals between the two crunches from a theoretical and empirical standpoint. In section 6, we conclude with our main results and policy implications.

2 Data

Our dataset is based on FDIC Call Reports[5] for the periods 1990Q1-1991Q2 and 2004Q3-2009Q2. The latter period covers the second crunch but also contains a control period to allow for some delay before some of the Basel II regulatory changes took place[6]. This is not possible for the first crunch as risk-weight data is unavailable prior to 1990.

After discarding all negative CR values, we construct various sub-samples of the dataset based on the distribution of the CR. The latter range from the 90th to the 50th percentiles. Our choice of cutoff values related to removing the effect of outliers mostly located in the upper percentiles of the data, while the limit of 50% is used to maintain a reasonable amount of observations. Descriptive statistics for the upper and lower bounds of the sub-samples are shown in Table 10 below.

[5]Also known as Reports of Condition and Income taken from the Federal Financial Institutions Examination Council (FFIEC).

[6]See Chapter 3 for more detail.

Table 10:
Summary Statistics

The data in this table relates to the beginning of each designated crunch period, 1990Q1 and 2004Q3. Values are shown after cleansing the data with respect to the CR at the 90th and 50th percentiles. Risk-weighted assets (RWA), Total Assets (TA) and Mortgage Assets (A) are in USD.

Panel A: 1990Q1

Pct	90%					50%				
Var	Obs	Mean	Std Dev	Skew	Kurt	Obs	Mean	Std Dev	Skew	Kurt
CR	12069	12.5	4.3	0.5	3.0	6714	9.5	2.1	-1.2	4.7
LR	12069	8.0	2.5	1.8	33.1	6714	6.7	2.0	5.2	155.2
RWA	12069	2.5^{8}	2.6^{9}	45.8	2903.8	6714	3.9^{8}	3.4^{9}	34.5	1636.1
TA	12069	3.1^{8}	2.5^{9}	34.9	1731.8	6714	4.8^{8}	3.3^{9}	26.6	997.0
A	12069	1.0^{8}	7.7^{8}	30.3	1198.2	6714	1.6^{8}	1.0^{9}	23.3	697.5

Panel B: 2004Q3

Pct	90%					50%				
Var	Obs	Mean	Std Dev	Skew	Kurt	Obs	Mean	Std Dev	Skew	Kurt
CR	8440	14.4	4.7	0.5	3.3	4077	10.7	1.3	-0.5	4.4
LR	8440	9.5	2.6	2.1	15.6	4077	8.1	1.2	2.2	40.2
RWA	8440	7.5^{8}	1.0^{10}	34.6	1408.7	4077	1.3^{9}	1.5^{10}	24.4	697.0
TA	8440	9.9^{8}	1.3^{10}	36.1	1528.0	4077	1.7^{9}	1.9^{10}	25.6	759.5
A	8440	3.3^{8}	3.9^{9}	33.5	1421.2	4077	6.1^{8}	5.5^{9}	24.4	742.8

These statistics allow us to re-assert the finding in Chami and Cosimano (2010) that banks were indeed better capitalized before the second crunch compared to the first by around two percentage points as indicated by both capital ratios. Moreover, had the regulators linked the CR and LR together by any linear association (for instance, CR - LR > Constant), we would expect similar distributions for each ratio. However, this is not the case as can be seen at the 90th percentile[7] with the quasi-normal distribution of the CR (Skewness ≈ 0, Kurtosis ≈ 3) versus a positively skewed and leptokurtotic distribution for the LR (Skewness ≈ 2, Kurtosis varies according to the period). This indicates that there might be a non-linear linkage between the two ratios which we develop in our last section.

The survivorship bias is apparent in our study as can be seen from the one-third reduction in the number of banks between both periods[8]. Furthermore, we witness

[7] Clearly, the sample distribution is no longer normal at the 50th percentile.

[8] We do not account for this bias in order to preserve the data at our disposal as the higher moments

an order of magnitude increase in the value of assets due to balance-sheet expansions, mergers and acquisitions.

3 The Change in Binding Capital Constraint

i Capital, the Common Numerator

The CR and LR are the most popular measures of capital adequacy. Since the two ratios are proportional to Tier 1 capital by definition[9], we can investigate changes to capital from the perspective of either ratio.

Greenspan et al. (2010) have shown that by the year 2000 the LR of the commercial banking sector had fallen to almost a fifth of its value two centuries ago[10]. This was followed by a period in which the market-valued LR was almost double its book value. However, the second crunch witnessed a full reversal of this trend. Since one can cast out the possibility of an increase in the market value of assets during crisis times, the only explanation for the fall in market-valued LR, must relate to a depreciation in the value of capital. That is mainly because of the failure of some capital components to play their role as loss absorption layers. As a matter of fact, this gave Basel III regulators the incentive to scrap the Tier 3 capital layer altogether and remove all elements in Tier 2 that cannot fulfill their purpose[11]. Consequently, this gave more importance to the role of Tier 1 capital.

of the data do not vary between the two periods.

[9] With reasonable approximation based on the risk-based capital definitions for Prompt Corrective Action (PCA) as posted by the FDIC, CR = K/RWA; LR = K/A where K is Tier 1 Capital. See section 4 for more details.

[10] This corresponds to an increase in the conventional sense of Debt/Equity.

[11] Mainly some types of preferred stock categorized under hybrid instruments.

ii The Capital Ratio (CR) versus the Leverage Ratio (LR): The Binding Constraint

In view of the common capital feature embedded in both ratios, any changes between the two can be attributed to changes in their denominators, risk-weighted versus unweighted assets. However, each of the CR and LR can have very different effects on a bank's behavior depending on which of the two is the binding constraint (Berger and Udell (1994), Hancock and Wilcox (1994), Peek and Rosengren (1994), Chiuri et al. (2002), Barajas et al. (2004), Blundell-Wignall and Atkinson (2010)). Before pointing out which of the two ratios was primarily responsible for destabilizing the banks during the second crunch, we start with a review of the first crunch which attracted most of the attention in terms of bank failure analysis with regard to capital regulation.

First, it is important to recognize that the substitution of the 1980s flat rate for risk-based capital (RBC) under Basel I meant that banks accounting for a quarter of total assets failed the newly imposed regulation according to Avery and Berger (1991). Based on Berger and Udell (1994), this amounted to a 20% increase in banks not abiding by the regulation. Moreover, Peek and Rosengren (1994) emphasized that, towards mid-1991, from the 20 largest First District commercial and savings banks, the numbers violating the targets on Tier 1 and Total capital were zero and seven, respectively.

Unlike the fixed CR targets, the choice of which LR is chosen to compare between banks is at each author's discretion. This is because CAMEL ratings, which guide national regulators in their discretionary LR requirement for each bank, are not disclosed[12]. This point is emphasized by Hall (1993) who demonstrated that if the average LR were assumed at 3%, the CR becomes the more likely first crunch culprit since most banks are able to fulfill the LR requirement. However, if the LR were established at a level of

[12]Under this rating scheme, the safest banks, attributed the best rating of 1, are given a leverage target of 3%. Depending on their condition, all other banks are set a target of either 1 to 2 percentage points higher. Even if it were known, the function underlying the "CAMEL-to-Leverage" specification is arguably not bijective.

5% then at least 18% of these would fail the leverage target.

Two studies which investigated the impact of the CR and LR on bank failures during the first crunch are Avery and Berger (1991) and Estrella et al. (2000). Although the latter study came at a much later time than the former, it only pointed out the critical regions at which banks were affected by one ratio or the other. Hence, no consideration was given to the combined effect of the two ratios. However, one important observation we make from the authors' results is that at least one year prior to its failure, a bank can have the same LR in the critical region as one which eventually survived. This supports the fact that the LR has no predictive power regarding bank failures in contrast to the CR, in line with the authors' conclusion. However, it is important to make sure this statement remains valid during the second crunch.

Avery and Berger (1991) make a similar assessment by which they calculate the number of banks that went bankrupt just before the start of the first crunch given that these banks had earlier failed to meet one or more of the CR and/or LR regulations. For example, almost a third of the 6% of banks which could not meet the targets for Tier 1 capital, Total capital or leverage failed over the next 2 years[13]. More importantly, 50% of all banks failing the Tier 1 target eventually went bankrupt, putting this requirement at pole position in terms of forecasting power.

Following the same line of thought as the previous authors we analyze the relationship between these capital standards and bank failures for the second crunch. This complements findings such as Berger and Bouwman (2013) who observed that a one standard deviation decrease in capital more than doubles the probability of bankruptcy. However, their result shows this trend as being linear even though authors which differed on their assessment of risk and capital (Koehn and Santomero (1980); Furlong and Keely (1987); Kim and Santomero (1988); Furlong and Keely (1989); Keely and Furlong (1990)) still agreed that capital shortfalls weigh more on a bank's survival rate than surpluses.

[13]Note that in the Basel framework, if a bank fails Tier 1 it automatically fails the Total requirement as the regulators impose that Tier 2 cannot exceed 50% of Tier 1.

Notwithstanding some components might have changed, the CR thresholds were not altered between the two Basel frameworks. This allows for a better comparison with Avery and Berger (1991). However, instead of exploring changes before and after the Basel II capital standards were brought in, our study uses three intervals (pre, mid and end of the crisis), in order to gauge the evolution in meeting these standards along with the leverage requirement as the crisis unfolded. As per Avery and Berger (1991) and Hall (1993), we also look at a range of leverage targets 3%, 4% and 5%. Finally, we look at how combinations of both standards impact on bankruptcies.

Table 11 shows a number of compelling findings. First, with respect to the 4% (median) leverage requirement, Avery and Berger (1991) had obtained a 94% estimate of the proportion of banks that passed all three requirements prior to the first crunch. This is still well below the corresponding 99% proportion at the onset of the second crunch which confirms the same result obtained by Greenspan et al. (2010). What's more is that the percentage of banks failing any of the standards was at least an order of magnitude less than those in Avery and Berger (1991)'s first crunch estimates. This confirms that, in quantitative terms, banks were holding capital well in excess of the targets (overcapitalization) prior to the second crunch.

Nevertheless, failing any of the standards in the last crunch had more serious repercussions since a much greater proportion of the pre-crunch bank pool ($> 50\%$) ended up bankrupt. Ultimately, all banks failing either the Tier 1 CR or a 3% LR went bankrupt. Therefore, since meeting either of the requirements did not make up for falling short of meeting the other, this brings back into question the purpose of imposing dual requirements. Moreover, we point out the increase in the failure to meet any of the requirements over time. This contrasts with a simultaneous decrease in bankruptcy rate, specifically between the start and end of the period under observation. The first finding stresses the weakened capital position of banks eroded by losses throughout the crunch period. The second finding relates to corporate finance theory in that survival rates increase for banks which can endure more phases of a crunch (Klapper and Richmond (2011)).

A striking feature is that during all three phases of the crunch, all banks that failed Tier 1, and obviously Total, capital also failed the average leverage requirement of 4%. This has crucial implications on Basel III as it suggests that the choice of imposing a backstop 3% requirement could be overly conservative. More importantly, increasing the leverage standard by 1% always resulted in an average doubling of the failure to meet the requirement across all periods. These reasons are why leverage would appear to be the binding constraint for this crunch; thus statistically corroborating the statements in Gilbert (2006)[14] and Blundell-Wignall and Atkinson (2010). This is in contrast with the first crunch where banks were mostly struggling to meet their CR requirements.

Table 11:
Bankruptcy Predictions from Banks Failing to Meet Various Capital Standards

Our results for the period 2004Q3-2009Q2 are broken down into three consecutive dates (pre, mid, end of crisis). With regard to the overall sample, we account for the bank percentage in terms of number (%B) and assets (%A). Each row consists of a different regulatory target. Numbers in brackets are for use in the last rows as combinations of the previous single standards where ‖ denotes the logical OR and & is the logical AND. The last row is for banks which passed all standards (with a 4% LR). In that case, the following identity can be applied: Prob[Pass] = 1 - Prob[(1)‖(2)‖(4)].

	Pre-crisis (2007Q2)			Mid-crisis (2008Q2)			End-crisis (2009Q2)		
Standard	%B	%A	%Bkrpt	%B	%A	%Bkrpt	%B	%A	%Bkrpt
Tier1-CR(1)	0.02	0.00	100.00	0.10	0.25	88.89	0.49	0.37	30.23
Total-CR(2)	0.10	0.12	55.56	0.25	0.11	63.64	0.94	0.37	12.20
3%-LR(3)	0.03	0.02	100.00	0.09	0.01	62.50	0.47	0.31	31.71
4%-LR(4)	0.07	0.05	66.67	0.15	0.25	46.92	0.89	0.45	27.27
5%-LR(5)	0.14	0.15	69.23	0.39	0.34	42.86	1.42	0.85	17.89
(1)‖(2)‖(4)	0.14	0.15	61.54	0.37	0.35	66.67	1.45	0.74	18.25
(1)&(2)&(4)	0.02	0.00	100.00	0.10	0.25	88.89	0.49	0.37	30.23
Pass	99.86	99.85	7.02	99.63	99.65	3.38	98.55	99.26	0.49

[14] Though the author uses a different definition for the binding capital requirement based on surpluses rather than the actual number of banks that achieved the given target.

iii Assessing the Basel III Changes from the Perspective of Capital Shortfall

When quantifying the magnitude of failing a specific standard one must relate it to surpluses, or alternatively shortfalls[15]. As a matter of fact, Brinkmann and Horvitz (1995) emphasize that regulators should not only look at how many banks are likely to fail a newly introduced standard but also by how much their (excess) capital cushion would vary. Hence, one motivation for performing the following study is to assess the adequacy of the new Basel III standards.

Focusing on shortfall is arguably a better choice then surplus. Firstly because, as was evoked earlier, the fact that banks were overly capitalized prior to the crunch did not fare well for some of them during the crunch. In other words, while size does matter for the regulators, it does not reflect quality of capital. This means that surplus could be a biased signal for the health of the banking sector. Secondly, shortfall is more amenable to the idea of setting minimum capital requirements. Hence, in the same spirit as Hancock and Wilcox (1994), we calculate the average shortfall as the difference between the target ratio and the actual ratio of banks which failed to meet any of the CRs. This turned out to be equal to 1.5% for Tier 1 and 1.4% for Total Capital[16] (conditional on having met Tier 1).

The Tier 1 shortfall is actually in line with the current steps taken by the Basel III Committee to increase the Tier 1 requirement by 2%. While the Total CR is set to remain at the existing 8% target level, this ratio is being supplemented by other capital buffers[17] bringing the overall requirement well above the shortfall of the recent crunch.

Finally, if the Basel III regulators had decided to abide by the median 4% leverage

[15]Regulators classify institutions into four main capital surplus/shortfall categories: Adequately/Under capitalized and Significantly/Critically undercapitalized.

[16]Note that the average shortage also decreased towards the end of the crunch due to the increase in number of failed banks.

[17]This will raise the target to between 10.5% and 15% via the conservation, countercyclical and TBTF systemic buffers.

requirement implemented in the U.S., this could end up short of expectations as our estimates for the second crunch revealed a close to 1% LR shortfall. This could explain why the regulators chose the absolute difference, 3%, as a conservative target for minimum compliance of all banks. Moreover, our finding suggests that the CAMEL ratings system should be revised upward by the same shortfall amount to reflect the median bank's actual leverage position. Note that this is only until the U.S. becomes fully compliant with Basel III as the introduction of the new framework is bound to render the regulators' rating system obsolete.

4 The Change in CR and LR Correlation Patterns

i Pattern Reversals and Economic Fundamentals

Having illustrated one crucial change between the two crunches with respect to the shift in binding capital constraint from CR to LR, we now move on to another differentiating aspect. To find out if there is any pattern in the co-movements of banks' LR and CR we plot the correlation between both ratios over each crunch period in Figures 2 and 3.

Various authors have measured this correlation over specific periods without mentioning if the obtained pattern is likely to be persistent over time. For instance, Estrella et al. (2000) perform their calculations for the first crunch only. Their yearly values coincide to a large extent with the ones we obtain for the first quarter of each year in Figure 2. To our knowledge, they are the first to have observed an imperfect correlation between the two capital measures which hints to the fact that each ratio can provide independent information on capital adequacy for a given bank.

As such, the keypoint of our analysis is with regard to changes in the correlation patterns for each of the crises. Excluding the reversals in the first and last quarters of each period, during the first crunch (Figure 2), the trend would seem to be monotonously decreasing with an apparent fall in 1990Q1. In contrast, the second trend appears to be

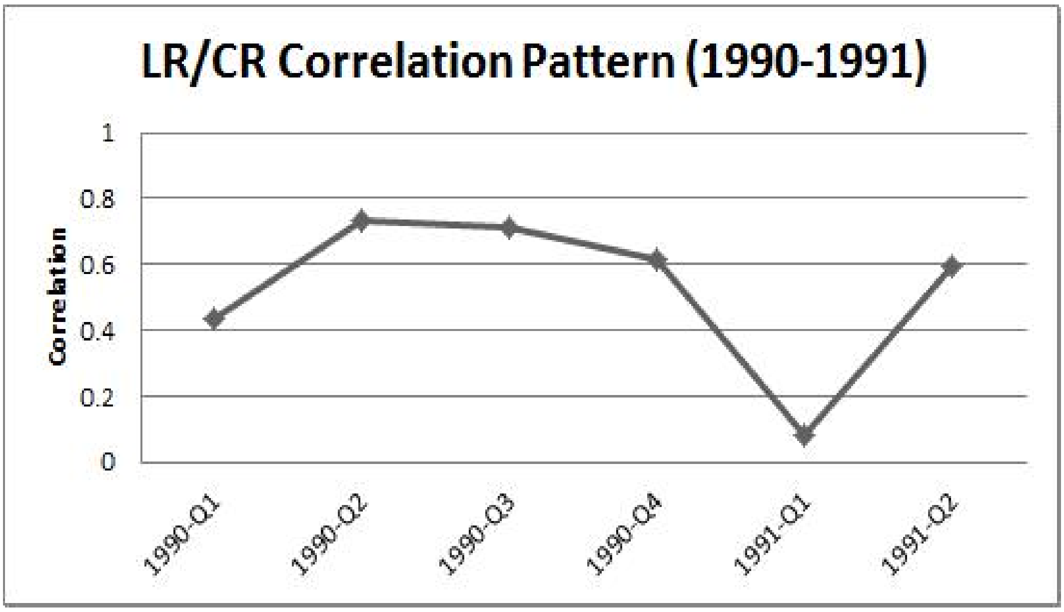

Figure 2: Correlation Pattern between LR and CR during the 1990-1991 crunch

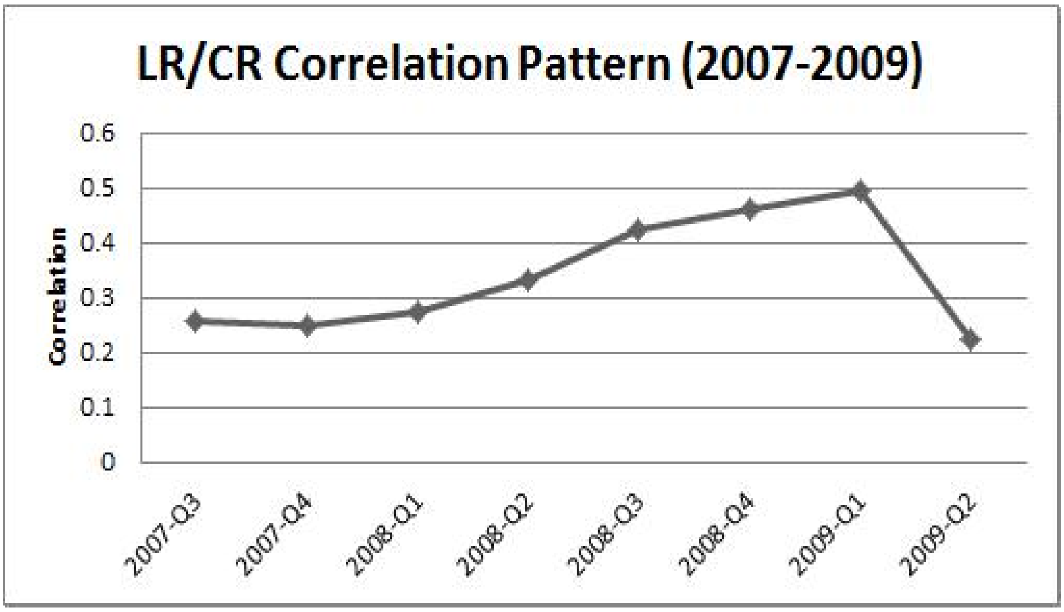

Figure 3: Correlation Pattern between LR and CR during the 2007-2009 crunch

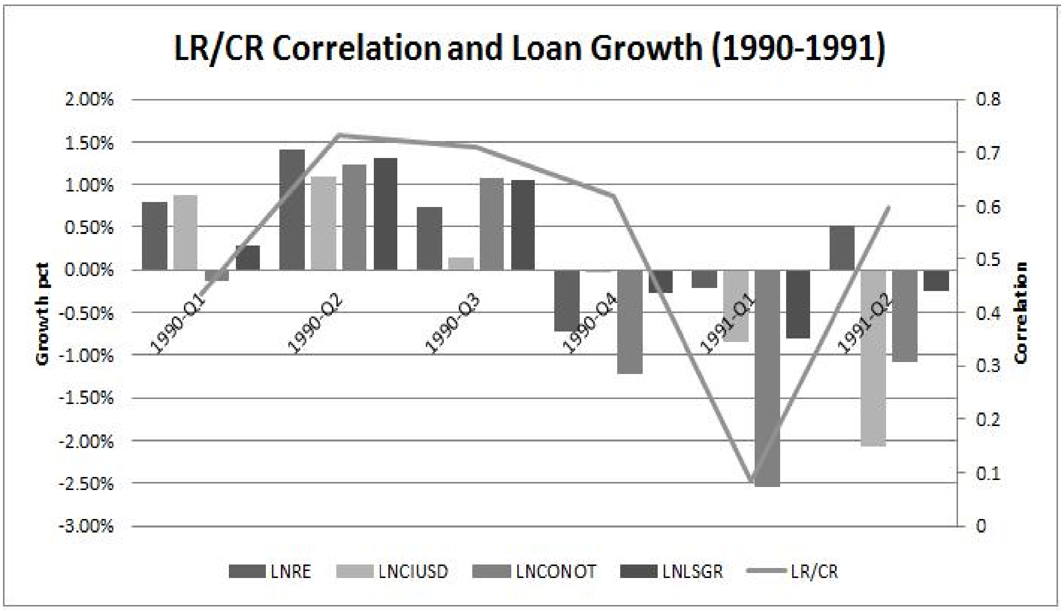

Figure 4: Relation between LR/CR Correlation Pattern (ρ) and Loan Growth for different loan categories during the 1990-1991 crunch

