Systemic Risk and Macroprudential Supervision in Europe: Lessons from a Change-Point Exploration of Evidence from the NYU Volatility-Lab

April 2016

Name of Thesis Advisor: Prof. Mark Hallerberg

Laurence Hendry, Master of Public Policy 2016

Lukas Müller, Master of Public Policy 2016

Hertie School of Governance

Executive Summary

We are skeptical of efforts by policymakers to recover and strengthen the European Union financial system since the 2007-08 Global Financial Crisis (GFC), and aim to help understand the effectiveness of their responses. Using NYU V-Lab's SRISK data to measure systemic risk, we provide an explorative *ex-post* study of two macroprudential policies of the European Commission: The Capital Requirement Regulation/Capital Requirement Directive IV (CRR/CRD IV; proposed in 2011) and the Bank Recovery and Resolution Directive (BRRD; proposed in 2012). We hypothesize that both policies contributed to a reduction in systemic risk for financial institutions within the EU.

For primary research, we conduct interviews with relevant decision-makers and professionals, which we use to derive five key policy event dates. We then quantitatively detect change points in SRISK data prepared for 234 financial institutions and use this to test for responses to policy event dates within a lead and lag period of 14 days. Finally, we propose an indicator to measure policy-SRISK effects: If a change point occurred in a specified timeframe for a policy event date then our indicator returns whether this change was an improvement (a reduction in SRISK) or a deterioration (an increase in SRISK). We find more deteriorations than improvements occurred in SRISK performance of financial institutions. We thus reject our H_1 and hazard that the CRR/CRD IV and the BRRD failed to reduce systemic risk in financial institutions within the EU around key policy event dates.

Our study takes cues from the latest innovations in statistical methods and risk management that can be used to improve policymaking through future research. All data and code necessary to reproduce this study is available online.

Acknowledgments

In pursuing this study we have borrowed a lot from other people's time, thoughts, and – frequently – patience. We thank them here.

First and foremost, the acquaintances made at the 2015 Financial Stability Conference who encouraged us with our study, many of whom later took valuable time out to discuss and share their professional opinions and advice at interviews.

The inception for many of the ideas, resources and methods connected together in this paper would not have been possible without stimulating conversations and colloquiums with Professors Bernoth (DIW), Koenig (DIW), our advisor Professor Hallerberg (Fiscal Governance Center), students of the Hertie School (Lars Mehwald & Matthias Weierer) and Michael Robles from the NYU V-Lab team. We thank Professors Bremus and Gandrud for making new concepts, such as systemic risk measures and change point algorithms, appear a lot less intimidating. The Hertie IT Department for providing us with the processing power to run our algorithm. Professor Enderlein, who we score a solid 8/10 (we were told we are not allowed to use 7), for his invigorating moderation of the "Crisis Prevention and Macroprudential Policy: Mission Impossible?" panel and prescient commentary at the "The Big Short" premiere.

Finally our families, who support us and hosted two 'thesis boot camps'.

List of Abbreviations

AMCs – Asset Management Companies

BIS – Bank for International Settlements

BRRD – Bank Recovery and Resolution Directive

CRR/CRD IV – Capital Requirement Regulation/Capital Requirement Directive IV

DGSD – Deposit Guarantee Schemes Directive

EBA – European Banking Authority

EC – European Commission

EFSF – European Financial Stability Facility

EFSM – European Financial Stabilisation Mechanism

EIOPA – European Insurance and Occupational Pensions Authority

EIOPA – European Insurance and Occupational Pensions Authority

ESAs – European Supervisory Agencies

ESAs – European Supervisory Authorities

ESFS – European System of Financial Supervision

ESM – European Stability Mechanism

ESMA – European Securities and Markets Authority

ESMA – European Securities and Markets Authority

ESRB – European Systemic Risk Board

G-SIIs – Global Systemically Important Institutions

GAAP – Generally Accepted Accounting Principles

GFC – Global Financial Crisis

ICAAP – Internal Capital Adequacy Assessment Process

IFRS – International Financial Reporting Standards

LSE – Used to refer to Systemic Risk Centre of the London School of Economics

O-SIIs – Other Systemically Important Institutions

PRA – Prudential Regulation Authority

RWA – Risk Weighted Assets

SRM – Single Resolution Mechanism

SSM – Single Supervisory Mechanism

Table of Contents

Figures & Tables

1. Introduction

We are skeptical of some of the efforts of professionals managing the financial system of the European Union, and seek to test their preparation for the next financial crisis by econometrically responding to their statements. Our aim is to help policymakers understand the effectiveness of their management.

The effects of the 2007-08 GFC have posed a painful and enduring burden on the 'crisis children' of Europe today. At the 2015 European Financial Stability Conference the authors approached professionals, who introduced themselves as the latest and most qualified stewards of Europe's financial systems, to present our concerns for macroprudential policies and the prevention of future financial – and generational – crises.

Have macroprudential policies been reducing systemic risk for European financial institutions?[1] How do governors and researchers of financial systems measure systemic risk? And do econometric methods exist that can help our investigation of policy success? In this paper we provide an explorative, *ex-post* study for two prominently-identified macroprudential policies, designed with a post-GFC "lesson learned"-character: The CRR/CRD IV and the BRRD.

Our paper is structured as follows: A statement of our research question and hypotheses (2), a literature review of systemic risk including the work of the NYU Volatility-Lab (3.1), background information on our two policies (3.2) and an explanation of institutional and theoretical frameworks (3.3). We then explain the steps taken in our qualitative and quantitative research methods and provide a comprehensive discussion on SRISK and the application of econometric change point analysis (4). Finally, we turn to our main results and analysis for the CRR/CRD IV and the BRRD (5) and suggest avenues for future research (6).

[1] For our definition of financial institutions see 4.2.1.

2. Research Question and Hypotheses

Did the European Commission CRR/CRD IV and BRRD reduce systemic risk of financial institutions in the EU? Does our proposed policy-SRISK performance indicator show a higher number of improvements than deteriorations for key policy event dates?

H_1: The CRR/CRD IV reduced systemic risk of financial institutions in the EU. Our proposed policy-SRISK performance indicator shows a higher number of improvements than deteriorations.

H_1: The BRRD reduced systemic risk of financial institutions in the EU. Our proposed policy-SRISK performance indicator shows a higher number of improvements than deteriorations.

3. Macroprudential Supervision & Systemic Risk in the EU

In our first step we provide an extensive literature review on the academic debate surrounding systemic risk. We then introduce our two macroprudential policies of interest: The CRR/CRD IV and the BRRD. Finally, we contextualize the two policies within an institutional framework for Europe and provide a theoretical framework for our research.

3.1. Systemic Risk Literature Review

In the course of our qualitative research, one interviewed professional described the ongoing academic debate about systemic risk as a 'true war of definition'. Far from being settled, the debate on how to operationalize systemic risk remains highly complex and multilayered. Before introducing controversial discussion – can we find evidence of agreement in at least some areas?

First, agreement that systemic risk exists as a concept appears widely accepted – despite confusion as to its constituents and causes. Or, as Gerlach states, "while the notion of systemic risk is clear, there is no agreement among regulators and academics about how best to operationalize it" (Gerlach, 2009).

Secondly, scholars most commonly agree on the negative chain of consequences that follow from very high levels of systemic risk: The higher the systemic risk, the higher the likelihood of undercapitalization and failure of the financial sector to provide financial intermediation, and – ultimately – the higher the likelihood of spillover-effects into the real economy (e.g. Acharya, Brownlees, Engle, Pedersen, & Philippon, 2010; Borio & Drehmann, 2009; Cerutti, Claessens, & McGuire, 2012; LSE Systemic Risk Centre, 2015; Reinhart & Rogoff, 2008).

The third commonly shared view refers to one of the key, overarching source of systemic risk: the phenomenon of globalization and the rise of

complexity in financial services (e.g. Altunbas, Marqués-Ibáñez, & Manganelli, 2011; Cerutti, Claessens, & Laeven, 2015).

How is it that so much agreement on the origins and consequences of systemic risk can be established when the concept of systemic risk lacks a universal definition and understanding of its operation? This nebulous concept calls for an exhaustive review of the academic approaches. We limit our focus to the systemic risks arising from and within the banking sector (although application to the wider financial sector is occasionally considered) in line with the majority of studies (Cerutti et al., 2012).

A 2009 statement of the IMF provides insight on the challenges to conducting a useful literature review: "Systemic risk is a term that is widely used, but is difficult to define and quantify. Indeed, it is often viewed as a phenomenon that is there "when we see it", reflecting a sense of a broad-based breakdown in the functioning of the financial system, which is normally realized, *ex-post*, by a large number of failures of financial institutions (usually banks)" (International Monetary Fund, 2009). We find this statement helpful to structure our literature review in two sections. In a first step, we summarize studies investigating on definitions and potential sources of systemic risk. In the second step, we turn to studies aiming to assess and identify systemic risk.

Overlap between these sections exists. For example, the controversy over where systemic risk originates might, at the same time, be relevant to constitutive terms on how to assess systemic risk. In the last step of this section, we provide a brief overview of studies specifically applying NYU V-Lab's SRISK data.

3.1.1. Definitions and Sources

The 2001 report of the G-10 provides a straightforward definition of systemic risk as: „the risk that an event will trigger a loss of economic value or

confidence in, and attendant increases in uncertainly about, a substantial portion of the financial system […]. Systemic risk events can be sudden and unexpected, or the likelihood of their occurrence can build up through time in the absence of appropriate policy responses“ (Group of Ten, 2001). However, this approach differs significantly from post-GFC definitions as it suggests an interpretation of systemic risk as a fully exogenous event. Post-GFC definitions may take truly exogenous events (e.g. natural disasters) into account, but emphasize their endogenous character (Hendricks, 2009). For example, various studies make the assumption that systemic risk builds up from within by examining banking linkages as trigger (e.g. Cetorelli & Goldberg, 2010; Huang, Zhou, & Zhu, 2011). This is in line with the Systemic Risk Centre of the LSE where they state “systemic risk refers to the risk of a breakdown of an entire system rather than simply the failure of individual parts” (LSE Systemic Risk Centre, 2015). The LSE further distinguishes systemic risk from ‘idiosyncratic risks’, described as only affecting single institutions or assets (LSE Systemic Risk Centre, 2015).

Given the definitions by the LSE and the IMF, we see systemic risk going beyond the micro-level of balance sheets or profit/loss information of the individual institution and what has become known within the field as ‘bank risk’. While bank risk is usually not used synonymously, it remains a highly relevant constitutive term for systemic risk (Laeven, Ratnovski, & Tong, 2014). The field provides evidence for various sources of bank risk, especially for the GFC. Noth and Tonzer test four main proxies (Z-Score, risk through non-performing assets, loan loss provisions and loan loss reserves) of bank risk (Noth & Tonzer, 2015). Of these, the former mentioned Z-Score (Altman, 1977) is especially popular (Almamy, Aston, & Ngwa, 2016; Lepetit & Strobel, 2015). Other studies focus on the relationship between bank risk and securitization processes (Keys, Mukherjee, Seru, & Vig, 2010; Mian & Sufi, 2009),

competition, complementarity and co-evolution as interaction terms between banks (Song & Thakor, 2010), corporate governance (Laeven & Levine, 2008) and diversification strategies (Stiroh & Rumble, 2006).

Altunbas et al. develop the idea that each and every individual bank contributes its own share of the total systemic risk and that it is indeed possible to measure this share individually. Their model calculates systematic risks for each bank using daily information from Datastream and excess stock market returns (Altunbas et al., 2011). Eijffinger finds that some studies rather define and frame systemic risk through the presence or absence of financial stability (Eijffinger, 2009). European institutions have traditionally followed this approach, with the ECB defining financial stability as "a condition in which the financial system – intermediaries, markets and market infrastructures – can withstand shocks without major disruption in financial intermediation and in the general supply of financial services" (European Central Bank, 2015a). De Haan et al. distinguish between cyclical and structural forms in their definition of systemic risk. While the structural dimension considers the risk that develops within the financial system, i.e. endogenously, the cyclical dimension contains a time component. In a non-distressed finance system, the authors argue, amplification mechanisms arise through the underestimation of risk and in contrast to a distressed finance system (de Haan, Oosterloo, & Schoenmaker, 2012).

The majority of studies attribute the sources of systemic risk to endogenous reasons. "Systemic risk is when an event with negative consequences takes place that inherently originates from the system itself. For example, a bank run, an infrastructure collapse (e.g. Herstatt crisis in 1974) or a financial market collapse" (Hendricks, 2009). Other studies find that systemic risk "can in theory arise from the failure of one financial institution, the much more

important systemic risk arises from a common exposure of many financial institutions to the same risk factors" (de Haan et al., 2012).

The LSE argues in line with this thinking. It traces systemic risk back to three key elements: Firstly, that systemic risk is endogenously created by, and within, the system. Secondly, that systemic risk worsens through amplification mechanisms (especially feedback loops). And thirdly, that well intentioned but poorly implemented and/or constructed policy responses to reduce systemic risk have adverse effects (LSE Systemic Risk Centre, 2015).

The influence of financial institution size as a contributing factor in systemic risk is heavily discussed in the field. On the one side scholars argue that, beyond certain thresholds, larger financial institutions attract relatively higher systemic risk (Laeven et al., 2014). Huang, Zhou and Zhu find that individual contributions to systemic risk are approximately linear, but highly nonlinear regarding size (Huang et al., 2011). The consequences of passing the threshold point of when an individual institution becomes 'too-big-to-fail' include neglecting key diversification necessities and improving incentive structure (e.g. Demirgüç-Kunt & Huizinga, 2013). Drehmann and Tarashev find that size is positively correlated with interconnectedness, which they argue to be another key driver of systemic risk (Drehmann & Tarashev, 2011). On the other side, and to the contrary, López-Espinosa et al. find no evidence that larger size increases relative systemic risk (López-Espinosa, Moreno, Rubia, & Valderrama, 2012).

Going beyond the size of individual institutions, in 2014 the European Systemic Risk Board (ESRB) tackled the question whether the European system is "overbanked". Treating the European banking system as their "overweight patient", the ESRB conducts a comparative investigation into the systemic size, concentration and leverage, the excessive private credit creation and excessive non-bank activities of European banks. Under their 'therapy and

diagnosis' they conclude size has indeed become problematic for sustaining financial stability and a low level of systemic risk (European Systemic Risk Board, 2014). Reinhart and Rogoff argue that, historically, and especially throughout the GFC, key drivers of systemic banking crises (i.e. the actual consequences of too high systemic risk after a breakpoint that is still unkown to the field) are asset price bubbles, large capital inflows and credit booms (C. M. Reinhart & Rogoff, 2009).

3.1.2. Assessment and Identification

The majority of studies aiming to assess and identify systemic risk share two characteristics. Firstly, most studies have an *ex-post* structure for the simple reason that "it is easier to look back and agree that a disruption was, in fact, systemic" (International Monetary Fund, 2009). Put differently: "Analysis of endogenous risk suggests such widely available market-based indicators react only after a crisis is underway, not before" (LSE Systemic Risk Centre, 2015), and that 'there now exists reconstructive logic, logic that might not have been there originally' before the Euro-crisis (contact from 22/12/2015 with officer at European Stability Mechanism). Secondly, the starting point for most assessments is often times at the micro-level that is then taken further to the macro-level during the phase of analysis: "The approach often taken at central banks and supervisory agencies is to identify systemic risk using disaggregated data, including information on the composition of banks' assets and liabilities, maturity and currency mismatches, and other balance sheet and income metrics" (Cerutti et al., 2012). In this regard, Stein offers a valuable contribution. The author argues that most studies in the field emphasize banks' interlinkages as key drivers of systemic risk and discusses how to assess and structure e.g. aggregated vs. micro with linked vs. unlinked data (Stein, 2013). Gerlach suggests to measure systemic risk in three steps: Firstly with aggregate

indicators of financial soundness. Secondly, with measuring the conditions of individual institutions and, lastly, by assessing systemic linkages (Gerlach, 2009).

Segoviano and Goodhart construct a banking stability index and estimate dependency through international banks' credit spreads (Segoviano & Goodhart, 2009). González-Hermosillo and Hesse assess systemic risk through indicators (e.g. forex swap, TED spread) and their respective levels of volatility (González-Hermosillo & Hesse, 2009). Adrian and Brunnermeier suggest measuring systemic risk via their CoVar – a variable extending the competitive value at risk (VaR) approach. The VaR of an institution is measured conditional on 'normal' circumstances and times of distress. The difference is what the authors call the institution's contribution to systemic risk (Adrian & Brunnermeier, 2011). López-Espinosa et al. extend this approach to 54 international banks and find that assesment of systemic risks should include an analysis of banks' short-term wholesale funding (López-Espinosa et al., 2012).