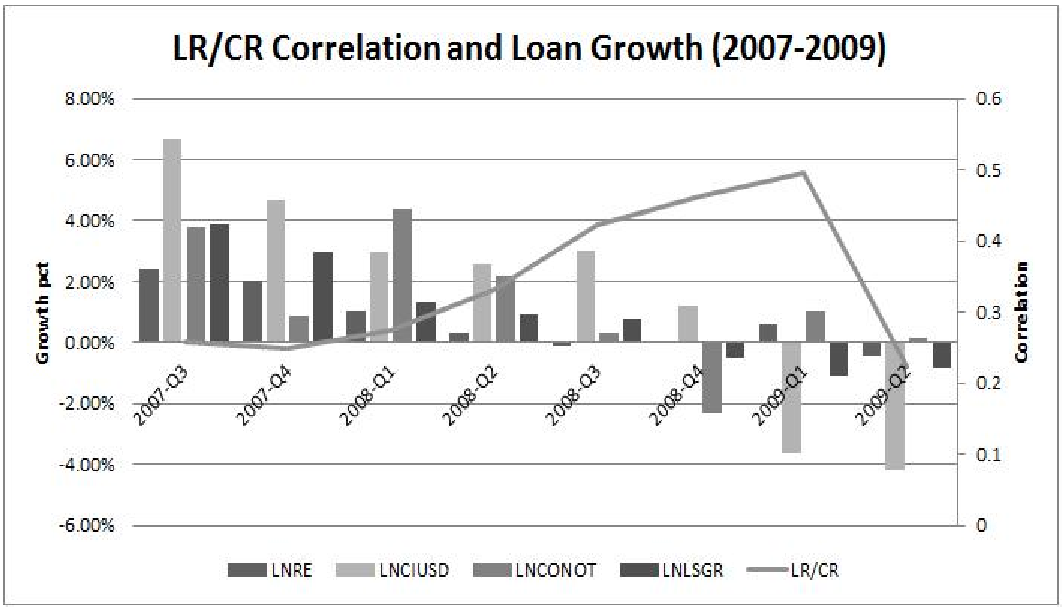

Figure 5: Relation between LR/CR Correlation Pattern (ρ) and Loan Growth for different loan categories during the 2007-2009 crunch

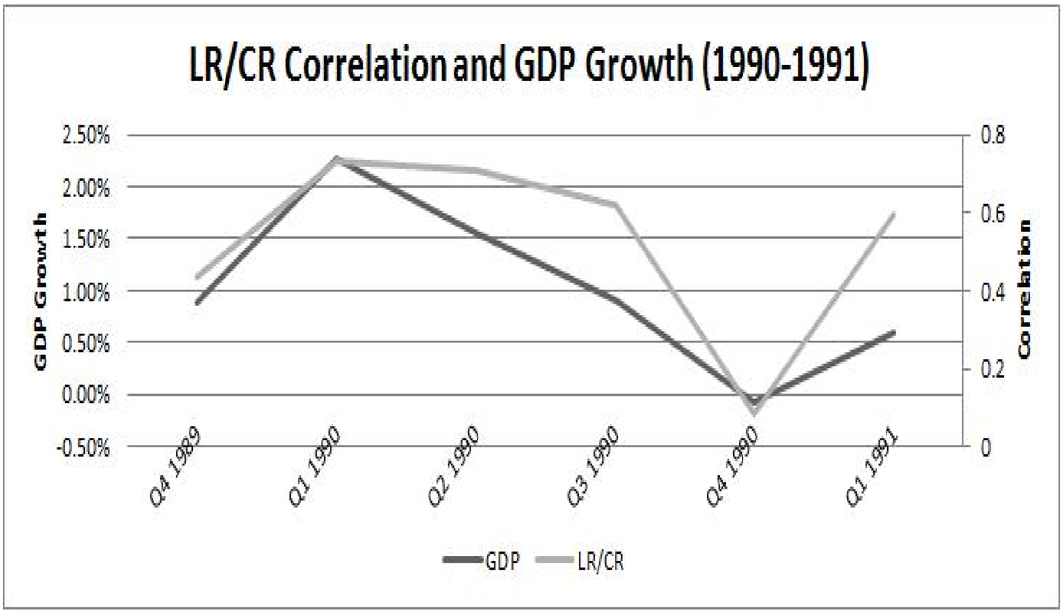

Figure 6: Relation between LR/CR Correlation Pattern and GDP for different loan categories during the 1990-1991 crunch

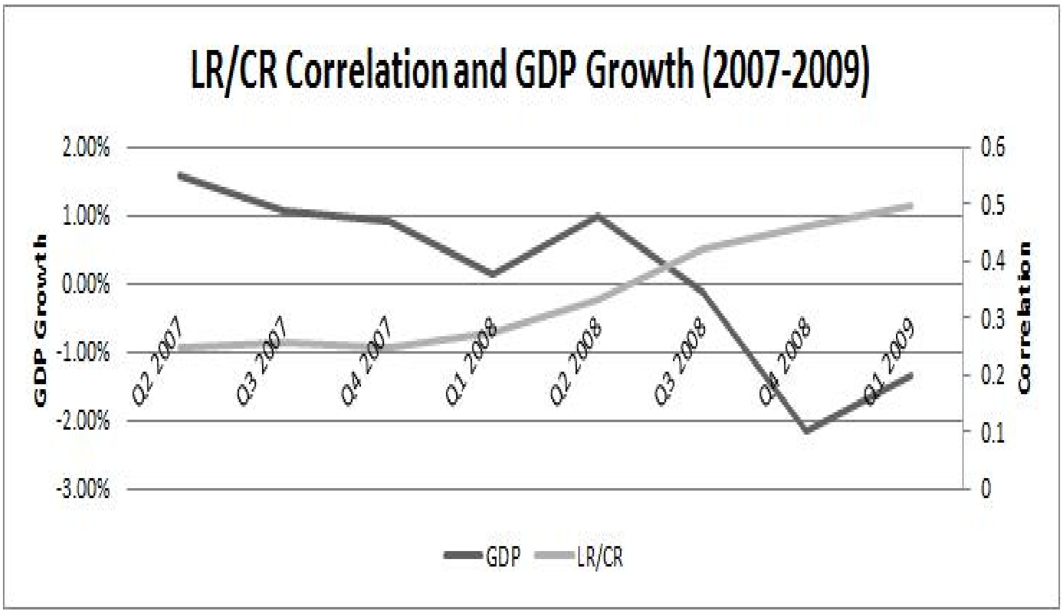

Figure 7: Relation between LR/CR Correlation Pattern and GDP for different loan categories during the 2007-2009 crunch

monotonously increasing with no noticeable changes (Figure 3). Note that the presence of a fall during the first period is hinted to by the size of the fluctuations whereby during the first (and shorter) crunch, the difference in correlation between peak and trough is double that in the second.

In addition, it seems as though each crunch period's correlation pattern between LR and CR, (hereafter referred to as ρ), is itself correlated with various economic fundamentals, starting with loan growth. As in Berger and Udell (1994) and Shrieves and Dahl (1995), we categorize lending growth into three major groups: real estate (LNRE), commercial and industrial (LNCIUSD) and consumer (LNCONOTH) loans. We also include the aggregate (LNSGR) which accounts for the loan categories we just stated as well as other types of loans. As is apparent during the first crunch, the correlation between ρ and the overall[18] loan growth pattern is positive (Figure 4). The opposite is true during the second crunch where the two are negatively correlated (Figure 5). This hints to a change in the dynamics between the two ratios and lending during the two crunch periods.

Our next step is to capture the loan category mostly linked to each of the crises by computing the correlation of each category with the LR/CR correlation pattern (ρ), denoted as "Correl". The results for each category are shown in Table 12. Total loans and consumer lending alternate in first place (in absolute value) in each crunch, followed by real-estate and commercial lending. Note as well that the correlation between ρ and the real estate category is relatively closer to that with the overall loan portfolio during the second crunch (-0.49 and -0.61, respectively) compared with that of the first (0.44 and 0.75, respectively). This illustrates the critical role this asset class played during each crunch.

Finally, the reversals witnessed earlier in the correlation patterns can be shown to be

[18] Although one cannot infer from observing these figures which of the loan growth categories is mostly correlated with ρ, the lending contraction is obvious in both figures. We look at the individual categories next.

an artifact of the data which could relate to our choice of the exact start and end dates of each crunch. In order to do so, we introduce a macroeconomic variable, GDP growth, to represent the state of the economy. However, one could argue that in a financial crisis, macro take longer to appear in the economy than at the micro-bank level. For this reason, we use a one-quarter lagged LR/CR pattern (ρ) instead of the concurrent one and plot it alongside GDP in Figures 6 and 7. Again, despite the exceptional GDP improvements in 2008Q2 (before the Lehman crash) and 2009Q1 (before an improvement in lending had been recorded), the correlation patterns between the lagged ρ and GDP match in both the first (Correl = 0.83) and second (Correl = -0.47) crunches. In sum, this highlights the fact that the correlation between CR and LR (ρ) is associated with lending and the economic cycle.

Table 12:
Correlation between ρ and Loan Asset Growth

The results in this table refer to the correlation between various loan asset classes and the observed LR/CR pattern (ρ) for each designated crunch period.

Loan Asset Class	Crunch 1 (1990Q1-1991Q2)	Crunch 2 (2007Q3-2009Q2)
LNRE	0.44	-0.49
LNCIUSD	0.28	-0.32
LNCONOTH	0.80	-0.54
LNSGR	0.75	-0.61

ii Establishing the Line of "Causality": Granger Tests

To determine whether the LR/CR process influences the loan growth pattern or vice versa, we look at the components of the CR. Denoting K as Tier 1 capital, it is apparent from equation (IV.1), that the more the bank invests in assets (A_i) with high risk-weight

$(w_i = 1)$, the more the CR tends towards the LR:

$$\lim_{w_i \to 1} CR = \lim_{w_i \to 1} \frac{K}{\sum_{i=1}^{N} w_i A_i} = \frac{K}{\sum_{i=1}^{N} A_i} = LR \qquad \text{(IV.1)}$$

Hence, as indicated in equation (IV.2), the higher the risk-weights, the more positive correlation ("Correl") between the LR/CR correlation pattern (ρ) and lending growth. This allows us to infer that loan growth is more likely to influence the LR/CR correlation pattern, the higher the level of the risk-weight.

$$\nearrow \frac{\Delta L}{L} \implies CR \to LR \implies \nearrow \rho \implies \nearrow Correl \qquad \text{(IV.2)}$$

We verify the postulates above via Granger causality tests[19].. We run a basic VAR[20] model between loan growth and ρ. The results in Table 13 show the causal effect between the two factors depending on which is chosen as the dependent/independent variable. The sign of "Correl" will effectively be given by the sign of the slope between the two variables[21]. The loan growth category mostly correlated with the LR/CR pattern (ρ) is determined via the Akaiki Criterion. We perform this analysis for each crunch.

We observe that for the first crunch the line of causality goes from the loan growth categories towards ρ. This can be seen through the p-values (and R^2) which are significantly lower (higher) than those of the reverse causal relation which can be interpreted as a rejection of the Granger hypothesis of non-causality. Note that the AIC and β coefficient are the highest in magnitude in the case of the LNRE category due to the impact on mortgage lending. More importantly, the positive sign given by β is a clear indicator of the pattern we observe in Figure 4.

[19]Note that we could have done the same correlation using lagged GDP instead of loan growth. However, the relationship between the ρ and GDP is not that straightforward.

[20]Using only 1 lag to limit the time effect of any variable on the next since they are expected to vary simultaneously. In spite of the small number of observations, the results we obtain are consistent with our reasoning.

[21]This comes from the basic econometric relation $\beta = Correl(x, y) \times \frac{\sigma_y}{\sigma_x}$ where the variances σ_i are positive.

The picture is not as clear during the second crunch as for some loan categories, the causal relation seems to have been reversed. Yet, with regard to mortgage lending (LNRE) which is the best-fit AIC model, the first crunch direction of causality is preserved. More importantly, the β sign becomes negative which points to the opposite correlation pattern we observe in Figure 5. Hence it appears that this transformation in correlation patterns was not random and could therefore have been caused by a differentiating aspect between both crises.

Table 13:
Causal link between Loan Growth and LR/CR Correlation (ρ)

The first two columns in this table refer to the variables in the VAR model. β is the slope coefficient, AIC gives the overall goodness of fit.

Panel A: Crunch 1 (1990Q1-1991Q2)

Dependent	Indepent	β	t-stat	p-val	R^2	AIC
ρ	LNRE	33.86	12.93	0.000	0.97	-9.56
LNRE	ρ	-0.02	-1.81	0.070	0.47	-9.56
ρ	LNCIUSD	29.49	12.87	0.000	0.82	-9.16
LNCIUSD	ρ	-0.00	-0.13	0.094	0.42	-9.16
ρ	LNCONOT	31.45	19.08	0.000	0.99	-9.20
LNCONOT	ρ	-0.08	-2.55	0.011	0.66	-9.20
ρ	LNSGR	31.54	11.27	0.000	0.97	-9.53
LNSGR	ρ	-0.03	-1.65	0.098	0.50	-9.53

Panel B: Crunch 2 (2007Q3-2009Q2)

Dependent	Independent	β	t-stat	p-val	R^2	AIC
ρ	LNRE	-12.84	-4.13	0.000	0.74	-10.40
LNRE	ρ	-0.00	-0.13	0.893	0.70	-10.40
ρ	LNCIUSD	3.16	2.12	0.034	0.47	-6.62
LNCIUSD	ρ	-0.30	-3.64	0.000	0.84	-6.62
ρ	LNCONOT	-2.74	-1.35	0.176	0.33	-7.05
LNCONOT	ρ	-0.207	-3.01	0.003	0.56	-7.05
ρ	LNLSGR	-2.25	-0.48	0.634	0.20	-7.74
LNSGR	ρ	-0.05	-0.80	0.422	0.81	-7.74

5 Explaining the Changes using the CR sensitivity to Risk-Weights

In order to explain the correlation reversals we highlighted in the previous section, we assess whether the two ratios LR and CR have any influence on each other. Furfine (2000) claims that the same magnitude change in either ratios can lead to drastically opposite effects in terms of portfolio risk. Similarly, Gilbert (2006) states that changing the risk-weights in the CR would impact the number of banks bound by the LR despite the fact that the latter is insensitive to risk-weights by definition. More specifically, using the exact scenario that occurred prior to the subprime crunch, in other words a reduction in the risk-weight attributed to first-lien residential mortgages[22], the author shows that a risk-weight lowering lead to an increase in the number of banks bound by the LR. This is a clear illustration of how the interaction between the two ratios can lead to a change in the binding constraint. In what follows, we undertake a mathematical approach in order to explain the LR/CR correlation pattern reversals.

i Deriving the relationship between CR and LR

The ratio of Risk-Weighted Assets (RWA) to Total Unweighted Assets (TA) in equation (IV.3) is commonly used as a measure of risk as it is bound between 0 and 1 in increasing order of credit risk. This is because RWA tends towards TA as the proportion of risky assets (high risk-weight) increases (see Equation (IV.1)). Note that this tendency drives the CR toward the LR, which explains how the two ratios can move together. Based on that, what is not noted in most of the recent literature which uses this credit risk proxy (Van-Roy (2005), Hassan and Hussain (2006), Berger and Bouwman (2013)) is that it

[22] Although the author's specification changes the original value of 50% to half its value, rather than the one chosen by Basel of 35%.

is equivalent to an interaction between the CR and LR, irrespective of capital K[23], as shown in equation (IV.3). This will be useful in deriving the formulae presented next.

$$\frac{RWA}{TA} = \frac{\frac{K}{CR}}{\frac{K}{LR}} = \frac{LR}{CR} \tag{IV.3}$$

In the next step, the change in CR is derived with respect to a change in risk-weight, w_i, affecting a certain asset category i out of a pool of N categories[24]. As can be seen from Equation (IV.5), this change is negatively related to the product of the CR and a second term which is dubbed "asset proportion" (AP_i). This term refers to the "proportion" (in currency amount) held by the asset whose risk-weight is being changed vis-a-vis the total amount of risk-weighted assets.

$$\begin{aligned}
\frac{\delta CR}{\delta w_i} &= \frac{\delta}{\delta w_i}\left(\frac{K}{\sum_{j=1}^{N} w_j A_j}\right) = K \times \frac{\delta}{\delta w_i}\left(\frac{1}{\sum_{j=1}^{N} w_j A_j}\right) \\
&= -K \times \left(\frac{A_i}{(\sum_{j=1}^{N} w_j A_j)^2}\right) = -\frac{K}{\sum_{j=1}^{N} A_j} \times \frac{\sum_{j=1}^{N} A_j}{\sum_{j=1}^{N} w_j A_j} \times \frac{A_i}{\sum_{j=1}^{N} w_j A_j} \\
&= -LR \times \frac{1}{\frac{RWA}{TA}} \times \frac{A_i}{RWA} && \text{(IV.4)} \\
&= -LR \times \frac{1}{\frac{LR}{CR}} \times AP_i = -CR \times AP_i && \text{(IV.5)}
\end{aligned}$$

The formula has intuitive appeal as the product of terms is always positive and hence the change in CR resulting from a positive change in w_i is always negative since an increase in risk-weight means more risky assets which implies a negative (positive) shock to the CR numerator (denominator) resulting in an overall decrease. Hence, in anticipation of such an artificial increase, regulators should not have maintained the same CRs after lowering the risk-weight on residential real-estate loans under Basel II. Instead, they should have increased the CR targets even further to maintain adequate

[23]Kamada and Nasu (2000) are the closest to reach this result as they use Total capital in the definition of the CR versus Tier 1 capital for the LR. This leads to a different but related concept: the asset quality index.

[24]Prior to Basel II, N=4 for i∈[0, 20, 50, 100].

capital buffers. While some might argue that this strategy could have exacerbated the crunch by increasing the contraction in lending, it might have proven worthwhile in weathering it by having forced banks to hold higher loss-absorption layers. Arguably, this has been taken into consideration under Basel III in the setting of the new CRs.

Note that the breakdown of the CR sensitivity into multiple product variables is in the same spirit as Van-Roy (2005) and Hassan and Hussain (2006)[25]. One interesting feature which is apparent from equation (IV.4) is that the sensitivity of the CR to a change in risk-weight is higher in absolute terms the higher the LR, the safer the bank in terms of credit risk (low RWA/TA), and the larger the affected asset proportion (AP_i). Hence, equation (IV.4) provides the mathematical framework to highlight the importance of the credit risk ratio and asset proportion in dampening or intensifying the sensitivity of the CR. The reason why the safest banks are the most sensitive to changes in CR can be understood in the context of an extreme scenario where the risk-weights are at zero. In that case, the CR is immune to changes in any amount of assets. However, any deviation in risk-weight away from zero is likely to perturb it significantly.

So far, our derivations highlight the dependence of the CR on the LR, affected by a negative sign for the case of a change with respect to a single risk-weight category, w_i. It is easy to show that the relationship between the CR and LR can be extended to all N categories which yields the following formulae in equations (IV.6) and (IV.7). We notice that most terms were adapted from the previous single risk-weight case, with the last factor being the product of asset proportions. Our focus, however, is on the preceding negative sign, which now changes to a sinusoidal pattern of positive/negative signs depending on the number of risk-weight categories. This captures, along with the

[25]However, the authors' derivations are with respect to CR itself, i.e. CR growth rather than with respect to a change in risk-weight.

factorial term[26], the interactions between different changes in risk-weights.

$$\frac{\delta CR}{\delta w_1 ... \delta w_N} = (-1)^N \times N! \times LR \times \frac{1}{\frac{RWA}{TA}} \times \prod_{i=1}^{N} AP_i \tag{IV.6}$$

$$= (-1)^N \times N! \times CR \times \prod_{i=1}^{N} AP_i \tag{IV.7}$$

Note that while the correlation between LR and CR (ρ) is always positive, the sensitivity of the CR, as captured by its derivative(s), could change which explains the variations in slope found in Figures 2 and 3. In sum, our finding depends on the total number and sign (positive/negative) of all possible changes affecting the risk-weight categories. We note as well that the behavior of the function in the CR sensitivity equations is undetermined as N tends to infinity. However, this is not an issue for a few number of risk-weight categories as is normally the case. Hence, short of adopting a continuous method, our method will prove helpful if regulators decide to improve the granularity of the risk-weight scheme.

To make sens of the previous formulae, we conjecture that the introduction of the risk-weight categories under Basel I took N from one to four, this triggers a change in the sign of the sensitivity of the CR. As such, the average risk-weight would have fallen from one to an arbitrary $\bar{W}$. This makes the change in w_i negative, resulting in a fall in CR for a positive change in LR. Thus the two ratios would vary in opposite ways, bringing down the correlation between them. This explains the sharp fall witnessed in Figure 2. In contrast, the four new risk-weights introduced under Basel II[27] which would have taken N to eight would not have altered the sign on the sensitivity of the CR even if they had been fully implemented. This clears the Basel framework from any responsibilty with respect to the crisis. We validate these statments empirically in the following section.

[26] This term arises from the successive derivations with respect to the risk-weights.

[27] Those were 35%, 75%, 150% and 300%.

ii Model Verification and Policy Implications

a The CR 3-Factor Model

In this section, we set out to test whether the 3-factor relation in equation (IV.4) can empirically explain the sensitivity of the CR to a change in a single risk-weight. Using the derivative decomposition rule we can write:

$$\frac{\delta CR}{\delta w_i} = \frac{\delta CR}{\delta t} \times \frac{\delta t}{\delta w_i} \Rightarrow \frac{\delta CR}{\delta t} = -\frac{\delta w_i}{\delta t} \times LR \times \frac{1}{\frac{RWA}{TA}} \times \frac{A_i}{RWA} \tag{IV.8}$$

To disentangle the effect of each factor in the equation we take logarithms at both ends. This translates into the following empirical model where the intercept α should equal the logarithm of the change in risk-weight which is constant for all banks in a given period:

$$ln\,(\Delta CR)_j = \alpha + \beta_1 ln(LR)_j + \beta_2 ln(InvCrRatio)_j + \beta_3 ln(AP)_j + \epsilon_j \tag{IV.9}$$

Using Newey-White robust estimators, we verify the findings of this model by comparing the cross-sectional estimates from the two periods in Table 10 which differ by the timing of one crucial event. The 1990Q1-1992Q2 period was marked by the phasing-in of Basel I with the shifting of the risk-weight on residential real estate mortgages from 100% to 50%. However, although the Basel II change from 50% down to 35% began to be factored in by U.S. banks between 2004Q3-2009Q2, the actual deadline for enforcing it would come later on[28]. For our empirical setup to function properly, any change in risk-weight would have to occur on a specific date and enforced by all banks simultaneously. If this assumption is verified, the first crunch should exhibit a noticeable difference at phase-in date compared to the second.

[28]The worldwide full implementation of Basel II was scheduled for 2011 (Berger et al. (1995)) which came a year after Basel III was endorsed.

Running the model at various sample percentiles as per Table 10 shows remarkably no difference for any periods. We therefore suffice with the results from the 90th percentile which are displayed in Figures 8 and 9 below[29]. These figures show the ability of the theoretical model to explain on average around 12% of the changes in CR. This suggests that in practice these changes are also governed by other exogenous factors or frictions which can arise from the fact that the LR and CR do not move in total freedom due to the constraint imposed by regulators on minimum thresholds.

Moreover, both crises show persistent coefficients for the inverse of the credit ratio while asset proportion barely has any effect in both periods. Despite the fact that both variables are a function of RWA, we base our finding on the fact that this component might have been factored in only by the credit ratio as a well-known determinant of the CR, while the importance of asset proportion, highlighted by equation (IV.4), was so far not recognized.