The IMF provides a comprehensive assessment of the systemic implications of financial linkages. The approach focuses on the measurement of systemic risk through traditional accounting balance sheet information, conditional correlation matrices and bank cluster analyses to more sophisticated methods such as Option-IPoD or Markov-regime switching (International Monetary Fund, 2009).

Another comprehensive approach is provided by Cerutti et al. for the Bank for International Settlements (BIS). The authors aim to group primary sources into three categories (Cerutti et al., 2012). A first category summarizes studies using bank balance sheets and data on their level of connectedness on an aggregated level. Examples include the spill-over effects of adverse liquidity shocks between markets through cross-border and affiliates' lending (Cetorelli & Goldberg, 2010), the connection between negative reports of banks' health and a

slowdown in credit to emerging markets (McGuire & Tarashev, 2008). The second category focuses on abundant market data (e.g. in credit spreads and equity prices) and correlation of shocks across different markets. Studies in this category point out the limitations of extrapolation from price mechanisms: While prices may work as measures of market stress, their usage as indicators (e.g. through measuring volatility) of systemic risk can be highly problematic (Borio & Drehmann, 2009). Lehar and Bartram et al. use stock-market data for global banks to infer the likelihood of default (Bartram, Brown, & Hund, 2005; Lehar, 2005). Studies that have an *ex-ante*, predictive character in form of simulations or scenarios, are based in the third category. Studies range from specific analysis of e.g. financial linkages and cross-border exposures between emerging and Western European countries (Árvai, Driessen, & Ötker-Robe, 2009) to more general approaches such as a cross-border bank contagion model (Tressel, 2010).

Finally, what databases exist that can measure systemic risk? The ESRB provides daily aggregate data for the Eurozone and the EU known as the Composite Indicator of Systemic Stress and the Probability of Simultaneous Default (European Systemic Risk Board, 2015). Concurrently, Laeven and Valencia also offer data for all global, systemically important crises from 1970 to 2012 (Laeven & Valencia, 2012). Schularick and Taylor provide data for 14 OECD countries from 1870 to 2008, including information on macroeconomic, money and credit indicators (Schularick & Taylor, 2012). For the dataset used in their study, Reinhart and Rogoff provide data on banking crises, inflation crises, sovereign debt crises and stock market crashes (C. Reinhart & Rogoff, 2016).

3.1.3. Recognition of SRISK in Research

In this section, we briefly summarize a small portion of available studies that apply the NYU V-Lab's SRISK. We distinguish the SRISK operational definition, composition and calculation as a subject for section 4.3.

In a 2014 report, researchers at the ESRB tested the effects of various covariates with SRISK as their dependent variable. The predictors the ESRB selected included bank credit/GDP (1Y lag), log of bank assets (1Y lag), real interest rate, lending margin and GDP growth. They concluded that SRISK is a useful measurement for systemic risk in the European setting (European Systemic Risk Board, 2014).

Additionally, SRISK has been applied to investigate regional- and country-specific differences. Soedarmono uses a sample of publicly-traded commercial banks in Asia from 2002-2008 to understand the consequences of bank capital inflows on SRISK (Soedarmono, 2012). Abdelkader et al. apply SRISK to explain higher degrees of instability of the financial system of Greece (Abdelkader, Slaheddine, & Aida, 2015). Sun & Yu apply SRISK for 31 financial institutions in Taiwan and conclude that SRISK is, amongst others, one helpful tool for "monitoring early warning signals of distress on the real economy" (Sun & Yu, 2016). In the European context, scholars find SRISK helpful for a general understanding of the (in-)stability of the financial system as a whole (Jondeau & Rockinger, 2013) and for assessments of potentially negative effects through monetary policy (Deev & Hodula, 2016). Critical analysis of SRISK itself is provided through the work of Fischer who discusses potential shortcomings (Fischer, 2015) and Guntay & Kupiec who are critical of the reliability of SRISK (Guntay & Kupiec, 2014). Tavolaro & Visnovsky critically discuss whether SRISK is a useful supervisory tool (Tavolaro & Visnovsky, 2014).

3.2. Macroprudential Policies of Interest

The inspiration to study the effects of macroprudential policies on systemic risk were a series of talks at the 2015 Financial Stability Conference on the topic titled "How to design the future EU Financial System? Resolution Framework, Crisis Prevention and Capital Markets Union" (Financial Risk and Stability Network, 2015). Using our understanding of the existing field of research on systemic risk, we now describe the two macroprudential policies under study for this paper.

Macroprudential policies stand in line with the approach of macroprudential supervision, which "focuses, by definition, on the monitoring and assessment of so-called systemic risks within the financial system […]. The intermediate objective of macroprudential supervision is to limit financial system-wide distress, with the ultimate objective of protecting the overall economy from significant losses in real output" (de Haan et al., 2012). For example, higher capital requirements for a financial institution would fall under the macroprudential approach when following de Haan et al. Other scholars would, however, base these requirements in the area of microprudential supervision (e.g. Schoenmaker & Wierts, 2016).

The GFC questioned policy approaches aiming to reduce systemic risk by simply preparing for stress events through higher levels of capitalization (International Monetary Fund, 2009). Prudential regulatory responses focusing on a raise of capital requirements (i.e. Basel I) were proven as obsolete approaches for connecting these requirements with internal risk analysis of the financial institutions (i.e. Basel II) (Altunbas et al., 2011). Two macroprudential policies aiming to correct these failures are of interest for this paper: The Capital Requirement Regulation (Nr. 575/2013)/Capital Requirement Directive IV (2013/36/EU) (CRR/CRD IV) and the Bank Recovery and Resolution Directive (2014/59/EU) (BRRD). We use Commission

nomenclature to refer to the Directive IV and the Regulation as simply CRR/CRD IV (European Commission, 2016). The difference between a regulation and a directive is their force to legally bind: "A regulation is binding in its entirety and is directly applicable in all Member States, and does not require transposition into the respective national laws […] A directive is binding upon each Member State to which it is addressed, but gives national authorities the choice of form and methods" (de Haan et al., 2012).

What constitutes our interest in these two policies? Firstly, both policies were aimed to enhance financial stability (European Commission, 2015b) of the European financial system. Our understanding of financial stability is inherently linked to the reduction of systemic risk. And the approach to systemic risk for this study is, in turn, provided through the NYU V-Lab's SRISK. To the best of our knowledge, no studies on the impact of these two policies on SRISK exist yet. Secondly, and more importantly, the conducted qualitative interviews with professionals (see 4.1) prompted us to investigate these initiatives.

Conceptually, both the CRR/CRD IV and the BRRD are structural policies aiming to reduce negative externalities – as opposed to cyclical policies aiming to only reduce financial imbalances (de Haan et al., 2012). Both policies also share a post-GFC, "lesson-learned" character: One of the major critiques of macroprudential supervision in the immediate years before the GFC (e.g. Basel I and II) was that it sought to limit each financial institutions' risk in isolation (Acharya et al., 2010). In this sense, both policies do take contagion and spillover effects into account, as we will outline below. Also, both policies include anticipatory components: The CRR/CRD IV in form of higher capital requirements and stricter supervision to which financial institutions may adapt earlier. The BRRD carries this component in form of the threats of potential intervention and resolution by supervisory authorities. We will elaborate in the according sections.

While both the CRR/CRD IV and the BRRD address systemic risk as the negative externality in question, their approach remains very different. The CRR/CRD IV directly imposes a change within each financial institution (e.g. through a changing composition of capital requirements and disclosure statements of the leverage ratio). The BRRD only indirectly implies adaption of behavior as a resolution framework: Given the perspective of potential resolution, financial institutions may alter their business model towards less risky behavior.

3.2.1. Capital Requirement Regulation/Capital Requirement Directive IV

With the CRR/CRD IV the EU Commission fulfills the obligation to implement Basel III on the European level:

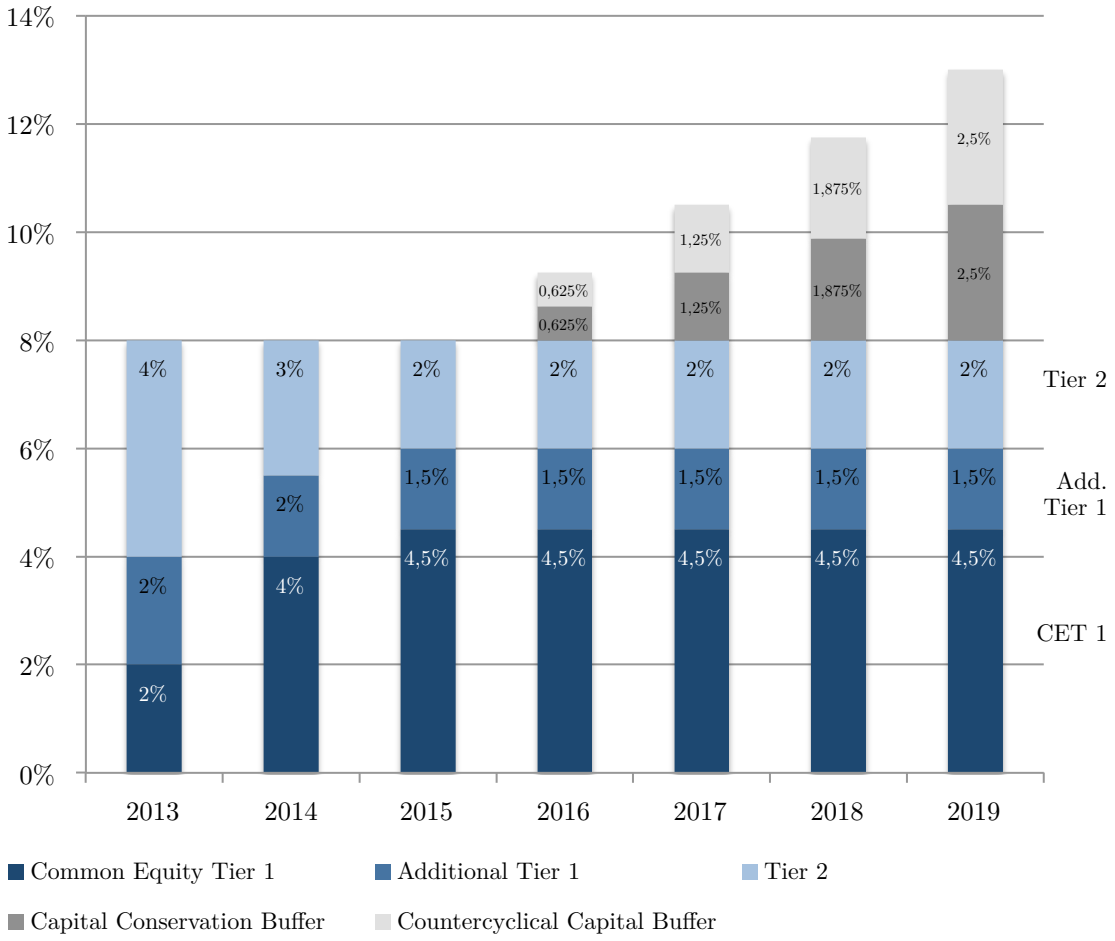
"CRD IV is an EU legislative package covering prudential rules for banks, building societies and investment firms. [It] is intended to implement the Basel III agreement in the EU. This includes enhanced requirements for:

i) the quality and quantity of capital;
ii) a basis for new liquidity and leverage requirements;
iii) new rules for counterparty risk; and
iv) new macroprudential standards including a countercyclical capital buffer and capital buffers for systemically important institutions" (Bank of England, 2013).

Under previous settings, financial institutions held too little liquid funds and capital, which was of bad quality. And financial institutions were too highly leveraged (de Haan et al., 2012). However, compared to the original Basel III agreement, the CRR/CRD IV includes various other requirements: Disclosure statements of the leverage ration, changes in corporate governance or even a

cap on the variable compensation of managers (German Federal Financial Supervisory Authority, 2013). Applicable in all EU member states (i.e. also members outside of the Eurozone) from 01/01/2014, the CRR/CRD IV forces financial institutions to hold a different composition of core capital. Capital requirements in this sense should be understood as "rules that stipulate the minimum amounts of own financial resources that credit institutions and investment firms must have in order to cover the risks to which they are exposed" (de Haan et al., 2012). Financial institutions (with international business models) were forced to hold 8% of their Risk Weighted Assets (RWA) under Basel I (Basel Committee on Banking Supervision, 1988). Under Basel II the basic requirement for financial institutions summed up to 8% of total capital with five components: Core Tier 1 (2%), Non-Innovative T1, Innovative T1, Upper Tier 2 and Lower Tier 2 (Basel Committee on Banking Supervision, 2005). **Figure 1** shows the changes under the CRR/CRD IV for the time period between 2013 and 2019.

Figure 1: Capital Requirements under CRR/CRD IV



NB (German Central Bank, 2013).

From 01/01/2014 until the end of 2015, the CRR/CRD IV expects – similar to Basel II – a basic capital requirement of 8%. However, the composition of the basic requirement is quite different compared to settings under Basel II. Financial institutions need to hold at least 4,5% of CET 1 capital, 1,5% of Additional Tier 1 capital and 2% of Tier 2 capital. Note that for 2014, CET 1 and Tier 2 capital were at slightly different levels. Since the time frame of analysis for this paper ranges until the end of 2015 (see 4.2) our results and findings yield from differences in the actual composition, and anticipation, of higher capital requirements in the future. Additionally, Capital Conservation and Countercyclical Buffers out of CET 1 capital are phased in

from 01/01/2016 (each at 0,625%) until 01/01/2019 (each at 2,5%). Member states may decide to impose additional systemic risk buffers/and or capital buffers for Global Systemically Important Institutions (G-SIIs) and Other Systemically Important Institutions (O-SIIs) from 01/01/2016 onwards (German Central Bank, 2013). Note that financial institutions exist to which different requirements already applied before January 2016. We discuss these institutions specifically below (see 5.2.).

In a retro-perspective, most European banking federations across member states conclude that the CRR/CRD IV had significant impact. The French bank federation states that the "CRR/CRD IV requirements have been a major incentive to increasing the capital of the banking industry" (Federation Bancaire Francaise, 2015). The European Banking Federation concludes similar (European Banking Federation, 2015). The European Banking Authority (EBA) monitors the impact of the CRR/CRD IV on a regular basis. In the latest report of September 2015, the EBA summarizes findings from a sample of 364 European banks, which provided comprehensive non-public confidential data on a best-effort voluntary basis. The study of the EBA mainly focuses on the impact of the CRR/CRD IV on bank's balance sheets. With regards to previous monitoring exercises, the EBA states that more favorable capital ratios, leverage ratios and liquidity standards were achieved (European Banking Authority, 2015). Researchers at the ECB conclude that the economy of the Eurozone experienced minor adverse impacts from the CRR/CRD IV via reduced loan supply. However, these effects were offset with the higher level of resilience of European financial institutions (European Central Bank, 2015b). This finding is in line with previous, *ex-ante* studies that aimed to predict the impact of the CRR/CRD IV. Most notably here is the study of the IMF which predicted a modest increase in lending rates in Europe (Santos & Elliott, 2012), which is in line with various other findings (e.g. Härle et al., 2010; KPMG, 2011).

3.2.2. Bank Recovery and Resolution Directive

The BRRD is "a single rulebook for the resolution of banks and large investment firms in all EU Member States. The new rules will harmonise and improve the tools for dealing with bank crises across the EU. They will also ensure shareholders and creditors of the banks pay their share of the costs through a "bail-in" mechanism" (European Commission, 2014b).

Note that the term "Bank" in the name of the directive is to some degree misleading. The scope of application of the BRRD *de facto* ranges across all EU credit institutions, subsidiaries, large investment firms (initial capital>€730.000) and EU based parent and intermediate financial holding companies (Lintner, 2015).

Starting from 01/01/2015 the BRRD is applicable in all EU member states (European Commission, 2014a). It has its legal basis in Art. 114 of the Treaty on the Functioning of the EU and was first proposed in June 2012 (Valiante, 2014). Note that there are countries whose implementation path took a different time frame. We address these and other issues in more depth under the according Result & Analysis Section (see 5).

One aim of the BRRD is to harmonize future resolution processes of financial institutions in the EU and enhance the provision of information about internal and external cross-border co-operation for the EU. The harmonization is based on the requirement of the production of recovery and resolution plans through national authorities. The BRRD also introduces a bail-in tool that shifts competencies from the given institute to authorities. Recapitalisation of a struggling financial institution can take place by writing-down liabilities or converting them to equity. Lastly, the BRRD delegates the task to establish resolution funds (financed through industry contributions) to member states (Lintner, 2015; Raffan, Newton, Schuster, & Lener, 2014). The striking point is that resolution under the BRRD includes the restructuring of a financial

institution by a resolution authority "at a stage before liquidation" (Lintner, 2015). Under chairman Erkki Liikanen, the High-level Expert Group concluded in 2012: "The proposed Bank Recovery and Resolution Directive gives the resolution authority the powers to require [an institution] to change its legal or operational structure to ensure that it can be resolved in a way that does not compromise critical functions, threaten financial stability or involve costs to the taxpayer" (High-level Expert Group, 2012).

Furthermore, the BRRD distinguishes "between the resolution of financial institutions that have become bankrupt from the recapitalization (also part of the resolution regime) of institutions that have become so fragile as to need intervention and recapitalization, but are not (yet) bankrupt" (Avgouleas & Goodhart, 2014). On the level of the Eurozone (see 3.3.1), the Single Resolution Mechanism (SRM) can be interpreted as a crucial extension of the BRRD (Wolff & Véron, 2013).

3.3. Frameworks

We briefly discuss the European institutional framework for both our macroprudential policies of interest and, in the second section, provide an overarching theoretical framework for our study.

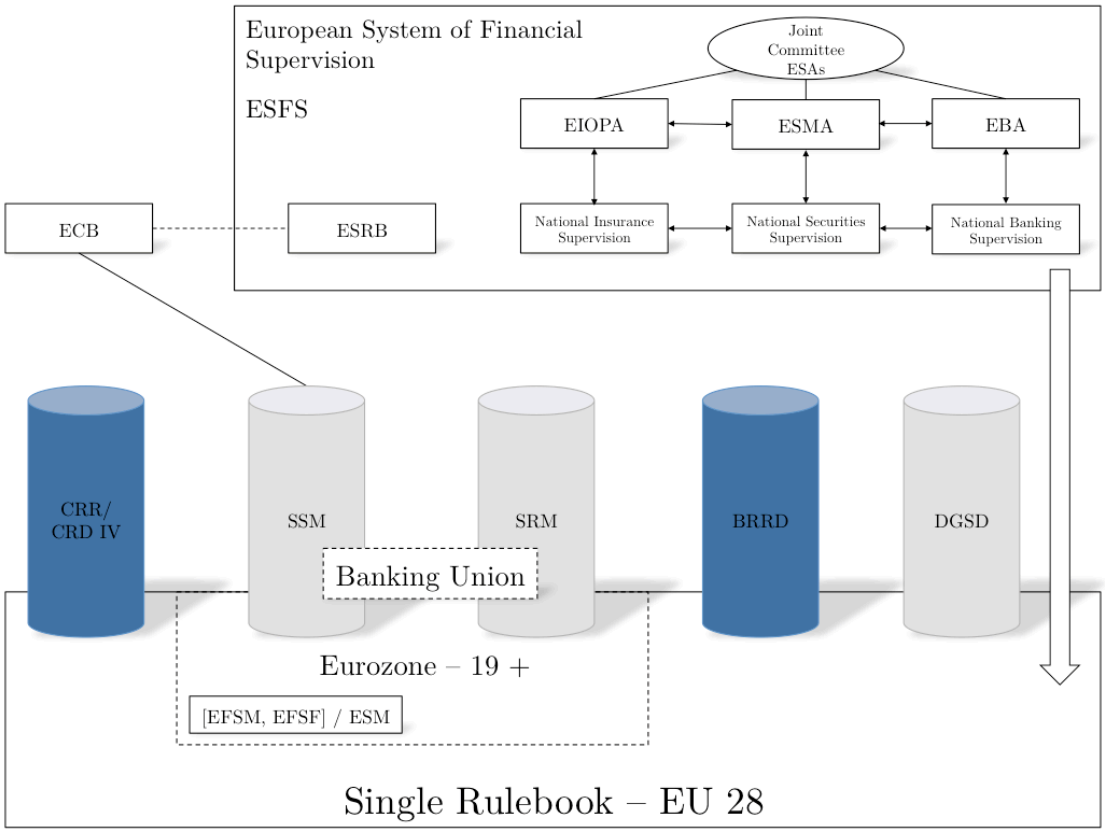
3.3.1. Institutional

In this section we briefly introduce the European institutional framework for the CRR/CRD IV and the BRRD. According to Article 127 (5) and (6) of the Treaty on the Functioning of the European Union, the treaty is "explicit of the principle of decentralization and allocation of regulatory and supervisory power" (de Haan et al., 2012). This principle of decentralization is also reflected in the supervision of the financial system: "The current regulatory system in the EU is based on the principle of home-country control combined with minimum standards and mutual recognition. A financial institution is thus authorized and

supervised in its home country and can expand throughout the EU by offering cross-border services in other EU Member States or establishing branches in these countries without additional supervision by host-country authorities" (de Haan et al., 2012).

Figure 2 presents the decentralization structure and depicts the broader institutional set-up of the CRR/CRD IV and the BRRD. Based on existing supervisory practice and the results of the 2009 de Larosière report, the European System of Financial Supervision (ESFS) was implemented on 01/01/2011. It is essentially based on its three European Supervisory Agencies (ESAs): The European Insurance and Occupational Pensions Authority (EIOPA), European Securities and Markets Authority (ESMA) and the EBA.

Figure 2: Institutional framework of the CRR/CRD IV and the BRRD



NB Figure by the authors. Based on previous work (de Haan et al., 2012; European Banking Authority EBA, 2016; European Commission, 2015; European Systemic Risk Board, 2016; German Federal Financial Supervisory Authority, 2014; Lintner, 2015)

All three ESAs are in constant bilateral exchange as well as through formal joint committees. Additionally, each of the three ESAs interacts with the corresponding national supervisory agency of the 28 member states. The ESFS also includes the ESRB, which is hosted at the ECB and focuses especially on the macro-prudential oversight of the financial system. The ESFS, and here especially the EBA, contribute to the establishment of a Single Rulebook for the 28 member states that aims to harmonize prudential rules across the EU. Three key policies are linked with the Single Rulebook and apply in all 28 member states: The CRR/CRD IV, the BRRD, and the Deposit Guarantee Schemes Directive (DGSD). Finally, the figure also presents the two main pillars of the Banking Union for the 18 members of Eurozone, the Single Supervisory Mechanism (SSM) and the SRM. The ESM, which replaced the transitional arrangements of European Financial Stabilisation Mechanism (EFSM) and the European Financial Stability Facility (EFSF), aims to further enhance financial stability within the Eurozone (de Haan et al., 2012; European Banking Authority, 2016; European Commission, 2015a; European Systemic Risk Board, 2016a; German Federal Financial Supervisory Authority, 2014; Lintner, 2015).

3.3.2. Theoretical

The theoretical framework for this paper builds on the work of Blanchard, Dell'Ariccia, & Mauro in their study "Rethinking Macroeconomic Policy". As the authors point out, pre-GFC regulation and supervision of the financial system (especially with regards to Basel I and II) focused on the individual institution and market – and largely ignored the possibility of contagion, spill-over effects and dependencies. In other words: pre-GFC regulation and supervision neglected to address systemic risk. Macroprudential regulation and supervision were lacking concern in the developments of the

financial sector, with the appetite and research into macroprudential supervision having changed dramatically since the Euro-crisis.

In dramatic contrast, macroprudential policies of the post-GFC generation have a "lesson learned"-character: They take the systemic component of each institution into account. What does the individual institution contribute? How can this contribution be reduced? (Blanchard, Dell'Ariccia, & Mauro, 2010).

Accordingly, the theoretical framework and our argument for this paper are as follows: The SRISK variable represents a measurement that also has a "lesson learned"-character. It provides the systemic risk contribution for each institution and ranks their relative performance within the financial system (see chapter 4.3). Likewise, through the implemented CRR/CRD IV and BRRD policies we observe two macroprudential policies of the new, post-GFC generation that possess this "lesson learned"-character, as well.

If SRISK correctly measures systemic risk as we assume, we are then able to conduct an *ex-post* study determining whether these policies have successfully reduced systemic risk of financial institutions in the European Union.

4. Methodology

In the following sections we discuss the four major methodological steps taken, and their accompanying challenges, for our investigation that combines both qualitative and quantitative sources.

4.1. Qualitative Evidence: Interviews

An important starting-point for this study was for professionals to identify a policy event date in which they expect SRISK to decrease. Based on a collection of interviews hosted between December and January 2015, we identify events and refine these to specific event dates through consultation of relevant literature. We note that from a total of 34 candidates contacted only eight interviews were arranged, with three interviewees not mentioning a specific date in discussion.

The overwhelming majority of candidates were identified, or referred to us by, acquaintances made at the 2015 Financial Stability Conference held in Berlin that both authors attended. The conference pitches itself as "bringing together regulators, industry experts, politicians, scientists and organizations in an international and extraordinary high level public discussion forum [...] attracting many experts, professionals, stakeholders as well as interested persons from different angles and countries" (Financial Risk and Stability Network, 2015). The interviews were conducted in an open format, with candidates asked to formulate a response to two open-ended questions in preparation for our interview:

"Whether, based on your professional background and understanding, you have witnessed a time window in which:

i) A policy or institution significantly influenced systemic risk?

ii) Given two similar groups of financial institutions in a country or region, whether a policy or institution significantly influenced

systemic risk in one country or region, but not the other? (Providing a controlled scenario viz. natural experiment)."

4.1.1. Policy Event Dates

Interviewees were generally reluctant to isolate specific dates, and made us aware of their concerns that a lot of 'noise' is an inherent characteristic of the financial system. Nonetheless, we discovered two key policy events existing in the fore of several of our interviewees' minds: the CRR/CRD IV and the BRRD. Prompted by our interviews, we consulted policy timelines on European Commission (EC) websites to determine three dates for the CRR/CRD IV, as well as two dates for the BRRD, that had occurred in periods of pivotal decision-making discussed (European Commission, 2015b).

Table 1: Interviews prompting policy event dates

Date	Policy Event	Prompted in interview with
CRR/CRD IV		
12.09.2010 (day 40431)	Final Announcement of Basel III by Basel Committee on Banking Supervision	**Office:** City Division, Association of German Banks (BDB) **Date:** 14th December, 2015 **Office:** Economics & Banking Policy Strategy, European Stability Mechanism **Date:** 22nd December, 2015 **Office:** Banking Sector, European Stability Mechanism **Date:** 22nd December, 2015 **Office:** Political Economy cluster, Hertie School of Governance; Member, Jacques-Delors Institute **Date:** January 19th, 2016
20.07.2011 (day 40742)	Original Proposal of European Commission	
01.01.2014 (day 41449)	CRR/CRD IV implemented	
BRRD		
06.06.2012 (day 41064)	European Commission publishes initial proposal	**Office:** Political Economy cluster, Hertie School of Governance; Member, Jacques-Delors Institute **Date:** January 19th, 2016
01.01.2015 (day 42003)	BRRD is applied to all European Member-States	

4.1.2. Natural Experiments

Our original ambition for the second question, to investigate a systemic risk natural experiment, was met with the complaint by one interviewee that such contrasting narratives are rare, and it is difficult to pinpoint a specific sector policy. However, two officers from the ESM and IMF delegation to Brussels did volunteer events:

i) Comparative macroprudential policy responses to the 2008 GFC of central banks in the Baltic states of Latvia, Estonia and Lithuania.

Two key features in this setting were identified: (a) Since the majority of these countries' financial sectors belong to the same group, it is reasonable to expect they would have similar risk practices and sizes, and (b) the macroprudential policy responses were quite different in aim and result between the three countries.

ii) For a discrete event, the prudential capital system reviews and liquidity stress-tests performed in Ireland in March 2011.

iii) For a discrete event, the IMF concessions to a package for the Hungarian financial sector in late-2008. A study investigating how SRISK performed in contrast to similar IMF packages implemented in Romania and Latvia at later stages would yield insight.

Preliminary studies into SRISK performance for these events found that units suffered from highly unbalanced panel data for financial institutions from these countries (Hungary) or unfortunately possessed institutions identified as 'Dead' in our data (Baltic states).

4.2. V-Lab Evidence: Validation, Cleaning & Limitations

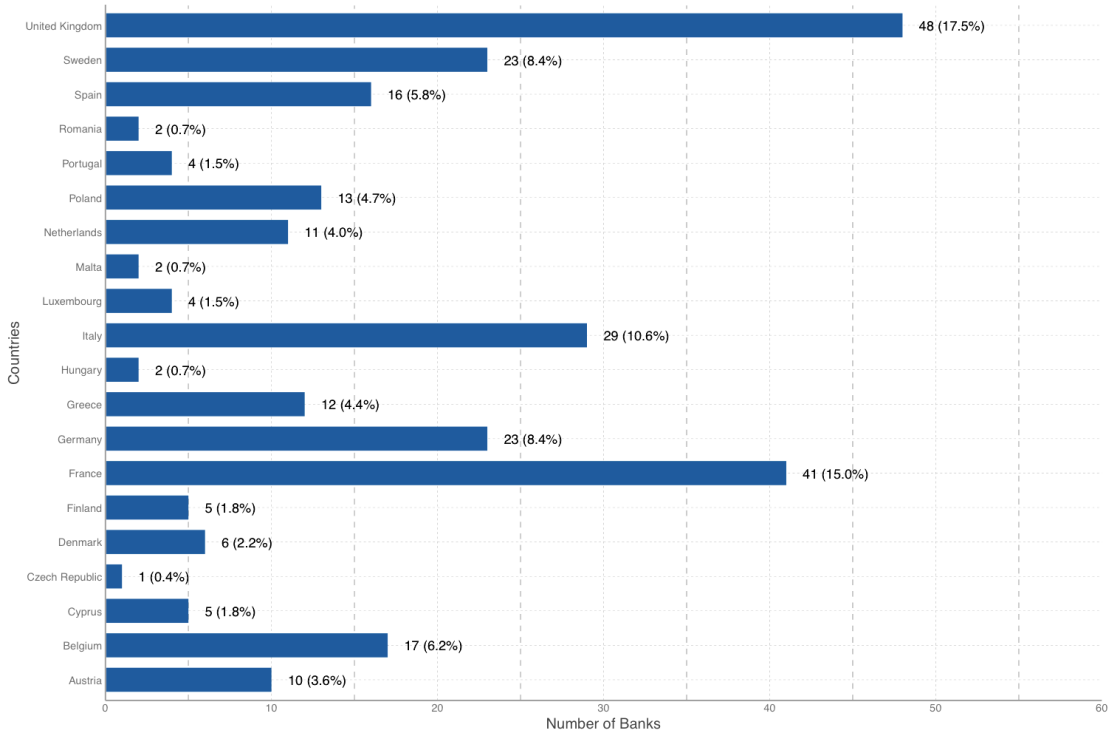
We next describe our data sources, the preparation of our dataset and the limitations we encountered through the transformations conducted.

The NYU V-Lab database is compiled of daily trading and auxiliary data for financial institutions including: leverage positions, capitalisation rates, variance in stock price, market index correlations (Betas) and trading statuses. Information has been collected and cleaned primarily over the last two years from data subscriptions to Thomson Reuters' Datastream and Bloomberg Terminal (contact from 01/15/2016 with data analyst at NYU V-Lab). For the 32 countries included in the 'European' dataset, data on 414 institutions exists from June 2000 and continues until the end of November 2015.

4.2.1. Data Validation

We applied three conceptual exclusions to our data. Firstly, all insurance companies (43 in total) were excluded from the original dataset. Our remaining sample consists of European investment and commercial banks and Asset Management Companies (AMCs), all of which fall under the scope of the two policies that we investigate. Further, we exclude nine non-EU member-states from the original dataset. We also exclude Croatia, as they would not be responsive to the majority of policy event dates under investigation given their late accession in 2013. Finally, 30 institutions that ceased operations (labeled 'Dead') were excluded since data for these financial institutions were unavailable after end of operations. The final sample consists of 234 financial institutions. **Figure 3** provides the final number of institutions per country.