Nevertheless, the crucial finding is how the coefficient on LR ($\beta 1$), Alpha_UC (α) and R^2 rise in the same way at exactly the point in time where the regulation was phased-in during the first period: after the end of 1990 (or beginning 1991) according to Woo (2003). While this pattern almost perfectly matches with the reverse correlation pattern in Figure 2, there is no such perceivable change for the second crunch as seen from Figure 3. We also note that, during the first period, the $\beta 1$ coefficient adjusts to around its expected value of 1 at the phase-in point.

Empirically, we observe a (1%) significant value of 4.3 for the unconstrained α (Alpha_UC) in 1991Q1 which is almost twice as high as the ones obtained throughout the corresponding period. However, despite also being significant, our value of 4.6 changes relatively little during the second period and does not exhibit the same noticeable change as in the first period. This refutes our assumption in that banks either did not change their risk-weight or rather did so continuously or not at all over the second period. Our

[29] Note that since the regulatory variables were introduced in 1990Q1 and we are looking at changes in capital ratios, this implies that we would lose one observation in this designated period.

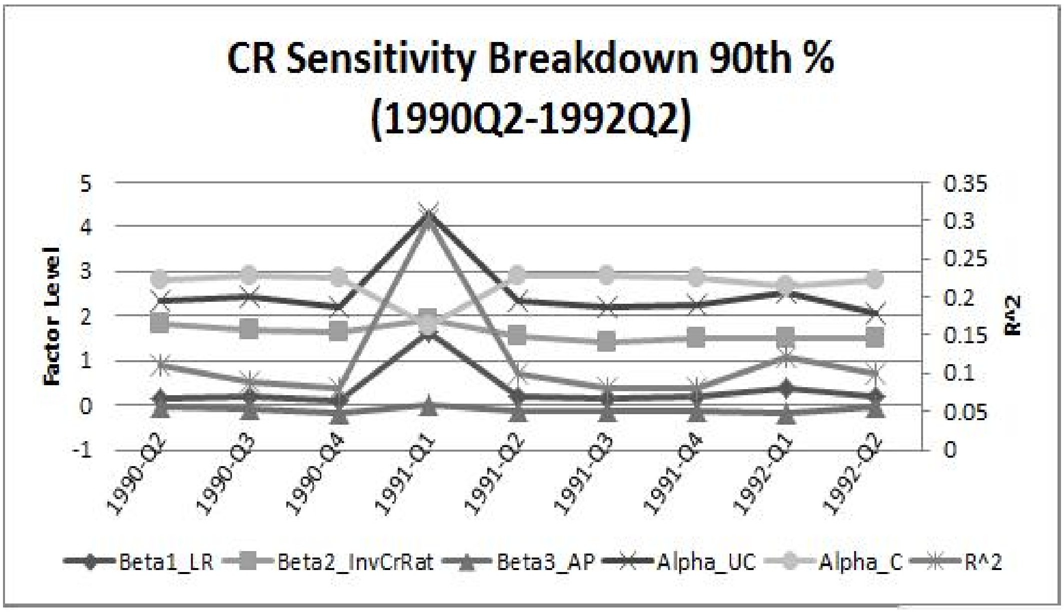

Figure 8: Three Factor Model for the CR sensitivity to a change in Risk-Weight during 1990Q2-1992Q2

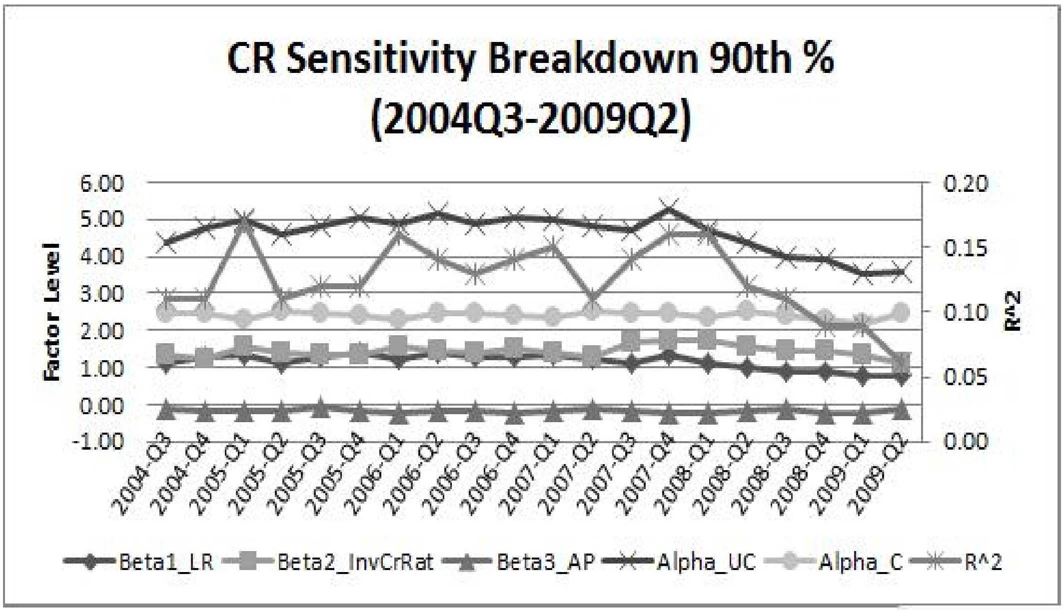

Figure 9: Three Factor Model for the CR sensitivity to a change in Risk-Weight during 2004Q3-2009Q2

model derivation in equation (IV.9) implies that we should detect an α of 3.9 (2.7) for the first (second) period[30]. However, these values did not prevail owing to the fact that our formula is not enforced by the banking industry. Nonetheless, this comparison between both periods confirms that banks ratios still account for instantaneous changes in risk-weight which our model is sensitive to.

Note that our empirical findings are only valid for changes in a single risk-weight which could not always be the case. Our results could have therefore been affected by disturbances from unaccounted changes. Hence, we force the theoretical constraint that all coefficients be equal to 1 in equation (IV.9). On one hand, the constrained α (Alpha_C) in the first period still undergoes a perceivable change in 1991Q1, falling to around 1.8. This indicates that our constrained model remains sensitive to the single change in risk-weight. On the other hand, while the constrained α in the second period is almost the same as its expected value at around 2.4, the fact that it remains almost constant over time suggests again that banks did not undertake a specified change in risk-weight during this period.

b Linking the CR to the LR: Policy Implications

In this section, we derive a framework for explicitely setting the CR with respect to the LR. Our starting point is equation (IV.7) which is a simple homogeneous partial differential equation (PDE) that can be solved in closed form. The derivations are stated in Appendix C. In the case of a single risk-weight change, the relationship becomes:

$$CR = LR \times e^{\sum_i^N [AP_i(1-w_i)]} \tag{IV.10}$$

As the exponential power term is always positive, the CR should always be greater than the LR. Indeed, the formula implies that banks should at least meet a lower thresh-

[30] These values are equivalent to ln(-(50-100)/1) and ln(-(35 - 50)/1).

old of CR at least equal to LR; afterwards, they should increment their respective risk-based capital positions by a weighted average of their asset proportions as captured by the exponential term in equation (IV.10). For example, with a 3% LR, the old Tier 1 CR of 4% is reasonable but for the less conservative LR of 5% it is not. Indeed, such distortions to the above identity could induce wrongful behavior on the part of banks as was reported earlier in Gilbert (2006). Hence, as the CR is set to increase to 6% under Basel III, this is in line with both LR targets of 3-5%, assuming appropriate asset proportions.

In the following, we test to what extent equation (IV.10) holds empirically using the following panel regression. Our results are shown in Table 14.

$$ln\left(\frac{CR}{LR}\right)_{jt} = \alpha + \beta\sum_{i}^{N}[AP_i(1-w_i)]_{jt} + \epsilon_{jt} \tag{IV.11}$$

We report that across the two sample periods all estimates are significant at the 1% level. As can be seen from panels A and B, at the 90th percentile, the R^2 increases to 93% (74%) for the first (second) periods. The relationship then weakens the smaller our sample becomes as this makes it more specific to a particular type of banks. This confirms that the above relationship holds for the banking sector taken as a whole. Moreover, we notice that the α converges to 0 (1 in anti-logarithmic terms) as suggested by our theoretical model. This confirms the lower threshold of CR being at least equal to LR[31] before any increments linked to asset proportions take effect.

Furthermore, we run a Chow test on the second period to verify that the coefficients are stable between pre-crisis and crisis periods with the delimiter date set to 2007Q3[32]. The results shown in Panel C illustrate that in most cases, the hypothesis of stability cannot be rejected which means that our model is valid independently of the period

[31] This can be seen by taking the Taylor series approximation for small numbers. For example, using the 50th percentile in Panel A: $\exp(0.086) \approx 1+0.086 = 1.086 \approx 1$.

[32] Choosing a different date such as 2006Q3 in relation to the Basel II implementation does not change our results.

under consideration[33]. Nevertheless, even at its peak of 0.4, the value of β is noticeably below 1. In other words, a good proportion of banks are operating below the theoretical CR requirement. This leaves policy-makers with the task of driving them upwards to ensure the compatibility between the two ratios is maintained.

Note that according to equation (IV.3), CR/LR is equivalent to TA/RWA; hence our results should hold whether we use either ratio as the LHS variable in equation (IV.11). Indeed, we rerun our robustness test version of our model in Table 15 and find that we reproduce to a large extent the results in Table 14.

Finally, our results showed that the Basel III guidelines with respect to CR increments are in line with the theoretical implications of our model. They also highlight that there is room to improve on the choice of capital targets by making them more adequate using a dataset of representative banks to calibrate a generalized model for the banking sector. Alternatively, this could create the possibility for having endogenous bank-specific requirements rather than a one-size fits-all guideline; a change called for by some critics since the birth of the Basel regulation. Notably, this would help European regulators especially in the context of establishing homogeneous capital requirements for all EU countries (see Chapter 5).

Table 14:
Testing the CR formula stability (CR/LR)

The results in this table are obtained after running the original version of the regression model in Equation IV.11: $ln\left(\frac{CR}{LR}\right)_{jt} = \alpha + \beta \sum_i^N [AP_i(1-w_i)]_{jt} + \epsilon_{jt}$. Pct denotes the percentage remaining from the original sample after removal of outliers. Chow tests are based on the delimitor date 2007Q3.

Panel A: 1990Q1-1992Q2

Pct	100%	99.9%	99%	95%	90%	80%	70%	60%	50%
α	0.445	0.445	0.195	0.136	0.119	0.109	0.100	0.095	0.086
β	0.108	0.108	0.420	0.497	0.521	0.533	0.543	0.547	0.557
R^2	0.458	0.458	0.898	0.924	0.928	0.917	0.906	0.893	0.885

[33] At the 90th percentile where the hypothesis is rejected, the coefficients are still equal up to one decimal place.

Panel B: 2004Q3-2009Q2

Sample	100%	99.9%	99%	95%	90%	80%	70%	60%	50%
α	0.368	0.376	0.371	0.345	0.131	0.116	0.115	0.116	0.107
β	0.038	0.037	0.035	0.056	0.438	0.452	0.437	0.411	0.411
R^2	0.175	0.111	0.075	0.370	0.742	0.674	0.600	0.509	0.546

Panel C: Chow Tests

Sample	100%	99.9%	99%	95%	90%	80%	70%	60%	50%
$\beta 1$	0.038	0.038	0.036	0.056	0.439	0.454	0.441	0.416	0.418
$\beta 2$	0.040	0.043	0.040	0.051	0.424	0.438	0.423	0.399	0.398
p-val	0.585	0.002	0.005	0.151	0.000	0.001	0.002	0.003	0.003
$\chi 2$	0.3	9.19	7.8	2.06	12.7	10.3	9.59	8.4	8.48

Table 15:
Testing the CR formula stability (TA/RWA)

The results in this table are obtained after running a parallel version of the regression model in Equation IV.11: $ln\left(\frac{TA}{RWA}\right)_{jt} = \alpha + \beta \sum_i^N [AP_i(1-w_i)]_{jt} + \epsilon_{jt}$. Pct denotes the percentage remaining from the original sample after removal of outliers. Chow tests are based on the delimitor date 2007Q3.

Panel A: 1990Q1-1992Q2

Pct	100%	99.9%	99%	95%	90%	80%	70%	60%	50%
α	0.442	0.442	0.192	0.133	0.116	0.106	0.097	0.092	0.083
β	0.105	0.105	0.416	0.494	0.517	0.529	0.538	0.542	0.553
R^2	0.457	0.457	0.897	0.924	0.928	0.917	0.906	0.894	0.8866

Panel B: 2004Q3-2009Q2

Sample	100%	99.9%	99%	95%	90%	80%	70%	60%	50%
α	0.367	0.374	0.351	0.343	0.129	0.114	0.113	0.115	0.105
β	0.038	0.037	0.059	0.056	0.437	0.451	0.436	0.411	0.412
R^2	0.177	0.111	0.421	0.371	0.743	0.674	0.601	0.510	0.547

Panel C: Chow Tests

Sample	100%	99.9%	99%	95%	90%	80%	70%	60%	50%
$\beta 1$	0.038	0.038	0.060	0.056	0.438	0.454	0.440	0.416	0.418
$\beta 2$	0.040	0.043	0.053	0.051	0.424	0.437	0.423	0.399	0.398
p-val	0.694	0.002	0.059	0.171	0.000	0.001	0.001	0.003	0.003
χ^2	0.15	9.14	3.56	1.87	12.48	10.34	9.75	8.69	8.83

6 Conclusion

In this paper, we investigate the impact a change in risk-weight can have on the behavior of banks towards adjusting their CRs and LRs. We first assess which of these latter two ratios was the binding constraint on banks prior to the 1990-1991 and 2007-2009 credit crunches. Our results indicate that unlike the first crunch, the LR was more to blame for triggering the subprime crisis. Our work complements the analysis of Avery and Berger (1991) and reveals the impact of crises on bank capital cushions, and vice versa. More specifically, we illustrate the erosion in capital ratios caused by the subprime crisis while establishing the beneficial impact of capital on survival rates.

Furthermore, we study the changes in correlation patterns between the two ratios with respect to the changes in binding constraint. The correlation patterns are seemingly related to loan growth (microeconomic) and GDP (macroeconomic with appropriate lag) market signals. We show that this reversal has its roots set in a mathematical relation emerging from the sensitivity of the CR to a change in its risk-weight(s). While the correlation patterns may have changed during different the crises, we show that the impact on the binding constraints could not have been caused by changes in risk-weights attributed to Basel II.

Finally, we provide a formula that relates the sensitivity of the CR to the LR, the inverse of the credit risk ratio, and a new factor conveniently dubbed "asset proportion". As the formula was not applicable as part of the Basel framework, its empirical testing reveals limited explanatory power and explains the multiplicity of other factors provided by the literature to study the behavior of capital ratios. While we welcome these additions, we emphasize that any model which does not account for the factors in our formula would inherently suffer from omitted variable bias. Note that an extension of our formula gives way to a first-order homogeneous partial differential equation (PDE) governing the behavior of the CR. We solve for single and multiple changes in risk-weights which fit into a generic closed form solution. This allows for setting adequate CRs which reflect changes in risk-weights while taking into consideration its counterpart capital measure, the LR. In fact, this can be done in a straightforward and rigorous manner with not much added complexity compared to enforcing arbitrary Basel ratios. Hence, this allows us to move away form the use of heuristics with regard to capital target selection.

In sum, the results of our research are helpful in assessing the improvements brought by the new Basel III regulation with respect to capital requirements. Considering the ongoing efforts of improving the granularity of the risk-weight scheme by introducing new risk-weight buckets, our framework will facilitate the setting of adequate CRs. Hence, doing so in a mechanical rather than heuristic way could eliminate the Basel capital ratio puzzle related to the diverse impact of regulatory capital on banks.

Chapter V:

European Bank Returns, Spillovers and Contagion: An Empirical Investigation

1 Introduction

Finance and economic researchers base their understanding of the interaction between countries on a scientific concept from the field of communications. In that respect, a financial shock acting as a signal is assumed to cross international borders using as its "media" the "linkages" between countries while being "amplified/reduced" by country-specific factors at the "sending/receiving" end. In this setting, the recipient country has almost no control over the initial shock, hence it can only regulate the strength of the transmission and the tuning at the receiving end.

The importance of understanding the forces that govern this interaction can be seen in the following two examples. When the United States (US) was hit by the subprime crisis in 2007, the Euro-Area (EA) suffered the aftermath. Similarly, the EA sovereign crisis that followed in late 2009[1] delayed the US recovery. In fact, the turmoil in the EA brought back into question the purpose of a unified Europe[2] as it revealed the downside of having safer countries put at risk from their riskier neighbors.

As these examples illustrate, the study of how one economy is affected by another

[1] According to Claessens et al. (2011), the euro crisis began on October 16, 2009, with the words of Greek prime minister "We have large hidden debts and spending".

[2] The birth of the Euro in 1999 was based on a series of economic treaties that brought the member countries within closer dependency of each other (single currency, free movement of population, removal of trade barriers).

is more than a matter of exchange rate fluctuations; especially in the case of the EA where the issue does not arise. Krugman (2008) first developed the concept of an "international finance multiplier" to help understand interconnections (linkages) between financial markets. Combined with financial vulnerabilities, this concept was later formalized in general equilibrium by Devereux and Yetman (2010). Many empirical works have lent themselves in one way or another to the same concept. Nonetheless, the empirical testing of related frameworks began much earlier in order to evaluate the cross-border impact on returns as well as the transmission mechanism by which returns are affected. This was based on acquired knowledge from pre-established models such as the CAPM, supplemented with a variety of explanatory variables including bilateral and country-specific factors (Dungey et al. (2004), Bekaert et al. (2005) and Poirson and Schmittman (2012) amongst others). As per Calvo et al. (1993), the latter are also known as push and pull factors, respectively.

In this research we contribute to the existing literature by analyzing the differential role played by these factors in jointly determining bank returns and shock transmission using a 2003-2012 dataset of eight EA countries and the UK. To our knowledge, this is the first paper to do so as Bekaert et al. (2009) conceded that different approaches could lead to different conclusions. This allows us to compare some of the contrasting results found in the literature under a unified framework while distinguishing between two types of shock transmission, spillovers and contagion. The separation we make relates to the role of fundamentals in explaining the first transmission effect as opposed to the residual transmission captured by the second effect. As such, our paper is closest to the work of Baele (2005) who focused on stock market volatility instead of bank returns and Fratzscher (2012) who examined portfolio equity flows on an international rather than European scale.

Whereas there is a restricted set of bilateral push factors to choose from that includes cross-border lending, investment and trade, there is an extensive list available for the set of country-specific pull factors which encompass various risk indicators. We select capitalization as our main country-risk variable and a proxy for credit risk in order to reflect on the impact of the Basel II capital regulation on Europe. Implemented as part of the Capital Adequacy Directive (CAD (2000) and CAD (2006)), this regulation was enforced by all EU member countries including the UK (FSA (2006)) by 2007. The reason the EU signed the agreement faster than other advanced countries, notably the U.S., was because legislators recognized that European banks became experienced at gaming the initial Basel I Accord, according to Shin (2012). Hence, one purpose of our work will be in assessing the Basel II regulation thereby determining the need for the new Basel III regulation.

Over the last two decades, capital has received mixed reviews in terms of how it can affect stock performance (see Chapter 3). While not referring to equity returns in particular, Berger and Bouwman (2013) examined the effects of capital on a different measure of profitability, ROA, for US banks between 1984 and 2009. Their view is that capital has a positive effect depending on the type of crisis and the size of the banks. Note that their study does not account for "Too-Big-To-Fail" banks (TBTF), otherwise known as Systematically Important Financial Institutions (SIFIs), in order not to bias the results towards banks with strong capital bases as highlighted by Chan-Lau et al. (2012a). Another contribution of our work will be to factor those banks into the analysis separately and in conjunction with other banks to gauge any differential impact.

Note that the effect of capital ratios can be dented by other factors which, until Basel III, were not part of the international regulation. One such factor is leverage, which is set by national regulators, and was found to be strongly associated with balance-sheet risk (Adrian and Shin (2010)). Looking jointly at both ratios, Chan-Lau et al. (2012a) find that banks' equity returns are boosted by high equity-to-asset i.e. leverage[3] ratios. This

[3]Leverage is not to be confused with the traditional corporate finance definition of Debt/Equity. In fact both "capital" measures differ mainly in their denominator: the leverage ratio uses Unweighted assets (UWA) whereas the capital ratio uses risk-weighted-assets (RWA) in relation to capital (numerator).

finding agrees with Devereux and Yetman (2010) and could be based on the inability of Basel's risk-based capital ratio to reflect risks adequately. Notably, a zero risk-weight was attributed to some EA countries' domestic government debt during the crisis despite the fact that their sovereign's creditworthiness had deteriorated.

With regards to international shock transmission, the study of cross-country effects of capital ratios goes back as early as Peek and Rosengren (1997) who examine the effects of these ratios for Japanese parent banks and how they influence the lending behavior of their branches in the US. The study showed how capital can act as a channel propagating a shock from parent to subsidiary. More importantly, the purpose behind the Basel regulation was to increase banks' resilience against such shocks, in other words, decrease the banks' sensitivity resulting from international exposure. A small exercise by the ECB (2011) showed that this is indeed the case. While this result is re-asserted in Poirson and Schmittman (2012), the authors are surprised to find occurrences of the opposite effect. This could either be due to their particular setup or their use of leverage instead of risk-based capital requirements as a proxy for the banks' capital level. We revisit this finding in our results.

Whereas similar variations in sample and time have lead previous authors to remain inconclusive regarding their results (Poirson and Weber (2011)), another contribution of our work is to test our findings across a spectrum of samples going from the largest national banks (SIFIs/TBTF) to the entire countries' banking sector. Also, in line with Berger and Bouwman (2013)'s suggestion of assessing the differential role of capital between crisis and normal times, we divide our sample into pre and post 2007. This would point out changes in the effect of capital during these two periods especially for those banks which were understood to be well-capitalised prior to the crisis (Chami and Cosimano (2010)). Note that Poirson and Schmittman (2012) made a similar split but did not account for the possibility that their results could be biased by the synchronous introduction of the new Basel rules with the unfolding of the crisis.

We find a set of consistent results across both time and banking samples. In particular, although Basel capital requirements reflect negatively on EU banking returns, they help prevent shock transmission. Note that while most of the literature focuses on individual banks, in our model, we use aggregate country measures in order to evaluate the broader macro implications of our findings, in agreement with the emphasis on macroprudential policy advocated by Basel III.

The paper is hence structured as follows. In section 2 we present an overview of the literature on shock transmission. In section 3, we introduce our methodology. This is followed by a discussion of our results and robustness tests in sections 4 and 5. We conclude with our contributions, policy recommendations and possible extensions.

2 Shock Transmission: Spillovers or Contagion?

During the EA crisis, country risk indicators, such as Credit Default Swaps (CDS) and bond spreads, displayed unprecedented high levels of co-movement across (peripheral) European countries compared to normal times (IMF (2011)). This suggests that, in times of economic turmoil, country indicators tend to behave similarly, meaning that the potential "spillover" between the countries is high which might lead to further failures (Cheung et al. (2010)).