Figure 3: Final number of financial institutions per country



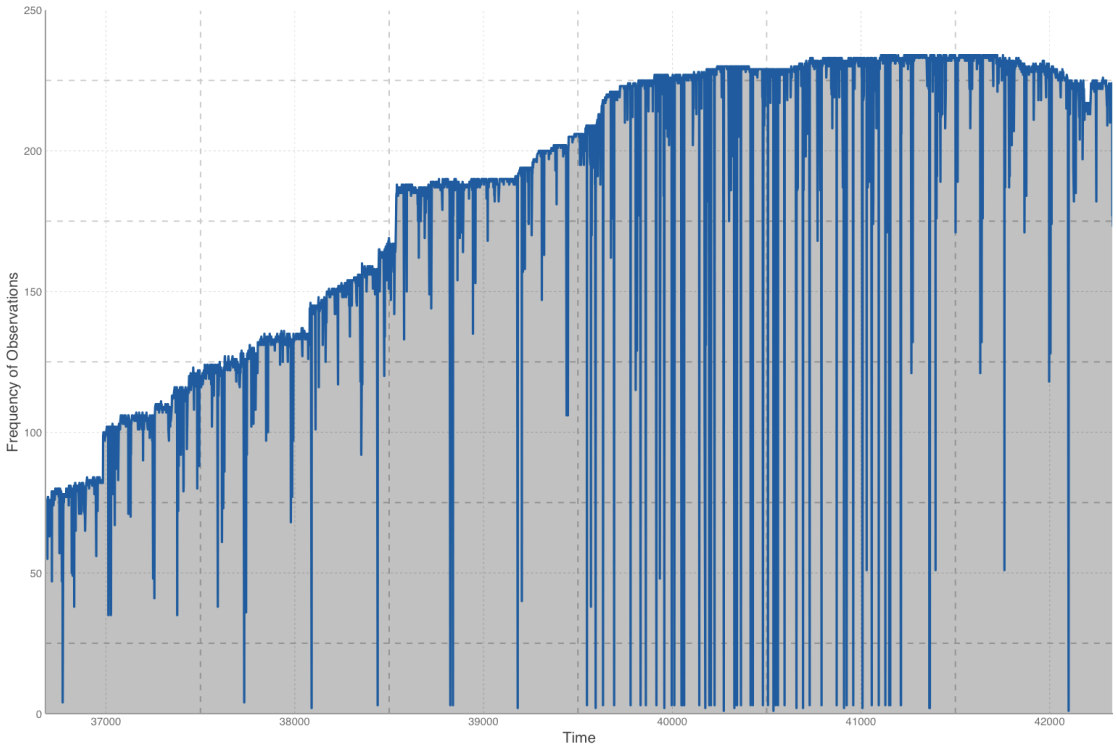
4.2.2. Data Cleaning

On 04/04/2015 the SRISK of OTP Bank of Hungary inexplicably drops to $-177,955,000,000.130m. We elected to drop this institution from our dataset based on a suspicious absence of corporate news in financial disclosures to the Budapest stock exchange for the erroneous observation at this time point (OTP Bank Plc., 2015).

4.2.3. Limitations

Financial reporting improved over time (see **Figure 4**), with frequencies of observations nearly comprehensive by early-2010 (the year of our first policy event date). However, the issue of small time gaps for specific dates is a persistent, frequent, and comprehensive risk to our study and any future modeling research.

Figure 4: Frequency of observations for cleaned and validated data



4.3. SRISK

How does the NYU V-Lab's SRISK metric contrast with the various outlined definitions and assessments of systemic risk from our literature review? In the following we discuss definitions and strengths of NYU V-Lab's SRISK and elaborate on potential limitations.

4.3.1. Definition and Strengths of SRISK

According to the NYU V-Lab, systemic risk originates from the overarching problem of undercapitalization of individual institutions, which in turn has a contagion effect on the overall financial sector. "We view systemic risk not in terms of a firm's failure per se but in the context of a firm's overall contribution to system-wide failure" (Acharya et al., 2010). Or in other words: "firms which contribute to an aggregate capital shortfall are systemically risky" (Acharya et al., 2010). In their working papers, Christian Brownlees and Robert Engle summarize this approach toward systemic risk as follows:

> "The SRISK index [aims] to measure the systemic risk contribution of a financial firm. The index associates systemic risk to the capital shortfall a financial institution is expected to experience conditional on a severe market decline. SRISK is a function of the firm's size, its degree of leverage and its expected equity loss conditional on a market downturn. The sum of SRISK across all firms is used to measure the degree of undercapitalization of the whole financial system" (Brownlees & Engle, 2015).

With the SRISK metric, the NYU V-Lab positions itself amongst the latest, post-GFC generation metrics with a "lesson learned" character (as outlined in theoretical framework in 3.3.2; Blanchard et al., 2010). The

combination of financial soundness of each institution and a simulated, market-based component allows various insights: What is the degree of undercapitalization, viz. capital shortfall per the V-Lab, of an institution? What is the degree of undercapitalization for the entire financial system? SRISK is able to provide this information. A further advantage of SRISK is the cumulative and unit-specific character of the variable, which allows us to make reasonable comparisons for example regarding firm size:

> "It is taken for granted that, ceteris paribus, larger financial firms are proportionately more systemic than smaller firms. […] While clearly large firms by construction do contribute more towards a capital shortfall, it may well be the case that collection of smaller firms, or a subsector of the finance industry, contribute more to systemic risk once firm size has been accounted for" (Acharya et al., 2010).

In the following we discuss the calculation of SRISK. Note that we can only provide a brief overview. For an in-depth discussion, the corresponding methodology sections of NYU V-Lab and the Center for Systemic Risk Lausanne provide excellent information (Center for Risk Management Lausanne, 2016; NYU V-Lab, 2016).

SRISK is measured in US$ and calculated on a working day basis with the following formula:

(1)

$$SRISK = k * DEBT - (1 - k) * EQUITY * (1 - LRMES)$$

DEBT and EQUITY for institutions in the sample are time series data, taken from Thomson Reuters Datastream and Bloomberg Terminal (contact from 15/01/2016 with data analyst at NYU V-Lab).

Time points refer to dates and are symbolized t. LRMES signifies 'Long Run Marginal Expected Shortfall' and is defined as the sensitivity to a hypothetical 40% semiannual decline of the aggregate market (NYU V-Lab, 2016) for that financial institution.

Finally, k denotes the capital requirement. For understanding k in the SRISK formula one needs to add two simple accounting definitions used by the NYU researchers and a more detailed explanation. $A_{i,t}$ denotes the 'quasi-market value' of the assets as the sum of the book value of debt ($D_{i,t}$) plus the market value of equity of the financial institution i at point t ($W_{i,t}$). $A_{i,t}$ also equals the book value of assets of i at time point t ($BA_{i,t}$) minus the book value of equity ($BW_{i,t}$) plus $W_{i,t}$:

(2)

$$A_{i,t} = D_{i,t} + W_{i,t}$$

(3)

$$A_{i,t} = BA_{i,t} - BW_{i,t} + W_{i,t}$$

The regulatory ratio for the financial institution i at time point t is given with:

(4)

$$W_{i,t} = \theta * A_{i,t}$$

Where θ is defined as the 'prudential ratio' (Center for Risk Management Lausanne, 2016; NYU V-Lab, 2016). "Assuming that firms can only operate if capital is a non-trivial proportion of their total liabilities, we define SRISK as the capital that would be needed to achieve a market cap that is 8% of the book value of assets in the event of another crisis" (Engle, 2012). θ is set at 8%, which "assumes a standard prudential capital buffer" (Acharya et al., 2010). In follow-up discussion on how the level of 8% had been agreed, we received the following information: "After speaking with Rob Engle, [the SRISK working

group] took the inverse of the leverage of what they considered conservative institutions before the financial crisis and concluded that value would be the capital requirement. k = equity/debt." (contact from 26/02/2016 with data analyst at NYU V-Lab, see **Appendix Item 1**). We critically assess this assumption in the next section.

Financial institutions in Europe follow the International Financial Reporting Standards (IFRS), whereas other countries (namely the U.S.) apply the Generally Accepted Accounting Principles (GAAP). In short, the two accounting regimes force financial institutions to report derivatives either on a net basis (GAAP) or on a gross basis (IFRS). "To deal with this important source of bias, we use a different prudential ratio θ in Europe: we use $\theta = 5.5\%$ for Europe institutions and $\theta = 8\%$ for the U.S. and the rest of the world" (Center for Risk Management Lausanne, 2016).

4.3.2. Limitations to SRISK

With the Long Run Marginal Expected Shortfall (LRMES) factor, SRISK contains a component influenced by developments in financial market developments. However, a major lesson from the GFC has been that market indicators, even shortly before the crisis, were highly misleading in many cases (Cerutti et al., 2012).

The lack of transparency in the calculation of SRISK capital requirements k is another limitation. It seems reasonable to adjust k to a level of 8% (and 5,5% under IFRS respectively) for the time period of 2000 to 2015 given the core requirements under Basel I (as mentioned, here only 8% of RWA for financial institutions with international presence), Basel II and Basel III (with different compositions and until the end of 2015). However, the assumption providing leverage ratios for k based on "conservative institutions"

seems worryingly normative and out-of-date considering the pre-GFC innovation of the SRISK index.

Finally, the formula behind SRISK links k in such a way that a higher k automatically raises SRISK. For the short-term this assumption seems reasonable (as, for example, refinancing becomes harder). But this stationary value is unrealistic in the long-term. Upon full implementation of the CRR/CRD IV, the parameter k will need to be adjusted. Here, SRISK appears more static than other approaches that differentiate between short-term and long-term views (as in López-Espinosa et al., 2012).

Limiting external validity, SRISK also does not offer information on off-balance sheet risks (for an in-depth discussion see also Fischer, 2015).

4.4. Change Points & Policy-SRISK Indicator

In the following two sections we demonstrate the steps taken to construct our indicator, designed to show the response of SRISK performance to the CRR/CRD IV and the BRRD using the SRISK evidence from the V-Lab (see 4.3).

4.4.1. Nonparametric Multiple Change Points Detection

Inspired by a late-2014 Twitter blog discussing the company's need to identify shifts in traffic data (Kejariwal, 2014) we learnt that modern commercial practice to record 'Big Data' time series has driven development in the R-statistical community for the detection of change points in time series.

The overarching idea of a change point test is to search for an intermediate transition period between two different steady states occurring in a time series, either by detecting a 'shift' in the mean of the time series or a 'ramping up' in the variance of a given variable (Rooch, 2012). With widespread application since the 1950s, there exist a variety of mathematical approaches for the exploration of change points in financial time series, each with competing

advantages and disadvantages (Gandrud & Young, 2014). For our study we required a method that would allow (i) setting of minimum segment sizes to daily intervals given the rich panel data, and (ii) that can otherwise function with minimum specification of *a priori* parameters.

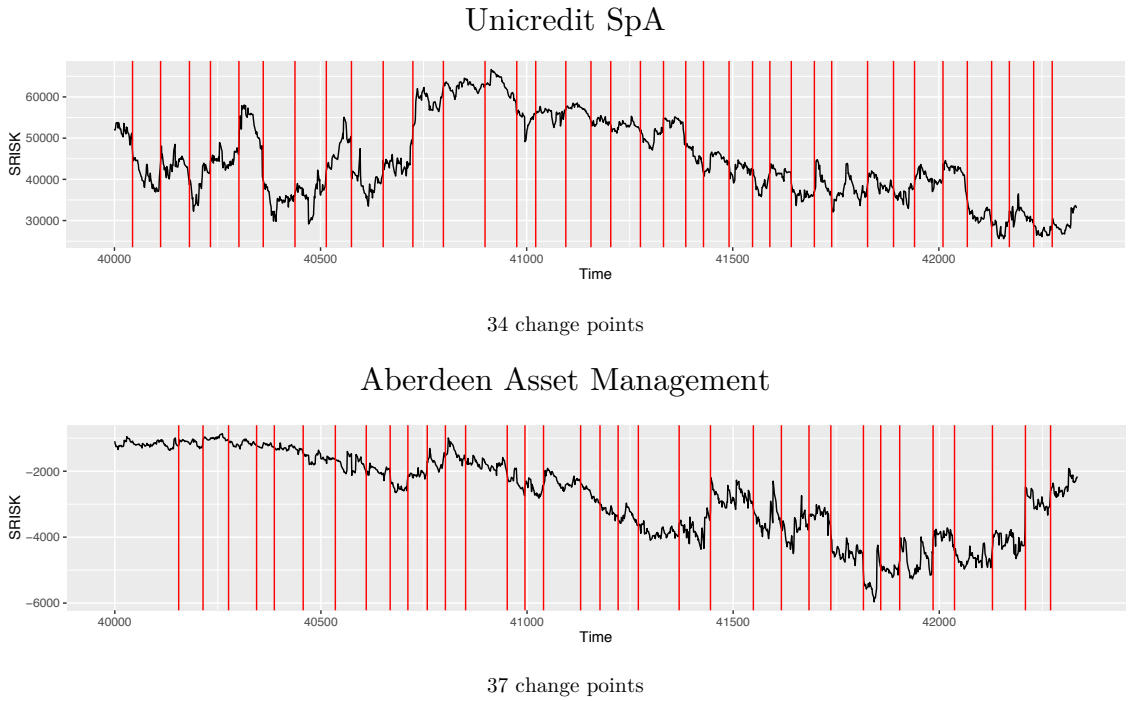
Matteson and James' (2014) energy divisive hierarchical change point estimation algorithm meets these requirements through use of the *energy divisive* command in their R package 'ecp' (James & Matteson, 2015). Energy refers to the 'energy distance', or transition periods, between two unique segments containing a steady state distribution of SRISK observations. Matteson and James (2014) detect segment transitions through the use of a binary bisection method and a permutation test, with each SRISK segment tested for a unique probability distribution with significance p=0.05 over 999 permutations (James & Matteson, 2015). [2]

Two relevant parameter adjustments require *a priori* input. The first adjustment is a limit on the number of change points the algorithm should detect, thus dropping any change points that fall below our limit according to a hierarchy of statistical significance. We set this to unlimited - thus capturing all statistically significant change points.

The second adjustment is the minimum distance ('cluster size') between intervals to record as segments. Since we expect SRISK response to policy event dates to be highly sensitive, we set this to the smallest minimum size for our panel data: 1 day.

[2] For proof see Rizzo & Székely, (2010); for an applied example with explanation see p.16 of the ecp package paper (James & Matteson, 2015).

Figure 5: SRISK distributions and change point locations for Unicredit SpA and Aberdeen Asset Management between 2009 and 2015



Several disadvantages to change point analysis exist. Firstly, there exists a risk of oversensitivity in change point estimation when cluster sizes are limited to 1, with daily market volatility potentially biasing estimates designed to measure systemic, not daily, shifts in variation. However, using the examples of two contrasting financial institutions from our sample (for choice of example explanation see 4.2), the low number of recorded estimates we can see in **Figure 5** the volatility of daily stimuli appears to have little effect (e.g. Aberdeen: 34; UniCredit: 37).

A further disadvantage is the lack of our change point controls. For instance, the relationship between SRISK and financial year cycles remains unknown. However, this cycle may be repeating an annual bias in our change point detection for all 15 years.

A practical shortfall of the energy divisive command is also the computational run-time required for estimate generation. Described as 'output-

sensitive' in (James & Matteson, 2015), some technical packages were needed in R[3] to reduce our calculation time from a predicted seven days for ~700,000 observations (R being the only suite to our knowledge enabling parallel-processing of calculations).

4.4.2. Proposed Policy-SRISK Performance Indicator

To mitigate methodological challenges, financial system supervisors of European national jurisdictions and the EC often assemble a portfolio of indicators to evaluate the impact of regulations and directives (contact from 30/03/2016 with officer at European Commission Financial System Surveillance and Crisis Management; Basel Committee On Banking Supervision, 2015). To assist in this objective of sound and prudent management we propose the policy-SRISK performance indicator. Development of this indicator remained mindful of 'SMART' (viz. Specific, Measurable, Attainable, Relevant and Time-bound) guidelines espoused by the Basel Committee report evaluating indicators from different jurisdictions (Basel Committee on Banking Supervision, 2015). We provide all data and guidelines needed to reproduce our indicator and findings in a code repository online.[4]

In this section we operationalise existing information from **Table 1** (policy event dates from interviews). We then derive functions for generating a lead and lag measure for policy event dates, and for identifying when a change point detection occurs within this period (a 'policy response'). Finally, we present our indicator that calculates whether a policy response was due to improvement or deterioration in the SRISK of the financial institution. **Table 2** and **Figure 6** demonstrate the steps for a fictional bank, Bankx.

Intervals t describes the date of each observation in our dataset. For the purpose of easier data-handling across statistical suites we used the convention

[3] R Packages: "doParallel", "iterators" & "parallel"

[4] Github repository: https://github.com/laurencehendry/SRISK_Thesis

for number of days since 01-01-1900. For our values that date back to the early 2000s this means:

(1)

$$t \in \{36680, \dots, 42340\}$$

Units i specify unique names for each of the 234 financial institutions in our dataset:

(2)

$$i \in \{1, \dots, 234\}$$

Policy event dates E_t are taken from **Table 1**:

(3)

$$E_{it} \in \{0,1\}$$

$$If\ policy\ event\ date\ identified\ from\ interview \rightarrow E_{it} = 1$$
$$and\ 0\ otherwise$$

S_{it} denotes the SRISK from NYU V-Lab in $ millions for financial institution i at time t, with range between:

(4)

$$S_{it} \in [-81{,}172.30, \dots, 191{,}245.20]$$

Finally, change point detections are provided by Matteson and James (2014) algorithm (see 4.4.1). Symbolised D_{it}, the number of statistically significant binary estimates is unlimited for each financial institution panel time series:

(5)

$$D_{it} \in \{0,1\}$$

The creation of a lead compensator is required to reflect the expectation time that financial institutions experience before a policy activity. Based on the

rapid dissemination, sensitivity and reaction times of financial institutions to regulatory news, we assume a reasonable expectation period of one fortnight anticipatory effect for all policy event dates.

Policy lags come in two broad categories. Inside lag refers to the time it takes for a regulatory decision to be made. It is disregarded here for both the CRR/CRD IV and the BRRD since both series of event dates transpired after the principal decision for EC intervention had already been taken. Outside lag is the "period between the application of political measures and the effects of these changes on the ultimate outcomes of economic policy" (Jovanovski & Muric, 2012).

Accurately judging the lag time to relate causal inference is very difficult. However, our interviewees were made aware of this specific limitation to our method, with discussion of the CRR/CRD IV and the BRRD event dates steered to those events with immediate policy responses. In response to this concern, we learnt that the impact response time of EC policy activity can be far less than seven days. For instance, when floating the idea of bail-ins under the BRRD, an 'immediate change occurred in the forecast cost of funding for banks that affected creditors by raising due diligence fees', shifting systemic risk. Another example involves the recent leaking of a EC information note concerning the CRR/CRD IV with the financial system 'reacting within two days' (contact from 30/03/2016 with officer at European Commission Financial System Surveillance and Crisis Management).

We decide on a fortnight lag period for recording of SRISK improvements. For $L_{t^\frown}(E_t)$ binaries are therefore generated for 28 days $\tilde{t}$ around policy event dates E_{it}:

(6)

$$t \in \{36680, \dots, 42340\};\ L_{i\hat{t}}(E_{it}) \in \{0,1\}$$

$$\hat{t} \in \{36680 \leq t \leq 42340 |\ E_{it} = 1\}$$

$$\tilde{t} \in \{\hat{t} - 14, \dots, \hat{t} + 14\} \rightarrow L_{i\tilde{t}}(E_{it}) = 1$$
$$and\ 0\ otherwise$$

A policy response R_t is detected for the financial institution if a change point occurs within the spread lead and lag period of a policy event date. Therefore:

(7)

$$R_{i\tilde{t}} \in \{0,1\}$$

$$If\ L_{i\tilde{t}}(E_{it}) = 1\ \wedge\ D_{i\tilde{t}} = 1 \rightarrow R_{i\tilde{t}} = 1$$
$$and\ 0\ otherwise$$

For our policy-SRISK performance indicator, an improvement Y_{it} is registered if the financial institution responds to the policy with a decrease in SRISK (see **Table 2** for a technical output example, and **Figure 6** for a graphical representation of this output).

This is conditioned on whether the average of the ten preceding SRISK observations is greater than the average subsequent to policy response date R_{it}:

(8)

$$Y_{it} \in \{0,1\}\ ;\ t \in \{\hat{t}-10, \dots, \hat{t}+10\}$$

$$If\ \frac{1}{10}\sum_{j=\hat{t}-10}^{\hat{t}-1} S_{ij} > \frac{1}{10}\sum_{j=\hat{t}+1}^{\hat{t}+10} S_{ij} \rightarrow Y_{\widehat{it}}(R_{it}) = 1$$

$$and\ 0\ otherwise$$

SRISK deterioration occurs for the reverse of Y_{it} and is signified Z_t:

(9)

$$Z_{it} \in \{0,1\}\ ;\ t \in \{\hat{t}-10, \dots, \hat{t}+10\}$$

$$If\ \frac{1}{10}\sum_{j=\hat{t}-10}^{\hat{t}-1} S_{ij} < \frac{1}{10}\sum_{j=\hat{t}+1}^{\hat{t}+10} S_{ij} \rightarrow Z_{\widehat{it}}(R_{it}) = 1$$

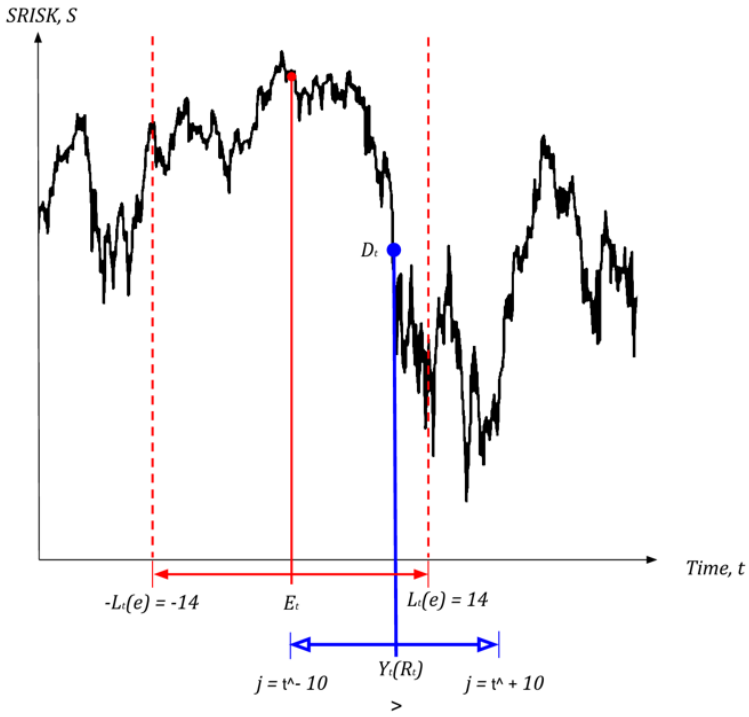
$$and\ 0\ otherwise$$

Table 2: Demonstration of improvement for fictional Bankx

t	i	E_{it}	$L_{\widetilde{it}}(E_{it})$	S_{it} ($m)	D_{it}	R_{it}	Y_{it}	Z_{it}
...	...	...	...	...	...	...	...	...
40430	Bankx	0	1	6300	0	0	0	0
40431	Bankx	1	1	6300	0	0	0	0
40432	Bankx	0	1	6200	0	0	0	0
40433	Bankx	0	1	3200	1	1	1	0
...	...	...	...	...	...	...	...	...

NB. Dashed border cell indicates date of final announcement for Basel III; shaded cells indicate where a dummy has been activated; thick border cell indicates that final announcement of Basel III lead to an improvement in the SRISK for Bankx.

Figure 6: Graph demonstrating improvement for fictional Bankx



NB. The thin vertical solid line signifies a policy event date; dashed lines signify the 14-day lead and lag compensation around this date; the thick vertical line signifies the date on which a change point in SRISK was detected; the horizontal arrows signify the 10-day averages used for determining whether this change was an improvement or deterioration.

There exist several limitations to our policy-SRISK performance indicator. Primary amongst these is the robustness of steps (8) and (9) that challenge the internal validity of our indicator with the risk of possible type I errors. For example, where SRISK performance appears to improve when taking the mean average before and after, alternative tests for central tendency for factors in (8) and (9) could yield different results. Averages for SRISK distributions before and after the policy event date can therefore be refined through the use of other appropriate metrics (such as median or standard distributions) to improve observation of SRISK change, and *ipso facto* judge policy performance.

External validity for our indicator method suffers from three main disadvantages:

i) At an earlier trial, 90 days were supplemented for all 14 day lag periods but yielded little difference in the distribution of our results. However, an issue with this finding and our methodology is that it presumes lead and lag compensation is generic across all policy event dates, despite interviews confirming that nuances exist for lag periods when comparing event types (e.g. announcements and proposals versus actual application in our study). However, lagging is a common potential downside for any such quantitative performance indicators (Basel Committee on Banking Supervision, 2015).

ii) Omitted antecedents have a biasing effect on SRISK in our timeframes for measurement. The assumption in causal inference at step (7) that assumes that all SRISK change points occurring within our specific event timeframes are *ipso facto* caused by EC policy activity is fallible. This can be tested with the use of counterfactuals (see 4.1.2) and regression modeling (Holland, 1986).

iii) Citing Sparrow (Sparrow, 2008) with approval, the Basel Committee states that "supervisors can better prove the plausibility of a causal relationship by reducing the level of abstraction at which effects are measured" (Basel Committee on Banking Supervision, 2015). That it was occasionally difficult to communicate our method in interviews with professionals suggests efforts should be aimed at simplifying the complexity of our measure.

5. Results & Analysis

Our results lead us to reject both hypotheses made in section 2. In our analysis we discuss prevailing assumptions in our method that might explain this, as well as inferences we can draw from our results for understanding relative country performance. However, we also consider the very unsettling implication of our results: For our panel data sample, the overwhelming majority of European financial institutions deteriorated, or did not improve, their systemic risk performance in direct response to key policy event dates for the CRR/CRD IV and the BRRD.

5.1. Prevailing Assumptions

In this section we remind the reader of the concerns to be kept in mind when considering results and the external validity of drawn inferences.

In our final data we limited our sample by excluding insurance companies to a smaller sub-category of European investment banks, commercial banks and AMCs (see 4.2.) that were affected by the policies of interest. The original sampling method employed by the V-Lab limits external validity further: Due to ease of automation, restrictions from data providers, as well as relatively low significance in SRISK for smaller firms, the V-Lab decided primary research would be 'best to select firms with significant market cap in their respective countries, liquidity and trading frequency for analyses' (contact from 15/01/2016 with data analyst at NYU V-Lab). The penalty is that our findings only reflect statuses for financial institutions that compete according to this definition. We are denied from making statistical inferences for the general population of all financial institutions. For example, considering the European population of banks represented in our sample (numbering over 8,400 in 2009; de Haan et al., 2012) we can only infer for the largest banks in every country.

Our data also does not contain information on mergers and acquisitions. A good example of this is the acquisition of Deutsche Postbank by Deutsche Bank: Postbank has been a fully owned subsidiary of Deutsche Bank since January 2015, however it is still listed as an independent entity with its own SRISK observations that remain uninfluenced by the acquisition (contact from 15/01/2016 with data analyst at NYU V-Lab).

We neglect consideration of changes in monetary policy, although "loose monetary policy is one intervening variable which drives abundant liquidity, balance sheet expansion and excessive risk-taking" (European Systemic Risk Board, 2014). An opinion with which Deev and Hodula concur (Deev & Hodula, 2016). The way in which SRISK interacts with these changes (since SRISK includes balance sheet information as a constituent term) remains unclear. A recent IMF working paper by Agur & Demertzis investigating expansive monetary policy argues that "monetary policy affects financial stability, even in the presence of macroprudential regulation" (Agur & Demertzis, 2015). The question remains then: In which ways do macro-prudential regulations interact with the expansionary policy of the ECB?

Finally, we do not differentiate between member states of the European Union and states that are also members of the Eurozone. With the exception of Croatia, we also do not control for different accession dates to the EU. Finally, the lack of observations ($n \leq 5$ per country) for the Czech Republic, Hungary, Malta, Portugal, Luxembourg and Romania means explanative power for these countries is very weak. They are included for speculative purposes, but accompanied with respective (n=…) sample sizes.

5.2. CRR/CRD IV

In this section we present general findings for the CRR/CRD IV performance on SRISK and introduce two micro-level examples, UniCredit SpA

(UniCredit) and Aberdeen Asset Management PLC (Aberdeen), for discussion of the heterogeneous results across European financial sectors.

According to our indicator, there were a total of 166 improvements and 338 deteriorations for all 234 financial institutions, thus clearly rejecting our H_1 that improvements would be indicated around the CRR/CRD IV policy event dates (see **Appendix Item 2** for an overview of all sample improvements and deteriorations).

Our European map (see **Figure 7**) studies improvements that *were* captured by the indicator; it represents the mean average number per country of improvements in SRISK responses to the CRR/CRD IV for banks and AMCs with significant market capitalisation in their respective countries.

The first finding to note is the high degree of heterogeneity. The only financial institution (n=1) in the Czech Republic performs notably well. Countries in the European periphery, namely Hungary (n=2), Romania (n=2) and Greece, experience poorer reactions to the CRR/CRD IV. Institutional size is also intriguing when considering policy impact, where we can assume many of these periphery financial institutions have smaller sizes than their core European counterparts. This concurs with interview feedback and our literature review, where institutional size, degree of centralization and exposure to capital markets were all identified as key determinants for the relative impact of changes in regulation (contact from 30/03/2016 with officer at European Commission, Financial System Surveillance and Crisis Management; Demirgüç-Kunt & Huizinga, 2013; Drehmann & Tarashev, 2011; Huang et al., 2011).

Further explanations for this heterogonous result are the different enforcement levels for compliance and prudential activities of national financial authorities. For the British banking sector since 2011, for instance, the domestic Bank of England and Prudential Regulation Authority (PRA) have actively supported legislation for the ring-fencing of core banking services, intended to

"improve the resilience and resolvability of deposit-takers." (Bank of England, 2014). Effectively intended to separate the investment side of banking from that of deposit-taking (or 'retail') activity, such initiatives will cause diametric response rates to EC directives amongst British banks, with the general effect being a cooling in receptivity. Note, that the UK also used deviant transitional provisions (e.g. regarding the CET 1) for the CRR/CRD IV for its financial institutions (Gaulard, Troiano, Lambert, & Theodore, 2016).