Essentially, spillovers are transmissions that occur due to the interconnectedness between countries (Dungey et al. (2004)). The transmissions usually relate to returns but can equally apply to volatility (Baele (2005)), growth (Poirson and Weber (2011)) and even fiscal aspects (Ivanova and Weber (2011)). Methods to capture them vary from a standard VAR model as in Diebold and Yilmaz (2009) to more complex SVAR models as in Ehrmann et al. (2004)[4]. While these models are able to integrate many components, they remain overly dependent on the sometimes unverifiable assumptions

[4] For a full list of applied VAR methods refer to Poirson and Weber (2011)

underlying the identification matrix. As a result, GARCH methods have also been used; however, the problem of selecting the model parameters arises and is subject to the choice of sample and information criteria (Dungey and Martin (2007)). Other methods have also been proposed which use the Conditional Probability of Distress (CoPoD) as in Sergoviano (2006).

A more tractable method of studying spillovers involves a two-stage regression, the first stage being a return model that includes at least a global factor (common to all stocks) and country-specific[5] factors belonging to the region, sector and industry. Before running the model, the standard regression constraint on the coefficients being constant is relaxed. This can be done through repeatedly estimating the model at various time periods (rolling window) or through using more elaborate time-varying coefficient models. The coefficients then become the dependent variable of a second-stage model where the explanatory variables are arbitrarily chosen.

For instance, Brooks and DelNegro (2006) use a latent factor model for emerging markets between 1985 and 2002. Their second stage factors include international sales and income ratios. Nonetheless, the more common practice evolves around bilateral linkages, specifically trade and finance, as these are well-known for varying across time and markets (Blanchard et al. (2010)). The first factor relates to how countries channel their excess demand (supply) through imported (exported) goods and are thus potentially affected, ceteris paribus, by changes to these economic forces (Kose and Yi (2006)). As a result, banks are also impacted by lower trade as they deal with most of the guarantees such as letters of credit (Claessens et al. (2011)). The second factor arises because of international capital flows such as lending (Foreign Claims-FC) and investment (Foreign Direct Investment-FDI). Similarly, if one country becomes reluctant to lend, its partner will experience tighter credit conditions resulting in a squeeze on banks and the economy.

With the creation of the Euro, these bilateral linkages were intensified thus creating

[5]The important difference with the country-specific factors mentioned earlier is that these are systematic whereas the previous ones were idiosyncratic.

“by far the biggest export market [and] largest single banking sector exposure” in the world according to Poirson and Weber (2011). However, there is a lack of consensus as to which linkage is more relevant. Clearly, this depends on other variables mainly: the prevailing circumstances, time period, sample and model specifications which greatly differ between authors thus leading them to different conclusions. For instance, Forbes and Chinn (2004) find that between 1986-1995, bilateral linkages are insignificant but from 1996-2000 they do play a role. Moreover, despite growth in international capital flows, they also observe that trade linkages are the most important channel in determining spillovers from the world’s largest economies to the rest of the globe. In contrast, while using the same methodology, Balakrishnan et al. (2009) find that financial linkages prevail during the period 1997-2009. The latter finding agrees with Blanchard et al. (2010) who investigated the post-subprime period, highlighting an intensification of the financial channel over time.

It is common in the literature to mix the spillover effect with contagion[6]. In fact, a survey of almost a dozen definitions of contagion is listed in Forbes (2012)[7]. The most popular are “excess co-movement” above what would be expected from economic fundamentals (Kaminsky et al. (2003), Bekaert et al. (2005) and Fratzscher (2012)). Other approaches include the Dynamic Conditional Correlation (DCC) used by Savva et al. (2009) and Yiu et al. (2010)[8] as well as the residual transmission (Masson (1999)) after accounting for other sources of transmission (Dungey and Martin (2007)). In our study, the choice of the latter definition seems sensible given our dual purpose of analysing spillovers and contagion. In other words, contagion refers to the co-movement after factoring out spillover effects.

[6]Dungey and Martin (2007) see the difference between spillovers and contagion in the timing of the initial impact of the shock. “Spillovers are the transmission at time t or later, of shocks which occurred at time t - 1 [...]. Contagion, however, is the contemporaneous or later transmission of unexpected shocks”.

[7]Some definitions of contagion such as that in Forbes and Rigobon (2002) which relies on unconditional correlation coefficients has lead the authors to reject the existence of contagion in many crises episodes (1987, 1994, 1997). We restrict ourselves to definitions that found some evidence of contagion.

[8]Refer to Dungey et al. (2004) for an exhaustive list of methods.

Determinants of contagion have evolved around Kaminsky et al. (2003)'s "leveraged common lender" effect. However, at the debtor's end, Forbes (2012) finds a clear association between leverage[9] and contagion. Bae et al. (2003), on the other hand, find that exchange rate changes, interest rate levels, and return volatility are good predictors of contagion. These variables are already factored into bilateral linkages such as trade, investment and lending, albeit with a certain lag. This justifies our use of the bilateral factors alongside capital and leverage ratios in order to explain contagion in line with Devereux and Yetman (2010).

3 Methodology

i Data

Our dataset contains nine EU member countries[10]: Austria, Belgium, Germany, France, Greece, Italy, Portugal, Spain and the United Kingdom. In 2012, these countries accounted for around 75% of EU GDP. On the other hand, the world's two largest economic areas, the US and EU (aggregate), each stood at 19% of World GDP; we label them as partners.

As in Ammer and Mei (1996) and Chan-Lau et al. (2012b), we use each country's Morgan Stanley Capital International daily price bank index (BKMSCI) between 2003 and 2012 to compute the simple return level using logarithmic price difference. All prices are taken in local currency to abstract from currency movements as suggested in Savva et al. (2009).

We also keep with the MSCI series when choosing the world and regional stock index for the US and EU series, denoted respectively as MSCI_US and MSCI_EU. This makes

[9] Leverage is defined as "the ratio of private credit by deposit money banks and other financial institutions to bank deposits, including demand, time and saving deposits in nonbanks".

[10] Ireland had to be removed as its country index became obsolete at one point in time according to MSCI. Likewise, the Netherlands data series was discontinued in 2007 and Finland had no Banks Industry Group. Aside from these three countries, the rest cover all countries in the IMF (2011) report and EU-countries in Chan-Lau et al. (2012a).

the data more homogeneous unlike the use of specific country indices (such as S&P) as in Baele (2005) and Dungey and Martin (2007). Note that an alternative would have been to run a PCA on the World stock index. However, the reason we opt for these two indices instead of picking the latter is because we want to compute the bilateral linkages between each individual country and its partners. Choosing the World as a "partner" would not only make the task more difficult and prone to measurement error, but it also prevents us from directly identifying any causal factor related to a specific partner as was the case in Poirson and Schmittman (2012). For these reasons, we selected the US as an identifier of global shocks because of its size (Dungey and Martin (2007) and Devereux and Yetman (2010)) and the EU aggregate as an identifier of regional shocks. In this case, linkages with the US or EU are readily available for each country.

According to Poirson and Schmittman (2012), the fact that the MSCI_US and MSCI_EU indices are the most highly correlated with the World index would suggest that it would be difficult to isolate the individual effect of each partner. This problem was stressed by Forbes and Chinn (2004) and admittedly biased the results in Brooks and DelNegro (2006). To remedy the problem we regress the EU index on the US index in similar fashion to Fratzscher (2012) to create orthogonal indices. The residuals become the new EU index for our study[11]. As can be seen in Table 16 the correlation between the two indices is now almost zero.

Furthermore, in order to measure the influence of bilateral push factors we obtain foreign direct investment (FDI) data from the OECD, (yearly aggregated) bank foreign claims (FC) from the BIS consolidated banking statistics and imports (IMP) from the IMF DOTS database. Consistently with Forbes and Chinn (2004) all flows are measured from partner to country to estimate the effect of a reduction of either factor on the recipient country[12]. All variables are weighted relative to the country's GDP to eliminate

[11] We do not perform the reverse procedure because based on Ehrmann et al. (2004)'s result, between 1999 and 2004, the US accounted for 26% of the variance in three different EA assets while the EA only accounted for 8%. This makes the spillover effect much stronger from the US to the EU.

[12] Depending on the direction of trade, other authors choose exports instead; however, in our setting,

stationarity concerns. Finally, capital (leverage) ratios TCERWA (TCETA), defined as Total Common Equity divided by Total Risk-Weighted Assets (Tangible Assets) are obtained from Bankscope. Correlation between all variables is provided in Table 17. Our positive correlation estimates between bilateral linkages are in line with those of Balakrishnan et al. (2009) and Fratzscher (2012). It is also important to point out that bilateral linkages and capital ratios are uncorrelated.

Table 16: Correlation matrix for MSCI bank indices (2003-2012)

The data below shows the correlation between the Morgan Stanley Capital International (MSCI) daily price indices of various countries in our sample.

	US	EU	AUS	BEL	DEU	FRA	GRE	ITA	POR	SPA	UK
US	1.00										
EU	0.07	1.00									
AUS	0.40	0.56	1.00								
BEL	0.43	0.55	0.62	1.00							
DEU	0.47	0.54	0.60	0.63	1.00						
FRA	0.47	0.67	0.65	0.71	0.69	1.00					
GRE	0.23	0.40	0.45	0.40	0.38	0.43	1.00				
ITA	0.49	0.62	0.62	0.67	0.69	0.81	0.41	1.00			
POR	0.28	0.42	0.45	0.52	0.44	0.55	0.39	0.54	1.00		
SPA	0.52	0.69	0.64	0.67	0.66	0.81	0.44	0.80	0.56	1.00	
UK	0.50	0.65	0.63	0.65	0.65	0.77	0.39	0.68	0.47	0.73	1.00

Table 17: Correlation Matrix for Explanatory Variables (2003-2012)

The data below show the correlation between the different explanatory variables in our model. Bilateral Variables are shown with respect to the US and EU partner countries. Capital and leverage ratios are computed for the FullSample (see Table 18) but results do not differ dramatically for other bank samples.

	FC_USA	FDI_USA	IMP_USA	FC_EUR	FDI_EUR	IMP_EUR	TCERWA	TCETA
FC_USA	1.00							
FDI_USA	0.52	1.00						
IMP_USA	0.48	0.40	1.00					
FC_EUR	0.46	0.41	0.36	1.00				
FDI_EUR	0.19	0.26	0.43	0.37	1.00			
IMP_EUR	0.10	0.15	0.62	0.32	0.65	1.00		
TCERWA	0.08	0.07	0.05	-0.07	0.01	0.03	1.00	
TCETA	0.06	0.07	-0.07	-0.13	-0.03	-0.04	0.53	1.00

exports from a given country are the imports of the partner which constitute the risk factor.

Table 18: Bank Numbers based on Sample Size

The data shows the number of banks that form each of our samples.

	SIFI	IMF	Top200	Top10	Top30	FullRank	FullSample
AUS	0	3	2	10	30	261	402
BEL	0	2	2	10	30	48	174
DEU	1	7	13	10	30	1587	2796
SPA	2	5	9	10	30	128	316
FRA	4	5	16	10	30	249	779
UK	4	6	17	10	30	269	714
GRE	0	1	1	10	18	18	42
ITA	1	5	8	10	30	576	1055
POR	0	3	2	10	30	33	78
Total	12	37	70	90	258	3169	6356

We assume that the effect on the banking sector is captured by the country bank index. Hence, the choice of what sample of banks to include in order to compute the country-specific variables becomes crucial. Bruno and Shin (2013) compute a global index based on the summation of a specified variable across the Top10 banks ranked according to asset size. However, this unweighted method along with averaging across a given sample, is subject to a bank size bias. In order to circumvent this problem in the same manner used by the World Bank to calculate international debt statistics, we compute country aggregate measures for the abovementioned ratios based on the median values of a specific sample. Note that in order to remove any sample bias we do so for seven sub-categories of banks (Table 18). In principal, each sub-category encompasses the previous and so on. The first, SIFIs, is based on a set of criteria in addition to size, defined in BCBS (2011)[13]. The second is a list of the most important banks per country as established by the IMF. For the next samples, instead of imposing heuristic thresholds as in Berger and Bouwman (2013), we rely on country rankings by Bankscope based on asset size. This creates a more reflective sample of each country's top banks, albeit creating wider dispersion in sample sizes. Hence, the third sample includes banks that figure amongst the world top 200. The fourth and fifth are top 10 and top 30 banks

[13]The full list is given in FSB (2012).

per country. The sixth sample includes all banks that were ranked by Bankscope for a given country. The seventh category includes all banks in the database.

Note that, based on the fact that more open economies are more exposed to larger trade shocks (VanRijckeghem and Weder (2003), Blanchard et al. (2010) and Claessens et al. (2011)) other measures could have been used instead of imports such as trade openness (Exports plus Imports divided by GDP) and financial or capital account openness (Foreign Assets plus Liabilities divided by GDP). While these variables could be expected to be influential, Balakrishnan et al. (2009) show that this is not the case which supports their exclusion from our model. As an alternative, the Chinn-Ito measure for capital account restrictions could have been used as in Fratzscher (2012)[14]; however, the measure is obsolete in our case as it is identical across our selected countries due to the removal of trade barriers between EU countries. Other variables have similarly been excluded mainly for reasons of collinearity and inconsistency between various authors. For a full list of variable exclusions see Appendix D[15].

ii Model

a Returns

The return model is setup using an adapted version of the CAPM[16]. In other words, country i's market index BKMSCI now becomes the LHS variable which is explained by the contemporaneous global and regional indices MSCI_US and MSCI_EU, where $j \in$ [US, EU]. We also add the matrices of Bilateral Variables (BV = [FC, FDI, IMP]) and Capital Variables (CV = [TCERWA, TCETA]) which are lagged to eliminate endogeneity concerns.

$$BKMSCI_{it,j} = \alpha_j + \beta_{0,j} MSCI_{j,t} + \beta_{1,j} BV_{it-1} + \beta_{2,j} CV_{it-1} + \epsilon_{it,j} \tag{V.1}$$

[14]These authors found no significance in this factor both during and after the crisis.

[15]Size is already factored into the definition of our samples as per Table 18.

[16]There have also been models who use Fama-French like factors instead as in Bekaert et al. (2009)

All models are estimated using fixed-effects and Newey-White robust estimators. Note that, in this context, robust estimation is done based on the country dimension (i), which, in other words, leads to the same results as clustering by country. Indeed, Poirson and Schmittman (2012) detected the presence of country clusters for individual banks while Claessens et al. (2011) found similar behavior for stocks clustered by SIC. However, as this study takes place at a more macro level (country banking industry), we can only cluster by country.

b Spillover

The standard single-factor spillover model of Frankel and Rose (1998) has been extended in the literature, leading to multi-factor models as in Forbes and Chinn (2004). As mentioned earlier, the time-varying nature of this model is due to a relaxation of the constant constraint on the coefficients of MSCI_US and MSCI_EU in equation (V.1). We use a window period of 6 months (180 days) as in ECB (2011) to concentrate on short-term fluctuations as opposed to longer windows such as Aharony and Swary (1983) and Bunda et al. (2009). The first stage model is captured by equation (V.2) below:

$$BKMSCI_{it,j} = \alpha_{i,j} + \sum_{j=US,EU} \beta_{it,j} MSCI_{j,t} + \epsilon_{it,j} \tag{V.2}$$

The "beta" coefficients now measure the time-varying sensitivity of the bank indices to shocks coming from the US or EU. Yearly aggregated betas then constitute the dependent variable for the next stage regression which incorporates BVs and CVs as the main set of explanatory variables.

$$\beta_{it,j} = \beta_{0,j} + \beta_{1,j} BV_{it-1} + \beta_{2,j} CV_{it-1} + \mu_{it,j} \tag{V.3}$$

In Figure 10, we plot the individual country betas at daily frequency based on equation (V.2). Increases in beta reflect periods of greater economic and financial integration across countries which is accompanied by increased sensitivity between them[17]. Bearing in mind the six month window used, in most graphs, one can see two peaks occurring respectively around the dates of the subprime and Euro crises, preceded by a period of relative calm. This suggests that a more interesting approach would be to divide the sample period into a tranquil (2003-2007) versus a crisis period (2007-2011)[18]. This can also be interpreted as a pre/post-Basel setting which would account for any differential role played by the exogenous implementation of the capital regulation in the second period.

c Contagion

Despite the possibility of misspecification in the case of contagion as highlighted in Bekaert et al. (2005), we model contagion as the portion of interdependence which is not accounted for by the spillover effect in accordance with Masson (1999).

$$\hat{\epsilon}_{it} = BKMSCI_{it} - \sum_{j=US,EU} \hat{\beta}_{it,j} MSCI_{j,t} \tag{V.4}$$

Residuals $\hat{\epsilon}_{it}$ are derived by re-arranging the terms in equation (V.2) using the yearly estimated spillover effect obtained from equation (V.3) as shown in (V.4). Figure 11 displays the yearly residuals stemming from (V.4) and thus reflects the contagion effect. As expected this effect is arbitrary for every country and hence we cannot capture any similarities at this stage as we did in the case of the spillover effect.

[17] This notion is underlined in Brooks and DelNegro (2004) using an aggregate developed market stock index during the period 1986-2001.

[18] Note the effect of the lag in shifting the end date of the crisis.

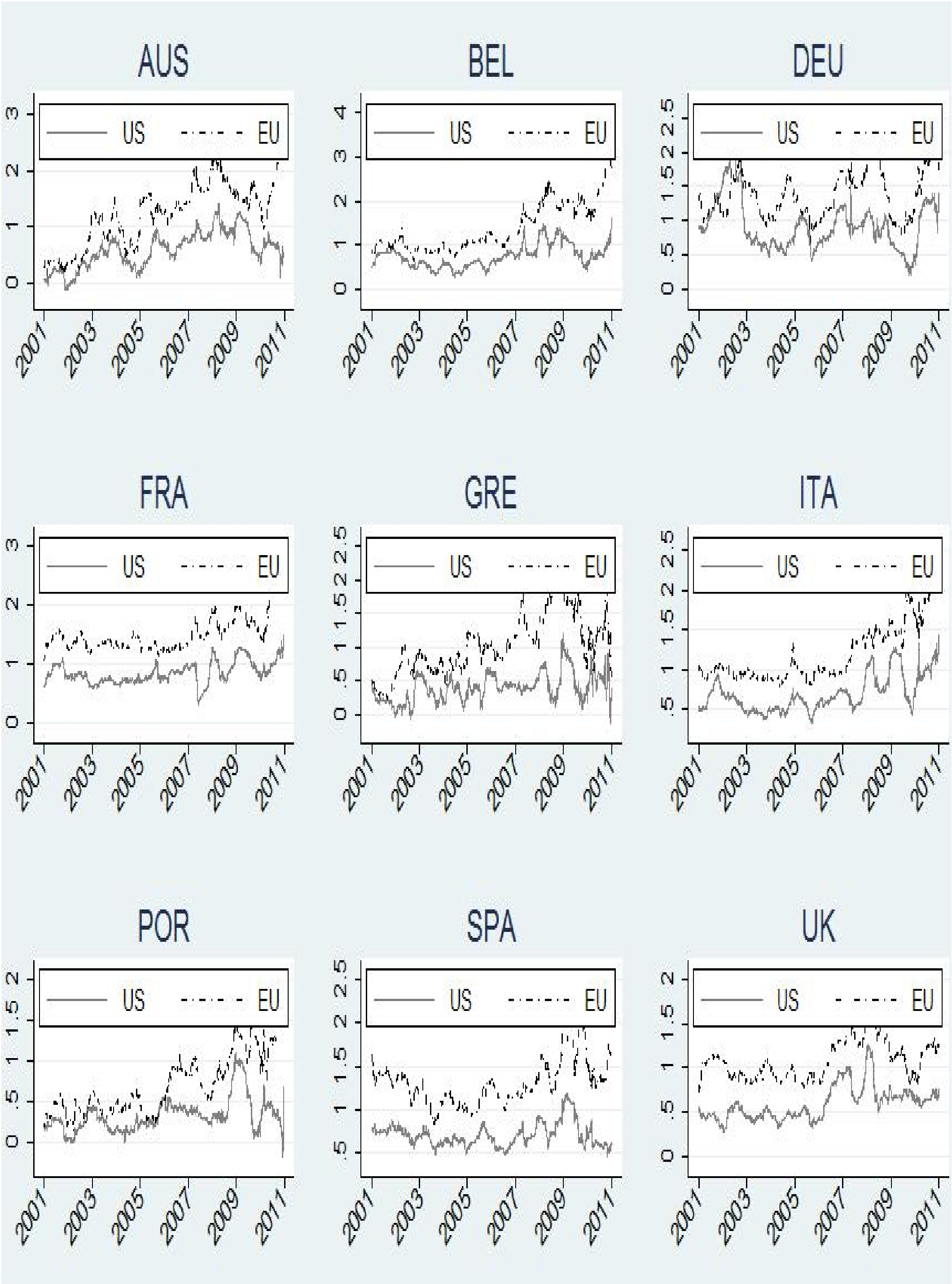

Figure 10: Country Betas (daily)

Figure 11: Country Residuals (yearly) - Horizontal line denotes the 0 intercept

4 Results

i Background Analysis

In this following, we measure to what extent any EU country is likely to be affected by its partnerships with the US and EU. We compute the betas for the whole period by regressing each individual country's BKMSCI index on that of MSCI_US and MSCI_EU[19]. The difference in beta between both partners is shown in Figure 12. In line with Bekaert et al. (2005), country betas with respect to the EU are all higher than those of the US by around 0.6, with France having almost double that of Portugal.

Next, we plot the individual country betas in Figure 13. We observe a linear beta trend between EU countries with regard to both the EU and US. We notice that the slopes of the linear fittings are almost the same across both groups with the R^2s being equal up to three significant figures. This is due to the orthogonalization we performed earlier on the MSCI indices.

Moreover, Figure 13 shows a clear separation between countries according to the magnitude of their respective betas. The ranking of countries by beta seems to be the same with respect to the EU and US in particular for countries with the lowest rankings. Aside from the UK whose beta could be affected by the fact that it is a non-EA member, the nations on the left-hand side are the peripheral countries which were subject to rescue programs during the euro crisis. Hence, these countries are referred to hereafter as "program" countries. In contrast, with the exception of Italy[20], the "non-program" countries at the right-hand side are the strongest powers within the EU. Also, the fact that France and Germany have the highest beta for the EU and US respectively reinforces the opinion of the IMF (2011) that spillovers within the EA will be mainly channeled by these two countries.

[19] All results are highly significant (p-value ≈ 0).

[20] Besides being a program country, Italy's position in the ranking is clearly a reflection of the size of its GDP: third (EA), fourth(EU).

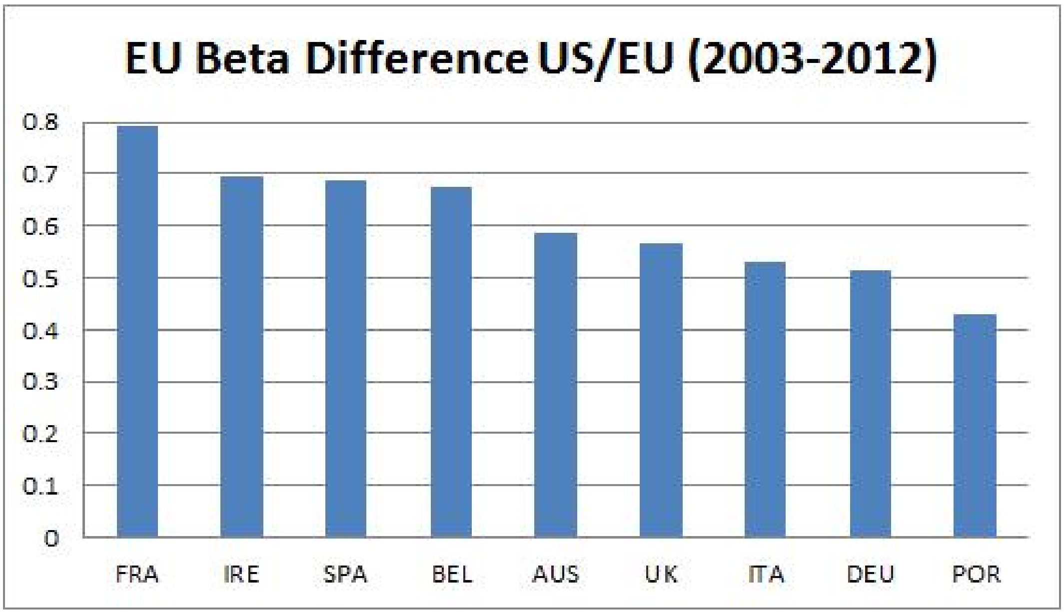

Figure 12: Difference Between EU and US Betas (2003-2012)

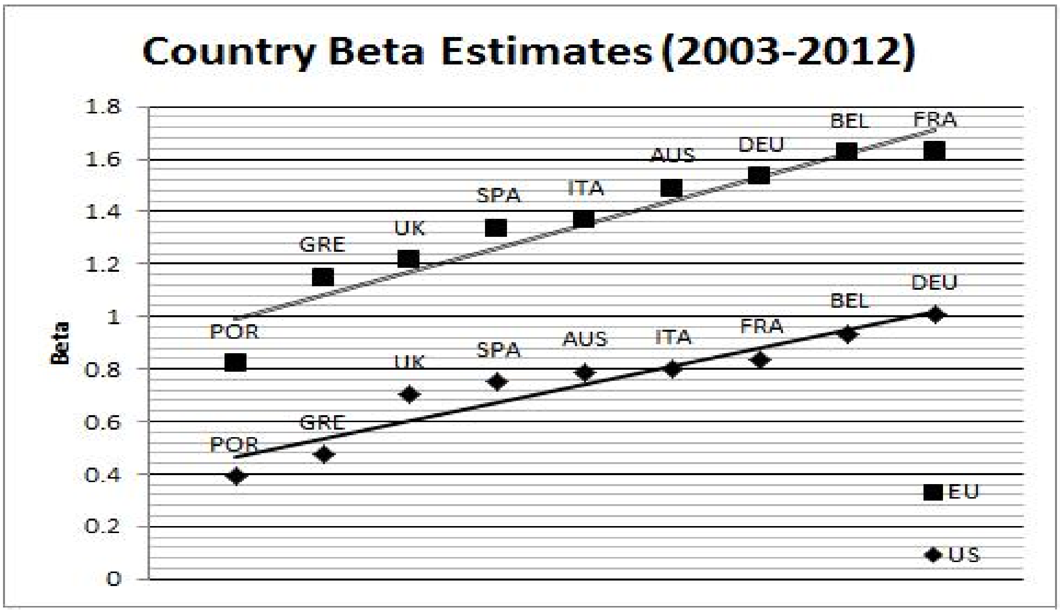

Figure 13: Beta Coefficients against US and EU (2003-2012)

In addition, lending to EA countries played a prominent role during the euro crisis. In the spirit of Waysand et al. (2010) and Shin (2012), we present some figures describing the overall situation of these countries. In Figure 14, we plot the amount of lending of US banks to their EU counterparties based on BIS estimates. We observe that the negative impact on lending from the US to EU countries was short-lived during the subprime crisis but increased considerably afterwards compared to pre-crisis levels. Note however, that with the exception of the UK, the bulk of lending went to the core countries (N-PRGM) as they were perceived as safe borrowers. In turn, this left the task of lending to peripheral countries (PRGM) to the core countries, specifically France and Germany, in addition to the UK. This is showcased in Figure 15 which illustrates the amount of lending from core countries to the periphery.

It is worthwhile pointing out that France who did not participate in funding Portugal and Spain held nonetheless the greatest debt proportion of the largest indebted country, Italy (130% of GDP according to IMF estimates). This raised spillover concerns between both countries during the EA-crisis. This is in contrast to Germany who drastically cut down lending to the Iberic peninsula and was therefore less at risk from a negative spillover emanating from Europe's periphery. Finally, note that the UK, which took part in lending to the periphery, is also the largest borrower from the US (almost equal to the total of EA countries). This points to the particular role held by this country, and numerous attempts to renegotiate its position, within the EU.

ii Preliminary ECB regression

Before running our model, we compute a country's banking sector capital variables by creating a hypothetical national representative bank for each of the samples in Table 18. The latter is constructed by computing the national median for each of the samples. To check that this method mimicks similar findings at the bank-level, we run the simple

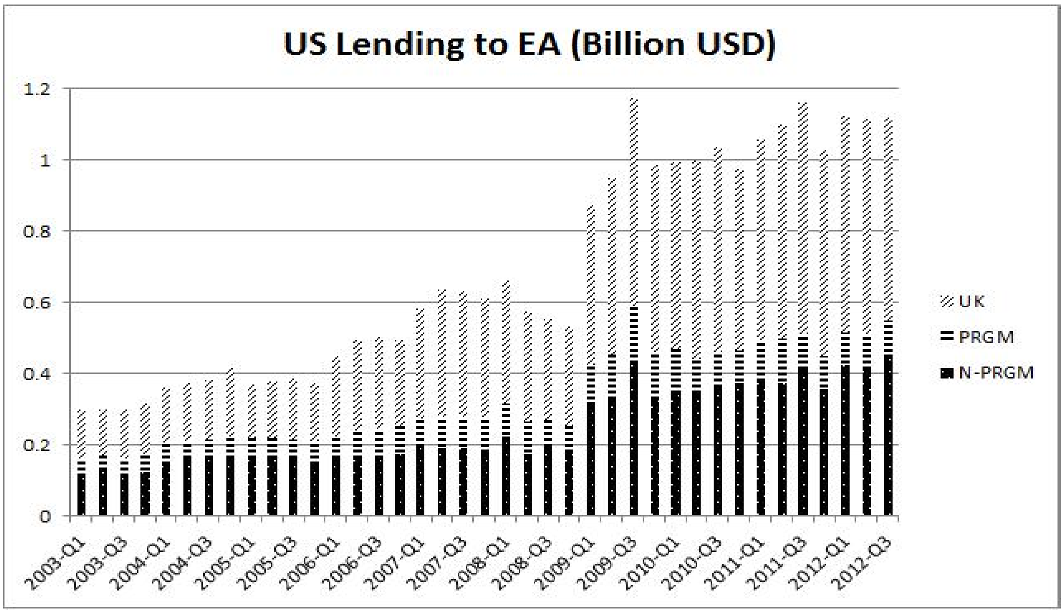

Figure 14: Foreign Claims (in Trillions) of US banks on EU counterparties (Source: BIS consolidated banking statistics)

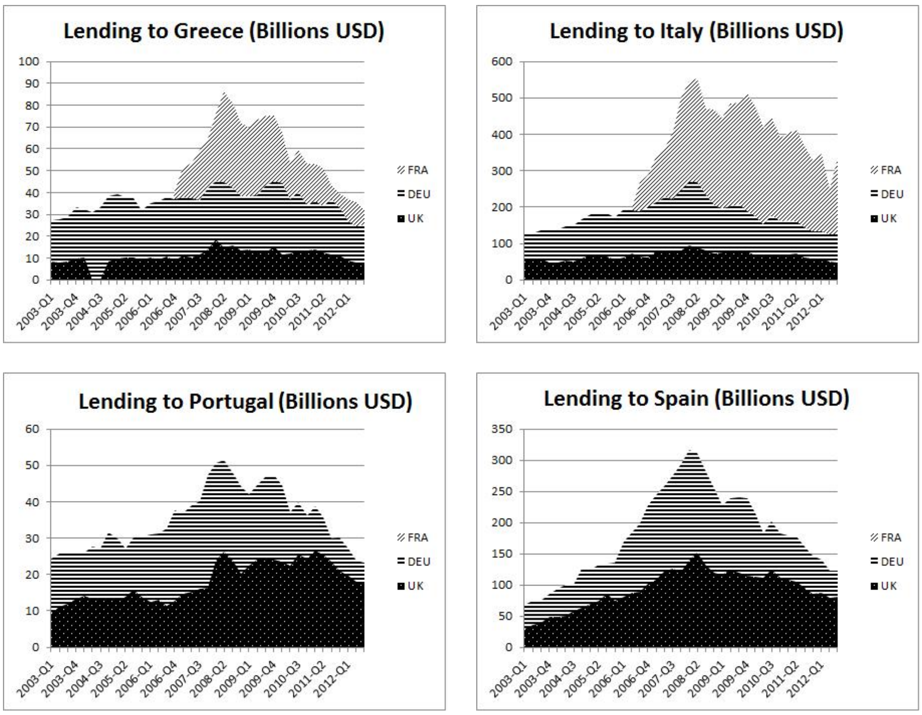

Figure 15: Lending by Core to Peripheral EA Countries

fixed-effect[21] regression in equation (V.5), which is a reduced version of equation (V.3), and compare the results with those of the analysis conducted by the ECB (2011). Our setting is fairly similar except that their period runs from 1995-2011 with a sample consisting of 54 large international banks headquartered in 18 different countries which includes non-European ones.

$$\beta_{it} = \beta_0 + \beta_1 TCETA_{it-1} + \epsilon_{it} \tag{V.5}$$

The result they find is that higher capital requirements reflected in a higher leverage ratio (TCETA) is significantly associated with lower bank spillover risk. We depict a similar result in Table 19, notwithstanding a possible size effect. Indeed, we observe that the sign on the leverage coefficient goes from slightly positively significant (SIFIs) to insignificant (IMF and Top200) before becoming negatively significant throughout in

Table 19: Preliminary ECB Regression

The data below show the results from the ECB Regression described in model V.5. $* \, p < 0.05, ** \, p < 0.01, *** p < 0.001$.

Sample	Beta	Coef	t-stat	Adj R^2	Num Obs
SIFI	US	0.089*	2.19	0.06	40
	EU	0.139	1.25	0.04	40
IMF	US	0.021	0.36	-0.01	75
	EU	-0.007	-0.05	-0.01	75
Top200	US	0.046	1.06	0.01	75
	EU	0.123	1.51	0.05	75
Top10	US	-0.023	-1.76	0.02	77
	EU	-0.052*	-2.00	0.03	77
Top30	US	-0.020**	-3.15	0.03	79
	EU	-0.048**	-3.20	0.05	79
FullRank	US	-0.019***	-3.99	0.02	81
	EU	-0.042***	-3.75	0.03	81
FullSample	US	-0.025**	-2.99	0.02	81
	EU	-0.045**	-2.86	0.02	81

[21] As in the report itself, our results are qualitatively unchanged by running a random-effect model.

line with the result of the ECB. The cutoff point lies between the samples that encompass the number of banks used (54) in the ECB report as shown in Table 18. Nonetheless, while our representative banks still reflect the overall composition of the banks in a given country, our aggregation method inevitably results in a much smaller number of observations for any given sample. We therefore managed to reproduce the ECB result using only a tiny fraction of their observations (3% - 6%) with only one sixth reduction in R^2.

iii Core Results

In the following we present the results of our models for returns, spillovers and contagion using all nine EU countries in our sample.

First, we highlight only the results which are found to be consistently significant across all banking samples using the order prescribed in Table 18. We were forced to drop the SIFI sample due to an insufficient number of observations as Austria, Belgium, Greece and Portugal are not on the FSB list (see Table 18); nevertheless, these banks are included in the IMF sample.

Second, we run the analysis for the pre and post crisis sub-periods, with emphasis on the latter as it is usually more deserving of policy attention. Note that we choose to emphasize the crisis rather than the regulatory effect as there seems to be no consistently significant regulatory change between pre and post 2007.

In this setup, we encountered a multi-collinearity issue. This is highlighted in Table 20 where the Variance Inflation Factors (VIFs) for the TCERWA and TCETA are larger then 10 and the Conditioning Index (CI) is above 30[22]. We attribute this to the property of the capital ratio of tending towards the leverage ratio when the proportion of highly risk-weighted assets increases. As shown in Chapter 4, this allows for the correlation between the two ratios to change. Hence, the 53% correlation between the two ratios in

[22]The VIF relates to an R^2 greater than 90% in the auxiliary regressions while the CI is the threshold for multi-collinearity as established by Belsley et al. (1980).

Table 17 is reasonable in a period that combines variations from a tranquil (pre-2007) and crisis (post-2007) periods.

Nonetheless, as can be seen by comparing the full sample and pre/post-2007 partitions, this problem is not due to high correlations between variables in our sample (as shown in Table 17); but to the smaller number of observations obtained by splitting the sample population across time partitions. To remediate the problem we use the ratio of risk-weighted assets to total assets (RWATA) instead of the capital and leverage ratios as shown in our Updated model in Table 20. Indeed, this modification removes the multi-collinearity problem as shown by the low CIs [23]. Note that according to Chapter 4, the RWATA ratio is reflective of the credit risk undertaken by a bank and is actually equal to the ratio of the leverage and capital ratios. Hence if this interaction between both ratios gives a significant result, we relate our findings to the capital (leverage) ratio on the basis that it is inversely correlated with risk-weighted assets (total assets).

Table 20: Multicolinearity Tests

This table shows the Variance Inflation Factors (VIFs) for our Return model variables and Conditioning Index (CI) of the overall regression. Results relate to the IMF Sample with the US partner. VIF is defined as $\frac{1}{1-R^2}$ where R^2 is the explanatory power of the auxiliary regression where each variable is regressed on the remainig ones. Typically a $VIF > 10$ or $CI > 30$ signals that multi-colinearity is present.

Original	Full Sample	Post-2007	Pre-2007	Updated	Full Sample	Post-2007	Pre-2007
MSCI	1.19	1.36	3.60	MSCI	1.12	1.30	3.21
FC	3.80	5.59	9.36	FC	3.17	3.45	8.24
FDI	2.11	3.08	1.75	FDI	2.09	2.44	1.82
IMP	5.65	10.07	9.07	IMP	4.05	4.01	8.62
TCERWA	21.31	38.70	22.69	RWATA	2.58	2.62	3.78
TCETA	10.47	13.16	13.02	-	-	-	-
CI	29.41	37.73	42.48	CI	15.84	18.37	17.87

[23] Effectively, this brings down our t-stats to the same magnitude as those in Poirson and Schmittman (2012). Also, to ensure that the problem does not arise again we display the CI in all upcoming regressions noting that all factors have a VIF less then 10.

A nice feature of our model is that it allows us to determine the significant variables for each scenario of returns, spillovers and contagion in a consistent manner. In fact, our small number of variables provide an easier tool for policy-makers to handle than huge multi-variate models. However, the fact that we are unable to go beyond the stated number of regressors to keep clear of multi-collinearity creates another problem, namely omitted variable bias. We resolve it by using fixed effects estimations in order to capture missing bank-specific effects as in Cetorelli and Goldberg (2011) who suffer from similar small sample problems.

a Returns

The MSCI index is a significant factor in our return model (Table 21). We find that the EU coefficient is twice as high as that of the US during crisis periods. This can be explained intuitively by the fact that each EU country is primarily affected by its regional context even before the effects of the subprime crisis were felt. Note that the Return model exhibits on average the highest explanatory power ($R^2 = 45\%$) compared to the Spillover ($R^2 = 15\%$) and Contagion ($R^2 = 7\%$) models, notably because of the MSCI component which does not feature in the latter two by construction. Indeed, running the Return model with either of the MSCI indices as a regressor can explain at least 30% of the changes in country returns. This is a characteristic of our country-level CAPM model where systematic components play a more important role than in the conventional bank-level model[24]. A similar finding was reported by Balakrishnan et al. (2009) who obtained an R^2 of 40% by regressing an emerging market index on an advanced market index.

In contrast, IMP is a consistent push factor affecting returns negatively during the pre-crisis periods and with respect to both US and EU partners. One reason could be that if a country's economy receives a boost in exports due to an exchange rate depreci-,

[24]For instance, Chan-Lau et al. (2012a) obtain $R^2 = 18\%$ using the regular CAPM framework.

Table 21: Returns

The results below are from running equation (V.1) for the six samples of banks using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given between brackets below the coefficients. * $p < 0.05, **p < 0.01, ***p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
MSCI	**2.277*** **	0.690	**4.579*** **	**1.423* **	**2.459*** **	0.769	**4.633*** **	**1.772** **	**2.609*** **	0.742	**5.020*** **	**1.763** **
	(7.23)	(1.25)	**(7.22)**	**(1.98)**	**(5.25)**	(1.40)	**(7.15)**	**(3.33)**	**(5.40)**	(1.28)	**(5.47)**	(3.19)
L.FC	-0.000	0.000	0.000	-0.000	0.000	0.000	0.000	-0.000	0.000	0.000	0.000	-0.000
	(-1.41)	(0.31)	(1.41)	(-0.46)	(0.31)	(0.08)	(0.69)	(-1.04)	(0.18)	(0.26)	(0.53)	(-1.01)
L.FDI	0.001	0.000	0.000	0.000	0.001	-0.000	0.000	0.000	0.000	-0.000	0.000	0.000
	(1.01)	(0.04)	(1.27)	(0.80)	(1.00)	(-0.25)	(1.18)	(1.16)	(0.25)	(-0.37)	(1.36)	(1.14)
L.IMP	-0.000	**-0.001*** **	-0.000	**-0.000* **	0.000	**-0.001*** **	-0.000	**-0.000* **	0.001	**-0.001*** **	-0.000	-0.000
	(-0.25)	**(-3.49)**	(-1.01)	**(-1.89)**	(0.00)	**(-5.35)**	(-0.92)	**(-2.01)**	(0.55)	**(-6.68)**	(-1.10)	(-1.73)
L.RWATA	0.000	-0.000	-0.000	-0.000	**0.000* **	-0.000	0.000	0.000	**0.000* **	-0.000	0.000*	-0.000
	(1.28)	(-1.70)	(-1.07)	(-0.93)	**(2.17)**	(-0.44)	(0.48)	(0.01)	**(2.17)**	(-0.97)	(1.88)	(-0.38)
CONS	-0.004	0.008**	0.007	0.007	-0.016*	0.005	0.003	0.003	-0.019**	0.006**	-0.003	0.004
	(-1.02)	(3.05)	(0.90)	(1.81)	(-2.08)	(1.70)	(0.31)	(1.23)	(-2.34)	(2.62)	(-0.86)	(1.55)
R^2	0.32	0.54	0.43	0.52	0.35	0.46	0.43	0.48	0.37	0.49	0.45	0.49
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	33.39	38.47	45.75	4.37	26.09	61.55	67.24	3.60	58.84	77.75	26.31	3.42
CI	18.38	17.88	12.78	17.00	15.96	23.29	10.50	15.60	19.91	23.31	11.98	14.57

SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
MSCI	**2.704*** **	0.887	**5.079*** **	**1.843*** **	**2.329*** **	0.887	**4.509*** **	**1.761*** **	**2.514*** **	0.887	**4.507*** **	**2.037*** **
	(4.83)	(1.49)	**(5.39)**	**(3.56)**	**(8.91)**	(1.51)	**(8.25)**	**(3.44)**	**(8.33)**	(1.57)	**(8.75)**	**(4.69)**
L.FC	-0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.000	-0.000
	(-0.45)	(-0.30)	(0.43)	(-1.34)	(-1.31)	(-0.30)	(1.17)	(-1.09)	(-0.93)	(-0.33)	(1.03)	(-1.37)
L.FDI	0.000	-0.000	0.000	0.000	0.000	-0.000	0.000	0.000	0.001	-0.000	0.001	0.000**
	(0.19)	(-0.22)	(1.04)	(1.12)	(0.31)	(-0.24)	(1.17)	(1.11)	(1.33)	(-0.22)	(1.10)	(2.44)
L.IMP	-0.001	**-0.001*** **	-0.000	**-0.000** **	-0.000	**-0.001*** **	-0.000	**-0.000** **	-0.000	**-0.001*** **	-0.000	**-0.000*** **
	(-0.26)	**(-5.66)**	(-1.04)	**(-2.47)**	(-0.26)	**(-5.88)**	(-0.98)	**(-2.39)**	(-0.13)	**(-6.43)**	(-0.94)	**(-3.73)**
L.RWATA	**0.000** **	-0.000	0.000*	0.000	0.000	-0.000	-0.000	0.000	**0.000** **	0.000	-0.000	0.000**
	(2.57)	(-0.02)	(1.89)	(1.36)	(1.38)	(-0.01)	(-0.45)	(0.43)	**(2.90)**	(0.19)	(-0.39)	(3.11)
CONS	-0.020***	0.004**	-0.004	0.002	-0.008	0.004***	0.006	0.003	-0.011	0.003***	0.007	0.000
	(-3.74)	(3.09)	(-0.82)	(1.15)	(-1.04)	(4.33)	(0.62)	(1.03)	(-1.67)	(3.46)	(0.55)	(0.02)
R^2	0.39	0.45	0.44	0.51	0.33	0.45	0.43	0.48	0.34	0.45	0.43	0.57
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	77.76	60.69	76.70	5.24	56.26	80.16	43.27	3.92	81.63	104.69	40.12	7.15
CI	20.11	20.51	12.78	15.94	23.06	20.30	14.79	16.45	25.25	22.03	15.96	16.92

-iation the adjusted return on the banking sector will decrease as expected from uncovered interest rate parity.

Finally, the RWATA ratio provides a significant pull mechanism for returns. Its positive sign suggests that banks with lower risk-weighted assets were obtaining lower returns during the crisis. This agrees with the standard risk-return relationship as shareholders expect lower returns from safer banks. The latter claim should always hold under the efficient market hypothesis according to Berger (1995), Admati et al. (2011) and Baker and Wurgler (2013).

However, the link between capital and returns is not straighforward when the latter assumption is relaxed. As pointed out in Osborne et al. (2013), the relationship between the two is governed by two competing hypotheses, the cost of capital and banking sector distress. The former hypothesis indicates that when the cost of capital is high, as is normally the case in boom periods, bank lending is subsequently reduced to meet regulatory requirements (Bernanke and Lown (1991), Baer and McElravey (1993) and Peek and Rosengren (1995b)). This curtails returns unless there is a markup in lending spreads which is not rejected by the demand side (Saunders and Schumacher (2000)). The alternative hypothesis prevails normally during crisis periods as safer banks which are more able to avert bankruptcy obtain lower funding costs which boosts their returns as highlighted by the findings of Demirguc-Kunt and Huizinga (1999), Carbo-Valverde and Fernandez (2007) and Demirguc-Kunt et al. (2010).

On the basis that for the same amount of capital, safer banks with lower risk-weighted assets exhibit higher capital ratios, our result that these banks were generating lower returns goes against the alternative hypothesis. This also contradicts the findings of Berger and Bouwman (2013) who explored the relationship between capital ratios and profitability in various crises. One justification could be made on the grounds of moral hazard (Berger et al. (1995) and Fischer et al. (2012)) in that maintaining higher capital cushions is costly for banks which are forced to, or willingly, compensate by investing in riskier projects. The negative repercussions of such behavior arise during crisis times and would seem to outweigh the pecuniary benefits achieved from lowering funding costs especially with regard to large banks which were excluded from Berger and Bouwman (2013)'s sample. However, our result can also be observed for the entire banking sector (FullSample) which includes smaller banks as well. Hence, an alternative explanation would relate to the failing of capital ratios, and in particular risk-weighted assets, to account for the true riskiness of mortgage securities (subprime crisis) and sovereign debt (European crisis). As such, the inflated amount of capital did not reflect the risk inherent in these instruments whose yields widened during the respective crises thus lowering returns.

Note that our result could also stem from the leverage effect meaning that banks with larger asset bases generated lower returns during the crisis. This has widely been reported as one of primary causes of the global financial crisis as excessive risk-taking endangers the whole financial system and leads to a breakdown in the risk-return relationship alluded to earlier.

b Spillover and Contagion

On one hand, based on Table 22, aside from the FC effect for the US during the pre-crisis period, no factor appears to have played a role in explaining spillovers in the EU. Taking into consideration the lag in this variable, this means that any increase in lending to these countries would result in an ex-post increase in their sensitivity to crises in the US. On the other hand, it appears that the only factor increasing the potential for contagion from the US is FDI according to Table 23.

In contrast to our earlier implications for returns, this implies that financial linkages play a much more vital role in shock transmission. As a matter of fact, the RWATA variable has no impact in both transmission models which implies that EU countries would not be be able to offset these shocks through the protective layers of capital. The

Table 22: Spillover

The results below are from running equations (V.2) and (V.3) for the six bank samples using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given in brackets below the coefficients. * $p < 0.05, ** p < 0.01, *** p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.008	**0.067*****	0.007	0.011	-0.004	**0.058****	0.008	0.010	-0.005	**0.056****	0.008	0.010
	(-0.67)	**(3.58)**	(1.00)	(1.22)	(-0.26)	**(2.42)**	(1.22)	(1.06)	(-0.44)	**(3.11)**	(1.26)	(1.15)
L.FDI	-0.011	0.002	-0.020	0.052	0.004	0.006	-0.021	0.052*	0.006	0.013	-0.018	0.050
	(-0.34)	(0.06)	(-1.09)	(1.77)	(0.15)	(0.21)	(-1.04)	(2.02)	(0.17)	(0.62)	(-0.90)	(1.83)
L.IMP	0.085	-0.003	-0.011	-0.008	0.081	0.031	-0.010	-0.007	0.077	0.016	-0.006	-0.009
	(1.10)	(-0.01)	(-0.61)	(-0.53)	(0.95)	(0.20)	(-0.62)	(-0.50)	(0.88)	(0.12)	(-0.35)	(-0.62)
L.RWATA	-0.006	0.002	-0.011	-0.006	-0.000	0.007	-0.011	0.008	-0.001	0.011**	-0.019	0.005
	(-0.91)	(0.20)	(-0.75)	(-1.53)	(-0.00)	(0.86)	(-0.90)	(1.43)	(-0.24)	(2.44)	(-1.58)	(0.77)
CONS	0.918*	0.309	2.041**	0.978**	0.593	-0.011	1.974**	0.353	0.661	-0.182	2.309***	0.501
	(1.92)	(0.62)	(2.35)	(3.22)	(0.83)	(-0.02)	(2.75)	(1.28)	(1.50)	(-0.65)	(5.00)	(1.81)
R^2	0.10	0.09	0.08	0.29	0.07	0.11	0.07	0.30	0.07	0.16	0.13	0.29
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	0.89	13.17	0.82	1.77	0.56	12.87	0.89	1.61	0.56	17.15	1.63	1.45
CI	18.07	16.69	12.68	15.10	15.55	20.92	10.30	14.21	19.49	21.22	11.80	13.36
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.005	**0.063****	0.009*	0.011	-0.004	**0.067*****	0.007	0.010	-0.006	**0.065*****	0.007	0.010
	(-0.47)	**(3.31)**	(2.03)	(1.43)	(-0.48)	**(3.63)**	(1.25)	(1.17)	(-0.59)	**(3.74)**	(1.48)	(1.16)
L.FDI	0.008	-0.020	-0.003	0.059*	-0.005	0.001	-0.009	0.055*	0.002	0.018	-0.004	0.053
	(0.20)	(-0.64)	(-0.14)	(1.91)	(-0.15)	(0.05)	(-0.47)	(1.86)	(0.07)	(0.75)	(-0.22)	(1.84)
L.IMP	0.084	-0.019	-0.003	-0.007	0.077	-0.015	-0.003	-0.007	0.082	-0.017	-0.017	-0.007
	(1.21)	(-0.10)	(-0.17)	(-0.48)	(0.92)	(-0.08)	(-0.17)	(-0.45)	(1.16)	(-0.08)	(-0.97)	(-0.36)
L.RWATA	-0.003	0.008	-0.035**	-0.006	0.005	0.006	-0.027	-0.002	-0.006	0.009	-0.028**	-0.001
	(-0.26)	(1.20)	(-2.55)	(-1.52)	(0.59)	(0.55)	(-1.27)	(-0.30)	(-0.81)	(0.87)	(-2.49)	(-0.09)
CONS	0.721	0.051	2.996***	0.980***	0.341	0.088	2.721**	0.806***	0.907*	-0.046	3.048***	0.751*
	(1.13)	(0.17)	(4.03)	(4.46)	(0.56)	(0.39)	(2.70)	(3.38)	(1.87)	(-0.14)	(3.54)	(2.25)
R^2	0.07	0.13	0.20	0.30	0.08	0.12	0.13	0.28	0.09	0.13	0.17	0.28
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	0.70	26.02	4.24	1.80	1.67	22.09	1.74	1.24	0.88	8.40	4.79	1.23
CI	19.77	19.10	12.65	14.39	22.68	18.72	14.63	15.22	24.73	20.32	15.72	15.49

Table 23: Contagion

The results below are from running equation (V.4) for the six samples of banks using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given between brackets below the coefficients. * $p < 0.05, **p < 0.01, ***p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.016	-0.058	0.011	0.006	0.001	-0.034	0.008	0.008	-0.007	-0.043	0.005	0.007
	(-0.31)	(-0.83)	(0.81)	(0.34)	(0.02)	(-0.49)	(0.45)	(0.57)	(-0.13)	(-0.60)	(0.60)	(0.48)
L.FDI	**0.389****	0.106	0.015	0.036	**0.405*****	0.102	0.009	0.037	**0.367*****	0.100	0.002	0.045
	(2.61)	(1.08)	(0.26)	(0.66)	**(3.76)**	(1.22)	(0.14)	(0.74)	**(4.26)**	(1.14)	(0.02)	(0.80)
L.IMP	-0.312	0.116	-0.004	-0.022	-0.296	0.077	0.003	-0.023	-0.271	0.119	-0.000	-0.019
	(-1.07)	(0.51)	(-0.11)	(-0.85)	(-1.02)	(0.54)	(0.08)	(-1.05)	(-0.99)	(0.69)	(-0.01)	(-0.78)
L.RWATA	-0.000	0.009	-0.020	0.009	0.017	-0.013	0.003	-0.017	0.013	-0.009	0.030	-0.014
	(-0.01)	(0.26)	(-0.58)	(0.28)	(0.35)	(-0.78)	(0.05)	(-1.18)	(0.38)	(-0.83)	(0.70)	(-1.03)
CONS	0.713	-0.520	0.513	-0.271	-0.278	0.547	-0.561	0.911	-0.067	0.301	-1.699	0.738
	(0.34)	(-0.45)	(0.36)	(-0.24)	(-0.10)	(0.63)	(-0.28)	(1.24)	(-0.03)	(0.45)	(-0.89)	(0.95)
R^2	0.12	0.05	0.03	0.04	0.13	0.07	0.02	0.08	0.13	0.07	0.04	0.07
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	59.71	11.40	1.63	0.90	28.24	1.43	1.59	0.91	14.27	1.73	1.55	0.86
CI	18.07	16.69	12.68	15.10	15.55	20.92	10.30	14.21	19.49	21.22	11.80	13.36
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.019	-0.045	0.010	0.009	-0.016	-0.048	0.006	0.007	-0.007	-0.049	0.005	0.006
	(-0.41)	(-0.64)	(1.12)	(0.63)	(-0.35)	(-0.74)	(0.65)	(0.54)	(-0.13)	(-0.67)	(0.60)	(0.43)
L.FDI	**0.417*****	0.141	0.015	0.044	**0.374*****	0.113	-0.007	0.053	**0.401*****	0.093	-0.016	0.036
	(8.28)	(1.35)	(0.20)	(0.78)	**(5.66)**	(1.71)	(-0.11)	(1.04)	**(5.23)**	(1.20)	(-0.24)	(0.67)
L.IMP	-0.289	0.159	0.004	-0.020	-0.318	0.183	-0.003	-0.014	-0.322	0.149	0.015	-0.011
	(-0.92)	(0.84)	(0.09)	(-0.94)	(-1.05)	(1.08)	(-0.07)	(-0.64)	(-1.05)	(0.76)	(0.47)	(-0.47)
L.RWATA	-0.017	-0.011	-0.010	-0.010	0.008	-0.020	0.031	-0.023**	0.038	-0.009	0.037	-0.012
	(-0.62)	(-0.66)	(-0.19)	(-0.64)	(0.17)	(-1.66)	(0.43)	(-2.46)	(0.88)	(-0.61)	(0.75)	(-0.74)
CONS	1.550	0.301	-0.035	0.509	0.272	0.775	-1.865	1.141**	-1.409	0.257	-2.530	0.580
	(1.08)	(0.44)	(-0.02)	(0.75)	(0.11)	(1.57)	(-0.60)	(3.27)	(-0.59)	(0.45)	(-0.91)	(0.90)
R^2	0.13	0.08	0.02	0.06	0.12	0.16	0.03	0.16	0.16	0.06	0.05	0.05
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	35.60	1.46	1.55	0.95	32.23	1.28	2.23	3.98	13.70	2.42	1.92	1.27
CI	19.77	19.10	12.65	14.39	22.68	18.72	14.63	15.22	24.73	20.32	15.72	15.49

Table 24: Non Program - Spillover

The results below are from running equations (V.2) and (V.3) for the six bank samples using non-program countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given in brackets below the coefficients. $* \ p < 0.05, * * \ p < 0.01, * * * p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	0.008	**0.059****	0.001	0.008	0.033	**0.039***	-0.001	0.009	0.017	**0.052***	0.007	0.011
	(0.51)	**(3.30)**	(0.23)	(0.76)	(1.85)	**(2.19)**	(-0.18)	(0.68)	(1.08)	**(2.32)**	(0.98)	(0.90)
L.FDI	0.008	-0.024	-0.051**	0.066	0.015	0.009	-0.036*	0.043	-0.039	0.016	-0.025	0.045
	(0.18)	(-0.81)	(-2.96)	(1.12)	(0.85)	(0.32)	(-2.26)	(1.13)	(-0.98)	(0.78)	(-0.72)	(0.93)
L.IMP	**0.198****	-0.131	0.030***	-0.011	**0.243*****	0.056	0.017	-0.001	**0.272*****	0.005	0.019	-0.011
	(3.54)	(-0.45)	(5.68)	(-0.44)	**(6.09)**	(0.36)	(0.97)	(-0.04)	**(4.88)**	(0.03)	(1.10)	(-0.48)
L.RWATA	0.008	**0.051****	0.025	0.009	0.025	**0.023***	0.016	0.022*	0.016	**0.018****	-0.027	0.013
	(0.95)	**(3.49)**	(1.50)	(0.34)	(1.53)	**(2.70)**	(1.45)	(2.23)	(1.16)	**(4.10)**	(-1.43)	(2.07)
CONS	-0.174	-1.062*	0.110	0.576	-1.210	-0.537	0.809	-0.076	-0.769	-0.234	2.074*	0.352
	(-0.29)	(-2.42)	(0.18)	(0.44)	(-1.46)	(-0.76)	(1.88)	(-0.13)	(-1.09)	(-0.54)	(2.69)	(0.95)
R^2	0.22	0.12	0.15	0.24	0.31	0.17	0.07	0.36	0.25	0.18	0.16	0.29
Num Obs	20	22	20	22	20	22	20	22	20	22	20	22
F-stat	99.68	102.11	116.69	10.67	19.43	32.05	1.74	96.03	61.29	82.73	2.46	35.25
CI	15.81	18.67	11.13	18.79	13.65	23.91	8.09	19.18	17.41	21.30	10.37	16.62
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	0.014	**0.059****	0.006	0.010	0.006	**0.068****	0.004	0.009	0.004	**0.067****	0.005	0.011
	(1.49)	**(3.32)**	(0.76)	(0.77)	(0.88)	**(3.56)**	(0.45)	(0.77)	(0.33)	**(4.60)**	(0.68)	**(0.93)**
L.FDI	-0.073	-0.055	-0.019	0.067	-0.057	-0.007	-0.024	0.062	-0.008	0.031	-0.011	0.054
	(-1.78)	(-1.69)	(-0.70)	(1.07)	(-2.02)	(-0.29)	(-0.92)	(1.09)	(-0.32)	(1.05)	(-0.38)	(1.22)
L.IMP	**0.238*****	-0.073	0.021	-0.009	**0.230****	-0.061	0.014	-0.010	**0.192****	-0.079	0.001	-0.014
	(4.92)	(-0.37)	(1.48)	(-0.35)	**(4.05)**	(-0.27)	(0.89)	(-0.35)	**(4.35)**	(-0.33)	(0.04)	(-0.39)
L.RWATA	0.031*	**0.016***	-0.028	-0.004	0.022*	0.009	-0.009	0.000	0.003	**0.020***	-0.023	0.006
	(2.14)	**(2.30)**	(-0.67)	(-0.44)	(2.27)	(0.63)	(-0.28)	(0.02)	(0.27)	**(2.37)**	(-0.86)	(0.31)
CONS	-1.275	0.058	2.168	0.972**	-0.877	0.211	1.663	0.863**	0.074	-0.175	2.505	0.646
	(-2.01)	(0.13)	(1.42)	(3.30)	(-1.72)	(1.38)	(1.26)	(3.93)	(0.20)	(-0.36)	(1.44)	(1.38)
R^2	0.33	0.18	0.10	0.24	0.33	0.15	0.05	0.24	0.20	0.22	0.09	0.24
Num Obs	20	22	20	22	20	22	20	22	20	22	20	22
F-stat	88.84	11.23	1.31	9.26	12.06	59.66	0.66	1.85	79.92	40.12	16.07	0.67
CI	15.56	20.27	12.48	19.26	21.65	19.85	18.40	20.48	24.75	24.23	17.50	23.87

relevant question thus becomes what factors could potentially prevent this transmission.

Before exploring other factors, we check first if our results are related to our sample choice. Building on the distinctions found in Figure 13, we split our sample into two partitions - non-program and program countries - for a more thorough analysis. This entails an unavoidable decrease in the number of observations, which, in the case of the program sample was too small to avoid excessive multi-collinearity and hence had to be discarded[25]. The size of the other two samples are in line with the existing literature (Poirson and Schmittman (2012)).

The contagion model using the NonProgram country sample reveals no new results in comparison to our original sample. For the spillover run (Table 24), we first confirm our previously obtained finding that FC is the key mechanism for this type of shock transmission. This could be explained by the fact that, according to Figure 14, overall lending to the EU's NonProgram countries (mainly Germany and France) increased towards the end of the subprime crisis. We can also speculate that this effect could also be present for the Program countries, since accounting as well for the six month (window) delay in Figure 10, the increase in sensitivity in all countries occurred mostly around the same time, arguably due to the same determinants. This confirms the statement by the IMF (2011) which described these countries as "exhibiting the greatest potential for spillover effects in times of stress".

Second, we observe a consistent IMP component from the US affecting non-program countries during the crisis period. This implies that if the US increased its imports from these countries, this would make them more reliant on the overall economic status of the US, as mentioned in Kalemli-Ozcan et al. (2012). We would normally expect the same, if not higher, significance for the EU partner. However, this is not the case. In fact, none of the factors in our model can explain shock transmission vis-a-vis the EU. This could likely be because of the stronger partnership between the member countries which

[25] We can potentially, however, infer the behavior of banks in this sample from the full and non-program country runs

provides a reassurance to the EU partner not to withdraw from crisis-stricken countries in order to maintain the stability of the EU as was seen in the recent EU crisis.

Third, for the NonProgram countries we find that higher RWATA lead to a higher potential for spillover effects (Table 24). This result is in agreement with those found previously in ECB (2011) and Poirson and Schmittman (2012)[26] using TCETA. Hence, core countries with higher capitalized banks are better able to cope with financial stress and are therefore more likely to avoid spillovers. This indicates that the banking sector distress hypothesis, alluded to in our earlier results on returns, prevails in a spillover setting where cost of capital is irrelevant.

As such, it would appear surprising that the same effect was not observed as well in our original sample. This could be due to asymmetric implications across EU countries with regard to risk assessment. Indeed, while the credit rating of France dropped a notch during the sovereign crisis, the spread on its debt narrowly budged. This is not the case for peripheral countries. Hence, if NonProgram countries lent to their Program country counterparties, the former's internal models could have reflected the change in credit-worthiness and built up sufficient capital. In contrast, spillovers from NonProgram countries are considered as highly unlikely, especially during the pre-crisis, which could deter other countries from protecting themselves from such risks.

Another reason why the RWATA effect is weakened during the crisis could be driven by the leverage ratio (TCETA) effect as there were no regulatory changes affecting the capital ratio (TCERWA) thresholds under Basel II. Indeed, Poirson and Schmittman (2012) note that leverage can in some cases have a positive effect on spillovers in contrast to the ECB (2011) results. They assume this peculiarity is due to a possible non-linear relation between bank size and vulnerability. However, we show here that our result occur irrespective of size (Table 24). We are inclined therefore to conclude that this

[26]Note that the explanatory power of our model coincides to a large extent with the 22-28% range of R^2 in Poirson and Schmittman (2012). However, the advantage of our model is in achieving the same power with a much smaller set of factors.

could be due to an offsetting effect introduced by voluntary changes to the leverage ratio (TCETA) between pre-crisis (build-up) and crisis (deleveraging) periods. In any case, this supports the introduction by Basel III of a stable leverage ratio as a backstop measure in order to maintain the beneficial aspect of risk-based capital ratios.

5 Robustness

In order to strengthen the validity of our results we run a series of robustness tests covering all three models presented above. Tables are listed in Appendix E.

First, we would like to assert whether the results obtained are driven by the UK as a non-EA country in our sample. Therefore, we remove the UK from our EU sample and check if the Returns results in Table 21 change. In Table II, we see that this is not the case except for a weakening of the trade relationship with the EU. This was expected given that the UK is one of the largest trading partners with the EU.

Second, in Table III, we introduce the credit-to-gdp gap (CRGDP), a cyclical macroeconomic variable which the Basel committee on Basel III views as the determinant of the new counter-cyclical capital cushions. We choose this variable for both its macroeconomic (control) and regulatory (new capital buffers) content. As described in BCBS (2010), we construct this variable by taking the CRGDP deviation from the long-term trend using a Hodrick-Prescott filter[27]. The variable introduces no additional explanatory power with regards to contagion[28]. The FDI factor remains significant as highlighted in Table 23. This implies that contagion is as likely to occur in any stage of the credit cycle.

Third, Poirson and Schmittman (2012) find that wholesale funding is a leading pull factor in spillovers despite that Tressel (2011) find no such evidence. We use the same

[27] Using a smoothness parameter of 400,000 as suggested by the BCBS.

[28] Except in the last regression for each sample where multi-collinearity occurs. We discard the results from these regressions.

indicator, loans-to-deposits, to gauge the effect of wholesale funding. In Table IV, we find that this ratio increases in significance (0.005-0.008) as the number of banks increases from the Top 10 to the whole of the banking sector. This brings together both findings regarding the impact of wholesale funding and confirms the necessity of our contribution in avoiding any sample effects. Moreover, this opens an interesting research question to explain why smaller banks are more sensitive to spillovers via wholesale funding. This could be due to the fact that larger banks are the main contributors to wholesale funding while smaller banks are more reliant and less capable of replacing these funding sources by other resources in the same way that larger banks are able to.

Finally, despite the fact that our checks revealed that including liquidity as an additional variable in our model might induce multi-collinearity for some runs, we include it only for illustrative purposes[29]. We find that liquidity is the only factor which is able to minimize the impacts of spillovers (Table V) and contagion (Table VI) simultaneously, noticeably in our sample of larger banks that do not suffer as much from multi-collinearity. This implies that liquidity is the best protection against transmission shocks especially when solvency constraints play no meaningful role. The latter agrees with the importance attributed by Fratzscher (2012) to country-specific characteristics[30], thus reinforcing the introduction of liquidity standards in Basel III.

6 Conclusion

Boosting a country's economy through higher returns while safeguarding it from externalities have always been main targets of policy-makers. With the creation of the EU, this objective became even more central as the targets shifted to a regional scale with the added concern of protecting the EU, not only from the rest of the world, but from itself. Indeed, the recent Euro crisis brought to light the internal vulnerabilities of

[29]Liquidity is defined as total liquid assets to total deposits and short term funding.
[30]Albeit not to bank-specific factors such as leverage and liquidity per se

Europe which threatened to break up the union just over a decade after its creation.

Through relaxing constraints on bilateral linkages between countries such as trade and investment, the EU's economic target was achieved in 1999. However, EU leaders witnessed during the recent crises that more was needed with regards to the safety mechanism to maintain financial stability. With EU regulatory bodies questioned for not achieving enough oversight, the EU Commission has favored extending the supervisory powers of the Central Bank (ECB) and calling for a full banking union.

In light of the diversity of country-specific vulnerabilities, the problem faced by EU regulators would be to choose uniform safety targets which so far have been outside their jurisdiction. One European regulation which would escape such difficulty is the Basel regulation due to its homogeneous enforcement across member countries under the capital requirement directive (CRDIII). Nonetheless, the regulation still got its share of criticsm for not having done enough to safeguard the sanctity of the banking sector. This has propelled efforts towards increased capital measures and a backstop leverage requirement under Basel III (CRDIV).

The main purpose of this research is to shed light on factors affecting the EU's banking sector in order to provide policy-makers with an adequate monitoring toolkit for achieving their targets. Our model encompasses both linkages between countries and a country-specific component linked to the Basel regulation which enables us to detect which factors are more prevalent in increasing returns and preventing spillovers and contagion.

We find that each element of the bilateral factors has a dominant effect in each of these scenarios. While trade contributes negatively to banking returns, lending and foreign direct investment increase the risk of spillovers and contagion respectively. With regard to country-specific factors, we find that while high capital ratios (low risk-weighted assets) decrease returns during crisis periods they emerge however, as the primary safety mechanism against spillovers especially for non-program countries.

The latter result has become a subject of concern for the banking industry as it reveals a tradeoff between profitability and safety. Hence, banks could have the incentive to reduce their capital ratios, thereby disregarding their protection against spillovers, in order to achieve higher returns. It is therefore important to maintain these capital ratios at sensible levels as they can act as a counterweight to the sometimes aggravating effects of bilateral linkages. This agrees with Cheung et al. (2010)'s recommendation for policy-makers to balance between the various tradeoffs that can affect the dynamics of global interdependence. It also accentuates the importance attributed to higher capital buffers despite the cautioning against a possible credit crunch arising from the newly-established capital increments under Basel III. Note that our results indicate that capital ratios are ineffective against contagion; however, they highlight liquidity as a contender to stave off both spillovers and contagion.

Moreover, some banks, particularly the SIFIs, have attracted a lot of criticism in both the US and EU crises. While we do not uncover any aspect particularly related to this sample of banks, one of our contributions has been in finding consistent results across a diversity of samples ranging from the largest banks (including the SIFIs) to the whole of the banking sector. Despite data limitations similar to those encountered in the literature, this makes our results more robust than those of authors who focus only on one particular sample. In addition, the literature has focused on explaining individual bank behavior whereas our method addresses the overall banking sector. This should prove more useful for regulators as it points the axis towards macroprudential policy which has become one of the central pillars of the Basel III regulation.

In light of the slow recovery the US faced due to the Euro crisis, we foresee that a similar study based on the effects of the EU on the US would be an interesting complement to our work in uncovering the common grounds for crisis prevention between the two strongest economic powers.

Chapter VI:

Conclusion

In this research, we studied the impact of the Basel capital requirements regulation on crises that hit the U.S. and E.U. With regard to the U.S., the lending contraction which occured during the 1990-1991 recession could be considered as the unavoidable cost of strengthening the financial sector, in some way an insurance premium. In contrast, the story for the 2007-2009 crunch was quite different as most banks met the regulatory requirements prior to the downturn. Hence, the story related to the second "capital" crunch had more to do with the lowering of the risk-weight on residential mortgages under Basel II.

As Chapter 3 reveals, this change had a beneficial impact prior to the crisis as it promoted mortgage lending and boosted the economy. However, this trend was short-lived as banks, despite being overcapitalized at the onset of the crisis, suffered severe losses. Moreover, leverage and liquidity seem to have exploited difficiencies in capital ratios related to moral hazard incentives and shortcomings of solvency constraints. Together, these two factors combined to coerce banks into cutting down on their lending during the subprime crisis. As such, the risk-based capital credit crunch hypothesis (RBC CCH) highlighted by many authors as a viable explanation for the first U.S. crisis is not the main culprit for the second crisis. It would make sense for us in the future to check whether the same conclusion holds for countries which effectively implemented Basel II ahead of the crisis, in particular the E.U.

As demonstrated in Chapter 4, changes in risk weights can lead to drastic changes in the behavior of banks with regard to setting capital and leverage ratios. Indeed, from a mathematical standpoint, we establish that the leverage ratio cannot be changed without affecting the sensitivity of the capital ratio to a change in one or more of its risk-weights. We show that such modifications are also behind changes across crises in the correlation patterns between the two ratios. However, the repercussions of this were not felt at the level of the binding capital constraint on banks.

Having explored the microeconomic impact of the Basel regulation in the U.S., we turn our attention in Chapter 5 to the macroeconomic impact of capital requirements in the E.U. Our setting is based on exploring the impact of the Basel regulation on countries having uniform bank capital requirements, which are bound together by monetary policy but not in terms of their risk credentials. Indeed this issue has come back to the forefront of policymaking with the advent of the euro crisis. In order to assess which factors matter the most for returns, spillovers and contagion, our model encompasses both the linkages between countries and country-specific components. We include a diversity of samples ranging from the largest banks (including the SIFIs) to the whole of the banking sector; the former having attracted a lot of criticism in both the US and EU crises. We find that while EU countries which have the highest capital ratios achieve the lowest returns, they are also better able to cope with spillover effects. Moreover, liquidity seems to be the only safety mechanism with regard to contagion. This study would benefit from testing whether the same factors which were deemed meaningful from the perspective of the EU also hold for the US and if not why. We hope to pursue this further in future research.

The policy implications with regard to Basel III are as follows. With regard to our findings in Chapter 3, the most recent change with respect to previous regulations was the decision to increase core Tier 1 capital despite lending concerns reminiscent of the first U.S. crisis. The justification for that seems to be that holding insufficient capital has had much more severe consequences than increasing capital levels. The second change was the inclusion of the leverage ratio as a "backstop" measure despite the hindsight of a proven-to-be-faulty tandem of both risk-based and leverage ratios particularly for the

U.S. The third change was the introduction of new liquidity measures, both short and long-term, to complement solvency guidelines at a much needed time. Unfortunately, the process of safeguarding against securitization has proven more difficult as the related entities such as SPVs are outside the reach of regulators. Nonetheless, efforts have been directed towards minimizing the risks of gaming the risk-weighting scheme via capital adjustments.

Our analysis in Chapter 4 complements previous findings with regard to the effect of capital during the first crisis by depicting the erosion in capital ratios caused by the subprime crisis. This re-affirms the impact that shortages in capital can have on survival rates while pointing the finger this time towards a different requirement, the leverage ratio, in terms of binding constraint. Hence, our study allows us to gauge the efforts by Basel III in quantifying the necessary increments to the capital ratio. But before adding those, our mathematical derivation showed that this process has to go through an adequate selection of the leverage ratio. Together with the credit risk ratio and "asset proportion", these three variables combine to influence the sensitivity of the capital ratio to changes in its risk-weight. Our formulae also reveal a simple closed-form way of establishing capital ratio thresholds taking into account the counterpart leverage ratio. This avoids heuristic methods for selecting capital targets for both requirements and could ultimately resolve the lack of synergy apparent from previous crises regarding the interaction between both ratios.

Finally, the purpose of Chapter 5 was to shed light on the vulnerabilities of the EU in order to help policy-makers in addressing them. This caters to the views of the Basel committee on the necessity of exploring micro and macro-prudential policy implications of new regulations such as Basel III. Hence, our main finding is that while high capital ratios can curb returns the benefits outweigh the cost. The reasons are that, on one hand, these ratios are helpful in mitigating the effects of spillovers. On the other hand, increasing capital buffers could actually reduce the moral hazard which the crisis showed is not linked to the level of capital per se but to the surplus of capital (overcapitalization). Hence, the Basel III recommendation to increase capital adequacy could make it more difficult for banks to partake in similar wrongdoing.

In light of all the controversy surrounding the impact of capital requirements, the Basel framework is still a work in progress as the question remains whether the BIS was able to deliver on its promise of safeguarding the banking sector. Our research has shown that while capital requirements certainly did not completely insulate the global banking system from financial crises, banks with better capital levels did benefit from higher levels of protection. As such, our analysis of the Basel regulation shortcomings was directed in an effort to substantiate the changes brought by Basel III and incorporate new ones before the time expires on the phase-in period of the new regulation. However, with as many Basel accords having been implemented as the number of crises cited in this research, the more important question becomes how many more "Basels" will be needed before the regulators converge to a stable draft that has proven capabilities to withstand crises? While Basel regulators seek to *capitalize* on their capital adequacy, talk about a Basel III.5 is already in the making...

Appendix A: The RBC CCH Theoretical Basis

B&U argued that movements into or out of risk-weighted categories should be uniform for the RBC CCH to hold. However, as per Keely and Furlong (1990), banks make decisions on the basis of an investment, rather than a risk-weight, opportunity set. Therefore, it is inaccurate to consider that a bank derives the same utility, in terms of capital requirements, from all assets in a certain risk-weight category; as one can assume that the banks' utility function depends on other variables than capital such as profitability (Kamada and Nasu (2000)).

This point can be more easily understood if one chooses mean-variance rather than utility maximization decision-making[1]. Indeed, according to Rochet (1992), competitive portfolio managers, who are responsible for setting the investment course for a bank, require a certain level of granularity that cannot be met by simply considering assets as being part of a risk-weight bucket, for reasons such as diversification gains. In other words, the uniformity assumption is only expected to hold from a regulators' point of view (utility); whereas banks' behavior should be explained from a portfolio manager's perspective (mean-variance) which cancels out B&U's assumption. This is the reason Merton (1995) was opposed to the regulators' idea of asset categorization instead of estimating the underlying instruments' contribution towards portfolio risk.

To justify this claim, we compute the average change in percentage portfolio composition between crunch and pre-crunch periods for different loan categories available in the Call Reports. This is done for each period following Basel I (1988-1992) and

[1] The two approaches can be mapped into each other in modern portfolio theory (Efficient-Market Hypothesis).

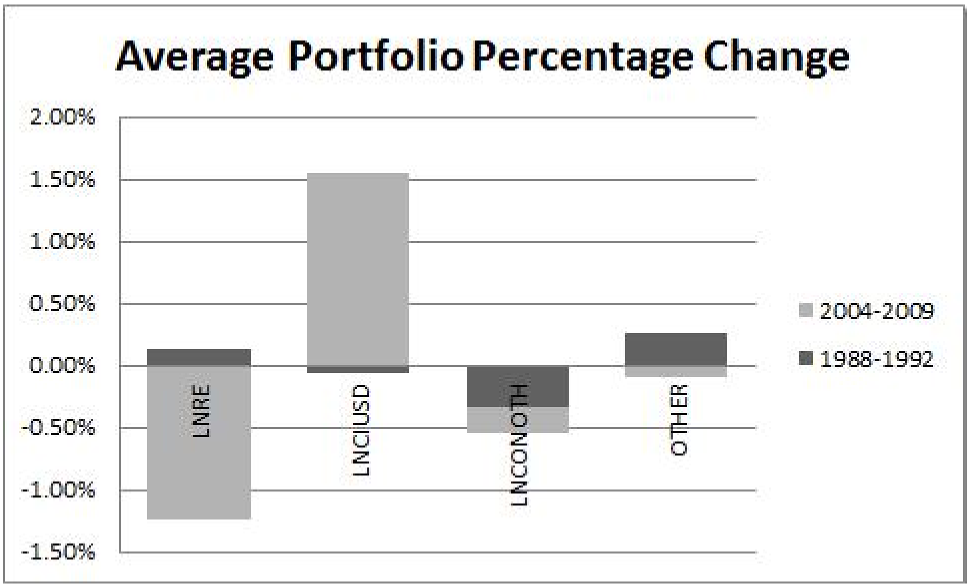

Figure 16: Change in loan portfolio composition from managers' perspective

II (2004-2009). The results shown in Figure 16 showcase how managers changed their perception of risk inherent in some loan types through changes to their overall portfolio composition. This is reflected in the opposite change in lending behavior between the two periods for commercial and industrial loans[2] (LNCIUSD) which belongs to the highest risk-weight class (100%). Residential real-estate mortgages (LNRE) and OTHER loans belonging to different classes also exhibit reversals. Note that the impact on LNRE and LNCIUSD is far more pronounced during the second period compared to the first in contrast to consumer loans (LNCONOTH) and OTHER loans.

In sum, were the uniformity assumption to hold, the managers' response would have been expected to be at least consistent for a particular loan category between the two crunches. This is not the case, however, due to the obvious pattern reversal which takes place at loan level rather than at the risk-weight class.

Hence, one must differentiate between a certain category of loans' growth rate and its change in percentage allocation within the portfolio. As a result, the perception that

[2] Variable names are different than in the main text to differentiate between individual growth and portfolio percentage growth.

under the RBC CCH, the reaction by banks to capital regulations will be uniform in each risk-weight category is flawed according to the assumptions of our research[3]. In other words, the RBC CCH can hold regardless of uniformity.

[3] This could also potentially allow for reconciling B&U's results with contemporaneous work. Unfortunately we cannot reproduce their results as the authors admit to having conducted hand approximations of the necessary components due to lack of data availability prior to 1990.

Appendix B: Geographic Factor

In order to establish that the South-West region was indeed the worse affected, our starting point is the survey conducted by Realtytrac (2009) which indicates that the number of foreclosures was the highest (5-9%) in the mentioned region along with Florida[1] (F). However, foreclosure by itself is not a direct measure of losses in dollar terms[2]. In contrast, our three NPL variables (Panel C) in Figure 17 - NPFRAT1 (Black), NPFRAT2 (Gray) and NPFRAT3 (Striped) - determine which geographic states incurred the heaviest losses. We restrict the ranking of each of the three variables to the top 15 states. As can be seen from Figure 17, Arizona (A) and Nevada (N) did not figure amongst the worse affected states prior to 2008Q1; whereas, towards the end of the crunch, both were in the top five with Arizona taking first place in two of the three rankings.

Note that these measures are computed in relative terms with respect to each state's total asset base. However, banks in some states had such large balance sheets that these measures were diluted and did not showcase the true severity of the crisis, for example in the case of California. Indeed, computing the measures in absolute terms, our results[3] show that Nevada headed all states while California ranked around tenth on an average basis during the crunch.

Hence California cannot be discounted as a subset of the SW states that suffered the most during the subprime crisis. We therefore include a SW dummy variable which, while showing contrasting results with the NE variable in Table 2[4], highlights the shift

[1]Since we are only interested in accounting for an area-specific geographic component, although Florida did lead the group in terms of losses, it does not fit into the wider geographic setting of our variable. Results are not changed by incorporating Florida alongside the South-West states.

[2]Foreclosure does not reflect the value of the property itself or the size of the write-off. Also, foreclosures entail a legal factor which may be postponed depending on the type of default and mortgage renegotiation (forbearance).

[3]Not reported here, but available upon request from the authors.

[4]We find that the increase in SW banks almost offsets the decrease in the number of those in NE

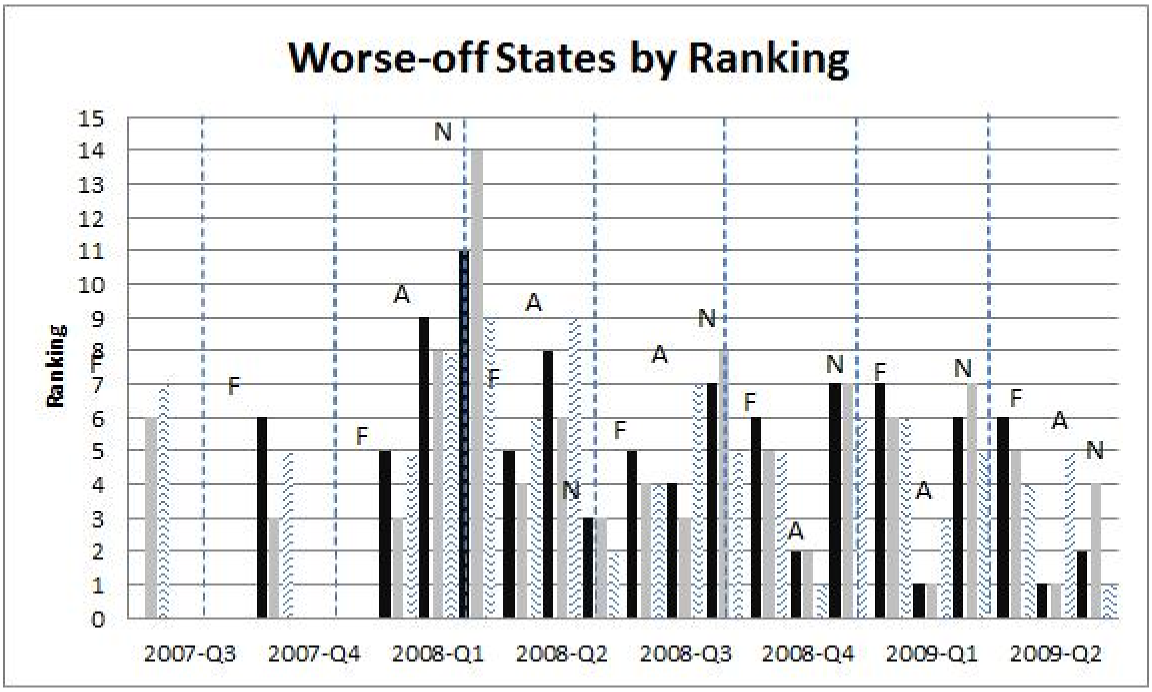

Figure 17: Variation in South West worse affected states (2007-2009)

in regional focus between the 1990-1991 and 2007-2009 crunches.

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between control and crunch periods. This is merely an artifact of non-monotonicity in our sample period as the SW banks decreased by twice as much during the crunch than they did in the control period which is also almost twice as long by construction. Yet, during the first four quarters of the crunch, there was a strong increase in SW banks to levels surpassing even those at the beginning of the control period which is responsible for the upward push in the estimates.

Appendix C: Solution to the CR equation

Assuming the CR is a function defined on $]0,1]^N$ with N possible risk-weights (w_i), the solution to the partial differential equation (PDE) in equation (IV.7) is solved in the exponential form $Ae^{\sum_{i=1}^{N} c_i w_i}$ where c_i are arbitrary constants to be found. Let g($w_1, ..., w_N$) be another function defined on the same support as CR and representing the product term in the equation ($\prod_{i=1}^{N} AP_i$). Substituting into (IV.7) we get:

$$\prod_{i=1}^{N} c_i = (-1)^N \times N! \times g(w_1...w_N) \tag{C.1}$$

As stated earlier, the only boundary condition we have is regarding the sensible approximation that CR(1,...,1) = $Ae^{\sum_{i=1}^{N} c_i}$ = LR. Denoting by n the subset of N asset categories with respect to which we are calculating the sensitivity of the CR, this yields a system of two equations with n+1 unknowns. We solve for the cases of n=1, n=2 and n=N.

i Solution with n=1

The system of equations for the case of a single risk-weight change becomes:

$$\begin{cases} c_i = -g(w_i) & \text{(C.2)} \\ LR = Ae^{\sum_{i=1}^{N} c_i} & \text{(C.3)} \end{cases}$$

By substitution:

$$LR = Ae^{\sum_{i=1}^{N} c_i} \rightarrow A = LR \times e^{-\sum_{i=1}^{N} c_i} \tag{C.4}$$

$$CR = LR \times e^{-\sum_{i=1}^{N} c_i} \times e^{\sum_{i=1}^{N} c_i w_i} = LR \times e^{-\sum_{k \neq i}^{N} c_k + AP_i} \times e^{\sum_{k \neq i}^{N} c_k w_k - AP_i w_i} \tag{C.5}$$

$$= LR \times e^{-\sum_{k \neq i}^{N} [c_k(1-w_k)] + AP_i(1-w_i)} \tag{C.6}$$

By symmetry, the same form applies for a change in asset j which gives:

$$CR = LR \times e^{-\sum_{k \neq j}^{N} [c_k(1-w_k)] + AP_j(1-w_j)} \tag{C.7}$$

By the ratio of the two changes in assets we get the following identity:

$$1 = e^{-\sum_{k \neq i}^{N=1} [c_k(1-w_k)] + AP_i(1-w_i) + \sum_{k \neq j}^{N} [c_k(1-w_k)] - AP_j(1-w_j)} \tag{C.8}$$

Taking logarithms at both ends and applying the principle of linearity we get: $c_k = -AP_k$ for all asset classes. This gives the final version of the CR equation given below. Note how the riskiest risk-weight class has no bearing on the differential between CR and LR in the same way that the safest risk-weight category has no impact on total RWA.

$$CR = LR \times e^{\sum_{i=1}^{N} [AP_i(1-w_i)]} \tag{C.9}$$

ii Solution with n=2

The boundary condition remains the same. Hence, using symmetry to overcome the underspecification in the case of 3 risk-weight categories, the system of equations for the case of any two risk-weight changes becomes:

$$\begin{cases} c_i c_j = 2 \times g(w_i, w_j) = 2 \times AP_i AP_j & \text{(C.10)} \\ c_j c_k = 2 \times g(w_j, w_k) = 2 \times AP_j AP_k & \text{(C.11)} \\ c_k c_i = 2 \times g(w_k, w_i) = 2 \times AP_k AP_i & \text{(C.12)} \end{cases}$$

Combining these equations together we get: $c_i^2 = 2AP_i^2, c_j^2 = 2AP_j^2, c_k^2 = 2AP_k^2$. This gives two possible solutions; however the first solution (C.13), is discarded as the CR is increasing in w_i which is counter-intuitive.

$$CR = LR \times e^{-\sum_{i=1}^{N}[\sqrt{2}AP_i(1-w_i)]} \tag{C.13}$$

$$CR = LR \times e^{\sum_{i=1}^{N}[\sqrt{2}AP_i(1-w_i)]} \tag{C.14}$$

iii Solution with n=N

Similarly, using symmetry and discarding the erroneous cases for n even, we obtain the general solution as below.

$$CR = LR \times e^{-\sum_{i=1}^{N}[\sqrt[N]{N!}AP_i(1-w_i)]} \tag{C.15}$$

Appendix D: Excluded Variables

Table I: List of Excluded variables

Variable	Source	Reason
VIX	Chan-Lau et al. (2012a)	Marginal contribution
Euribor-OIS	Chan-Lau et al. (2012a)	Insignificant (High Collinearity)
BtM	Brooks and DelNegro (2006)	No substantial addition
Size	Berger and Bouwman (2013)	No impact on capital effect
IP/LIBOR	Balakrishnan et al. (2009)	Not significant
Commodity Price Growth	Balakrishnan et al. (2009) & Forbes (2012)	Opposite results
Interest Rates/TED	Forbes (2012)	Significant depending on sample
Current account/fiscal deficits	Balakrishnan et al. (2009)	Reflected in bilateral linkages

Appendix E: Robustness Tests

Table II: Returns - noUK

The results below are from running equation (V.1) for the six samples of banks using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given between brackets below the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
MSCI	**2.303*** **	0.363	**4.595*** **	1.389	**2.539*** **	0.579	**4.632*** **	**1.767** **	**2.838*** **	0.509	**5.182*** **	**1.766** **
	(6.66)	(0.64)	**(7.85)**	(1.84)	**(5.52)**	(1.13)	**(8.75)**	**(3.01)**	**(4.44)**	(0.87)	**(5.77)**	**(2.84)**
L.FC	-0.000	0.001	0.000	-0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	0.000	-0.000
	(-0.32)	(1.59)	(0.98)	(-0.51)	(-0.06)	(0.75)	(0.77)	(-0.88)	(0.24)	(0.93)	(0.31)	(-0.85)
L.FDI	0.000	-0.001	0.001	0.000	0.001	-0.000	0.001	0.000	-0.000	-0.001	0.000	0.000
	(0.55)	(-1.13)	(1.30)	(0.56)	(0.57)	(-0.76)	(1.13)	(0.96)	(-0.17)	(-1.00)	(1.33)	(0.90)
L.IMP	-0.000	**-0.002*** **	-0.000	-0.000	0.000	**-0.002*** **	-0.000	-0.000	0.001	**-0.002*** **	-0.000	-0.000
	(-0.20)	**(-5.90)**	(-1.04)	(-1.22)	(0.06)	**(-6.45)**	(-0.97)	(-1.56)	(0.94)	**(-5.15)**	(-1.03)	(-1.25)
L.RWATA	0.000	-0.000	-0.000	-0.000	**0.000*** **	-0.000	0.000	0.000	**0.000***	-0.000	0.000	-0.000
	(1.11)	(1.21)	(-0.84)	(-1.01)	**(3.68)**	(-0.46)	(0.06)	(0.12)	**(2.01)**	(-1.15)	(1.79)	(-0.31)
CONS	-0.004	0.010***	0.008	0.007*	-0.017**	0.005	0.005	0.003	-0.024*	0.007**	-0.002	0.004
	(-1.29)	(4.44)	(0.84)	(1.93)	(-2.86)	(1.60)	(0.37)	(1.03)	(-1.92)	(2.78)	(-0.39)	(1.43)
R^2	0.31	0.62	0.45	0.53	0.34	0.49	0.45	0.48	0.38	0.54	0.46	0.49
Num Obs	32	34	32	34	32	34	32	34	32	34	32	34
F-stat	67.62	70.93	34.48	3.89	45.87	108.99	37.42	3.22	39.78	102.37	27.21	2.88
CI	23.19	25.75	21.86	23.46	19.06	26.53	16.41	22.05	25.05	24.63	16.67	20.89
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
MSCI	**2.738*** **	0.717	**5.076*** **	**1.836** **	**2.359*** **	0.756	**4.406*** **	**1.759** **	**2.530*** **	0.681	**4.437*** **	**2.122*** **
	(4.42)	(1.04)	**(5.21)**	**(3.23)**	**(7.84)**	(1.09)	**(8.34)**	**(3.03)**	**(6.89)**	(1.11)	**(8.35)**	**(3.89)**
L.FC	-0.000	0.000	0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	0.000	-0.000
	(-0.03)	(0.70)	(0.28)	(-0.83)	(-0.35)	(0.66)	(0.97)	(-0.80)	(-0.15)	(0.72)	(0.80)	(-0.74)
L.FDI	0.000	-0.000	0.000	0.000	0.000	-0.000	0.001	0.000	0.001	-0.001	0.001	0.000*
	(0.08)	(-0.77)	(1.16)	(1.15)	(0.08)	(-0.72)	(1.27)	(0.97)	(0.76)	(-0.77)	(1.22)	(2.06)
L.IMP	-0.000	**-0.002*** **	-0.000	-0.000	-0.000	**-0.002*** **	-0.000	-0.000	-0.000	**-0.002*** **	-0.001	**-0.000** **
	(-0.20)	**(-4.87)**	(-1.05)	(-1.86)	(-0.20)	**(-5.01)**	(-1.04)	(-1.67)	(-0.08)	**(-5.62)**	(-1.02)	**(-3.22)**
L.RWATA	**0.000***	-0.000	0.000	0.000	0.000	-0.000	-0.000	0.000	**0.000** **	-0.000	-0.000	0.000**
	(2.31)	(-0.60)	(1.51)	(0.75)	(1.26)	(-0.47)	(-0.83)	(0.28)	**(2.54)**	(-0.57)	(-0.54)	(2.87)
CONS	-0.022**	0.005***	-0.001	0.002	-0.009	0.004***	0.010	0.003	-0.012	0.004***	0.011	0.000
	(-2.43)	(3.95)	(-0.23)	(0.83)	(-1.06)	(4.50)	(0.81)	(1.03)	(-1.78)	(5.91)	(0.69)	(0.05)
R^2	0.39	0.49	0.45	0.50	0.32	0.48	0.45	0.49	0.33	0.48	0.45	0.58
Num Obs	32	34	32	34	32	34	32	34	32	34	32	34
F-stat	56.23	90.86	49.75	4.33	87.61	104.42	29.73	3.25	58.06	84.05	23.57	6.12
CI	22.34	24.93	17.81	19.23	24.87	25.79	17.72	18.13	28.41	28.44	19.58	19.98

Table III: Contagion - CRGDP

The results below are from running equation (V.4) for the six samples of banks using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given between brackets below the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	0.004	0.034	0.013	0.034	0.018	0.043	0.008	0.035*	0.007	0.038	0.006	0.035*
	(0.05)	(0.28)	(0.78)	(1.80)	(0.20)	(0.39)	(0.44)	(2.09)	(0.11)	(0.33)	(0.54)	(2.03)
L.FDI	**0.436****	0.177	0.015	0.123**	**0.439****	0.169	0.008	0.116**	**0.400*****	0.171	0.001	0.119**
	(2.82)	(1.47)	(0.26)	(2.41)	**(3.02)**	(1.56)	(0.14)	(2.39)	**(3.38)**	(1.42)	(0.02)	(2.55)
L.IMP	-0.303	0.096	-0.006	-0.072**	-0.284	0.083	0.002	-0.069**	-0.264	0.112	-0.002	-0.068**
	(-1.02)	(0.47)	(-0.16)	(-2.78)	(-0.97)	(0.60)	(0.05)	(-3.13)	(-0.94)	(0.69)	(-0.04)	(-3.08)
L.RWATA	0.004	0.011	-0.021	0.015	0.017	-0.009	0.003	-0.004	0.012	-0.004	0.031	-0.005
	(0.09)	(0.35)	(-0.58)	(0.61)	(0.35)	(-0.49)	(0.07)	(-0.36)	(0.34)	(-0.39)	(0.70)	(-0.47)
L.CRGDP	0.009	-0.009	-0.005	-0.018**	0.008	-0.008	-0.003	-0.017**	0.008	-0.008	-0.004	-0.017**
	(0.55)	(-1.43)	(-0.43)	(-2.90)	(0.93)	(-1.39)	(-0.23)	(-2.91)	(1.00)	(-1.31)	(-0.34)	(-3.17)
CONS	0.292	-0.912	0.591	-0.928	-0.474	0.027	-0.591	-0.073	-0.167	-0.231	-1.719	-0.042
	(0.10)	(-0.85)	(0.38)	(-0.89)	(-0.15)	(0.03)	(-0.31)	(-0.10)	(-0.08)	(-0.29)	(-0.90)	(-0.06)
R^2	0.13	0.13	0.03	0.27	0.13	0.13	0.02	0.26	0.13	0.12	0.04	0.26
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	73.58	33.45	1.73	9.99	26.89	7.63	1.32	10.96	9.47	21.60	1.31	14.68
CI	19.44	17.29	16.31	36.34	17.00	21.71	11.93	35.53	21.63	22.11	13.39	34.30
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.006	0.034	0.012	0.040*	0.002	0.003	0.006	0.031*	0.022	0.036	0.005	0.035*
	(-0.09)	(0.28)	(1.06)	(2.13)	(0.03)	(0.03)	(0.47)	(2.06)	(0.30)	(0.30)	(0.42)	(2.08)
L.FDI	**0.439*****	0.181	0.017	0.127**	**0.407*****	0.152	-0.007	0.116**	**0.461*****	0.168	-0.017	0.118**
	(5.05)	(1.56)	(0.21)	(2.69)	**(4.91)**	(1.81)	(-0.11)	(2.32)	**(3.45)**	(1.57)	(-0.23)	(2.53)
L.IMP	-0.284	0.123	0.003	-0.084**	-0.308	0.165	-0.003	-0.058*	-0.303	0.127	0.016	-0.069**
	(-0.90)	(0.62)	(0.06)	(-3.33)	(-1.02)	(0.94)	(-0.06)	(-2.26)	(-1.00)	(0.68)	(0.42)	(-2.72)
L.RWATA	-0.015	-0.002	-0.014	0.013	0.011	-0.017	0.032	-0.013	0.044	-0.005	0.038	-0.001
	(-0.45)	(-0.11)	(-0.24)	(1.36)	(0.20)	(-1.29)	(0.39)	(-1.14)	(0.88)	(-0.35)	(0.72)	(-0.12)
L.CRGDP	0.007	-0.008	-0.005	-0.021***	0.009	-0.005	0.001	-0.014**	0.014	-0.009	0.001	-0.017**
	(0.58)	(-1.13)	(-0.34)	(-3.78)	(0.78)	(-1.11)	(0.07)	(-2.62)	(1.06)	(-1.42)	(0.10)	(-3.12)
CONS	1.279	-0.350	0.140	-0.945	-0.058	0.434	-1.907	0.364	-2.009	-0.215	-2.568	-0.248
	(0.66)	(-0.39)	(0.06)	(-1.80)	(-0.02)	(0.73)	(-0.54)	(0.63)	(-0.65)	(-0.39)	(-0.85)	(-0.44)
R^2	0.13	0.12	0.02	0.28	0.13	0.18	0.03	0.29	0.17	0.12	0.05	0.26
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	34.54	41.46	1.14	11.58	35.89	15.02	1.88	26.40	8.40	61.97	1.48	10.09
CI	21.27	19.60	15.12	35.34	25.16	19.28	16.00	35.80	28.41	21.14	17.19	36.00

Table IV: Spillover - LTD

The results below are from running equations (V.2) and (V.3) for the six bank samples using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given in brackets below the coefficients. * $p < 0.05, **p < 0.01, ***p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.007	**0.067*** **	0.008	0.011	0.001	**0.056***	0.008	0.010	-0.003	**0.046****	0.008	0.009
	(-0.56)	**(3.59)**	(1.85)	(1.18)	(0.03)	**(2.05)**	(1.10)	(1.03)	(-0.29)	**(2.47)**	(1.42)	(0.99)
L.FDI	0.011	0.001	-0.042	0.050	0.008	0.002	-0.026	0.052*	0.011	0.021	-0.022	0.047
	(0.22)	(0.03)	(-1.79)	(1.72)	(0.34)	(0.11)	(-1.50)	(2.00)	(0.36)	(1.32)	(-1.22)	(1.82)
L.IMP	0.074	-0.004	0.001	-0.009	0.107	0.043	-0.008	-0.007	0.086	-0.044	-0.005	-0.011
	(0.92)	(-0.02)	(0.06)	(-0.56)	(1.31)	(0.25)	(-0.49)	(-0.49)	(1.14)	(-0.25)	(-0.32)	(-0.87)
L.RWATA	-0.006	0.002	-0.013	-0.006	-0.002	0.002	-0.013	0.007	-0.006	0.006*	-0.024*	0.003
	(-1.11)	(0.24)	(-1.33)	(-1.24)	(-0.17)	(0.16)	(-0.92)	(1.25)	(-1.05)	(1.94)	(-2.00)	(0.61)
L.LTD	0.002	-0.000	0.006	-0.001	0.005	0.006	0.004	0.000	**0.005***	0.008	0.006	0.003
	(1.24)	(-0.21)	(1.48)	(-0.49)	(1.83)	(1.00)	(0.81)	(0.03)	**(2.15)**	(1.48)	(1.10)	(1.46)
CONS	0.660	0.338	1.009	1.025**	-0.111	-0.549	1.429*	0.348	0.147	-0.781	1.755**	0.219
	(1.58)	(0.63)	(0.91)	(3.15)	(-0.14)	(-0.64)	(1.89)	(1.26)	(0.31)	(-1.50)	(2.77)	(0.57)
R^2	0.13	0.09	0.17	0.29	0.16	0.18	0.09	0.30	0.16	0.28	0.17	0.31
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	0.83	10.68	2.49	1.30	1.50	6.41	1.13	1.38	2.88	4.67	2.88	2.39
CI	20.89	18.64	18.10	17.33	21.30	23.31	19.79	17.45	23.99	25.54	21.75	19.76
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	0.005	**0.070****	0.007	0.010	-0.003	**0.065*** **	0.006	0.010	-0.005	**0.060*** **	0.007	0.009
	(0.42)	**(3.18)**	(1.22)	(1.66)	(-0.38)	**(3.76)**	(1.19)	(1.14)	(-0.59)	**(3.72)**	(1.55)	(1.08)
L.FDI	0.025	-0.027	-0.003	0.063*	-0.009	-0.002	-0.009	0.054	-0.012	0.010	0.002	0.052
	(0.76)	(-1.00)	(-0.15)	(2.04)	(-0.31)	(-0.12)	(-0.48)	(1.77)	(-0.43)	(0.40)	(0.11)	(1.56)
L.IMP	0.096	-0.057	-0.003	-0.010	0.093	-0.029	-0.002	-0.007	0.103	-0.047	-0.020	-0.007
	(1.81)	(-0.31)	(-0.19)	(-0.75)	(1.26)	(-0.15)	(-0.12)	(-0.45)	(1.68)	(-0.22)	(-1.03)	(-0.36)
L.RWATA	-0.004	0.011	-0.034**	-0.004	0.008	0.007	-0.020	-0.002	-0.009	0.009	-0.034***	-0.001
	(-0.45)	(1.55)	(-2.84)	(-0.97)	(1.17)	(0.60)	(-1.02)	(-0.26)	(-1.84)	(1.00)	(-3.65)	(-0.05)
L.LTD	**0.005***	0.002	0.006	0.001	**0.007****	0.001	0.012	0.000	**0.008*** **	0.003	0.015	0.001
	(2.23)	(1.29)	(1.53)	(1.21)	**(2.51)**	(0.86)	(1.36)	(0.07)	**(2.53)**	(1.81)	(1.59)	(0.17)
CONS	0.063	-0.336	2.211**	0.745***	-0.601	-0.058	1.116	0.795**	0.205	-0.305	1.874*	0.697
	(0.10)	(-0.85)	(2.57)	(4.17)	(-0.84)	(-0.16)	(0.68)	(2.60)	(0.33)	(-0.94)	(1.92)	(1.44)
R^2	0.14	0.24	0.24	0.34	0.14	0.14	0.19	0.28	0.17	0.18	0.29	0.28
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	6.37	5.92	36.10	1.79	49.97	33.15	7.35	1.57	4.60	10.59	15.66	1.72
CI	20.48	21.84	27.68	19.18	27.75	21.96	17.18	17.46	28.58	23.50	18.16	19.11

Table V: Spillover - LIQR

The results below are from running equation (V.4) for the six samples of banks using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given between brackets below the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.008	**0.069****	0.010	0.011	-0.001	**0.041****	0.011*	0.017*	-0.002	**0.043****	0.010*	0.017*
	(-0.78)	**(3.35)**	(1.70)	(1.13)	(-0.07)	**(2.66)**	(2.16)	(1.94)	(-0.25)	**(3.06)**	(2.04)	(1.98)
L.FDI	0.009	-0.009	-0.012	0.052	0.052	-0.025	-0.013	0.073**	0.008	-0.009	-0.009	0.074**
	(0.23)	(-0.22)	(-0.74)	(1.72)	(1.41)	(-0.62)	(-0.69)	(2.98)	(0.25)	(-0.28)	(-0.44)	(2.48)
L.IMP	0.096	-0.036	-0.015	-0.008	0.083	0.026	-0.011	-0.020*	0.098	0.002	-0.018	-0.020*
	(1.39)	(-0.17)	(-0.92)	(-0.52)	(1.08)	(0.18)	(-0.79)	(-2.27)	(1.14)	(0.01)	(-0.87)	(-1.97)
L.RWATA	-0.006	0.004	-0.014	-0.006	0.003	0.007	-0.012	0.008	0.005	0.010*	-0.011	0.007
	(-0.85)	(0.47)	(-1.07)	(-1.52)	(0.37)	(0.97)	(-1.10)	(1.35)	(0.92)	(2.27)	(-0.78)	(1.16)
L.LIQR	-0.008	0.011	**-0.020*****	0.000	**-0.015****	0.007	**-0.026*****	**-0.013***	**-0.015***	0.005	**-0.025***	**-0.013***
	(-1.40)	(1.02)	**(-4.71)**	(0.02)	**(-2.37)**	(0.98)	**(-3.70)**	**(-1.99)**	**(-2.01)**	(0.76)	**(-2.10)**	**(-2.30)**
CONS	1.017*	0.002	2.457**	0.972**	0.674	-0.119	2.383***	0.582*	0.591	-0.138	2.496***	0.568*
	(2.29)	(0.00)	(3.21)	(3.25)	(1.05)	(-0.28)	(3.80)	(2.07)	(1.39)	(-0.43)	(5.50)	(2.12)
R^2	0.15	0.13	0.19	0.29	0.20	0.14	0.23	0.38	0.16	0.17	0.21	0.38
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	1.78	8.66	7.47	1.67	2.41	7.85	7.13	3.65	4.81	12.83	5.92	2.47
CI	33.99	30.07	22.13	44.54	26.23	40.64	24.69	24.52	25.25	36.37	24.34	27.33
SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.002	**0.082*****	0.009*	0.012**	0.000	**0.066*****	0.007	0.011	-0.002	**0.064*****	0.006	0.011
	(-0.18)	(3.68)	(2.10)	**(2.34)**	(0.04)	(3.70)	(1.19)	(1.10)	(-0.14)	**(3.63)**	(0.93)	(1.19)
L.FDI	0.005	-0.018	-0.004	0.058	-0.015	0.002	-0.011	0.055	0.012	0.015	-0.011	0.054
	(0.13)	(-0.65)	(-0.20)	(1.65)	(-0.45)	(0.09)	(-0.51)	(1.84)	(0.29)	(0.64)	(-0.56)	(1.83)
L.IMP	0.089	-0.074	-0.004	-0.009	0.103	-0.032	-0.002	-0.008	0.096	-0.023	-0.005	-0.009
	(1.20)	(-0.43)	(-0.22)	(-0.76)	(1.17)	(-0.16)	(-0.15)	(-0.46)	(1.26)	(-0.12)	(-0.21)	(-0.42)
L.RWATA	0.002	0.008	-0.032*	-0.006	0.009	0.007	-0.025	-0.002	-0.005	0.009	-0.024**	-0.000
	(0.17)	(1.43)	(-2.14)	(-1.12)	(1.22)	(0.59)	(-1.02)	(-0.32)	(-0.79)	(0.85)	(-2.56)	(-0.04)
L.LIQR	-0.012	**-0.010****	-0.007	-0.008	**-0.018***	-0.003	-0.005	0.001	-0.013	-0.003	**-0.024***	0.005
	(-0.92)	**(-2.48)**	(-0.50)	(-1.36)	**(-2.04)**	(-1.42)	(-0.24)	(0.76)	(-1.69)	(-1.64)	**(-2.03)**	(1.60)
CONS	0.652	0.308	2.968***	1.110**	0.343	0.177	2.721**	0.773**	0.993*	0.043	3.095***	0.630
	(0.97)	(0.94)	(4.03)	(3.12)	(0.64)	(0.85)	(2.68)	(2.87)	(2.21)	(0.12)	(3.71)	(1.65)
R^2	0.10	0.21	0.21	0.36	0.13	0.14	0.13	0.28	0.12	0.13	0.21	0.29
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	1.54	20.26	3.33	1.85	48.34	87.76	1.84	1.66	2.14	7.40	9.10	1.23
CI	26.91	30.47	20.81	22.71	28.55	21.66	33.94	18.24	29.13	24.24	30.10	19.31

Table VI: Contagion - LIQR

The results below are from running equation (V.4) for the six samples of banks using all EU countries in our dataset. L. denotes lagged values. Highlighted cells are factors mostly consistent across bank samples. t-stats are given between brackets below the coefficients. * $p < 0.05$, $**p < 0.01$, $***p < 0.001$.

SAMPLE	IMF				Top200				Top10			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.017	-0.060	0.011	0.008	0.008	0.012	0.008	0.023	-0.006	-0.021	0.005	0.015
	(-0.30)	(-0.88)	(0.73)	(0.42)	(0.10)	(0.15)	(0.46)	(1.69)	(-0.12)	(-0.27)	(0.65)	(1.00)
L.FDI	**0.418****	0.121	0.014	0.035	**0.498****	0.184	0.008	0.082	**0.368*****	0.137	0.004	0.072
	(3.00)	(1.07)	(0.24)	(0.64)	**(3.15)**	(1.66)	(0.12)	(1.84)	**(4.01)**	(1.26)	(0.05)	(1.44)
L.IMP	-0.296	0.163	-0.004	-0.021	-0.292	0.090	0.003	-0.052**	-0.265	0.144	-0.003	-0.031
	(-0.89)	(0.73)	(-0.10)	(-0.79)	(-0.90)	(0.64)	(0.09)	(-2.55)	(-0.84)	(0.88)	(-0.08)	(-1.41)
L.RWATA	0.000	0.005	-0.019	0.006	0.024	-0.013	0.003	-0.016	0.015	-0.007	0.032	-0.012
	(0.01)	(0.16)	(-0.53)	(0.18)	(0.50)	(-0.70)	(0.06)	(-1.32)	(0.45)	(-0.56)	(0.75)	(-0.84)
L.LIQR	-0.012	-0.015	0.002	-0.012	-0.029	-0.020	0.003	**-0.028****	-0.005	-0.008	-0.006	**-0.014****
	(-0.37)	(-0.83)	(0.04)	(-0.68)	(-1.02)	(-1.27)	(0.06)	**(-2.80)**	(-0.11)	(-0.81)	(-0.14)	**(-2.47)**
CONS	0.860	-0.085	0.480	0.085	-0.121	0.836	-0.600	1.414**	-0.090	0.224	-1.654	0.812
	(0.38)	(-0.07)	(0.27)	(0.07)	(-0.04)	(1.02)	(-0.29)	(2.34)	(-0.04)	(0.34)	(-0.82)	(1.04)
R^2	0.13	0.08	0.03	0.05	0.15	0.14	0.02	0.21	0.13	0.08	0.04	0.11
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	57.71	4.23	2.43	0.60	30.10	1.25	2.05	7.76	11.18	1.15	1.47	4.23
CI	33.99	30.07	32.13	44.54	26.23	40.64	25.69	24.52	25.25	36.37	24.34	27.33

SAMPLE	Top30				FullRank				FullSample			
PARTNER	US		EU		US		EU		US		EU	
PERIOD	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007	Post-2007	Pre-2007
L.FC	-0.010	-0.004	0.010	0.012	0.007	-0.049	0.003	0.001	0.004	-0.052	0.004	0.004
	(-0.18)	(-0.06)	(0.97)	(1.70)	(0.11)	(-0.88)	(0.20)	(0.06)	(0.06)	(-0.70)	(0.26)	(0.25)
L.FDI	**0.408*****	0.146	0.005	0.042	**0.324*****	0.115	-0.055	0.050	**0.426*****	0.086	-0.023	0.035
	(6.40)	(1.79)	(0.06)	(1.06)	**(3.58)**	(1.82)	(-0.62)	(1.10)	**(5.27)**	(1.13)	(-0.36)	(0.63)
L.IMP	-0.274	0.045	-0.006	-0.026**	-0.184	0.122	0.003	-0.008	-0.287	0.130	0.027	-0.008
	(-0.78)	(0.24)	(-0.13)	(-2.61)	(-0.58)	(0.97)	(0.07)	(-0.46)	(-0.89)	(0.68)	(0.62)	(-0.31)
L.RWATA	-0.001	-0.010	0.015	-0.009	0.029	-0.019*	0.073	-0.021**	0.041	-0.009	0.041	-0.013
	(-0.04)	(-1.17)	(0.24)	(-1.22)	(0.55)	(-1.90)	(0.91)	(-2.77)	(0.89)	(-0.66)	(0.83)	(-0.80)
L.LIQR	-0.041	**-0.020****	-0.052	**-0.020*****	-0.093	**-0.012*****	-0.130	**-0.011****	-0.032	**-0.010****	-0.023	**-0.009****
	(-0.56)	**(-3.06)**	(-0.78)	**(-6.37)**	(-1.51)	**(-6.12)**	(-1.57)	**(-2.87)**	(-1.39)	**(-3.26)**	(-0.40)	(-2.82)
CONS	1.316	0.828*	-0.239	0.856***	0.280	1.106**	-1.871	1.446***	-1.189	0.514	-2.485	0.829
	(0.80)	(1.92)	(-0.11)	(3.49)	(0.11)	(2.54)	(-0.67)	(4.88)	(-0.47)	(0.87)	(-0.83)	(1.21)
R^2	0.14	0.19	0.04	0.20	0.18	0.25	0.13	0.23	0.17	0.08	0.05	0.07
Num Obs	36	38	36	38	36	38	36	38	36	38	36	38
F-stat	23.20	34.19	1.80	48.10	25.12	12.70	3.43	13.60	14.21	4.57	2.36	4.20
CI	29.91	27.47	20.81	22.71	28.55	21.66	33.94	18.24	29.13	24.24	30.10	19.31

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