Figure 7: Average improvements of financial institutions per country CRR/CRD IV

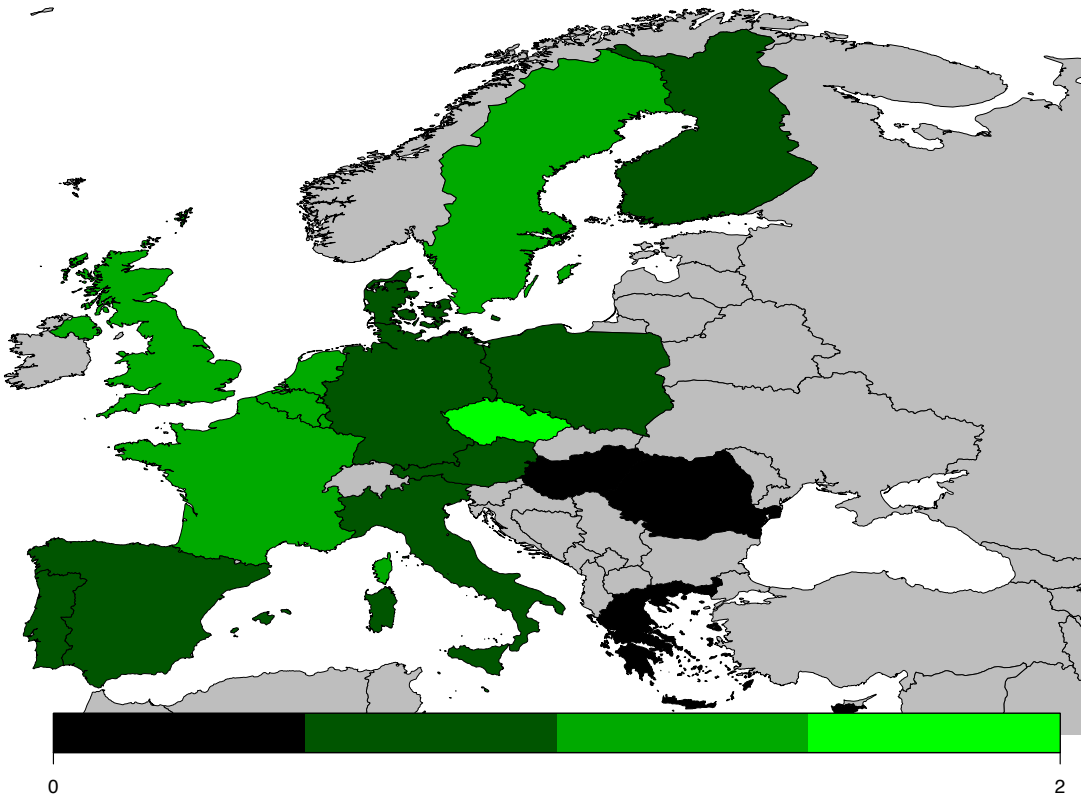


Figure 8: SRISK of UniCredit SpA and Aberdeen Asset Management with policy event dates for the CRR/CRD IV

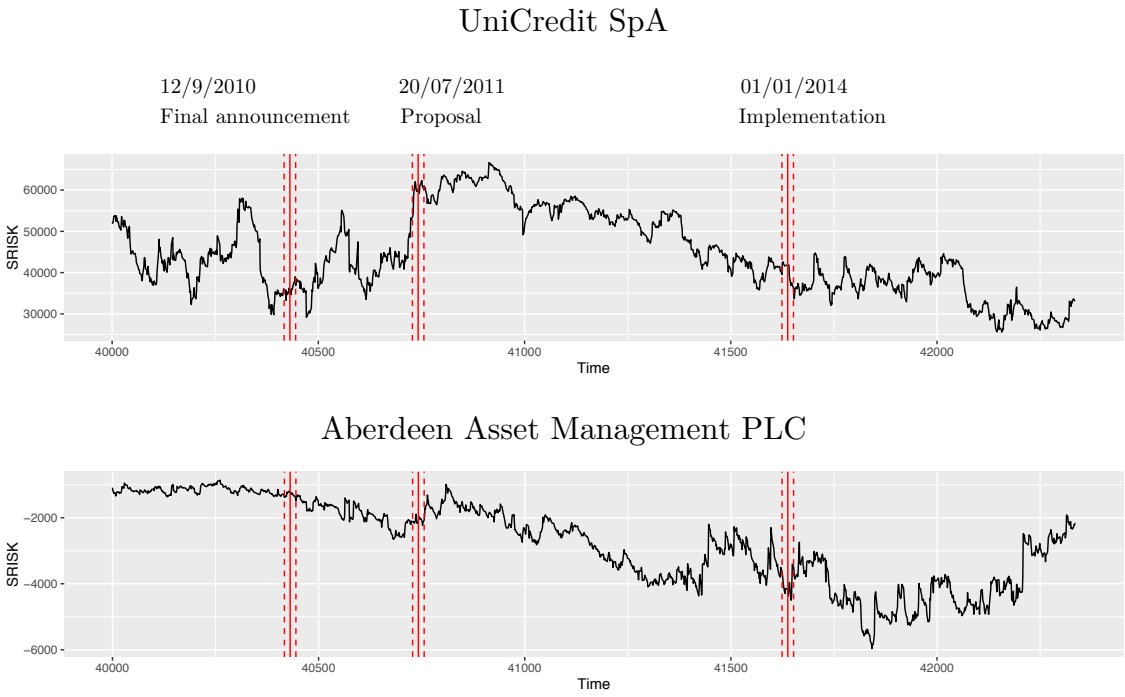


Figure 8 shows SRISK plots over time for the Italian bank UniCredit and Scottish AMC Aberdeen Asset Management. Aberdeen shows negative SRISK contribution, i.e. the negative externality of the threat of systemic collapse to the British financial sector has been effectively internalized by the group. This AMC is clearly well capitalized, indicating by how it would not require a fiscal bailout in case of a 40% downturn in the aggregate market (see 4.3), and runs a business model far more resilient to contagion collapse than UniCredit. An Aberdeen annual report for 2013 (the year in which SRISK decreased markedly and an improvement was captured on 11/12/2013 in anticipation of the CRR/CRD IV implementation; see **Table 3**) includes a statement crediting compliance with the UK regulatory requirement for Internal Capital Adequacy Assessment Process (ICAAP). The capital adequacy requirements of transitional provisions has been developed to strongly complement the CRR/CRD IV strategy (Bank of England, 2015a).

In contrast to the UK, UniCredit represents a major G-SII with significant levels of SRISK that peak soon after the CRR/CRD IV proposal:

> "Whilst a first group of countries – including Denmark, Slovakia, Sweden and UK – have already adopted a significant variety of measures – as for example, conservation and countercyclical buffers, sectoral risk weights and different caps on liquidity and leverage - a second group of countries – such as Germany, Spain, France, Austria, Italy and Portugal - is still characterized by an embryonic development of the regulatory structure" (Amorello, 2015).

To understand the much higher and volatile SRISK performance of UniCredit it is helpful to understand the position of the Bank of Italy. Reluctant towards intervention, the Bank of Italy met its requirements in the

CRR/CRD IV with immediate acknowledgment of the flexible margins for implementation until January 2019, and exempted small- and medium-sized investment firms from applications of the capital conservation buffer. However, as a G-SII, UniCredit has been susceptible to some evolutions in the Italian macroprudential framework – as of 01/01/2016 a capital buffer of 2.5% and a countercyclical capital buffer requirement have been instated. Measures that appear to be confirmed in the visible downward trend in SRISK after the CRR/CRD IV implementation policy event date visible in **Figure 8**. As Amorello comments on the Italian appetite for the CRR/CRD IV: "A first obstacle towards a strong macroprudential regime lies into the failure of Italian lawmakers to approve a legal act establishing a national macroprudential authority, as specifically required by the ESRB with recommendation ESRB/2011/3" (Amorello, 2015). This is in part mostly due to the slow recovery of the Italian economy, and fears of further jeopardizing already diminished domestic capital market activity (ibd.).

Table 3: CRR/CRD IV improvements and deteriorations UniCredit and Aberdeen

CRR/CRD IV / **Fin. Institutions**	12/9/2010 **Final announcement**	20/07/2011 **Proposal**	01/01/2014 **Implementation**
UniCredit SA	Deterioration in lag	Improvement in lead	Deterioration in lag
Aberdeen Asset Management	No response	Deterioration in lead	Improvement in lead

An important consideration is that the CRR/CRD IV does not reach full implementation until 01/01/2019 (European Banking Authority, 2015b). We therefore expect our response results to occur in the years until this date, albeit with possibly less-visible and gradual improvements in SRISK.

Also of note, is that capital requirements set by the CRR/CRD IV are often exceed by the institutions in question. This implies the existence of other external factors influencing internal capital management, such as credit rating agencies, internal self-assessments or market expectations (European Central Bank, 2015b). We do not account for these factors in our research design.

Finally, we suspect the reasons for Sweden and Denmark only experiencing moderate improvements is due to their higher capital requirements (via a non-mandatory capital buffer of 1% to 3%). These were applied to Danish O-SIIs before 01/01/2016 and the four largest Swedish banks (systemic risk buffer of 3%) since 01/01/2015 (European Systemic Risk Board, 2016b).

5.3. BRRD

The ratio between improvements and deteriorations for the full sample for the BRRD policy event dates is 149 deteriorations to 125 improvements for 234 institutions. Note that the number of improvements and deteriorations is naturally lower than for the CRR/CRD IV since our primary research only yielded two policy event dates for investigation (see **Appendix Item 3** for an overview of all sample improvements and deteriorations).

Figure 9 represents the mean average improvements of financial institutions per country in response to the BRRD. Low level performance is observed in Greece that mirrors their receptivity to the CRR/CRD IV, yet this remains highly surprising given the expected impact on systemic risk that would be expected for bail-in initiatives at the heights of the Euro-crisis in 2012 and 2015. Our findings can consequently support to some length the work of Kern, who predicts that the BRRD will prove inefficient without greater coherence within the EU, and a higher level of centralization of sovereign authority (Kern, 2013).

Figure 9: Average improvements of financial institutions per country BRRD

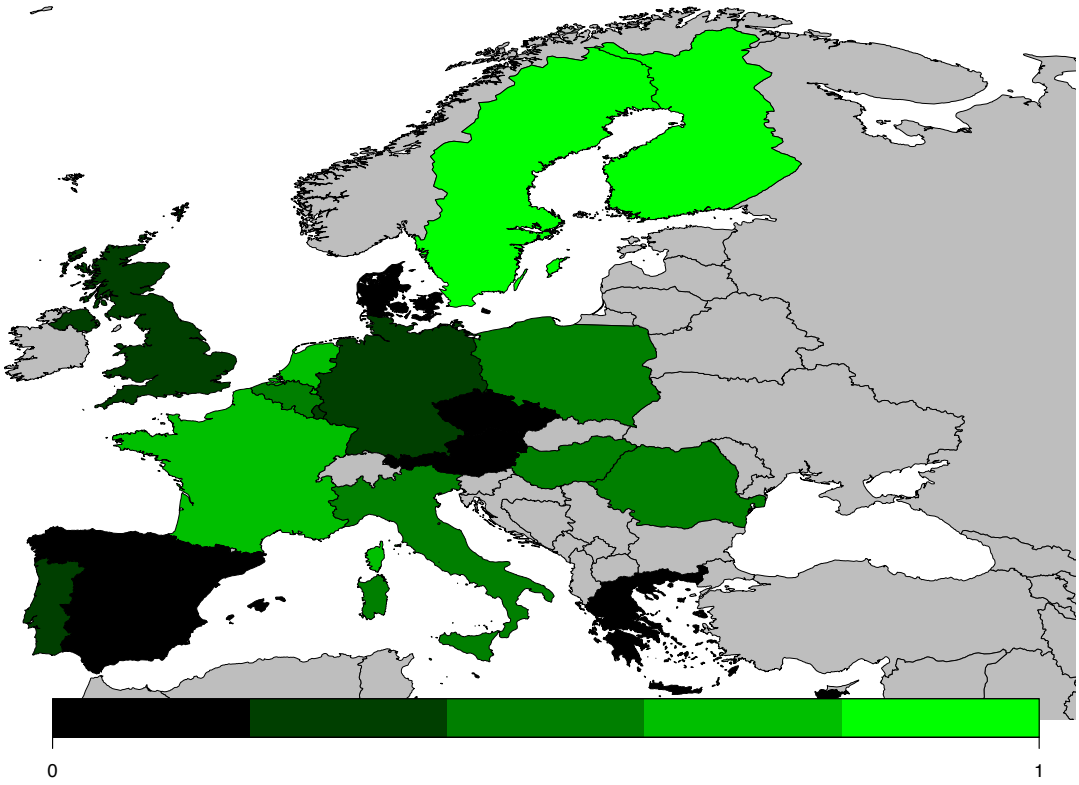
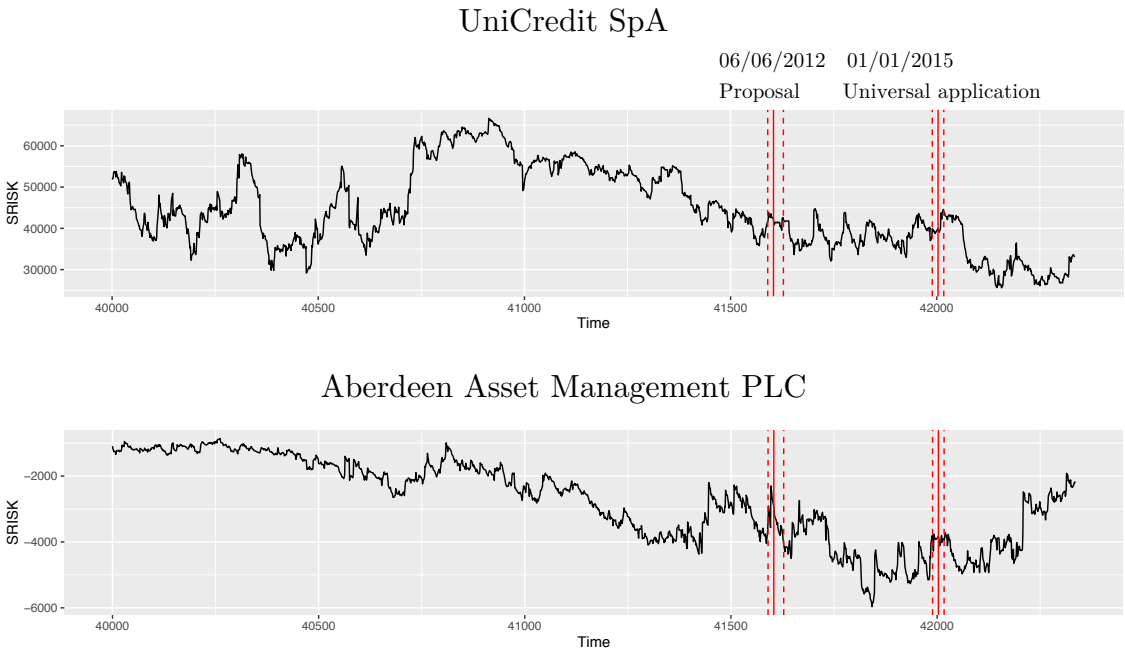


Figure 10: SRISK of UniCredit SpA and Aberdeen Asset Management including event dates for the BRRD



Also visible in **Figure 9** is the low level of improvements for Spain. In Spain, the BRRD was only fully transposed into national law in June 2015 (Ley 11/2015). Spain already established a resolution framework on the national level in 2012 (Ley 9/2012) which was then substituted accordingly (Pardo, Santillana, & Martín, 2015).

Figure 10 presents the corresponding SRISK plots for Unicredit and Aberdeen that we use to guide our understanding of the key policy event dates. For both UniCredit and Aberdeen we do not observe any improvements. This is unusual, especially in the case of the UK, where the large number of merchant banks suggests it would be highly sensitive to EC directive proposals. The publication of the bail-in concept – effectively forcing a borrower's creditors to bear some burden by writing down debts – had an immediate effect on the predicted cost of financing for financial institutions, and eliminated the implicit subsidy for financial institutions by increasing their cost of funding (e.g. by increasing the need for due diligence). Although this was expected to have the intended effect of 'increasing financial stability and reducing the risk in the system' (contact from 30/03/2016 with officer at European Commission, Financial System Surveillance and Crisis Management) results in **Table 4** yielded a worsening in institutional systemic risk contributions.

We trace missing improvements of the two examined institutions under the BRRD back to the fact that both institutions were already subject to resolution mechanisms before the tested policy event dates. UniCredit as a G-SII within the Eurozone falls under the Banking Union and the supervision through the SRM and the SSM (Gros & Schoenmaker, 2013) – which in turn may be contributing to the overall improvement trend visible in SRISK (see **Figure 10**). Aberdeen is subject to the UK's special resolution regime (SRR) since 2009 (Bank of England, 2015b). Aberdeen not showing improvements in

this sense is unsurprising since the BRRD "draws considerably on the principles and practices set forth in the UK's special resolution regime" (Kern, 2013).

Table 4: BRRD improvements and deteriorations UniCredit and Aberdeen

BRRD / **Fin. Institutions**	06/06/2012 **Proposal**	01/01/2015 **Universal application**
UniCredit SA	No response	Deterioration in lead
Aberdeen Asset Management	No response	Deterioration in lag

5.4. Implications of findings

Our analysis reveals the significant disparities and politicisation of national prudential policymaking that receives the supranational directives of the European Commission. As we have seen in the cases of UniCredit and Aberdeen, this alters the sensitivity of financial institutions to European Commission activity, with differences between the two firms clearly observable in **Table 3** and **Table 4**.

Thus, findings are in line with other studies concerned about the effectiveness of macroprudential policies and supervision in the EU (Hartmann, 2015; Masera, 2014). Our findings therefore appear to support the view that well intentioned but poorly implemented and/or constructed policy responses to reduce systemic risk can carry the risk of having contrary effects (LSE Systemic Risk Centre, 2015).

6. Future Research

The first improvement to our study would be the relatively simple calculation to understand under which policy event ('announcement', 'proposal' or 'implementation), and for what reason, sensitivity of financial institutions was greatest to European Commission activity. Secondary to this study would be to improve understanding of the magnitude of the effect experienced by financial institutions.

Further studies should investigate the use of regression modeling to isolate the independent effects of neglected variables, as discussed under section 4.4.2. Not only would this help further understand other influencing factors such as monetary policy, but would allow the drawing of specific conclusions on the explanative power for our policies of interest. What factors, for example, bring institutions to exceed their corresponding capital requirements under the CRR/CRD IV? Regression modeling could also apply our policy-SRISK performance indicator as a dependent variable and control for countries as covariates and provide more robust predictions than the mean averages used for maps in **Figure 7** and **Figure 9**. These results should provide interesting information for the coherence level of macroprudential supervision across the EU.

Additionally, since funds and insurance companies are included in the original NYU V-Lab dataset – yet excluded from our sample – future research could rearrange our methodology in a way that allows drawing conclusions from SRISK for the financial system as a whole. Future research could also investigate systemic risk arising from cross-country banking within the EU. If national authorities have a mandate for maintaining financial stability in their own system the possible reluctance to neglect cross-border externalities may disrupt stability (de Haan et al., 2012). However, as mentioned, the SRISK

variable is not suitable in this regard. Future research could also revisit our method with a more specific focus on the Eurozone. Especially promising here are the suggestions from interviewees to investigate effects on the Banking Union in general and the SRM and SSM in specific, as well as natural experiments per section 4.1.2.

Specific to the CRR/CRD IV, future research could distinguish between the regulation and the directive – and not treat them as one unit. Can different levels of implementation in member states and compliance of financial institutions be detected? Can these differences be traced back to the legal characters of a regulation and a directive?

Future research could also always use our method and investigate on different policy event dates and/or alter the time frame of the according leads and lags that we applied in this study.

Finally, a comprehensive study of the existing functions and strengths of systemic supervision for individual countries could always apply our method and data to critically assess the work and efficiency of the European Systemic Risk Board as an intermediate institution between supervision, policy making and policy implementation in the EU.

7. Conclusions

Using SRISK data from the NYU V-Lab, we provided an explorative, *ex-post* study of two macroprudential policies: the European CRR/CRD IV and BRRD. We hypothesized that both policies reduced systemic risk of financial institutions in the EU.

We commenced by conducting interviews with several policy professionals and decision-makers. Based on the results of the interviews, we derived three policy event dates for the CRR/CRD IV and two policy event dates for the BRRD. Given the policy event dates, we found more deteriorations in SRISK for both the CRR/CRD IV and the BRRD around key policy event dates which lead us to reject both our hypotheses.

However, by verifying results from micro-analyses, we succeeded in generating insights for the suspected causes of heterogeneous effects, focused on activity by national prudential authorities from the British and Italian settings and opened avenues for future research using our indicator. We ended by locating our findings within the broader policy debate and concerns on the effectiveness of macroprudential policy today.

Bibliography

Abdelkader, D., Slaheddine, H., & Aida, S. (2015). Systemic risk of the Greek financial institutions: application of the SRISK model. *African J. of Accounting, Auditing and Finance*, *4*(1), 7 – 28. http://doi.org/10.1504/AJAAF.2015.071751

Acharya, V., Brownlees, C., Engle, R., Pedersen, L., & Philippon, T. (2010). *How to Measure and Regulate Systemic Risk*. New York City.

Adrian, T., & Brunnermeier, M. K. (2011). *CoVaR*. New York City.

Agur, I., & Demertzis, M. (2015). Will Macroprudential Policy Counteract Monetary Policy ' s Effects on Financial Stability ? *IMF Working Paper*, (283).

Almamy, J., Aston, J., & Ngwa, L. N. (2016). An evaluation of Altman's Z-score using cash flow ratio to predict corporate failure amid the recent financial crisis: Evidence from the UK. *Journal of Corporate Finance*, *36*, 278–285. http://doi.org/10.1016/j.jcorpfin.2015.12.009

Altman, E. I. (1977). The Z-Score bankruptcy model: past, present, and future. *Financial Crises*, *1977*, 89–129. http://doi.org/10.1017/CBO9781107415324.004

Altunbas, Y., Marqués-Ibáñez, D., & Manganelli, S. (2011). Bank Risk During the Financial Crisis: Do Business Models Matter? *ECB Working Paper Series*, 1–53.

Amorello, L. (2015). Macroprudential policy tools : " State of the Art " in Italy in view of the ESRB report " A review of macro-prudential policy in the EU one year after the introduction of the CRD / CRR ". *Meeting at the ESRB*, 1–5.

Árvai, Z., Driessen, K., & Ötker-Robe, I. (2009). Regional Financial Interlinkages and Financial Contagion within Europe. *IMF Working Paper*, *09*(6), 522–540. http://doi.org/10.1002/9781118267646.ch34

Avgouleas, E., & Goodhart, C. (2014). A Critical Evaluation of Bail-in as a Bank Recapitalisation Mechanism. *CEPR Discussion Paper Series*,

(10065), 1–49.

Bank of England. (2013). CRD IV - Capital Requirements Directive IV. Retrieved March 1, 2016, from hhttp://www.bankofengland.co.uk/pra/pages/crdiv/default.aspxtml

Bank of England. (2014). News Release - Bank of England announces proposals to strengthen the financial system through structural reform. Retrieved March 1, 2016, from http://www.bankofengland.co.uk/publications/Pages/news/2014/125.aspx

Bank of England. (2015a). Assessing capital adequacy under Pillar 2. *Consultation Paper*, (CP1/15). Retrieved from http://www.bankofengland.co.uk/pra/Documents/publications/cp/2015/pillar2/cp115.pdf

Bank of England. (2015b). Legislative framework for the UK resolution regime. Retrieved March 1, 2016, from http://www.bankofengland.co.uk/financialstability/Pages/role/risk_reduction/srr/legislation.aspx

Bartram, S. M., Brown, G. W., & Hund, J. E. (2005). Estimating Systemic Risk in the International Financial System. *FDIC Center for Financial Research Working Paper*, 1–60.

Basel Committee on Banking Supervision. (1988). *International Convergence of Capital Measurement and Capital Standards*. Basel.

Basel Committee on Banking Supervision. (2005). *International Convergence of Capital Measurement and Capital Standards. A Revised Framework*. Basel.

Basel Committee on Banking Supervision. (2015). Report on the Impact and Accountability of Banking Supervision. *Bank for International Settlements*.

Blanchard, O., Dell'Ariccia, G., & Mauro, P. (2010). Rethinking Macroeconomic Policy. *IMF Staff Position Note*, *SPN/10/03*, 1–19. http://doi.org/10.1111/j.1538-4616.2010.00334.x

Borio, C., & Drehmann, M. (2009). Assessing the risk of banking crises – revisited. *BIS Quarterly Review*, (March), 29–46. Retrieved from http://www.bis.org/publ/qtrpdf/r_qt0903e.pdf

Brownlees, C., & Engle, R. (2015). *SRISK: A Conditional Capital Shortfall Index for Systemic Risk Measurement*. New York City.

Center for Risk Management Lausanne. (2016). Systemic Risk. Retrieved March 1, 2016, from http://www.crml.ch/index.php?id=44

Cerutti, E., Claessens, S., & Laeven, L. (2015). The Use and Effectiveness of Macroprudential Policies : New Evidence. *IMF Working Paper*.

Cerutti, E., Claessens, S., & McGuire, P. (2012). Systemic Risks in Global Banking: What available Data can tell us and what more Data are needed? *BIS Working Papers*, (376), 1–26. http://doi.org/10.3386/w18531

Cetorelli, N., & Goldberg, L. S. (2010). Global Banks and International Shock Transmission: Evidence from the Crisis. *National Bureau of Economic Research Working Paper Series*, (15974), 1–39. http://doi.org/10.1007/s13398-014-0173-7.2

de Haan, J., Oosterloo, S., & Schoenmaker, D. (2012). *European Financial Markets and Integration : Origins and History* (2nd ed.). Cambridge: Cambridge University Press.

Deev, O., & Hodula, M. (2016). The Impact of the ECB Monetary Policy on Systemic Risk Changes in Eurozone, 50–59.

Demirgüç-Kunt, A., & Huizinga, H. (2013). Are banks too big to fail or too big to save? International evidence from equity prices and CDS spreads. *Journal of Banking & Finance*, *3*(37), 875–894. http://doi.org/10.1007/s13398-014-0173-7.2

Drehmann, M., & Tarashev, N. (2011). Measuring the systemic importance of interconnected banks. *BIS Working Papers*, 586–607. http://doi.org/10.1016/j.jfi.2013.08.001

Eijffinger, S. C. W. (2009). Defining and Measuring Systemic Risk. *European Commission, Directorate General for International Policies*, 1–8. Retrieved from http://www.sylvestereijffinger.com/wordpress/wp-content/uploads/Defining and Measuring Systemic Risk.pdf

Engle, R. F. (2012). Dynamic conditional beta. *NYU Stern Business School Working Paper*, 1–32.

European Banking Authority. (2015). *CRD IV – CRR / Basel III monitoring exercise report. Results based on data as of 30 June 2014*. London. Retrieved from http://www.eba.europa.eu/documents/10180/950548/CRDIV-CRR+Basel+III+monitoring+Report+-+Results+as+of+June+2014.pdf/92bc3251-f527-4f6f-9dc0-5edd5132f65d

European Banking Authority. (2016). The Single Rulebook. Retrieved March 1, 2016, from http://www.eba.europa.eu/regulation-and-policy/single-rulebook

European Banking Federation. (2015). *EBF response to the European Commission consultation on the possible impact of CRR and CRD IV on bank financing of the economy*. Bruxelles.

European Central Bank. (2015a). *Financial Stability Review November 2015*. Frankfurt am Main.

European Central Bank. (2015b). The impact of the CRR and CRD IV on bank financing. Eurosystem response to the DG FISMA consultation paper. *Eurosystem Response to the DG FISMA Consultation Paper*, 1–39. http://doi.org/10.1017/CBO9781107415324.004

European Commission. (2014a). EU Bank Recovery and Resolution Directive (BRRD): Frequently Asked Questions. Retrieved March 1, 2016, from http://europa.eu/rapid/press-release_MEMO-14-297_en.htm?locale=en

European Commission. (2014b). Press Release – A single rulebook for the resolution of failing banks. Retrieved March 1, 2016, from http://europa.eu/rapid/press-release_IP-14-2862_en.htm?locale=en

European Commission. (2015a). Deposit Guarantee Schemes. Retrieved March 1, 2016, from http://ec.europa.eu/finance/bank/guarantee/index_en.htm

European Commission. (2015b). EU response to the crisis. Retrieved March 1, 2016, from http://ec.europa.eu/economy_finance/crisis/index_en.htm

European Commission. (2016). Krisenbewältigung. Retrieved March 1, 2016, from http://ec.europa.eu/finance/bank/crisis_management/index_de.htm

European Systemic Risk Board. (2014). Is Europe Overbanked? *Reports of the Advisory Scientific Committee*, (4), 1–52.

European Systemic Risk Board. (2015). Systemic Risk Indicators Database. Retrieved February 2, 2015, from http://sdw.ecb.europa.eu/browse.do?node=bbn3351

European Systemic Risk Board. (2016a). Mission , Objectives and Tasks of the ESRB. Retrieved March 1, 2016, from https://www.esrb.europa.eu/about/tasks/html/index.en.html

European Systemic Risk Board. (2016b). National measures in the EU / EEA notified to the ESRB of macro-prudential interest. Retrieved March 1, 2016, from https://www.esrb.europa.eu/mppa/html/index.en.html

Federation Bancaire Francaise. (2015). *FBF Response to European Commission on the possible Impact of the CRR and CRD IV on Bank Financing of the Economy*. Paris.

Financial Risk and Stability Network. (2015). Financial Risk and Stability Conferences. Retrieved March 1, 2016, from Financial Risk and Stability Network

Fischer, D. (2015). A critique of SRISK as an alternative to regulatory leverage ratio. *Working Paper*, 1–8.

Gandrud, C., & Young, K. (2014). Creating Scrutiny Indicators : A Change Point Exploration of Congressional Scrutiny of the US Federal Reserve, 1–15.

Gaulard, J.-H., Troiano, M., Lambert, P., & Theodore, S. (2016). The State of Bank Capital in Europe : a Guide to Requirements by Country The State of Bank Capital in Europe : a Guide to Requirements by Country. *Scope Ratings*, *49*(June 2015), 1–9.

Gerlach, S. (2009). Defining and measuring systemic risk. *Directorate General for Internal Policies, European Parliament*, 1–9.

German Central Bank. (2013). Implementing Basel III in European and national law. *Monthly Report of the Deutsche Bundesbank*, *65*(6), 55–71.

German Federal Financial Supervisory Authority. (2013). CRD IV - Capital Requirements Directive IV. Retrieved March 1, 2016, from http://www.bafin.de/SharedDocs/Veroeffentlichungen/DE/Fachartikel/201

3/fa_bj_2013_05_crd_iv.html

German Federal Financial Supervisory Authority. (2014). European Supervision (ESFS and SSM). Retrieved March 1, 2016, from http://www.bafin.de/EN/International/EuropeanSupervision/europeansupervision_artikel.html

González-Hermosillo, B., & Hesse, H. (2009). Global Market Conditions and Systemic Risk. *IMF Working Paper*, *230*, 1–22. http://doi.org/10.1177/097265271101000204

Gros, D., & Schoenmaker, D. (2013). European Deposit Insurance and Resolution in the Banking Union. *Journal of Common Market Studies*, *52*(3), 1–20.

Group of Ten. (2001). *Group of Ten Report on Consolidation in the Financial Sector*. Washington D.C., Basel, Paris. Retrieved from http://www.imf.org/external/np/g10/2001/01/Eng/

Guntay, L., & Kupiec, P. (2014). Taking the Risk out of Systemic Risk Measurement.

Härle, P., Lüders, E., Pepanides, T., Pfetsch, S., Poppensieker, T., & Stegemann, U. (2010). Basel III and European banking: Its impact, how banks might respond,and the challenges of implementation. *McKinsey Company Working Papers on Risk*.

Hartmann, P. (2015). Real Estate Markets and Macroprudential Policy in Europe. *Journal of Money, Credit and Banking*, *47*(S1), 69–80. http://doi.org/10.1111/jmcb.12192

Hendricks, D. (2009). Defining systemic risk. *PEW Economic Policy Department, Financial Reform Project Note*, 1–6. Retrieved from http://fic.wharton.upenn.edu/fic/policy page/PTF-Note-1-Defining-Systemic-Risk-TF-Correction.pdf

High-level Expert Group. (2012). Reforming the structure of the EU banking sector. *Final Report*. Retrieved from http://indice.astrid-online.it/rassegna/Rassegna-213/08-10-2012/EU-Banking-sector_High-level-group_Liikanen-Report_02_10_12.pdf

Holland, P. W. (1986). Statistics and Causal Inference. *Journal of the American Statistical Association*, *81*(396), 945–960. http://doi.org/10.2307/2289064

Huang, X., Zhou, H., & Zhu, H. (2011). Systemic Risk Contributions. *Finance and Economics Discussion Series*, *42*(8), 1–42. http://doi.org/10.1007/s10693-011-0117-8

International Monetary Fund. (2009). Responding to the Financial Crisis and Measuring Systemic Risks. *Global Financial Stability Report*, *2*, 1–273.

James, N. A., & Matteson, D. S. (2015). Package " ecp ." Retrieved March 1, 2016, from https://cran.r-project.org/package=ecp

Jondeau, E., & Rockinger, M. (2013). Systemic Risk in Europe. *Global Credit Review*, *03*(1), 145–190. http://doi.org/10.1093/rof/rfu012

Jovanovski, T., & Muric, M. (2012). The Phenomenon of Lag in Application of the Measures of Monetary Policy. *European Center for Peace and Development*. http://doi.org/10.1017/CBO9781107415324.004

Kejariwal, A. (2014). Breakout detection in the wild. *Twitter Blog*. Retrieved from https://blog.twitter.com/2014/breakout-detection-in-the-wild

Kern, A. (2013). Bank resolution and recovery in the EU: Enhancing banking union? *Academy of European Law Forum*, *14*(1), 81–93. http://doi.org/10.1007/s12027-013-0284-1

Keys, B. J., Mukherjee, T., Seru, A., & Vig, V. (2010). Did Securitization Lead to Lax Screening? Evidence from Subprime Loans. *Quarterly Journal of Economics*, *125*(1), 307–362. Retrieved from http://www.mitpressjournals.org/doi/abs/10.1162/qjec.2010.125.1.307

KPMG. (2011). Basel III : Issues and implications. *KPMG Report*, 1–20. Retrieved from https://www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/basell-III-issues-implications.pdf

Laeven, L., & Levine, R. (2008). Bank Governance, Regulation, and Risk Taking. *NBER Working Paper Series*, *14113*, 1–42. http://doi.org/10.1017/CBO9781107415324.004

Laeven, L., Ratnovski, L., & Tong, H. (2014). Bank Size and Systemic Risk.

IMF Staff Discussion Note, 1–34. http://doi.org/10.2139/ssrn.2437729

Laeven, L., & Valencia, F. (2008). Systemic Banking Crises: A New Database. *IMF Working Paper*, *224*, 1–78. http://doi.org/10.1057/imfer.2013.12

Laeven, L., & Valencia, F. (2012). Systemic Banking Crises Database: An Update. *IMF Economic Review*, *163*, 1–32. http://doi.org/10.1057/imfer.2013.12

Lehar, A. (2005). Measuring systemic risk: A risk management approach. *Journal of Banking and Finance*, *29*(10), 2577–2603. http://doi.org/10.1016/j.jbankfin.2004.09.007

Lepetit, L., & Strobel, F. (2015). Bank insolvency risk and Z-score measures: A refinement. *Finance Research Letters*, *13*, 214–224. http://doi.org/10.1016/j.frl.2015.01.001

Lintner, P. (2015). Overview on the BRRD. *Financial Sector Advisory Center Workshop*, 1–60.

López-Espinosa, G., Moreno, A., Rubia, A., & Valderrama, L. (2012). Short-term wholesale funding and systemic risk: A global CoVaR approach. *IMF Working Paper*, *46*(12), 1–35. http://doi.org/10.1016/j.jbankfin.2012.04.020

LSE Systemic Risk Centre. (2015). Systemic Risk. Retrieved December 1, 2015, from http://www.systemicrisk.ac.uk/systemic-risk

Masera, R. (2014). CRR / CRD IV : The Trees and the Forest. *Università Degli Studi Guglielmo Marconi*. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2418215

McGuire, P., & Tarashev, N. (2008). Bank health and lending to emerging markets. *BIS Quarterly Review*, (December), 67–80. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1491002

Mian, A., & Sufi, A. (2009). *The consequences of mortgage credit expansion: Evidence from the 2007 mortgage default crisis*. Retrieved from http://ssrn.com/abstract=1072304

Noth, F., & Tonzer, L. (2015). Bank Risk Proxies and the Crisis of 2007 / 09 : A Comparison. *IWH Discussion Papers*, (13), 1–7.

NYU V-Lab. (2016). Global Systemic Risk Rankings. Retrieved March 1, 2016,

from http://vlab.stern.nyu.edu/doc/17?topic=mdls

OTP Bank Plc. (2015). Announcements 2015 December November. Retrieved March 1, 2016, from https://www.otpbank.hu/portal/en/IR/Annuoncements/2015#04

Pardo, J. C., Santillana, V., & Martín, G. (2015). BRRD transposition in Spain : a milestone in implementing an effective resolution regime. *BBVA Research*, (June), 1–9.

Raffan, M., Newton, A., Schuster, G., & Lener, R. (2014). European Bank Recovery and Resolution Directive. *Freshfields Bruckhaus Deringer Working Paper*, 1–12.

Reinhart, C. M., & Rogoff, K. S. (2009). Banking Crises: An Equal Opportunity Menance. *NBER Working Paper Series*, (14587), 1–82. http://doi.org/10.1007/s13398-014-0173-7.2

Reinhart, C., & Rogoff, K. (2016). List of Figures and Tables by Chapter with Corresponding Data to "This Time is Different." Retrieved March 1, 2016, from http://www.carmenreinhart.com/this-time-is-different/

Rooch, A. (2012). Change-Point Tests For Long-Range Dependent Data. *Ruhr University Bochum*.

Santos, A. O., & Elliott, D. J. (2012). Estimating the Costs of Financial Regulation. *IMF Staff Discussion Note*. Retrieved from http://www.imf.org/external/pubs/ft/sdn/2012/sdn1211.pdf\nhttp://www.brookings.edu/research/papers/2012/09/11-financial-regulation-elliott

Schoenmaker, D., & Wierts, P. (2016). Macroprudential Supervision: From Theory to Policy. *National Institute Economic Review*, *235*(November), 50–62.

Schularick, M., & Taylor, A. M. (2012). Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008. Retrieved from https://www.aeaweb.org/articles.php?doi=10.1257/aer.102.2.1029

Segoviano, M. A., & Goodhart, C. (2009). Banking stability measures. *IMF Working Papers*, (4), 1–54. http://doi.org/10.5089/9781451871517.001

Soedarmono, W. (2012). Bank Capital Inflows, Institutional Development and

Risk: Evidence from Publicly-Traded Banks in Asia. *Bulletin of Monetary Economics and Banking*.

Song, F., & Thakor, A. (2010). Financial System Architecture and the Co-evolution of Banks and Capital Markets. *Economic Journal*, *120*(547), 1021–1055. http://doi.org/10.1111/j.1468-0297.2009.02345.x.

Sparrow, M. K. (2008). The Character of Harms : Operational Challenges in Control. *Cambridge University Press*.

Stein, R. M. (2013). Aligning Models and Data for Systemic Risk Analysis. *The Handbook of Systemic Risk*, 37–65.

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

Sun, E. W., & Yu, M.-T. (2016). Systemic Risk , Financial Markets , and Performance of Financial Institutions. *Annals of Operation Research, Forthcoming*.

Tavolaro, S., & Visnovsky, F. (2014). What is the information content of the SRISK measure as a supervisory tool? *Débats économiques et Financiers*, *10*, 1–24.

Tressel, T. (2010). Financial Contagion Through Bank Deleveraging: Stylized Facts and Simulations Applied to the Financial Crisis. *IMF Working Papers*, *10/236*, 1. http://doi.org/10.5089/9781455209361.001

Valiante, D. (2014). Unemployment in the euro area. *CEPS Working Document*, *August, 22*(389), 1–23.

Wolff, G. B., & Véron, N. (2013). From Supervision to Resolutio: Next Steps on the Road to European Banking Union. *Bruegel Policy Contribution*, *04*, 1–33.

Appendix

Appendix Item 1: Email contact with data analyst at NYU V-Lab from

26/02/2016

Date: 26/02/2016 5:22 pm
Subject: Re: Friday Talk
To: "Laurence Hendry MPP"
Cc:

1. There are banks which are listed "dead" but still have comprehensive data (e.g. leverage ratio and srisk). Example: Aktiv Kapital ASA (AIK_NO) is a Norwegian bank, from beginning of records in 2001 until end of records in Nov 8 2012. Why are they still included in the dataset if they are dead?
Answer:
1. Dead assets are still included in the dataset for historical purposes. They do not influence any of the other SRISK numbers after its last day of trading; however, users have expressed interest in seeing SRISK for firms during the financial crisis that are no longer alive.

2. Can we use the variables Firm Market Cap and Correlation with MSCI World Index without problems as covariates/independent variables in a regression model with SRISK as Dependent Variable? We fear that both are "indirectly" already measured in SRISK.
Answer:
2. From my understanding, the correlations and Beta are used to derived the MES value which is used to produce the SRISK value per firm.

3. We understand that capital requirement k is 8% for the USA and 5,5% for Europe due to different accounting regimes and that it is reasonable to apply this rate from 2000 to 2015 (So for a time frame that was covered by Basel I, II and III). However, from 1/1/2016 Basel III will rise and end up with (from 1.1.2019) 10,5% of RWAs.
a) Will the Vlab take that into account?
b) Where can we find the estimates/studies that state that total assets of US banks would be up to 40-60% higher under the European accounting regime (IFRS)?
Answer:

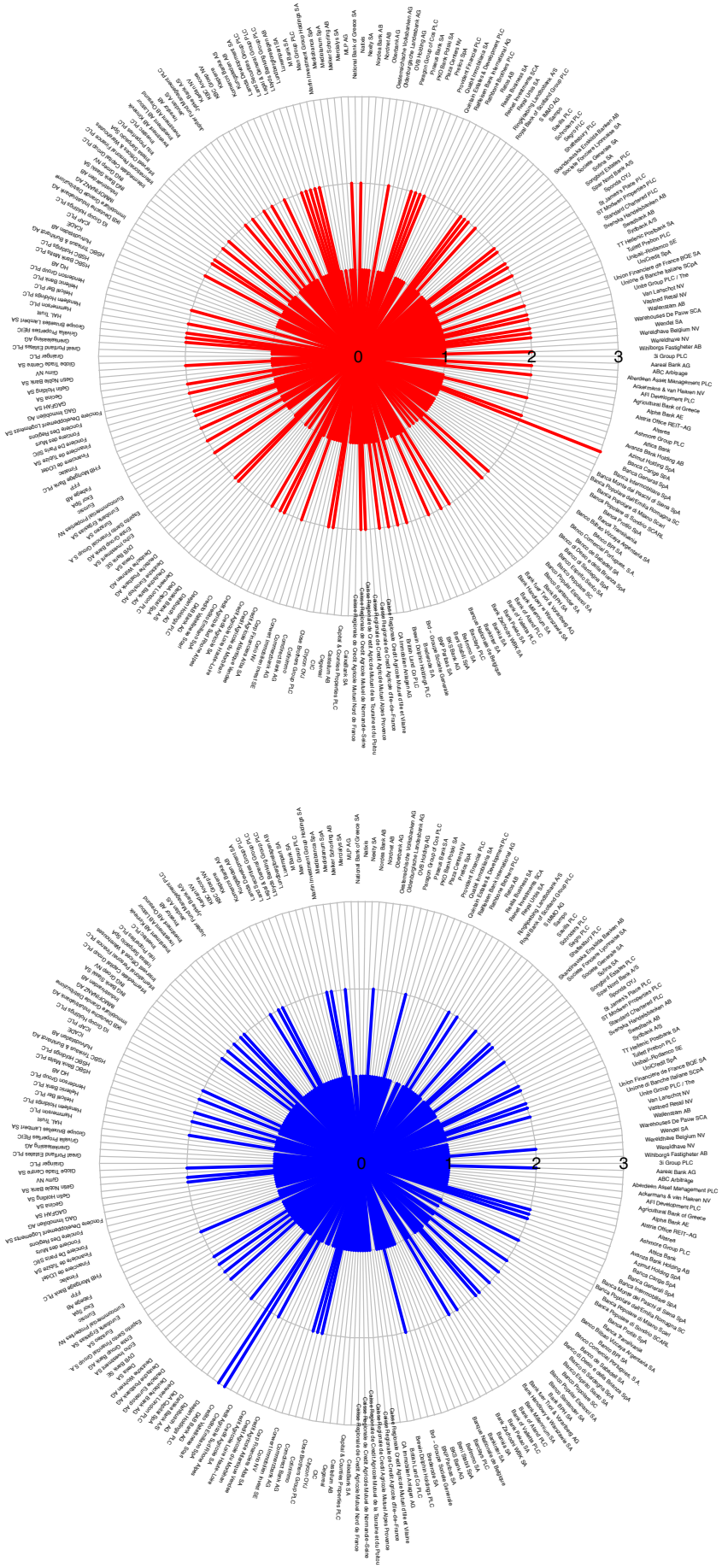
3. Our K has nothing to do with risk-weighted assets, since risk weights are often a proxy for the next crisis (think mortgage debt in 2007 and sovereign debt in 2009)
After speaking with Rob Engle, they took the inverse of the leverage of what they considered conservative banks before the financial crisis and concluded that value would be the capital requirement. k = equity/debt.

4. Is cross-border banking somehow included in the dataset? (The average penetration in Europe was around 20% in 2009?) In the principal data research step that V-Lab undertook, was there any concern given to the country division of an international bank you were collecting data on? Were there any clues as to make this step, i.e. in which country a bank is holding its reserves or operating most heavily, that came up in your data collection?
Answer:
4. Not sure what you are asking in this question, but we assume the stock price, market cap, total asset and total equity describes the entire asset regardless of cross-border banking.

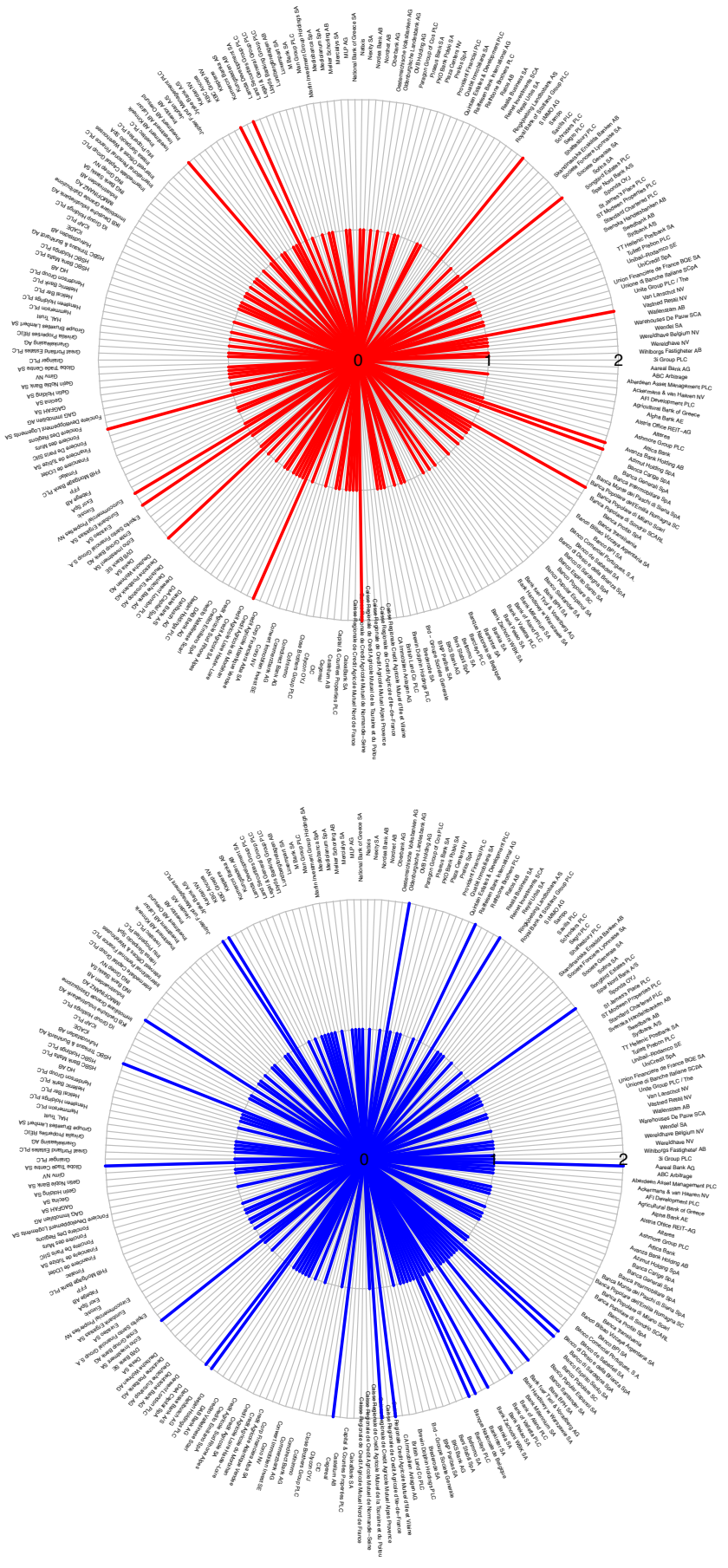
5. Is a comprehensive list available that names all papers/studies using dataset? Would there be any possibility of previewing the part of the paper relevant to dataset sampling you mentioned in your email from January 14th?
Answer:
5. I am still trying to curate the paper for you on how the dataset was assembled.

Data Analyst, Volatility Institute
NYU Stern School of Business

Appendix Item 2: Improvements and deteriorations CRR/CRD IV



Appendix Item 3: Improvements and deteriorations BRRD



Statements of Authorship

Statement of Authorship

I hereby confirm and certify that this master thesis is my own work. All ideas and language of others are acknowledged in the text. All references and verbatim extracts are properly quoted and all other sources of information are specifically and clearly designated.

DATE: 01/04/2016

NAME: Laurence Hendry

SIGNATURE:

Statement of Authorship

I hereby confirm and certify that this master thesis is my own work. All ideas and language of others are acknowledged in the text. All references and verbatim extracts are properly quoted and all other sources of information are specifically and clearly designated.

DATE: 01/04/16

NAME: Lukas Müller

SIGNATURE: