Did the Basel Process of Capital Regulation Enhance the Resiliency of European Banks?

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Abstract

This paper analyses the evolution of the safety and soundness of the European banking sector during the various stages of the Basel process of capital regulation. In the first part we document the evolution of various measures of systemic risk as the Basel process unfolds. Most strikingly, we find that the exposure to systemic risk as measured by SRISK has been steeply rising for the highest quintile, moderately rising for the second quintile and remaining roughly stationary for the remaining three quintiles of listed European banks. This observation suggests that the Basel process has succeeded in containing systemic risk for the majority of European banks but not for the largest institutions. In the second part we analyse the drivers of systemic risk. We find compelling evidence that the increase in exposure to systemic risk (SRISK) is intimately tied to the implementation of internal models for determining credit risk as well as market risk. Based on this evidence, the sub-prime crisis found especially the largest and more systemic banks ill-prepared and lacking resiliency. This condition has even aggravated during the European sovereign crisis. Banking Union has not (yet) brought about a significant increase in the safety and soundness of the European banking system. Finally, low interest rates affect considerably to the contribution to systemic risk across the whole spectrum of banks.

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1 Introduction

This paper has two main contributions: it is the first paper that traces the long-run evolution of various risk measures of banks and financial institutions for the past three decades. Particular emphasis is laid on measures of systemic risk as well as on distributional and cross-sectional heterogeneity. In fact, distributional differences across size groups as well as across types of intermediaries are substantial, and systemic risk measures evolve quite differently for different bank types. The second contribution attempts to move beyond the purely descriptive analysis and provide insights into the underlying economic forces and mechanisms. In particular, what are the drivers of systemic risk exposure? This is quite a challenging task since, besides innovations in technology and increasing globalization, also the regulatory landscape has been transformed deeply within the three decades of our analysis. While there are quite a number of interesting partial analyses about the effects of individual stages of the regulatory process on bank business models, we are not aware of any other studies that systematically compare and quantify the combined effect on, as well as the relative contributions to systemic risk, of such regulatory changes over time.

The present analysis is motivated by the drawn-out Basel process of capital regulation. This process was initially intended to increase the **safety and soundness** of banks and the global banking system while at the same time maintaining a **level playing field** in an increasingly globalized banking industry (Basel Committee of Banking Supervision, 1988).[1] But did these rules, and their modifications afterwards achieve their goals? How did they affect the conduct of banks in European banking markets? We concentrate on European banks because the many components of the Basel process have not been implemented in the U.S.

After almost thirty years of capital regulation, it seem the right time to ask what this process has achieved. Accordingly, this analysis may be viewed as an evidence-based evaluation of the economic consequences for the whole portfolio of the numerous regulatory interventions since the initial adoption of the Basel Capital Accord in 1988 - now commonly referred to as "Basel I". From an economic point of view this seems even more relevant, since the Basel Process was set into motion at a time of basically well functioning global banking markets, and without reference to any form of apparent market failure that required correction (see Goodhart, 2011)[2]. Subsequently, elements of self-regulation were introduced into the regulatory framework, initially to reward banks for implementing modern risk-management techniques in order to model market risks (market risk amendment of Basel I), and later even more prominently for modelling credit risk ("Basel II"). The evaluation of Basel II is complicated by the fact that the implementation period (2006) was immediately succeeded and, in fact, over-shadowed by the Great Financial Crisis and the subsequent repair operations now known as "Basel III" starting in November 2008. Since the Santiago meeting of the Basel Committee in November 2016 it has become evident that there is wide disagreement among policy makers about which lessons to learn from the regulatory experiments and the empirical experiences of the past decades. In particular, US-proposals on limitations on the use of internal model are highly contested

[1] In its 1988 Report the Basel Committee on Banking Supervision explicitly states: "Two fundamental objectives lie at the heart of the Committee's work on regulatory convergence. These are, firstly, that the new framework should serve to strengthen the soundness and stability of the international banking system; and secondly that the framework should be in [sic!] fair and have a high degree of consistency in its application to banks in different countries with a view to diminishing an existing source of competitive inequality among international banks." (BIS, 1988)

[2] This is not saying that there was no issue of banking crises. Thus the implementation of Basel I coincides with the end of the S&L-crisis in the United States, which, however, according to general current perception is related to risk insensitive deposit insurance pricing. The argument that under-capitalized banks might be tempted to engage in risk taking has never been officially made by the Basel Committee.

among European policy makers. This calls for an in-depth analysis of fact-based European evidence.

Accordingly, this paper illustrates and attempts to explain how the Basel process of Capital Regulation has affected the resilience of European banks. In particular, we track down the evolution of the resilience of European banks right from its implementation date and we identify its main drivers. If resiliency was generally enhanced by the regulatory process we would expect a long-run decline in the trajectories of any measures of systemic risk, reflecting an overall enhancement in the safety and soundness of European banking system. But alas, we find differently.

The novel risk measures that we employ are currently widely discussed in academia and readily available in the public domain: i) SRISK has been developed by Brownlees and Engle (2017) and measures the capital shortfall (Acharya, Engle, Richardson, 2012), ii) Delta CoVaR developed by Adrian and Brunnermeier (2016) is built on comovements of asset prices. While SRISK can be viewed as an aggregate measures of banks' *exposure* to systemic risk, Delta CoVar is an aggregate measure of banks' *contribution* to aggregate risk. Accordingly, SRISK is a measure of resiliency of a bank, and Delta CoVar a measure of contagion risk originating in a particular bank.[3]

The SRISK measure is made publicly available for 100 European banks from 2000 onwards by Robert Engle's V-Lab.[4] We reconstruct the measure back to the late 1980s, and for a larger sample of listed European financial institutions, in order to trace its evolution all the way from the early days of the Basel Committee.[5] Since SRISK is a market-based measure the analysis focuses on stock banks, and hence relatively large banks.[6]

Our first robust finding is that we do not find any indications of a sustainable increase in bank resiliency and a decline in systemic risk exposure. The contribution measure Delta CoVaR appears rather stationary across time, while the exposure measure SRISK is increasing overall. The thrust of the increase, however, is borne by the upper quintile in the riskiness of banks, while the lower three quintiles exhibit much more stationarity in comparison. This finding suggests that the original goals of the Basel Committee have not been met at large. Neither stability in the sense of containing systemic risk nor level playing field in the sense of making banks business models more uniform have been achieved. In particular, the amendment of the Basel Accord in 1996 and the implementation of Basel II in 2006 appear as major drivers of systemic risk at least in the highest risk segment.

In retrospect our empirical results may not come as a big surprise. Academics have always been critical of the Basel process of Capital Regulation already at the time of inception of the various regulations. Hellwig (1995) was worried about correlations between market and credit risk not being properly addressed by Basel I regulation.[7] Danielson, Embrechts, Goodhart, Keating, Münnich, Renault and Shin (2001) raised serious concerns about the endogeneity of risks not being addressed at all within the Basel II framework, suggesting that Basel II might unintentionally and paradoxically

[3]We present more precise formal definitions below in subsequent chapters.

[4]http://vlab.stern.nyu.edu/welcome/risk/.

[5]In this sense our analysis also extends Engle, Jondeau and Rockinger (2014) who analyse 196 European financial institutions from 2000-2012.

[6]However, we expect that many of our findings will carry over to non-listed banks.

[7]On a Panel Discussion on Capital Requirements for Market Risks Based on Inhouse Models in 1995 Hellwig (1996) suggests "that ten years later there may well be another panel, this one devoted to problems of quality assessment for inhouse models of credit risk and that a key question is what will happen to banks and banking systems in the ten intervening years". History has replaced that panel with a true field experiment in the 2007-8 crisis. So this paper can also be viewed as a response to Hellwig's (1996) request for an evidence-based evaluation of the internal model based approach to market risk.

even reduce safety and soundness of the banking system.[8]

But also on a purely methodological level the Basel approach attracted criticism of not accounting properly for extreme events and tail risk in particular. Notably, Eberlein and Keller (1995) demonstrate that hyperbolic Levy processes track real world market data far better than Gaussian processes. Building on this insight Eberlein et al. (1998) determine value-at-risk estimates and demonstrate that they tend to be much larger than under normality assumptions. At the standard 99%-VAR, typically Levy models would require double the amount of capital than Gaussian models would impose.[9]

Hence our second major contribution does address the question about the underlying drivers of the significant built-up of systemic risk in certain segments of the European banking market, and particularly about exposure risk. Admittedly, identifying contributions of a whole drawn-out process of regulatory changes is an awesome task relative to clinically identifying the effects of single policy changes. Nevertheless, cross-sectional heterogeneity is helpful and many of the policy changes during that process are complementary instruments addressing the same goal of increasing aggregate system stability. Hence, we conduct panel and quantile regressions that allow us to control for macroeconomic factors, the generally known drivers of bank asset prices and risk measures, as well as bank-specific balance sheet items. We then control for the implementation of important amendments at the various crucial stages of the Basel process of capital regulation, both at the aggregate level, as well as at the level of the individual bank.

We observe that the implementation of market as well as credit risk models along Basel II regulation have a strong non-linear impact on individual bank systemic risk exposures as measured by SRISK. However, the impact of internal credit risk model on systemic risk exposure largely outweighs the impact of market risk models. Market risk models even achieve a moderation of systemic risk exposure in the lower quantiles. These findings are verified by quantile regressions. Furthermore, in counter-factual exercises with behavioral parameters of the respective pre-implementation periods we simulate alternative trajectories of the systemic risk measures. Also these exercises establish that the dramatic increase in the exposure risk cannot be explained by pre-Basel II bank business models. It is rather the change of business models induced by Basel II that has become a major contributing factor of systemic exposure risk.

To dig even deeper, we study the effect of credit risk internal models with bank-level implementation data, and we observe a strong aggravating impact on SRISK from the implementation of advanced internal models. The results is particularly robust in a difference-in-differences approach carried out on the sample of banks implementing advanced IRBA models after Basel II, versus a sample of control banks matched by propensity score matching.

Overall we verify that the ECB, as a supervisor, was successful in identifying the most systemic banks when it took over supervisory responsibilities within the newly established European Banking Union in 2014. However, the systemic risk of those banks did not decline significantly after various stages of re-capitalisation and after entry into the Banking Union. Disconcertingly, both the recent innovations of Basel III as well as the regulatory attempts within the European Banking Union did not result in a significant decline in the aggregate SRISK measure. The individual SRISK of most

[8] On the problem of neglecting the endogeneity of systemic risk see also Hellwig (2010).

[9] Incidentally, Eberlein et al. (1998) determine value-at-risk based capital for Deutsche Bank at more than double the amount required under the normality assumption of the market risk amendment (see their Table VIII).

systemic European institutions remains at levels considerably elevated relative to levels prior to the Great Financial Crisis of 2007-8.

While the academic literature has focused on methodology and on developing new systemic risk measures, few studies exist about the market reactions to Basel-driven regulation in the banking industry. One important study is Wagster (1996) who has linked the Basel process to the competitiveness of banks across countries. In particular, he identified market reactions at various stages of the discussion about Basel I reforms. He shows that the Basel process can be viewed as a bargaining process between national regulators; many agreements by Japanese authorities, in particular concerning the regulatory treatment of hidden reserves, were elicited by concessions to the Japanese banking sector that were capitalized in market prices and can be measured accordingly. To the best of our knowledge our work is the first systematic evaluation of the effect of the Basel process of capital regulation on the safety and soundness of banking systems.

Concerning internal credit risk models we confirm and extend the results of Behn, Haselmann and Vig (2016) and Mariathasan and Merrouche (2014) about the limitations of model-based regulation. We also find that internal models are used to systematically reduce - or even manipulate - risk weights. However, in addition to earlier analyses we can assess the differential contribution of internal credit risk models to the distributional build-up of systemic risk exposures relative to earlier policy instruments of the Basel process, such as internal market risk models. It turns out that internal credit risk models indeed are the main driver of systemic risk relative to all the other policy stages.

An important contributing result to our analysis is the consistently negative effect of the policy rate of monetary policy on the systemic risk exposure throughout the whole distribution of banks. Thus expansionary monetary policy induces the implementation of riskier business models in the banking sector, and, hence, a reduction in resiliency and stability. But unlike internal models the policy rate has a pretty much uniform affect across the whole distribution.

Interestingly, we also observe a considerable build-up of systemic risk in the insurance sector. We can trace this evolution back beyond the time span of other studies (Berdin, Sottocornola (2015), IMF Global Stability Report, 2016), starting in 1996 with the Market Risk Amendment of the Basel Accord, and increasing in size and relevance thereafter. This findings are consistent with the existence of significant spillover effects from the banking sector to the insurance, following the change in regulation in the banking activity (Gehrig, Iannino, 2016).

The paper will proceed as follow: Section 2 briefly describes the Basel process. Section 3 introduces the data and the methodology used in the empirical analysis. Section 4 presents the main descriptive results and the main multivariate results. Section 5 highlights the policy role of our market-based measures. Finally, Section 6 concludes summarizing the unintended consequences of the Basel process.

2 The Basel Process

The Basel process of capital regulation was triggered in late 1974. The first meeting of Basel Committee on Banking Regulations and Supervisory Practices took place in February 1975. After a long period of consultations[10], the first Basel Capital Accord (Basel I) was approved by the G10 governors in December 1987 and publicly announced in July 1988. The Accord was formally implemented in December 1992.

The Accord had already been amended in 1991, to reform the treatment of loan loss reserves, and later repeatedly in 1995 and 1996. The most important amendment was the introduction of internal models under supervisory review as an alternative to statutory rules in January 1996 as part of the market risk amendment (Basel Committee of Banking Supervision, 1996). This amendment essentially provided a choice between a self-regulatory regime under supervisory review and statutory regulation. It provided incentives to improve in-house risk management models, which were highly deficient in the 1990s even in multinational banks (see Wuffli, 1995). However, the amendment also implicitly provided incentives to employ internal models as an instrument to reduce regulatory burdens and capital charges, and, hence, to reduce resiliency (see Hellwig, 1995).

Proposals for a new capital accord were triggered by the initiation of a consultation process on a Revised Capital Framework in June 1999. This became the basis of the three-pillar framework of Basel II, which formally culminated in June 2006 in the agreement on Basel II: "International convergence of capital measurement and capital standards: a revised framework for comprehensive supervision".

Basel II was adopted in most countries with the notable exception of the U.S., one of its strongest original supporters. However, the impact of its implementation could not be properly assessed[11] since already in 2007 the subprime crises developed into a worldwide crisis and depression. Hence, already in September 2008, the Basel Committee was forced to reconsider its regulatory framework with its guidelines on Principles for Sound Liquidity Risk Management and Supervision triggering the discussion on reforming Basel II, a process now commonly referred to as Basel III.

3 Sample and Methodology

In order to assess the implementation of the Basel principles, we propose an empirical investigation on a sample of European financial institutions from 1987 to 2015. The sample includes the listed institutions covered by Compustat Global and belonging to sector groups 4010 (banks), 4020 (diversified institutions), 4030 (insurance companies) and 4040 (real estate companies). To reduce survivorship bias, we include active as well as non-active institutions. We estimate systemic risk for 400 institutions from the Euro-area, Switzerland, and the United Kingdom, with at least 10 years of balance sheet data.

Compustat Global provides us with both daily market prices and capitalization and quarterly/annual fundamental data, such as book values of equity, assets and debt. As our quarterly data on European institutions go back till 1996, we complete the information back to 1987 with annual balance sheet data. We use the MSCI Europe index as the broad market return (Datastream data), and the yield on German federal bonds (Bundesbank data) as the risk free rate. Moreover, we use the market stress indicator CISS from Hollo, Kremer and Lo Duca (2012), and information on credit

[10] See Goodhart (2011) for details on the early years of the Basel Committee.

[11] Given the length of the consultancy process for Basel II, it is quite likely that the process did affect bank business models already well before the official implementation. Moreover, the self-regulatory pillar allowing internal models was available to officially and fully compliantly drive bank business models since 1996.

risk internal models from SNL Financial data, from the Bundesbank and from the Österreichische Nationalbank.

The empirical analysis proceeds as follows. We estimate the bank's exposure to systemic risk according to the SRISK measure proposed by Brownlees and Engle (2017) and its contribution to the aggregate systemic risk as the Delta CoVaR developed by Adrian and Brunnermeier (2016).

We analyse the impact of the Basel regulation on our measures of systemic risk considering both bank-level and market-level dummies for the use of internal model for credit risk (IRBA hereafter). SNL provides bank-level quarterly information on the implementation of standardized versus internal credit risk models from 2006, that we complete with the approval dates of internal models for all the German banks and the Austrian banks. Moreover, we use milestone dates that have affected the business models of the institutions in our sample: the introduction of market risk internal models in January 1996, the implementation of Basel II as June 2006, and the first publication of Basel III guidelines in September 2008.

We then control for a large set of potential drivers of the SRISK measure using information on either quarterly accounting bank data or weekly market data. We use bank cost of equity, market beta, market value, market-to-book ratio, total assets, investments in fixed income, investments in equity securities, non-performing loans, Z-score of distance to default. As market-level characteristics, we consider the MSCI Europe index, the long-term country rates, and the financial market stress indicator CISS.

Finally, we perform a counterfactual analysis to estimate the predicted SRISK with parameters pre-Basel environment, and a difference-in-differences analysis to pin down the effect of credit risk internal models on systemic risk.

3.1 SRISK and Delta CoVaR Measures

We use measures of systemic risk that capt the contribution to aggregate risk of an institution in distress (Delta CoVaR) and the exposure in a distress market (SRISK and MES).[12]

Building on the theoretical work of Acharya, Pederson, Philippon and Richardson (2017), Brownlees and Engle (2017) develop a measure of systemic risk, SRISK, that builds on market information to value the expected capital shortfall. SRISK, hence, measures the exposure of an individual bank to systemic risk as the amount of capital to raise in order to keep the bank running in an orderly way if a major macro shock happens. This systemic risk measure considers the combined effect of the sensitivity of the bank returns to aggregate shocks, leverage and market capitalization of the bank, and the weakness of the whole financial system. A firm is considered systemically risky if it is likely to face a proportionally relevant capital shortfall when the financial sector is weak.

Adapting this methodology, we estimate (i) an asymmetric GJR GARCH model (Glosten, Jagananthan and Runkle, 1993) of the returns volatility of each institution and of the market equity index, (ii) a DCC correlation model (Engel, 2002) for the correlation between the institution return and the European market index, and (iii) the performance of the bank, and the capital shortfall in case of extreme financial downturns.

[12]The literature provides of multitude of related shortfall measures such as CATFIN (Allen, Bali, Tang, 2012).

We assume a bivariate daily time series model of the equity returns of institution i, dependent on a value-weighted market index m:

$$\begin{aligned} r_{m,t} &= \sigma_{m,t}\varepsilon_{m,t} \\ r_{i,t} &= \sigma_{i,t}(\rho_{i,t}\varepsilon_{m,t} + \sqrt{1-\rho_{i,t}^2}\xi_{i,t}) \end{aligned}$$

where the volatilities are asymmetric GJR GARCH processes and correlations are Dynamic Conditional Correlations (DCC). We use the MSCI Europe index for the market returns as a more representative benchmark for our sample of European banks.

The measures of performance and systemic risk are evaluated in the event of an extreme aggregate shock. We identify extreme downturns by falls in the daily market index higher than its 95% VaR. The expected daily loss of the bank returns, in this case, is the Marginal Expected Shortfall (MES):

$$MES_{it}(c) = E_{t-1}(r_{it}|r_{mt} < c = q_{5\%}) \tag{1}$$

The higher the bank's MES, the higher is its exposure to the risk of the financial system.

We estimate both the performance of the bank in such extreme events and the capital shortfall. The Long-Run Marginal Expected Shortfall (LRMES) is the expected loss in equity value of bank i, if the market were to fall by more than the above threshold within the next six months. As Acharya, Engel and Richardson (2012), we approximate it without simulation using the daily MES:[13]

$$LRMES = 1 - e^{(-18*MES)} \tag{2}$$

Finally, given the above conditional expected equity losses, the current equity market value and the outstanding book value of debt, we determine the expected capital shortfall a bank would experience in case of distress. SRISK is defined as such capital shortfall in the event of an aggregate crisis:

$$\begin{aligned} SRISK_{i,t} &= E_{t-1}[Capital\ shortfall_i|Crisis] \\ &= E_{t-1}[k(Debt + Equity) - Equity|Crisis] \\ &= E_{t-1}[k(Debt_{i,t}) - (1-k)(1-LRMES_{i,t})Equity_{i,t}] \end{aligned} \tag{3}$$

where: k is the prudential capital ratio, that we assume 8% in our main analysis. As robustness checks, we also conduct the inference analysis using capital ratio of 3% and 5.5%.

Once the individual $SRISK_{i,t}$ are estimated per each bank, the relative exposure of firm i to the aggregate SRISK of the financial sector is:

$$SRISK\%_{i,t} = \frac{SRISK_{i,t}}{\sum_{j\in J} SRISK_{j,t}}, \ \ where\ J = firms\ with\ SRISK > 0 \tag{4}$$

It represents the percentage aggregate capital shortfall that would be experienced by this firm in the event of a crisis, and it allows to identify the most systemic institutions in the sector.

[13]The approximation represents the equity value loss over a six-month period conditional on a market fall by more than 40% within the next six months. Alternatively, we also estimate LRMES as the NYU VLab is currently estimating it: 1 - exp(log(1 - d)*beta), where d=40% is the six-month crisis threshold for the market index decline, and beta is the dynamic market beta.

Besides the estimation of the SRISK and its components, we also estimate the Delta CoVaR developed by Adrian and Brunnermeier (2016). It corresponds to the VaR of market returns conditional on a critical event on the returns of a bank i. The marginal contribution of bank i to the overall systemic risk, ΔCoVaR, is the difference between the CoVaR in distress and the CoVaR in a median state.[14]

This measure starts from the estimation of an aggregate extreme loss in terms of Value-at-Risk, as the maximum loss of the market return within the α%-confidence interval, conditionally on some event $C(r_{it})$ observed for bank i:

$$Pr(r_{mt} \leq CoVaR_t^{m|C(r_{it})}) = \alpha \tag{5}$$

Using a quantile regression approach, we identify this distress event of firm i as a loss equal to its $(1-\alpha)$% VaR: $r_{it} = VaR_{it}(\alpha)$.

The systemic risk of the bank i is then defined as the difference between the CoVaR of the financial system conditional on firm i being in distress and the CoVaR of the financial system conditional on firm i being in its median state:

$$\Delta CoVaR_{it}(\alpha) = CoVaR_t^{m|r_{it}=(VaR_{it}(\alpha))} - CoVaR_t^{m|r_{it}=Median(r_{it})}) \tag{6}$$

Expressed in dollar terms, we weight it with the market capitalization of bank i:

$$\Delta^{\$}CoVaR_{it}(\alpha) = \Delta CoVaR_{it}(\alpha) * size_{it} \tag{7}$$

3.2 Drivers of Systemic Risk

Historically, prudential regulation of banks has focused on individual bank risk and micro-prudential regulation, neglecting the correlated systemic effects of several institutions in distress and in needs of recapitalization at the same time.[15] Therefore, it is of great interest to understand the potentially differential effects of the Basel measures on individual bank risk (microprudential risk) and aggregate systemic risk (macroprudential risk), and how the market prices systemic risk (Hellwig, 2009).

The analysis proceeds in the following steps. First, we perform a baseline regressions of SRISK with quarterly data on the overall sample, both as panel fixed effects and unconditional quantiles regressions. Next, we address the long-run relationship between average SRISK and market capitalization, distance to default and interest rate with a VECM on weekly averages. Results from these initial steps are motivating a more granular analysis. Thus, we analyze a subsample of banks where microdata on the implementation on credit risk models is available. We use the full longitudinal information applying both panel fixed effects and quartile regressions to address non linearities in the relations between the systemic risk measure and the explanatory variables. Finally, we perform a counterfactual analysis to compare the observed SRISK on the systemic risk that would have been realized without Basel regulation. Many robustness checks are discussed separately in the Appendix.

[14]See Benoit et al. (2013) for a comparison of the two measures.
[15]Only under Basel III capital surcharges for systemically important financial institutions (SIFI) are introduced.

In first baseline specifications on the full sample of 400 institutions, we regress the SRISK measure on Basel dummies, systematic risk proxies, market stress indicator, controlling for lagged quarterly firm characteristics Z_{kq-1}. In order to address issues of mixed frequencies, we aggregate the higher frequency measures (SRISK, Beta, market capitalization, CISS) to their quarterly median, and perform the following regression:

$$\begin{aligned} SRISK_{iq} &= \alpha + \gamma_0 SystematicRisk_{iq} + \gamma_1 CISS_q + \sum_k \gamma_k L.Z_{kiq} \\ &+ \lambda_1 BIAmend + \lambda_2 BII + \lambda_3 BIII + \mu_i + \varepsilon_{iq} \end{aligned} \tag{8}$$

As measures of systematic risk, we consider alternatively (i) time-varying Beta between the bank asset returns and the market index, and (ii) cost of equity measured by means of a CAPM model.

The time-varying beta is estimated from the previous GJR-DCC GARCH model. The Cost of Equity is the CAPM return required by the market given the estimated dynamic beta and the risk premium of the market portfolio:

$$CostEquity_{it} = R_{ft} + \widehat{beta}_{it} * (R_{mt} - R_{ft}) \tag{9}$$

We use the daily annualized yield on German Bonds as a proxy for the risk-free rate for the European banks, and the MSCI Europe return compounded over the previous year as benchmark market return.

Concerning the Basel dummy variables, we perform our analysis considering three important milestones of the process in the time span of our sample: the introduction of Market Risk internal models (BIAmend, January 1996), the implementation of Basel II (BII, July 2006), and the guidelines of Basel III (BIII, September 2008). We therefore include three dummy variables identifying these subperiods: (i) Basel I and statutory regulation, (ii) Basel I and self-regulatory regime by use of internal market risk models, (iii) Basel II and self-regulatory regime concerning credit risk models, and (iv) Basel III.

Finally, we control for market stress (CISS[16]), lagged total assets, non-performing loans, investments in equity security assets, investments in fixed income assets, market capitalization and leverage (Z_{kq-1}).[17] These variables should capt all the most important factors in the asset pricing literature (Fama and French, 1993) in order to address endogeneity due to our market dependent variable. We also control for macroeconomics variables that could affect the banking environment in each country, as GDP growth, unemployment rate, long-term interest rates, and equity share prices growth.

Important non-linearities result from the graphical observation of the SRISK, therefore we regress the above specification both as a panel fixed effect model, and on three quantile regressions (at 0.25, 0.50 and 0.75 percentiles). The quantile regressions, with respect to conditional mean estimator, allows us to observe any location and shape shift in the conditional distribution of SRISK due to

[16]We use the CISS measure as an indicator of the systemic stress that the European financial market as a whole experiences through time (Hollo, Kremer and Lo Duca, 2012). It consists in a weighted index of the instability in five different market segments: financial intermediaries, money markets, equities and bonds markets, and foreign exchange markets. The measure is publicly available from the ECB databank from 1999. We thank Manfred Kremer for sharing the CISS estimated from 1987.

[17]In a robustness check, we use the lagged SRISK as dependent variable to address the dynamic structure, instead of total assets. The two variables are highly correlated.

our Basel dummies and the other control covariates.

The second step of the analysis looks more carefully at the long-run relationship between SRISK, market capitalization, distance to default and interest rates. Distance of default is proxied by the Z-score (Boyd and Runkle, 1993, Fiordelisi and Marques-Ibanez, 2013). It measures the distance to becoming insolvent, as number of standard deviations away from the bank's ROA:

$$Zscore_{it} = \frac{ROA_{it} + E_{it}/TA_{it}}{\sigma_{ROA_i}} \tag{10}$$

We apply a VECM (with 4 lags) to weekly averages of the four variables, choosing the number of lags optimally given the AIC, HQIC and SBIC information criteria and assuring no autocorrelation is left in the residuals. To address breaks at the Basel introduction, we regress the VECM separately in three subperiods, before 1996, between 1996 and 2006, and from 2006 to 2015. Johansen tests of cointegration assure that we have one cointegrating equation in any period.[18]

The results from the previous two steps motivates the the third and more detailed part of the analysis. We introduce bank-level information on the credit risk internal models implementation (IRBA). This inclusion allows us to have a better understanding of how the usage of this regulatory tool has impacted on the systemic risk of the European banking sector. However, it reduces our sample size to 100 banks covered by SNL Financial and by the data provided by Bundesbank and Oesterreiche Nationalbank.

With the introduction of Basel II, banks were allowed to use in-house internal models to quantify risks of their loan portfolios instead of the standardized approach where the risk weights are assigned by coarse categories by the regulator. They have two options on how to implement IRBA, subject to authority approval: a foundation approach and an advanced approach. Under the former, banks are allowed to build their own models estimating the probability of default of individual clients or portfolios of loans. Under an advanced approach, banks can also estimate internally exposure-at-default and loss-given-default in order to quantify the risk-weighted assets.

We therefore regress weekly SRISK on a bank-level categorical variable, $IRBA_{it}$, equal to 1 for standardized models as Basel II regulation, 2 for the implementation of foundation internal models, 3 for mixed approaches, 4 for advanced IRBA models, and 0 before the introduction of Basel II regulations. With the introduction of this bank-level variables, we thus remove the time dummies identifying Basel II and Basel III. To account for the dynamic patterns we have evinced from the VECM, we regress a dynamic panel data model of SRISK, or we regress the residuals of a AR(2) model[19] of SRISK on market- and bank-characteristics.

$$\begin{aligned} SRISK^{e}_{it} &= \alpha + \sum_k \gamma_k L.Z_{kit} + \sum_q \gamma_q L.X_{qt} \\ &+ \lambda_1 BIAmend + \sum_p \lambda_p IRBA_{pit} + \mu_i + \varepsilon_{it} \end{aligned} \tag{11}$$

[18] As a robustness check, we also proceed estimating possible lag-lead effects with a VAR model between exposure to systemic risk (SRISK), contribution to systemic risk (Delta CoVaR), systematic risk (Beta), and market capitalization. We use 4 or 8 weeks to construct our VAR, and we test causality between these variables with Granger causality tests, however knowing we need caution about stationarity of SRISK. Results are reported in an online Appendix.

[19] An autoregressive process of order two removes the autocorrelation structure in SRISK.

We quantify the impact of proxies for systematic risk, using, alternatively, market Beta or CAPM cost of equity as previously estimated.

We control for market-characteristics (X_{qt}) that would proxy for market investment opportunities (European market return, country policy rate, market stress indicator CISS), and bank-characteristics (Z_{kit}) as market capitalization, intrinsic distance to default Z-score, and market over- or undervaluation of the bank (market-to-book ratio). Importantly, we apply country interest rates in order to control for monetary policy and growth opportunities. We regress the panel model with fixed effects μ_i for either bank or country. As above, we address the main factors in the asset pricing literature, particularly size and market-to-book, as drivers of market prices that could introduce endogeneity in our model.

Since we observe important nonlinearities in SRISK, we also use quantile regressions to address potentially differential effects of our covariates across the three main quantiles (q25, q50 and q75) of the distribution of the SRISK. We use an unconditional quantile approach as Firpo, Fortin and Lemieux (2009), where we marginalize the quantile coefficients using the recentered influence function. The interpretation of the estimated coefficients therefore corresponds to the usual interpretation as the marginal effect on the unconditional quantile of SRISK of a location shift in the distribution of the covariates, ceteris paribus.

3.3 Counterfactual analysis

The last step of the analysis is to estimate the counterfactual of systemic risk in the absence of Basel regulation. The complexity of this step is straightforward as all European banks are abiding to Basel regulation. We therefore provide two analyses to strengthen our previous findings: (i) we compare the impact of the market risk amendment and Basel II between different sub-sectors of financial institutions, banks versus insurers and real estates; (ii) we estimate the effect of Basel II in a difference-in-differences analysis where we observe treated banks with credit risk internal models versus control banks without treatment.

First, we apply the former weekly panel specification to estimate the parameters in two pre-Basel windows, separately for the three sub-groups of banks, insurance companies and real estates:

$$SRISK_{it}^{e} = \alpha + \sum_{k} \gamma_k L.Z_{kit} + \sum_{q} \gamma_q L.X_{qt} + \mu_i + \varepsilon_{it} \tag{12}$$

We have two estimation periods, as prior to the Market Risk Amendment (January 1996), and prior to Basel II regulation (June 2006). We do not re-estimate our parameters after 2008, because the effect of the crisis would confound our estimates.

Then, we predict what SRISK would have been in the following post-Basel periods, with the assumption of constant parameters. We have two post-event windows where we predict SRISK as:

$$\widehat{SRISK}_{i\tau}^{(e,noMRA)} = \widehat{\alpha} + \sum_{k} \widehat{\gamma}_k^{(\tau<Jan1996)} L.Z_{kit} + \sum_{q} \widehat{\gamma}_q^{(\tau<Jan1996)} L.X_{qt} \tag{13}$$

$$\widehat{SRISK}_{i\tau}^{(e,noBII)} = \widehat{\alpha} + \sum_{k} \widehat{\gamma}_k^{(Jan1996\leq\tau<Jun2006)} L.Z_{kit} + \sum_{q} \widehat{\gamma}_q^{(Jan1996\leq\tau<Jun2006)} L.X_{qt} \tag{14}$$

Comparing the observed SRISK with the predicted $\widehat{SRISK}$ for each financial sector helps us to reach a more robust interpretation of the effects of Basel regulation on the banks resiliency. In a well-functioning regulatory environment, we would expect to see a lower level for observed SRISK compared to the predicted SRISK only for the individuals affected, as such the banks and not other institutions.

Next, we use the variation in credit risk internal model implementation to discriminate between treated versus control banks, before and after Basel II implementation on June 2006. We implement a Difference-in-Differences analysis, such as:

$$SRISK^{e}_{it} = \sigma_0 + \sigma_1 IRBA + \sigma_2 BaselII + \sigma_3 BaselII * IRBA + \varepsilon_{it} \tag{15}$$

where IRBA is the dummy variable identifying banks with advanced or mixed credit risk internal models, BaselII is the time dummy capturing changes after the implementation of Basel II, and BaselII * IRBA is the interaction term identifying IRBA banks after June 2006. The difference in differences parameter is therefore:

$$\widehat{\sigma_3} = (\overline{SRISK}_{IRBA,post} - \overline{SRISK}_{IRBA,pre}) - (\overline{SRISK}_{nonIRBA,post} - \overline{SRISK}_{nonIRBA,pre}) \tag{16}$$

In order to identify more precisely the control group and avoid selection bias, we perform first a kernel Propensity Score Matching (Rosenbaum et al. (1983)). We run a probit regression to estimate the probability of implementing IRBA models given market beta, Z-score, market capitalization, market-to-book ratio. A propensity score is then assign to balance the treated and the comparison groups. Next, the DD weighted regression is estimated, where observations are weighted to ensure that each group reflects the covariate distribution in the pre-Basel II period.

With this analysis, we remove both the bias in the post-Basel period between the treated and the control groups that could result from permanent differences between banks, and biases from comparisons over time in the treatment group that could be the result of other changes.

4 Empirical Results

We start our analysis by documenting the evolution of systematic as well as systemic risk. We will then illustrate cross-sectional properties of our systemic risk measures before analyzing the drivers of our measure of exposure to systemic risk (SRISK) by means of panel and quantile regression analyses. Next, we complement the analysis on SRISK by adding microdata on the implementation of internal credit risk models. In the fifth subsection, we report the results from the counterfactual analysis. In the subsection on robustness, we mention a variety of additional analyses not reported in detail in this paper. The underlying tables of that section are collected in an (Online-) Appendix. The last section concludes with a robustness analysis of the drivers of our measure of contribution to systemic risk Delta-CoVaR.

4.1 Evolution of Systemic and Systematic Risk between 1987-2015

Arguably, the Basel process of capital regulation was intended to increase the stability and safety of the banking industry.[20] Accordingly, we might expect to see a decrease in the riskiness of bank

[20] Gehrig (1995) suggests that harmonization of regulation and creating a level playing field was another goal of the Basel Committee.

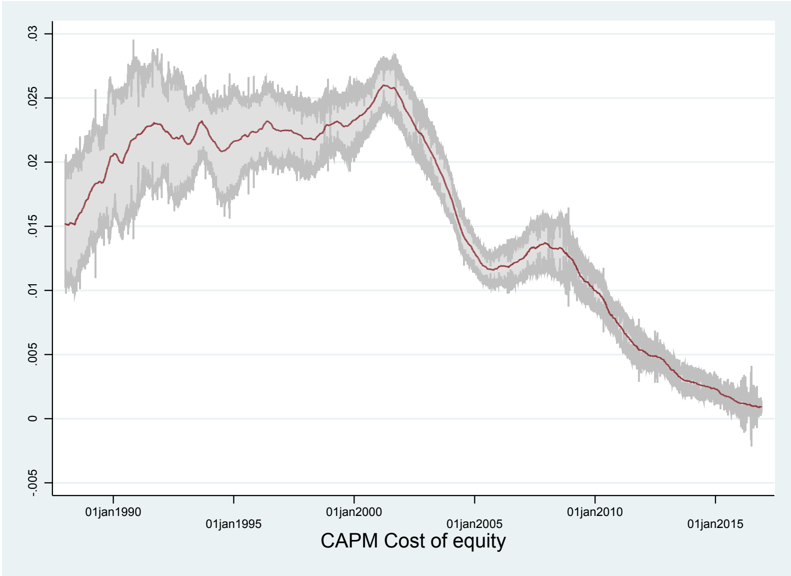

Figure 1: Evolution of CAPM cost of bank equity. The Figure presents the evolution of the daily average cost of equity across time, from January 1987 to 2015. We report a central moving average of 4 years, with confidence intervals around the estimated cost of equity. The cost of equity is the return required by the market applying a CAPM model with the time-varying beta and the annual risk premium required on the market return, as Equation 9: $CostEquity_{it} = R_{ft} + \widehat{beta}_{it} * (R_{mt} - R_{ft})$. We use the yield on German Bund as risk-free rate, and the MSCI Europe index compounded over the previous year as market return. The time-varying beta is estimated by a GJR DCC Garch model.

business models after the formal implementation of the various stages of the Basel process. This should ideally be reflected in lower risk premia and, hence, lower funding costs such as lower costs of bank equity. Moreover, we would expect that an improvement in stability and safety of the banking sector would also be reflected in a reduction in the exposure of banks to systemic risk. So what do the data tell us about the evolution of these measures for (almost) the past three decades?

Indeed, it turns out that market-based measures of the cost of bank equity did decrease significantly on average (Figure 1).[21] The trend is pervasive across countries and we do not observe particularly different time trends. [22]

While permanently declining long-term interest rates contributed to a decline in cost of bank equity, most of this decrease is actually driven by an average decline in systematic risk, as measured by the beta (Figure 2). This finding implies increasingly more favorable funding conditions for banks and lower costs of issuing bank equity.[23] It is also worth noting that this long-run evidence runs counter to the perception of contemporary observers in the early phase of the Basel process. The ubiquitous sense of increasing risk in banking due to narrower intermediation margins caused by

[21] We follow the Federal Reserve System (Barnes and Lopez, 2006) and the BIS (King, 2009) approaches in measuring costs of bank equity on the basis of a CAPM-model. Moreover, again following King (2009) we provide a moving-average presentation of the daily cost of capital, which is notoriously volatile. Unlike King (2009) we provide confidence intervals to allow an assessment of statistical significance.

[22] This decrease did happen across most of the advanced economies such as Germany and Great Britain, consistent with previous literature on the G-10 countries and the US in particular (Baker and Wurgler, 2015, Maccario et al. 2002).

[23] This finding is in line with Barnes and Lopez (2006) and King (2009) who also find downward trending cost of bank capital except for the case of Japan.

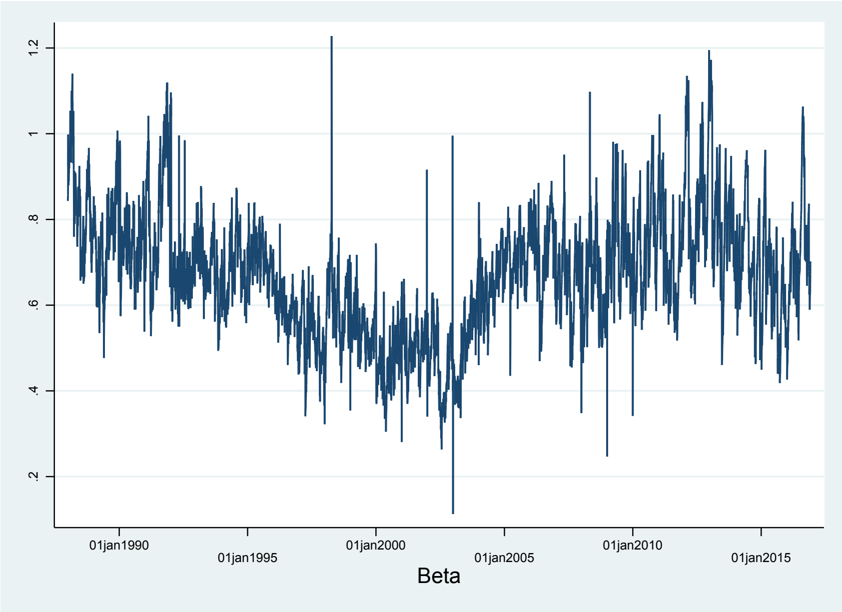

Figure 2: Evolution of systematic risk (Beta). The Figure presents the evolution of the daily average beta across time, from January 1987 to 2015. It represents the sensitivity of the bank equity returns to the MSCI Europe index returns. It is estimated by a GJR DCC Garch model.

deregulation and intensified competition (e.g. Gehrig, 1995, 1996) is not reflected in average risk premia across European banks in subsequent decades.

How does this evidence of lower risk premia and systematic risk in the financial industry relates to measures of systemic risk? Has the safety and stability of the banking system been enhanced by the Basel process at large? Are there segments in the banking system where resilience has actually declined?

To address these questions, we employ two standard measures of systemic risk, the Delta CoVaR measure of Adrian and Brunnermeier (2016) as a measure of an institution's contribution to systemic risk, and the SRISK measure of Brownlees and Engle (2016) as a market-based measure of an institution's exposure to systemic risk.

The Delta CoVaR measure first peaks in the late 1980's at the end of the S&L crisis. After the Basel accord of 1988 the Delta CoVaR measure is in decline until 1996, from which on it remains heightened until about 2005 (Figure 3). This period roughly corresponds with the period after the introduction of the market risk amendment of Basel I until the end of the consultancy process of Basel II. This period also covers the dot-com bubble, which apparently did not affect contagion risk of European financial institutions. The next huge increase in Delta CoVaR coincides with the European sovereign crisis in 2009-10.

Surprisingly, while figuring significantly, the subprime crisis does not figure prominently according to the Delta CoVaR measure. There is a single peak around Lehman failure in September 2008, but Delta CoVaR remains below pre-crisis levels. To the effect that the subprime crisis has been characterized by a drying-up of liquidity, it appears remarkable that contagion risk has not shot up

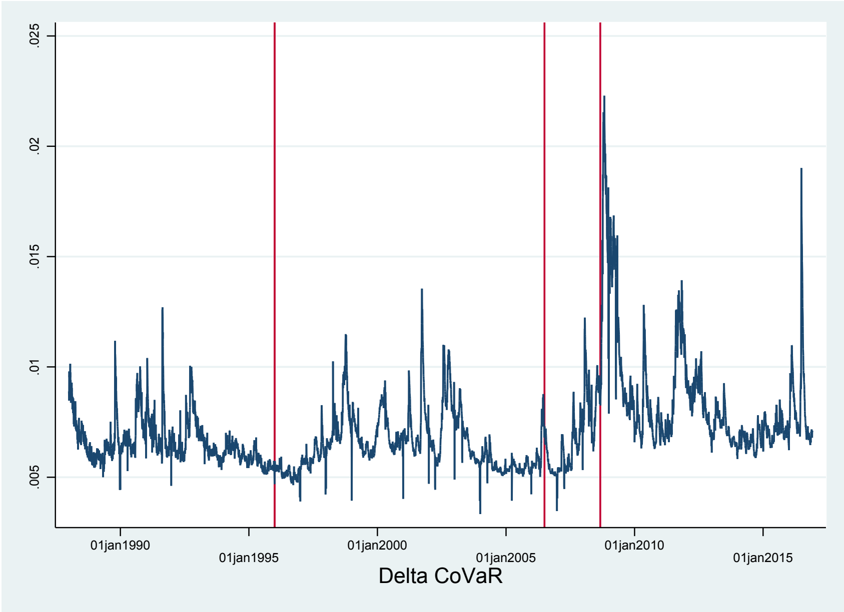

Figure 3: Evolution of contribution to systemic risk - Delta CoVaR. The Figure reports the evolution of the daily average estimated Delta CoVaR in Equation 6, estimated with quantile regressions.

dramatically during the 2007-8 period.

The SRISK measure exhibits a markedly different pattern. In fact, we present two versions: i) in the first version we aggregate over shortfalls and surpluses of individual banks (Figure 4), and ii) in the second version we only aggregate positive shortfalls (Figure 5). While the first version does implicitly allow for inter-industry netting of bank capital, the second version measures the total amount of re-capitalization needed for a given capitalization standard. Thus, the net measure is a measure of the shortfall from a societal level after potential redistribution of bank capital, while the latter measure is an indicator of overall industry stress.

In Figure 6, we report the evolution of SRISK across different countries. We see similar patterns in the euro area, where banks steadily build up SRISK with the trend essentially being unbroken as of today. On the contrary, Switzerland shows a different more stationary pattern. SRISK actually decreases before the beginning of the 21st century, and the upward trend is bounded between 2000 and 2010. In later years, the exposure to systemic risk does not deviate from the average behaviour of the beginning of the 90s as drastically as in the other countries.

Overall, both measures exhibit an increasing trend suggesting a growing reduction in resilience. Both SRISK measures are quite low around the dot-com bubble, which may just be a reflection of the bubble per se.[24] The measure shoots up when the bubble bursts, but remains elevated prior to the subprime crisis. During the Great Recession it shoots up again after the Lehman failure, but

[24]Since SRISK is a market-based risk measure it underestimates true exposure to systemic risk in periods of overpricing (bubbles) and it overestimates true exposure to systemic risk in periods of underpricing. In this sense SRISK is not a useful early warning indicator.

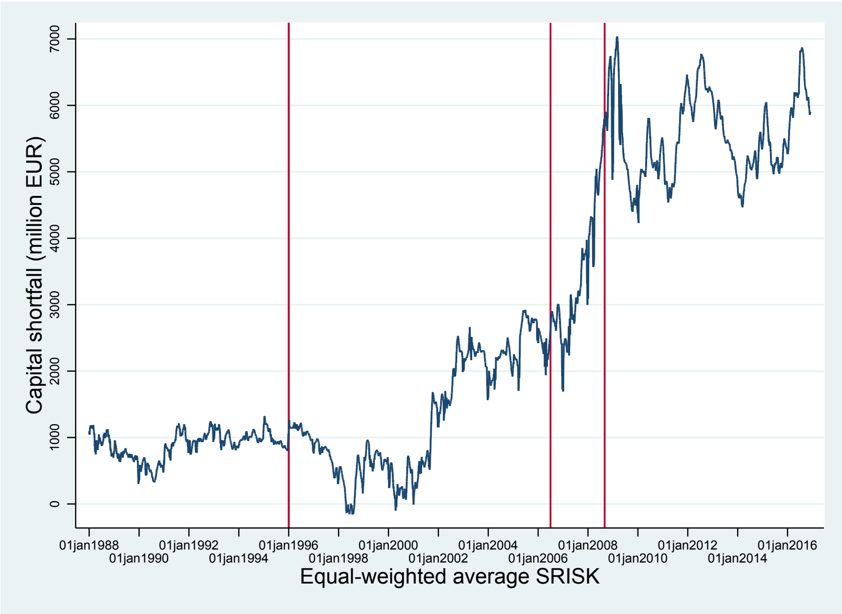

Figure 4: Evolution of exposure to systemic risk - average SRISK. The Figure reports the evolution of the daily average estimated SRISK in Equation 3. We report a central moving average of 20 days. We consider both positive and negative values of SRISK, respectively as shortfall and surplus of capital. The SRISK is estimated by MLE using a GJR-DCC Garch model. We use a capital ratio k=8%.

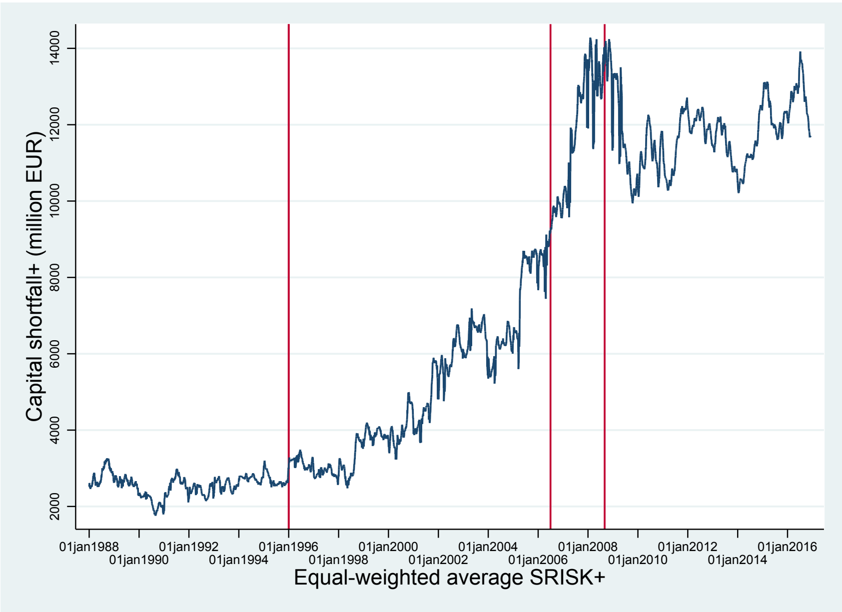

Figure 5: Evolution of exposure to systemic risk - average positive SRISK. The Figure reports the evolution of the daily average estimated SRISK (Equation 3) in case of capital need (positive SRISK). We report a central moving average of 20 days, and we consider only positive values of SRISK, representing the capital shortfall in the system. The SRISK is estimated by MLE using a GJR-DCC Garch model. We use a capital ratio k=8%.

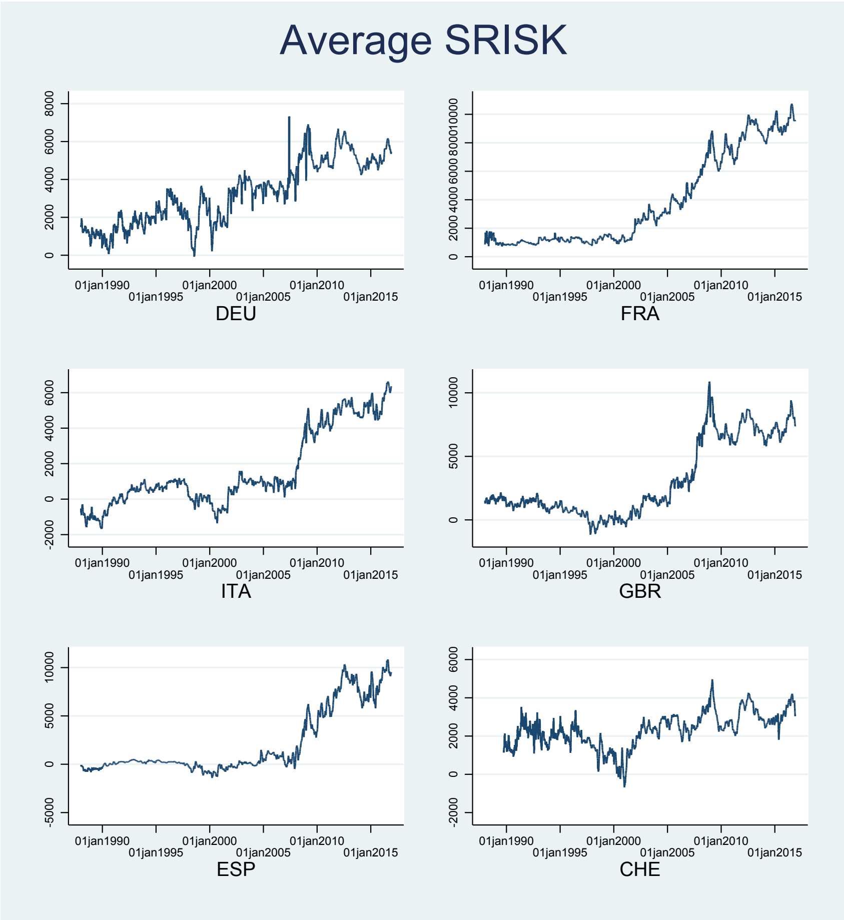

Figure 6: Cross-country variation of exposure to systemic risk - average SRISK. The Figure reports the evolution of the daily average estimated SRISK in Equation 3. We report a central moving average of 20 days. We consider both positive and negative values of SRISK, respectively as shortfall and surplus of capital. The SRISK is estimated by MLE using a GJR-DCC Garch model. We use a capital ratio k=8%. We report Germany (DEU), France (FRA), Italy (ITA), United Kingdom (GBR), Spain (ESP) and Switzerland (CHE).

subsequently, and in contrast to Delta CoVaR, remains at almost identically high levels during the European sovereign crisis. On the positive side though, the Basel III measures seem to be effective in preventing a further rise in SRISK, albeit at a rather high level well above that observed in the 1990s.

By visual inspection of the first SRISK measure three major level changes in aggregate SRISK catch the eye: i) the early stage from 1988-2001, ii) the period from 2002-2009 and the iii) sovereign crisis stage from 2009 onwards. Again the liquidity crisis of 2007-8 does not exhibit dramatic effects on SRISK.

While SRISK clearly indicates a sharp build-up of exposure to systemic risk, also Delta CoVaR does not provide any evidence of a reduction in the contribution to systemic risk, and, hence, an increase in resiliency in the banking system. According to these measures, the Basel process does not seem to have achieved the goal of increasing the stability and safety of the banking system relative to the pre-Basel era, at least for the European countries.

4.2 Evolution across Banks and Sectors

These results lead to a fundamental question: Can we say anything about the sources of the build-up of systemic risk? We first check whether the build-up has been uniform across the banking system or whether it is related to particular institutions or business models.

When looking into quintiles of the SRISK measure it turns out that it is the upper two quintiles that massively build up SRISK, while in the case of CoVaR, banks seem to be more uniformly affected. Accordingly, important non-linearities show up in the case of SRISK (Figures 7).

It is interesting to note that the introduction of internal market risk models in 1996 did exert a short-lived but discernible moderating effect on the SRISK-trajectories across all quintiles.

Let us now take a system's perspective on the whole financial system by differentiating according to banks (1), diversified financials (2), insurance companies (3) and real estate companies (4).

The most striking differences across intermediary groups can be witnessed in the exposure to systemic risk as demonstrated in Figure 8. SRISK has considerably increased both for banks, around 2001 and again after 2009, and for insurance companies especially after 2002. Moreover, exposure to systemic risk is still increasing in the case of the insurance sector.

To summarize: according to the SRISK measure, the overall exposure to systemic risk has increased considerably after the implementation of the Basel accord. This finding may seem surprising, since it suggests that the Basel process of capital regulation has failed to achieve its stated goals of increasing the safety and stability of the banking system at large. This conclusion is less strict by employing Delta CoVaR as a measure of contributing to systemic risk. However, also Delta CoVaR certainly does not suggest a general reduction of contagion risk during the various stages of the Basel process of capital regulation. The evolution of these systemic risk measures runs counter to the evolution of measures of systematic risk, which appears to be on a declining long-term trend for most European countries, albeit at very slow pace.

4.3 Internal Credit Risk Models and Banks' Choices of Business Models

The Basel II innovations did allow banks to assess their credit risk by using their own internal models albeit subject to supervisory approval. Thus according to the proponents of this policy, incentives

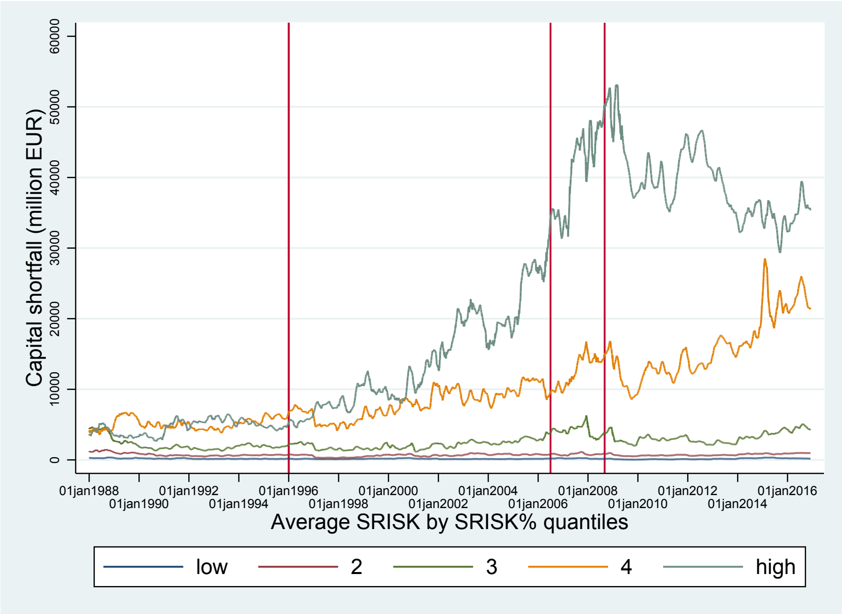

Figure 7: Quantile effects and non-linearities. The first frame reports the evolution of the daily average estimated SRISK (Equation 3), distinguishing five equal-size quintiles of contribution to capital shortfall (SRISK%), as in Equation 4. The top quintile (gr5) corresponds to the group of banks with the highest level of positive SRISK, while the bottom quintile (gr1) corresponds to the group of banks with the lowest level of capital shortfall. We report a central moving average of 50 days, and we average both positive and negative values of SRISK.

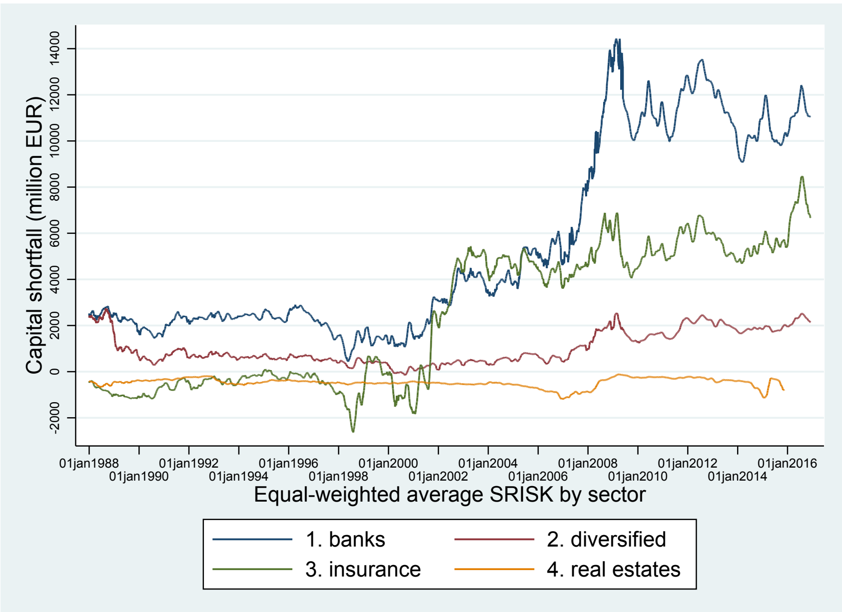

Figure 8: Evolution of systemic risk - SRISK. The Figure reports the evolution of the daily average estimated SRISK in Equation 3. We report a central moving average of 20 days. We consider both positive and negative values of SRISK, respectively shortfall and surplus of capital. The SRISK is estimated by MLE using a GJR-DCC Garch model. We report banks (1), diversified financials (2), insurance companies (3) and real estates (4).

should be provided for "improved risk management". Ex post we are interested to see whether we can see any effects of this effectively self-regulatory option on banks' choices of business models.

Figure 9 demonstrates that institutions that opted for the advanced or mixed approaches did experience a drastic increase in their exposure to systemic risk subsequently. On the other side, the banks that chose the standard or the foundation approaches were effectively able to maintain their systemic risk exposure, or even slightly improve it. This speaks in favor of using a standardized approach with respect to regulation and against the use of self-regulatory options under supervisory approval in order to enhance bank resiliency.

Can we identify any material changes in banks' balance sheets after the adoption of the advanced approach? In other words, can we identify traces of changes in banks' business models on their balance sheets? In order to address this question we trace the trajectories of average book and market characteristics for the banks that opted for the advanced or mixed approach and compare them with those that opted for the standard approach. In our sample we have too few observations for a meaningful judgment about the foundation approach. Data limitations currently restrict our analysis to the years onwards from 2005.

Figure 10 establishes that banks opting for the advanced or mixed IRBA subsequently experience both higher levels of SRISK and higher levels of Delta CoVaR. This confirms that precisely those banks opting for the self-regulatory options became the most systematically relevant banks especially in the crisis years of 2008 and 2011.

We also observe that the systematic risk as measured by market beta is trending higher for advanced IRBA banks with respect to the other two groups, and diverging from the level of the year in which Basel II was finalized. This result is more consistent with a shift in the business models of these banks, rather than with an increased riskiness of the banking market at large. Regardless of the market index, these banks' business models are becoming ever more riskier over the years.

The size of total assets in Figure 11 reveals also that these banks opting for self-regulatory options, are also the largest in terms of total assets and capital. However, they are compliant with capital regulation by holding enough (risk-weighted) Tier 1 capital over assets. Nevertheless, it becomes apparent that they have always held the smallest amount of equity over assets, and that their risk-weighted credit risks are proportionally far below the ratio of the other groups.

In our data we can also confirm the finding of Mariathasan and Merrouche (2014) that banks exploiting the IRBA-options hold far lower levels of risk-weighted assets. We can also observe that the level of credit risk scaled by total assets is particularly low for the banks using advanced/mixed approach, compared to the level of credit risk scaled by risk-weighted assets (Figure 12).

Looking more carefully at the assets composition (Figure 13), we observe differences in the business models of banks according to the IRBA they choose. We see that banks with advanced IRBA tend to have proportionally less gross loans over total assets, in particular to banks, but they hold significantly more derivatives contracts (Figure 13).

Moreover, inspecting loan quality we observe that banks using advanced or mixed IRBA have seen a pejorative trend in the non-performing loans, higher than the banks with foundation approach. This all suggests that banks use of self-regulatory options was intimately tied to their choice

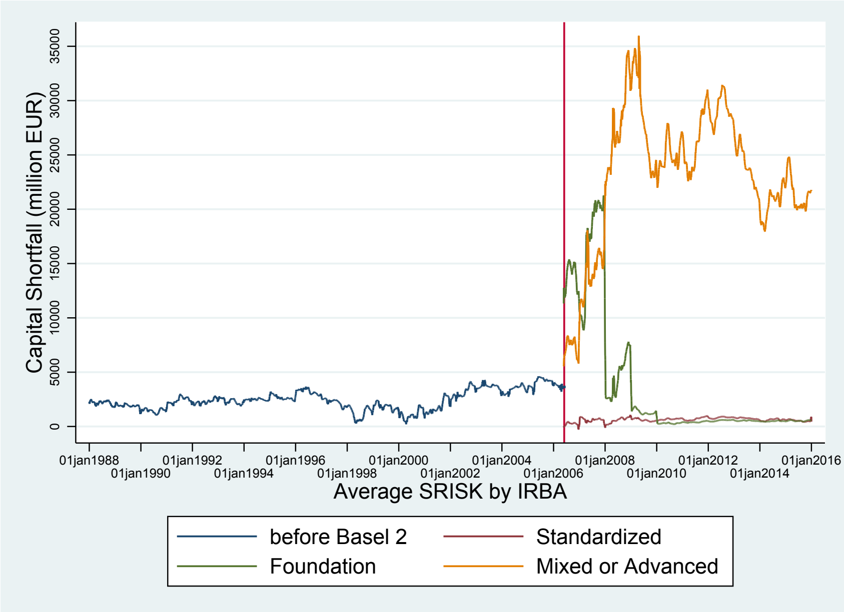

Figure 9: Credit Risk Internal models and SRISK. We report the evolution of the daily estimated SRISK (Equation 3), distinguishing for the usage of credit risk internal models (IRBA). The blue line represent the behaviour of systemic risk before the introduction of Basel 2. After June 2006 (red vertical line), we distinguish between banks using the regulatory standardized approach (red line), the foundation approach (green line) and the banks using the mixed or advanced approaches (blue line). We report a central moving average of 1 year.

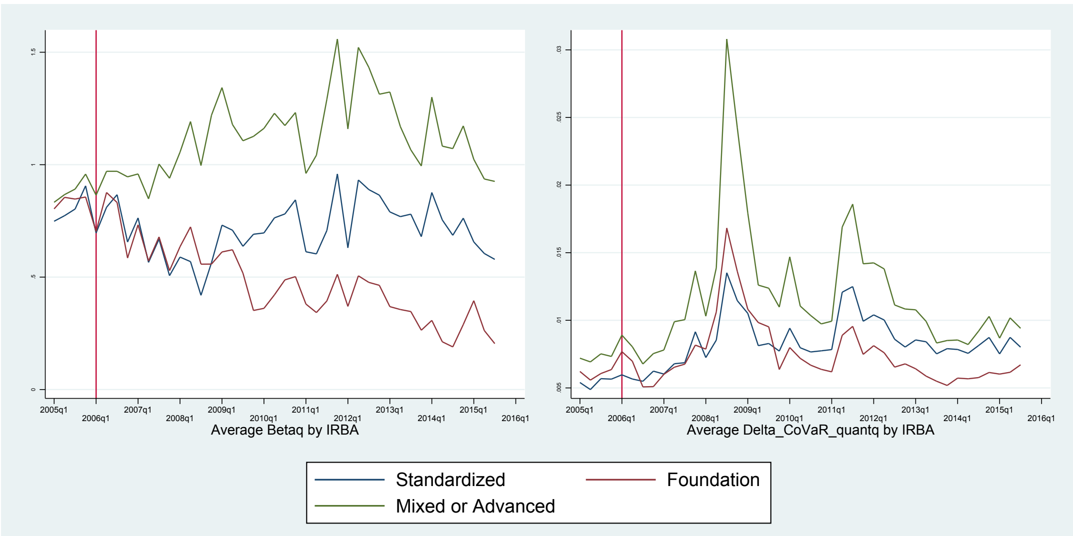

Figure 10: Credit Risk Internal models and Beta and Delta CoVaR. We report the evolution of the daily estimated market Beta and Delta CoVaR, distinguishing for the usage of credit risk internal models (IRBA). After June 2006, we distinguish between banks using the regulatory standardized approach (blue line), the foundation approach (red line) and the banks using advanced or mixed approaches (green line).

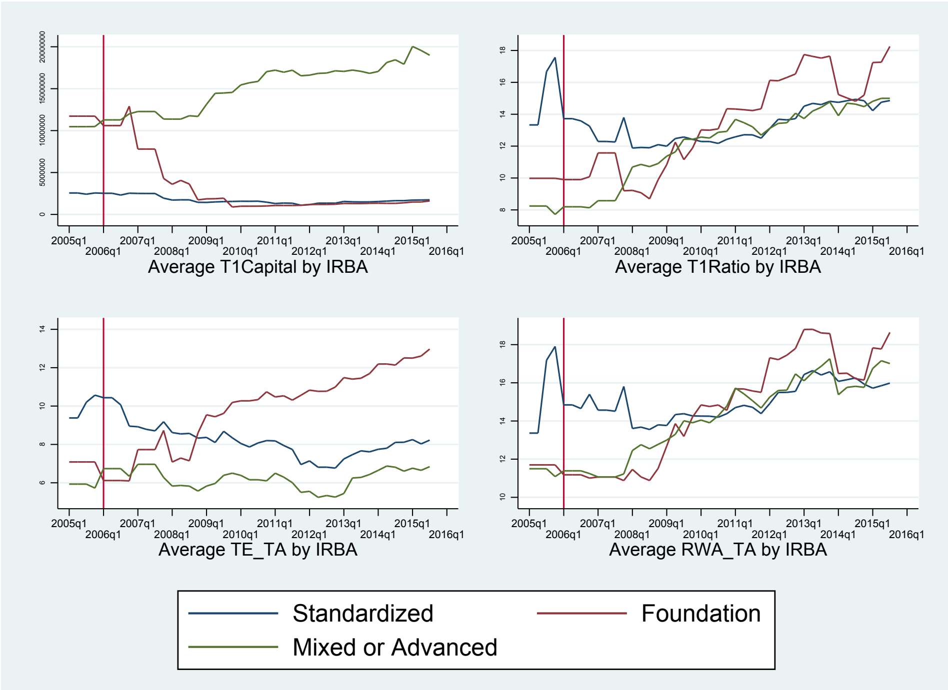

Figure 11: Credit Risk Internal models and total assets. We report the evolution of quarterly book values of assets, as Tier 1 Capital (top left frame), Tier 1 Capital Ratio (top right), leverage ratio such as total equity over total assets (bottom left), and Risk-Weighted Assets over total assets (bottom right). We average in groups based on the usage of credit risk internal models (IRBA). After June 2006, we distinguish between banks using the regulatory standardized approach (blue line), the foundation approach (red line) and the banks using advanced or mixed approaches (green line).

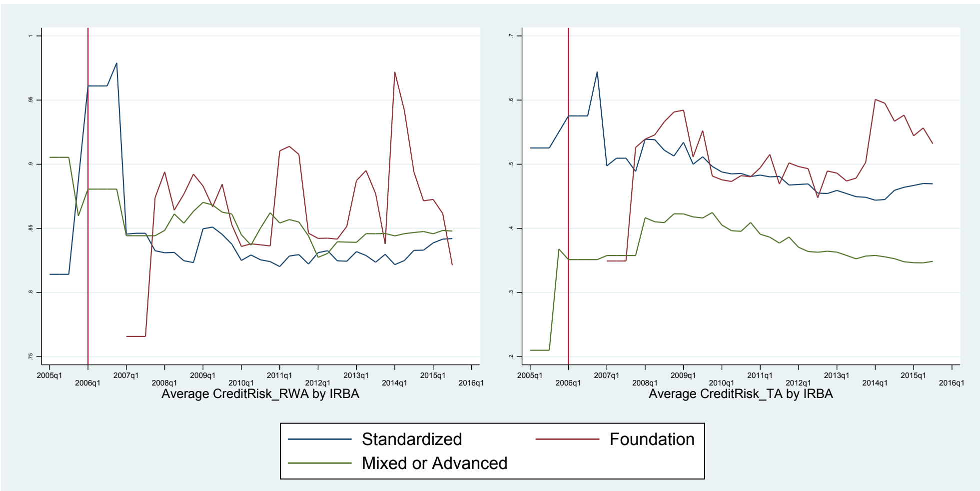

Figure 12: Credit Risk Internal models and risk-weighted credit risk. We report the evolution of reported quarterly risk-weighted credit risks, as scaled by risk-weighted assets (left frame) and total assets (right frame). We average in groups based on the usage of credit risk internal models (IRBA). After June 2006, we distinguish between banks using the regulatory standardized approach (blue line), the foundation approach (red line) and the banks using advanced or mixed approaches (green line).

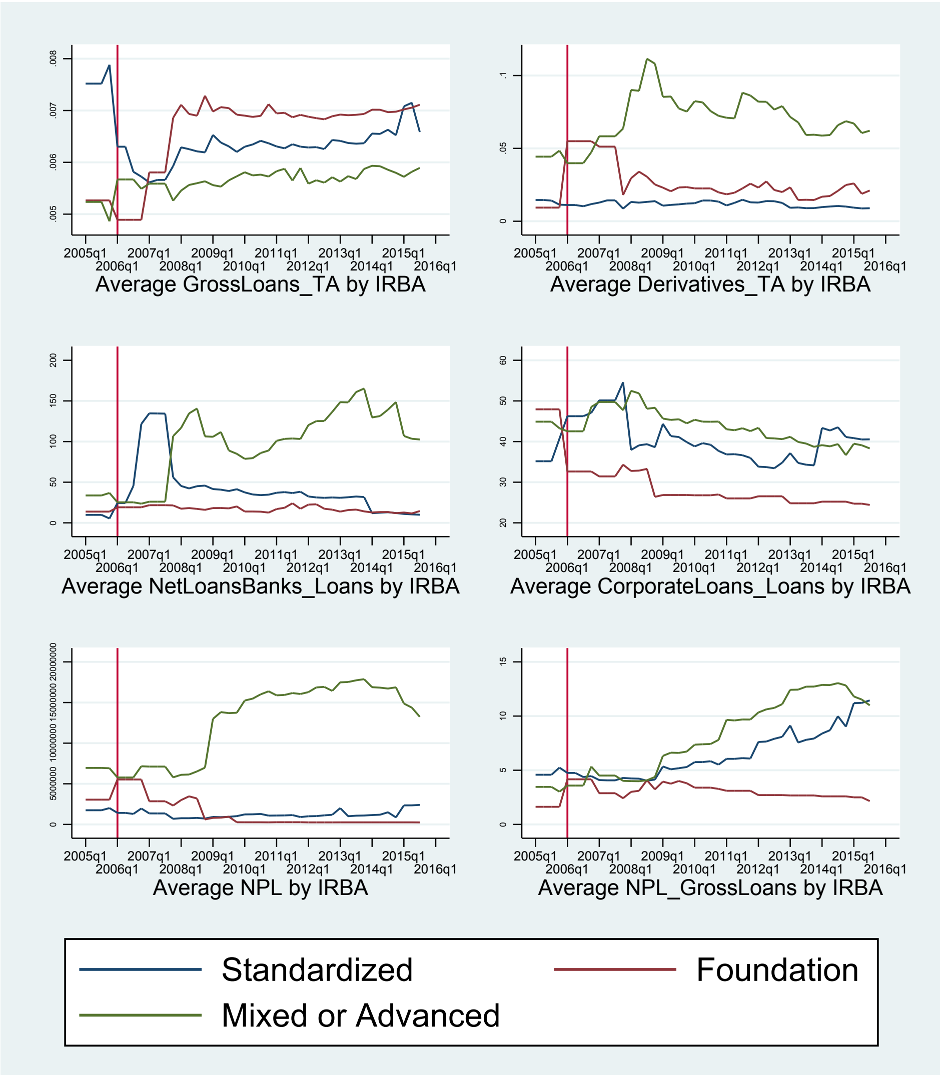

Figure 13: Credit Risk Internal models and assets composition and loans quality. We report the evolution of quarterly assets composition, as Gross Loans and Derivatives contract, both scaled by total assets (top frames), net loans to banks and customers, scaled by total loans (middle frames), and non-performing loans in level and scaled by gross loans (bottom frames). We average in groups based on the usage of credit risk internal models (IRBA). After June 2006, we distinguish between banks using the regulatory standardized approach (blue line), the foundation approach (red line) and the banks using advanced or mixed approaches (green line).

of business models.[25] Hence, we confirm similar findings by Ayadi, Ferri and Pesic (2016).

The rich nature of our descriptive results strongly suggest a multivariate analysis for understanding better and even identifying the various drivers of systemic risk and the impact of internal models.

4.4 Drivers of Systemic Risk

While the bivariate analysis reveals a systematic and permanent increase in the SRISK measure, it does provide only limited information about the potential drivers of these developments, such as size and other balance sheet items. To analyze the causes of the increase in systemic risk, a fully fledged multivariate analysis is required. We regress the estimated SRISK on different cost of equity measures, as well as lagged balance sheet items, including fixed effects and year dummies.

Table 1 reports the first motivating results for panel regressions with firm or country effects and year effects, with and without macro-variables. SRISK is positively affected by the composite indicator of systemic stress in the overall system and by the size of the total assets, in all specifications. Therefore, controlling for market stress and total assets, we observe that SRISK is contained by the market capitalization of the bank. Non-performing assets are positively related, but unexpectedly not significant in mean. Systematic risk, as measured by the market beta, is also a significant aggregating driver of SRISK. Counter-intuitively, on the other hand, the CAPM cost of bank equity has a strongly moderating effect on systemic risk. Evidently, it is the low-cost banks that impose the largest contribution to SRISK. We have previously seen that the cost of equity has strongly declined in mean from 2000 to 2010, just when the exposure to systemic risk has heightened. We also add macro-variables to control for the country environment of the bank. These factors largely appear insignificant, with the exception of the growth of the country equity market. It does not come as a surprise that our measure of systemic risk is affected by the market prices, therefore introducing lagged market growth, market value and book value account for the main pricing factors in the literature.

Interestingly, with regard to the Basel process we observe that the internal models dummy for market risk is positive and highly significant in the specifications controlling for equity market growth and country effects. This result suggests that the market risk amendment of January 1996 has indeed not reduced systemic risk. Moreover, the Basel II and III dummies exhibit contrasting results across specifications. The Basel II dummy (July 2006) shows an insignificant reduction in systemic risk in the market beta specification, while suggesting a positive and significant risk increasing role in the CAPM cost of equity specification, probably due to the drop in cost of equity in 2000s. These reforms were steered towards improving capital and liquidity positions on banks' balance sheets. The Basel III dummy remains inconclusive. To gain additional insights, we interact the three dummies with the sub-sector of the institution. We observe, then, the effect of the introduction of Basel II to banks, that were the prime focus of the regulation, in comparison to other financial institutions. We observe that if the institution is a bank or a diversified institution, the impact of Basel II is particularly sharp, positive and significant.[26]

[25]Even if one does not want to go as far as Mariathasan and Merrouche (2014) terming such behaviour as manipulation of risk weights, it is evident that internal models were used as a convenient instrument to reduce capital charges

Table 1: Drivers of SRISK: panel regressions (quarterly)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Beta	1,459***	1,504***	905.1**	923.0**				
	(217.2)	(305.6)	(355.1)	(357.7)				
Cost of Equity					-2,077**	-1,735**	-1,419	-1,428
					(1,044)	(856.6)	(1,159)	(1,163)
Tot.Assets	0.0688***	0.0482***	0.0749***	0.0748***	0.0686***	0.0485***	0.0751***	0.0750***
	(0.00738)	(0.0129)	(0.00516)	(0.00522)	(0.00744)	(0.0130)	(0.00517)	(0.00524)
NPA	0.135	0.0530	0.0534	0.0509	0.147	0.0931	0.0550	0.0522
	(0.138)	(0.105)	(0.0470)	(0.0447)	(0.139)	(0.104)	(0.0479)	(0.0453)
Equity Securities	-0.0297	-0.129	-0.0769	-0.0796	-0.0317	-0.136	-0.0896	-0.0924
	(0.0295)	(0.106)	(0.0901)	(0.0916)	(0.0322)	(0.109)	(0.0951)	(0.0968)
Fixed Income Securities	-0.00536	0.00969	-0.00201	-0.00172	-0.00315	0.0119	0.000836	0.00137
	(0.00462)	(0.0214)	(0.0151)	(0.0152)	(0.00600)	(0.0224)	(0.0161)	(0.0164)
Market Value	-0.569***	-0.569***	-0.563***	-0.560***	-0.561***	-0.559***	-0.550***	-0.547***
	(0.0607)	(0.0814)	(0.0868)	(0.0890)	(0.0622)	(0.0836)	(0.0929)	(0.0952)
CISS	1,550***	1,594***	1,423***	1,421***	754.8	1,006***	931.8**	931.4**
	(347.1)	(344.9)	(379.1)	(382.2)	(664.7)	(365.9)	(428.1)	(429.8)
L.GDP_growth		-16.55	-24.04	-24.60		-31.76*	-33.49**	-33.61**
		(14.02)	(15.37)	(15.72)		(16.68)	(15.83)	(16.18)
L.Unemployment		-16.63	-10.34	-10.58		4.180	5.237	7.003
		(26.76)	(15.15)	(15.09)		(22.73)	(12.71)	(12.70)
L.Share Prices growth		3.667**	4.909**	4.831**		5.204***	6.363**	6.339**
		(1.755)	(2.305)	(2.307)		(1.917)	(3.167)	(3.188)
Market Risk Amendment	305.8	534.1	557.9***	594.8***	383.4	1,718**	762.4***	-5.043
	(240.8)	(622.2)	(46.44)	(60.41)	(247.1)	(795.5)	(83.49)	(116.9)
Market Risk Amend. # Bank				-92.75				-8.860
				(69.40)				(79.77)
Basel 2	-39.04	-26.76	11.88	-114.4	80.33*	105.0**	97.88**	21.82
	(42.39)	(34.75)	(36.54)	(73.66)	(42.63)	(42.74)	(39.71)	(58.37)
Basel 2 # bank				291.1**				178.1
				(127.2)				(114.8)
Basel 3	42.98	57.14	151.4	29.08	-130.1	-36.63	98.00	1.819
	(109.0)	(106.8)	(113.0)	(112.5)	(194.4)	(159.3)	(142.5)	(155.8)
Basel 3 # bank				290.6				218.1
				(198.3)				(177.2)
Constant	-925.9***	-988.6***	-591.1***	-583.2***	-373.1*	-805.5**	-557.6***	-569.4***
	(270.4)	(350.5)	(185.6)	(200.0)	(211.7)	(330.6)	(185.1)	(199.1)
Year Effects	yes	yes	yes	yes	yes	yes	yes	yes
Firm Effects	yes	yes	no	no	yes	yes	no	no
Country Effects	no	no	yes	yes	no	no	yes	yes
Observations	16,746	8,993	8,993	8,993	16,745	8,993	8,993	8,993
R-squared	0.825	0.646	0.937	0.937	0.823	0.642	0.937	0.937
Number of groups	400	249	249	249	400	249	249	249

Robust standard errors in parentheses (Driscoll and Kraay (1998))
*** p<0.01, ** p<0.05, * p<0.1

[a] This table reports the results from the quarterly panel regressions of SRISK with firm (models 1-2 and 5-6) or country fixed effects (models 3-4 and 7-8) and year dummies. We regress the SRISK measure on CISS (indicator of systemic stress in the European system, Hollo et al, 2012), cost of equity measures, such as market Beta (models 1-4) or CAPM cost of equity (model 5-8), an internal model dummy from January 1996 and two Basel dummies, Basel II from June 2006 to September 2008, and Basel III from September 2008. In models 4 and 8 we introduce Basel dummies interacted with the sub-sector of the financial institutions, being 1 for banks and diversified institutions and 0 for all other institutions. The Beta is estimated from a GJR-DCC Garch model between the bank stock returns and the MSCI Europe index. The CAPM cost of equity is the return required by the market applying the time-varying beta to the annual risk premium required on the market return, as Equation 9: $CostEquity_{it} = R_{ft} + \widehat{beta}_{it} * (R_{mt} - R_{ft})$. We use the yield on German Bund as risk-free rate. Moreover, we include bank-level drivers as total assets, non-performing assets, other investment in equity and fixed income securities, market capitalization and leverage, and macro-variables as GDP growth, unemployment rate, equity share prices growth by country. Standard errors are robust for temporal and cross-sectional dependence (Driscoll and Kraay (1998)).

Surprisingly, CAPM cost of equity has a moderating effect on SRISK. This contemporaneous effect could, however, result from endogeneity. Well capitalized banks will enjoy lower cost of bank equity and for that reason exhibit lower SRISK. We therefore focus most of the next analysis on the Beta as proxy for systematic risk.

Next, the above results could be driven by the non-linearities that we have observed earlier in the discussion of the SRISK measure. Therefore, we estimate the impact of Basel and the other covariates at different quantiles of the SRISK conditional distribution in order to control for potential non-linearities. We present the results from regressions at 0.25, 0.50 and 0.75 quantile in Table 2, and indeed the quantile regressions contribute to resolving the puzzle on the mean estimations. It turns out that both regulatory instruments, the market risk amendment of Basel I (January 1996) and the implementation of Basel II (July 2006) significantly contributed to reduce systemic risk in the lower quartile of the SRISK distribution, while they affect SRISK gradually less moving to the upper quantiles. Moving to the upper quantiles of the SRISK distribution, we observe that the option to effectively self-regulate by means of internal models of market risk under supervisory approval has effectively increased the exposure to systemic risk.

While internal models for measuring market risk contributed to increase resiliency in the safer segment of the distribution, they have contributed to a build-up of systemic risk precisely in the systemically relevant segment. Hence, after 20 years of evidence, it turns out that Hellwig's (1995) concerns proved right, while Wuffli's (1995) optimism was unfounded. With hindsight, we witness that it was the smaller banks that reduced their systemic risk contribution while the large banks (mis-)used the options offered by the use of internal models to effectively enlarge their systemic risk exposure and reduce their resiliency. Clearly this effect appears as an unintended consequence of the 1996 amendment. The Basel II dummy suggests a significant risk-reducing effect only in the lowest quartile. In the higher quartiles the moderating effect becomes economically smaller and statistically insignificant. These motivate the analysis in the next section, where we introduce detailed micro-econometric information about the implementation dates of internal models.

To check robustness we also report regression results with quarterly country-specific macro variables, such as GDP growth, unemployment rate, share price growth, policy interest rate, and country effects. We observe the same impact of market risk amendment in 1996 on the largest contributors to SRISK. However the macro variables are not improving the fit of the regressions and they are mostly insignificant, while they dramatically decrease the number of observations and the countries under analysis. Therefore, we prefer to focus on specifications without these macro-variables.

Overall the robustness analysis adds confidence that we did not unintentionally omit important drivers of SRISK. Essentially, in our regressions we did control for all the standard drivers of stock prices such as the Fama French factors, that are crucial determinants of our SRISK-measure.

Figure 14 reports the coefficients estimated at various quantiles of SRISK. It allows us to trace the parameters across the SRISK distribution. While the sensitivities of market value and total assets are monotonically increasing in SRISK, the sensitivity of leverage is U-shaped while CISS-sensitivity is anti-U-shaped. Hence, these graphs unveil important non-linearities and the importance for a dis-

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for risky assets with supervisory consent.

[26]We report in the appendix the results on similar specifications, where we use the dynamic structure of SRISK and introduce the lagged SRISK. We remove total assets, due to the very high correlation with SRISK, and use as above firm or country effects, macro-variables and interacted dummies.

Table 2: Drivers of SRISK: quantile regressions (quarterly)

	(1) Q.0.25	(2) Q.0.50	(3) Q.0.75	(4) Q.0.25	(5) Q.0.50	(6) Q.0.75
Beta	108.6***	76.34***	36.66***	88.12***	70.20***	45.39***
	(13.89)	(10.34)	(11.21)	(21.96)	(17.82)	(11.76)
CISS	103.4***	87.05***	64.61***	73.44***	76.22***	50.71***
	(16.97)	(12.24)	(12.20)	(19.51)	(17.87)	(13.34)
L.GDP growth				-0.874	-1.014	-0.366
				(0.860)	(0.712)	(0.365)
L.Unemployment				-0.457	0.0778	0.0546
				(2.916)	(1.773)	(0.993)
L.Market growth				0.138	0.192***	0.132***
				(0.125)	(0.0727)	(0.0449)
Interest rate				-402.6	-195.8	153.8
				(392.2)	(256.6)	(167.1)
Tot.Assets	0.0791***	0.0822***	0.0854***	0.0786***	0.0818***	0.0849***
	(0.000732)	(0.000308)	(0.00292)	(7.08e-05)	(0.000400)	(0.000114)
NPA	0.00915***	-0.00652*	-0.0199	0.00155	-0.0112	-0.0480***
	(0.00236)	(0.00368)	(0.0550)	(0.00663)	(0.0218)	(0.00455)
Equity Securities	0.0247***	0.0314***	0.0315	0.0147	-0.00450	-0.00209
	(0.00311)	(0.00148)	(0.0393)	(0.287)	(0.0220)	(0.00819)
Fixed Income Securities	-0.00359***	-0.0112***	-0.0178***	-0.00189	-0.00405**	-0.00964***
	(0.00106)	(0.000448)	(0.00390)	(0.0444)	(0.00177)	(0.00123)
Market Value	-0.803***	-0.752***	-0.671***	-0.794***	-0.744***	-0.678***
	(0.0239)	(0.00623)	(0.00627)	(0.00445)	(0.0226)	(0.00698)
Market Risk Amendment	-20.43*	3.790	20.66*	3.568	10.07	22.87**
	(12.10)	(10.71)	(11.04)	(30.84)	(12.79)	(9.326)
Basel 2	-13.77***	-5.424	-1.510	-5.728	-1.557	-1.139
	(4.701)	(3.722)	(1.718)	(4.995)	(3.723)	(1.900)
Basel 3	-24.89***	-13.82**	10.56	-9.949	-5.554	12.29*
	(6.540)	(6.001)	(10.27)	(8.132)	(6.427)	(7.051)
Constant	-61.35***	-49.35***	-43.39***	-62.08	-61.06*	-56.79*
	(13.09)	(12.04)	(12.12)	(43.72)	(36.64)	(29.80)
Year Effects	yes	yes	yes	yes	yes	yes
Country Effects	no	no	no	yes	yes	yes
BEL				26.81	18.88	4.169
				(27.77)	(27.20)	(30.92)
DEU				50.93***	38.64	21.76
				(19.62)	(26.25)	(31.23)
FIN				49.35**	29.75	6.018
				(19.86)	(26.82)	(31.59)
FRA				29.36	25.51	11.42
				(23.98)	(27.49)	(31.30)
GBR				70.09**	-10.41	-30.32
				(34.94)	(117.9)	(50.53)
ITA				46.85**	24.17	2.017
				(19.05)	(26.35)	(30.84)
LUX				13.46	2.971	-17.22
				(21.50)	(27.67)	(31.51)
NLD				-28.01	-27.98	-7.165
				(29.14)	(35.89)	(34.90)
PRT				39.71*	-30.48	-79.04**
				(21.80)	(28.36)	(33.88)
Observations	16,746	16,746	16,746	8,555	8,555	8,555
R-squared	0.925	0.935	0.939	0.923	0.931	0.934

Clustered standard errors in parentheses (Parente et al. (2016)
*** p<0.01, ** p<0.05, * p<0.1

[a] This table reports the results from the .25, .50 and .75 quantile regressions of SRISK. We regress the SRISK measure on the market Beta, the CISS indicator of systemic stress, the internal model dummy from January 1996, the Basel II dummy from June 2006 and the Basel III dummy for September 2008. The Beta is estimated from a GJR-DCC Garch model between the bank stock returns and the MSCI Europe index. We control for year effects, with (models 1-3) and without country effects (models 4-6), total assets, non-performing assets, other investment in equity and fixed income securities, and market capitalization. Models 4-5 also introduce the main country lagged macro-variables, such as GDP growth, unemployment rate, share price growth and policy interest rate. The standard errors are clustered for banks (Parente et al. 2016).

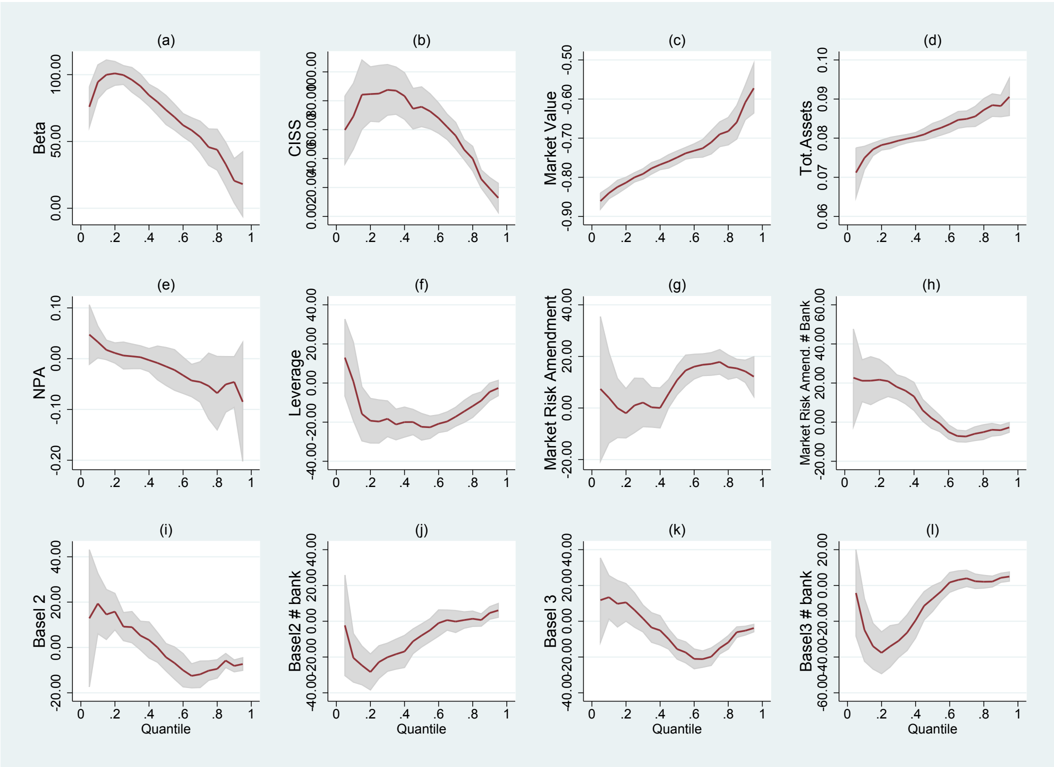

Figure 14: Quantile coefficients for SRISK. The Figure provides a graphical view for the SRISK quantiles as function of the different covariates and Basel dummies. We report the distribution of SRISK conditional on market beta, CISS, market value, total assets, non-performing assets, leverage, and the three Basel dummies, with and without interaction with the banking sub-sector. We report bootstrapped standard errors.

tributional quantile approach. On the top segment of the distribution, size has a stronger impact on systemic risk exposure, increasing the scale of the distribution. On the contrary, market beta has a non-monotonic, but mostly decreasing impact on SRISK: on low level of systemic risk the impact of market beta is increasing, but it quickly starts reducing the scale moving to higher quantiles.

Focusing on the Basel dummies, we observe strong non-linearities, not captured by the conditional mean estimation. The risk amendment in 1996 clearly affects differently the lower and the upper part of the distribution: on smaller quantiles, institutions improved their systemic risk exposure since the amendment, but on the contrary on larger quantiles, systemic risk increased. This shift, however, is reversed looking at banks alone, consistently with spillovers of SRISK from banks to other sub-sectors of the system. The results are very different for the Basel dummies. The effect of Basel regulation for banks is actually increasing (though non-monotonically) along the quantiles of SRISK, being its impact must stronger at higher segments of the distribution.

We will comment more carefully on the quantile effects of Basel in the next part of the analysis, using bank-level information on the implementation dates of the internal risk models. In those cases unconditional quantile regressions are more appropriate.

So far, we conclude this section looking more carefully at the long-run relationship between SRISK and market capitalization, that could hide a Too-Big-To-Fail story. We perform a VECM analysis on weekly averages with 4 lags, testing for AIC information criteria, LR and test of no-autocorrelation in the residuals. Johansen tests suggest a cointegration equation exists in each subperiod. We perform the VECM on weekly average SRISK, market capitalization, Z-score and EU policy rate. Table 3 reports on the top panel the short-run parameters and reveals that SRISK is a strongly autocorrelated series, significantly affected by short-run movements in Z-score and market capitalization. We do not see endogeneity between SRISK and Z-score, however we do observe endogeneity between market capitalization and systemic risk in the first sub-period. The middle panel reports the cointegrating vector parameters, and we see that both Z-score and the policy rate significantly affect SRISK in a long-run relationship. In the next section, we will also include this dynamic behaviour into our specifications.

Table 3: VECM (4 week-lags)

	1987-1996				1996-2006			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	D_SRISKww	D_zscoreww	D_mvww	D_PolicyRateww	D_SRISKww	D_zscoreww	D_mvww	D_PolicyRateww
LD.SRISKww	-0.216***	0.000156	-0.195***	5.33e-07	0.205***	-0.000243**	-0.270***	-1.46e-07
	(0.0691)	(0.000273)	(0.0531)	(6.54e-07)	(0.0463)	(0.000106)	(0.0453)	(1.74e-07)
L2D.SRISKww	-0.0395	0.000224	-0.0266	-4.55e-07	0.0451	-9.01e-05	-0.0128	3.44e-08
	(0.0703)	(0.000278)	(0.0540)	(6.66e-07)	(0.0485)	(0.000111)	(0.0474)	(1.82e-07)
L3D.SRISKww	-0.0791	-0.000261	-0.141***	-2.44e-07	-0.0490	8.06e-05	-0.0433	1.69e-07
	(0.0681)	(0.000269)	(0.0523)	(6.45e-07)	(0.0470)	(0.000107)	(0.0460)	(1.77e-07)
LD.zscoreww	50.82**	-0.282***	-13.01	0.000358*	-30.08	-0.300***	-11.32	-3.01e-05
	(21.62)	(0.0854)	(16.61)	(0.000205)	(20.02)	(0.0456)	(19.58)	(7.53e-05)
L2D.zscoreww	40.01*	-0.0781	-25.30	0.000485**	-0.829	-0.117**	-8.363	4.09e-05
	(20.44)	(0.0808)	(15.71)	(0.000194)	(20.64)	(0.0471)	(20.20)	(7.76e-05)
L3D.zscoreww	1.198	-0.108	-20.90	0.000243	17.29	-0.105**	-33.61*	6.17e-06
	(16.72)	(0.0661)	(12.85)	(0.000158)	(19.60)	(0.0447)	(19.18)	(7.37e-05)
LD.mvww	-0.178**	0.000759**	-0.277***	-1.84e-06**	-0.172***	-0.000216*	-0.147***	-2.36e-07
	(0.0847)	(0.000335)	(0.0651)	(8.03e-07)	(0.0497)	(0.000113)	(0.0487)	(1.87e-07)
L2D.mvww	-0.231***	0.000342	-0.327***	-4.72e-08	-0.0428	4.56e-05	-0.0845*	-4.82e-08
	(0.0876)	(0.000346)	(0.0673)	(8.30e-07)	(0.0511)	(0.000117)	(0.0500)	(1.92e-07)
L3D.mvww	-0.156*	0.000751**	-0.141**	-2.00e-06**	0.0260	2.54e-05	0.00319	2.50e-07
	(0.0865)	(0.000342)	(0.0665)	(8.20e-07)	(0.0501)	(0.000114)	(0.0490)	(1.88e-07)
LD.PolicyRateww	1,303	-21.49	-4,993	0.0524	4,410	-13.63	5,984	-0.0117
	(6,763)	(26.73)	(5,197)	(0.0641)	(11,446)	(26.10)	(11,199)	(0.0430)
L2D.PolicyRateww	6,801	13.34	-3,400	-0.0376	-33.88	-8.418	5,225	-0.0200
	(6,732)	(26.60)	(5,173)	(0.0638)	(11,452)	(26.11)	(11,204)	(0.0431)
L3D.PolicyRateww	12,363*	17.00	-3,197	-0.0490	-12,320	-15.42	996.8	-0.0214
	(6,712)	(26.53)	(5,158)	(0.0636)	(11,392)	(25.98)	(11,146)	(0.0428)
Constant	-0.440	-0.0652*	9.254	-8.51e-05	5.471	-0.0108	7.521	-4.53e-05
	(8.778)	(0.0347)	(6.745)	(8.32e-05)	(9.237)	(0.0211)	(9.038)	(3.47e-05)
L._CE1	-0.0678***	-0.000507***	-0.00323	-3.57e-07	-0.0183***	2.62e-05	0.0133*	-1.10e-07***
	(0.0244)	(9.66e-05)	(0.0188)	(2.31e-07)	(0.00710)	(1.62e-05)	(0.00694)	(2.67e-08)
CE1 beta	1	888.6288***	0.28429	-24453.22**	1	-750.126***	-0.25925	60611.31***
		(114.963)	(0.220)	(10980.8)		(197.740)	(0.203)	(23649.9)
Observations	261	261	261	261	541	541	541	541
r2_1	0.169	0.169	0.169	0.169	0.126	0.126	0.126	0.126
r2_2	0.374	0.374	0.374	0.374	0.131	0.131	0.131	0.131
r2_3	0.237	0.237	0.237	0.237	0.0860	0.0860	0.0860	0.0860
r2_4	0.0801	0.0801	0.0801	0.0801	0.0497	0.0497	0.0497	0.0497

[a] This table reports the a VECM of weekly averages of SRISK, market capitalization, Z-score and country policy rates, with 4 lags. We choose the number of lags optimally given the AIC, HQIC and SBIC information criteria and assuring no autocorrelation is left in the residuals. We regress the VECM before 1996 (columns 1-4), and separately between 1996 and 2006 (columns 5-8). Johansen tests of cointegration assure that we have one cointegrating equations in the two periods respectively.

4.5 SRISK and Internal Models of Credit Risk based on Microdata

Overall, so far our results suggest that the January 1996 amendment on market risk had ambiguous effects in reducing systemic risk. While the shift towards internal models apparently was successful in containing systemic risk in the lower quantile of the SRISK distribution, supposedly larger banks in the upper SRISK-quartile tended to benefit less, or even exploit market risk internal models to effectively increase their SRISK positions. Clearly, the aggregate risk enhancing effect dominated the intentional gains on the smaller and less risky banks.

We investigate this self-regulatory tool, looking now at credit risk internal models. One of the pillars of Basel II is the option to widen the scope for internal models also to cover credit risks. While at this stage we do not have sufficiently many (micro) data on the implementation or approval of internal models for market risk, we obtained this micro information about approval and/or adoption of internal credit rating models for a subsample of 100 European banks.[27]

Accordingly, we investigate the relation between SRISK and Basel regulation on the basis of the available bank-level data on the implementation of internal credit risk models. We recall that the variable IRBA takes the value 0 before 2006, the value 1 for the standardized approach, 2 for

[27] We are in the process of extending this dataset to all banks. The SNL dataset is relatively small for European banks and needs to be complemented by search for hand-collected implementation dates for the institutions not reported in SNL. We gratefully acknowledge the support of the Bundesbank and the Bank of England in providing the data for all banks in their respective countries. The current subsample is already large enough to allow for meaningful analyses. Behn and Haselmann (2016) analyse an even smaller subsample of German banks.

Foundation-IRBA, 3 for mixed approaches, and 4 for the Advanced-IRBA for credit risk.

Table 4 reports the results of weekly panel mean regressions of SRISK on, alternatively, Beta, CAPM cost of equity, and Delta CoVaR. Banks that implement internal models are larger in size, therefore we include the IRBA dummies with and without interaction with the market value of the bank. It seems that internal models do exert a significant and positive effect on exposure to systemic risk. Especially the mixed approaches seem to contribute increasing the systemic exposure of banks both in mean and in interaction. The choice of using internal models to estimate credit risk contribute to the systemic exposure especially for the largest banks. The market risk amendment dummy is now strongly positively impacting on the systemic exposure.

These results are robust with respect to different models, as different measures of systematic risk or contribution to systemic risk. This evidence stands in stark contrast to the original goals of the Basel Committee in strengthening the safety and soundness of banks.

In the quantile regressions, we address non linearities without an exogenous allocation of banks into the different risk buckets. We focus on the specification with the market Beta, and Table 5 reports the results with the IRBA dummies interacted with market capitalization. The coefficients are estimated via "unconditional" quantile regressions, therefore they can easily interpreted as usual as unconditional effects. We confirm the previous results observing a strong significant impact of internal credit risk models. Very interestingly, the use of mixed or advanced internal model particularly increase the exposure to systemic risk of the institutions in the largest quantile of SRISK. The results are very strong when we look at the intercept effects, while the interacted terms show that it is not only a size-story, but internal models could mitigate the negative effect of size on the exposure to systemic risk of the most systemic banks.

In sum, we find no evidence that the introduction of internal models introduced in 2006 did succeed to increase bank resiliency. The disgression given to the regulated banks apparently, while in compliance with statutory regulation, did not stop banks from engaging in (sophisticated) risk taking activities. The next section aims at showing the robustness of these results in a counterfactual analysis.

So far we confirm the empirical results of Behn and Haselmann (2016) about the unintended consequences of internal models for credit risk for German banks and extend them to European banks and financial institutions. Moreover, we find that the risk enhancing effect of internal models for credit risk are increasing in the systemical importance of banks; in larger and more systemic banks internal models contribute more strongly to an increase in SRISK of European banks and across risk classes. Based on our results the concerns raised about Basel II by Danielson et al. (2001) seem more than justified. By neglecting the endogeneity of systemic risk, Basel II regulation did not succeed to reduce systemic risk ironically precisely in those sectors that turned out to become the most vulnerable ones.

The implementation of Basel II in July 2006 has contributed to moderate the build-up of systemic risk. However, the moderating effect is less striking for precisely the major contributors to systemic risk. In this regard, the speculation of Hakenes and Schnabel (2011) is not supported by the data. Based on theoretical considerations Hakenes and Schnabel argue that the IRB-approach of Basel II induced smaller and medium-sized banks to take larger risks in order to compete effectively with larger banks employing the IRB-approach. We find that their basic assumption that IRB contributes

Table 4: Weekly Panel Regressions of SRISK (residuals, k=0.08%)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Beta	-186.0***	-186.2***	-118.1***						
	(48.19)	(48.94)	(30.22)						
Cost of Equity				-135.0**	-130.0**	-125.8**			
				(57.05)	(56.39)	(60.43)			
Delta_CoVaR							26,436***	26,255***	15,950***
							(5,795)	(5,639)	(3,902)
CISS	-2.253	-11.65	-9.949	-88.42**	-95.69**	-83.70**	-248.3***	-258.6***	-151.7**
	(33.06)	(31.68)	(31.41)	(39.54)	(38.92)	(36.74)	(87.22)	(88.86)	(60.14)
Z-Score	-1.136	-1.118	-0.0187	-0.846	-0.838	0.0288	0.340	0.278	0.0931*
	(1.007)	(0.962)	(0.0326)	(0.865)	(0.775)	(0.0257)	(1.088)	(0.924)	(0.0532)
Market return	-13,267***	-13,239***	-13,309***	-13,308***	-13,284***	-13,296***	-12,576***	-12,552***	-12,910***
	(3,448)	(3,439)	(3,460)	(3,481)	(3,474)	(3,478)	(3,246)	(3,238)	(3,335)
Policy rate	822.1**	976.2**	1,170***	1,765***	1,915***	1,656***	2,482***	2,673***	1,740***
	(405.5)	(427.9)	(373.4)	(486.2)	(508.9)	(428.7)	(796.4)	(815.7)	(488.3)
Market-to-Book	0.127***	0.138***	0.132***	0.144***	0.155***	0.136***	0.131***	0.142***	0.112***
	(0.0111)	(0.0118)	(0.0109)	(0.0101)	(0.0124)	(0.0109)	(0.0178)	(0.0190)	(0.0239)
MV	0.00248	0.00560***	0.00505***	0.00392*	0.00705***	0.00384***	0.00639**	0.00953***	0.00197
	(0.00192)	(0.00203)	(0.00137)	(0.00208)	(0.00202)	(0.00116)	(0.00260)	(0.00233)	(0.00124)
1.IRBA#MV	-0.00129		0.00162	-0.00105		-0.000532	0.000397		-0.00498**
	(0.00488)		(0.00430)	(0.00333)		(0.00299)	(0.00279)		(0.00205)
2.IRBA#MV	0.00931**		0.00976***	0.00993**		0.00918***	0.0113***		0.00872**
	(0.00452)		(0.00333)	(0.00403)		(0.00338)	(0.00352)		(0.00351)
3.IRBA#MV	0.00460**		0.00185	0.00463**		0.00300	0.00452*		0.00494***
	(0.00201)		(0.00201)	(0.00230)		(0.00183)	(0.00262)		(0.00155)
4.IRBA#MV	0.00575		0.00510	0.00540		0.00448	0.00522		0.00385
	(0.00492)		(0.00502)	(0.00462)		(0.00440)	(0.00549)		(0.00365)
1.IRBA	-14.33	-8.897	-15.23	18.55*	24.11**	17.62*	51.27**	60.04***	47.93**
	(14.82)	(13.22)	(14.25)	(9.786)	(10.40)	(10.32)	(19.82)	(20.95)	(18.32)
2.IRBA	-34.42	133.2**	-51.28*	-36.08	143.0**	-6.346	-26.97	177.0**	41.35
	(64.84)	(63.56)	(26.77)	(60.90)	(68.46)	(25.04)	(51.40)	(80.92)	(36.78)
3.IRBA	55.27	130.3**	71.72**	0.738	75.99*	26.48	-64.64*	9.044	-44.70
	(34.27)	(50.08)	(31.64)	(26.30)	(41.90)	(21.35)	(38.57)	(44.88)	(27.19)
4.IRBA	-44.73	47.54	4.758	-26.97	58.47	8.108	-10.92	70.29	-6.639
	(67.85)	(61.54)	(38.76)	(47.86)	(50.03)	(25.08)	(95.32)	(58.21)	(37.81)
Market Amend.	57.47**	35.95	22.09	42.52*	20.48	50.80***	-8.392	-28.24	64.66***
	(26.43)	(24.20)	(15.89)	(24.57)	(21.46)	(16.75)	(27.30)	(26.32)	(21.07)
BEL			-50.84**			-65.89***			-69.09*
			(21.91)			(19.53)			(37.77)
CHE			-30.32			9.175			62.95
			(18.79)			(12.32)			(46.50)
CYP			-7.357			8.138			40.87
			(17.08)			(12.23)			(47.92)
DEU			10.44			17.68			47.48
			(16.09)			(12.38)			(37.90)
ESP			-49.22			-54.15*			-88.31*
			(31.98)			(32.06)			(52.58)
FRA			37.02			41.62***			52.68
			(28.75)			(14.09)			(36.58)
GBR			-38.00			-34.73			-18.50
			(34.54)			(32.55)			(47.30)
GRC			37.25**			7.222			47.09
			(18.75)			(10.47)			(37.47)
IRL			-50.39			-59.21*			-7.019
			(37.10)			(34.64)			(44.88)
ITA			17.01			5.262			-7.699
			(17.79)			(11.87)			(38.70)
NLD			-40.42**			7.994			31.91
			(18.16)			(10.69)			(35.51)
Constant	5.667	-7.302	-45.73*	-117.1***	-130.0***	-142.0***	-280.0***	-294.5***	-261.7***
	(32.52)	(32.68)	(26.46)	(26.71)	(29.03)	(32.18)	(60.96)	(63.35)	(67.49)
Observations	55,586	55,586	55,586	55,582	55,582	55,582	55,586	55,586	55,586
R-squared	0.014	0.014	0.016	0.012	0.011	0.014	0.019	0.018	0.019
Number of gvkey	95	95		95	95		95	95	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[a] This table reports the results from panel regressions with firm fixed effects of the residuals from a first-step AR(2) regression of weekly median SRISK. We regress alternatively, market Beta, CAPM cost of equity, and Delta CoVaR. We include the bank-level IRBA dummies (categories 1 to 4) with and without interaction with the market capitalization of the bank. We also include as regressors the internal model dummy (from January 1996), lagged CISS systemic stress, Z-score, market capitalization, MSCI index and EU country policy rate. The standard errors are clustered for banks.

Table 5: Weekly Unconditional Quantile Regressions of SRISK residuals (k=0.08%)

SRISK	(1) Q.25	(2) Q.50	(3) Q.75	(4) Q.25	(5) Q.50	(6) Q.75
L.SRISK	0.00622***	0.00619***	0.169***	0.0103***	0.0110***	0.271***
	(0.00235)	(0.00235)	(0.0462)	(0.00181)	(0.00202)	(0.0411)
L2.SRISK	-0.00632***	-0.00698***	-0.161***	-0.00361**	-0.00351*	-0.0889**
	(0.00164)	(0.00164)	(0.0358)	(0.00180)	(0.00202)	(0.0410)
L.Beta	77.72**	56.18	3,292***	-5.214	170.5***	4,372***
	(34.58)	(49.12)	(687.2)	(5.392)	(5.194)	(93.97)
Zscore	-14.78***	-19.10***	-110.6**	-0.0197	0.340***	-3.659***
	(3.973)	(3.789)	(53.17)	(0.0232)	(0.0437)	(0.244)
L.CISS	406.4***	339.8***	4,035***	310.2***	254.5***	2,535***
	(68.94)	(68.11)	(1,200)	(13.98)	(14.71)	(211.9)
L.market return	-711.1***	-572.9**	-9,580***	-649.5**	-612.4**	-11,634***
	(235.0)	(224.0)	(2,947)	(299.6)	(309.7)	(4,350)
L.policy rate	-6,574***	-8,558***	-52,525**	-4,451***	-3,803***	-8,343**
	(1,661)	(1,691)	(20,667)	(284.0)	(279.1)	(4,178)
Market-to-Book	-0.465***	-0.375***	-6.981***	-0.551***	-0.263***	-3.178***
	(0.0570)	(0.0977)	(0.431)	(0.0220)	(0.0205)	(0.188)
Market Value	-0.00901**	-0.00973***	-0.0813*	0.000749**	0.0116***	0.262***
	(0.00366)	(0.00326)	(0.0434)	(0.000294)	(0.000332)	(0.00578)
1.IRBA-Standardized	22.38	95.56	468.1	176.4***	97.08***	-453.5***
	(60.09)	(62.30)	(580.5)	(8.409)	(6.919)	(81.82)
2.IRBA-Foundation	13.92	32.16	860.7	-121.5***	293.5***	-2,519***
	(155.3)	(160.3)	(1,175)	(16.33)	(14.50)	(181.2)
3.IRBA-Mixed	227.9*	250.5**	7,136***	219.6***	440.0***	9,082***
	(126.5)	(122.5)	(2,037)	(9.790)	(9.982)	(188.2)
4.IRBA-Advanced	441.4*	403.6*	589.2	375.5***	879.9***	766.7***
	(235.7)	(206.3)	(1,741)	(10.81)	(12.82)	(164.0)
intermodel	-453.9***	-432.3***	-184.4	-521.6***	-657.5***	-4,561***
	(104.1)	(102.5)	(2,041)	(16.49)	(16.63)	(273.7)
1.MV#IRBA-Standardized	0.00258	-0.00136	-0.0191	-0.0138***	0.0207***	0.487***
	(0.00750)	(0.00758)	(0.135)	(0.00131)	(0.00117)	(0.0219)
2.MV#IRBA-Foundation	0.00688	0.00582	0.0817	0.00532***	-0.00576***	0.0444***
	(0.00582)	(0.00569)	(0.0734)	(0.000689)	(0.000704)	(0.0150)
3.MV#IRBA-Mixed	0.00385	0.00405	0.0432	-0.00448***	-0.0155***	-0.272***
	(0.00560)	(0.00546)	(0.0892)	(0.000361)	(0.000392)	(0.00714)
4.MV#IRBA-Advanced	-0.0117	-0.0105	0.0814	-0.0180***	-0.0319***	-0.189***
	(0.00832)	(0.00784)	(0.136)	(0.000744)	(0.000788)	(0.0140)
Firm Fixed Effects	yes	yes	yes	no	no	no
Country Fixed Effects	no	no	no	yes	yes	yes
BEL				-58.89***	97.53***	3,351***
				(12.95)	(16.40)	(382.3)
CHE				-541.4***	-212.9***	-4,143***
				(13.53)	(16.07)	(154.2)
CYP				-126.3***	229.9***	-4,715***
				(12.21)	(17.29)	(160.9)
DEU				-299.4***	-434.9***	-3,131***
				(7.291)	(11.43)	(157.0)
ESP				-379.4***	-206.8***	-3,564***
				(12.10)	(14.19)	(239.1)
FRA				0.879	194.7***	3,088***
				(7.818)	(12.15)	(214.3)
GBR				-380.6***	-352.0***	-4,473***
				(11.13)	(12.94)	(198.9)
GRC				-415.1***	-149.5***	-3,122***
				(12.46)	(14.95)	(235.8)
IRL				-424.4***	-194.8***	-4,866***
				(15.33)	(16.60)	(225.3)
ITA				-195.1***	-59.60***	-3,916***
				(9.059)	(12.85)	(190.8)
NLD				83.65***	533.7***	-7,861***
				(8.049)	(13.25)	(221.9)
Constant	750.7***	1,011***	3,866	650.5***	633.6***	4,253***
	(171.3)	(160.9)	(2,529)	(27.75)	(28.81)	(430.1)
Observations	56,571	56,571	56,571	56,571	56,571	56,571
R-squared	0.165	0.192	0.261	0.189	0.418	0.572

[a] This table reports the results from the .25, .50 and .75 unconditional quantile regressions of weekly SRISK (Firpo, Fortin and Lemiux, 2009). We include the bank-level IRBA dummies (categories 1 to 4) with and without interaction with the market capitalization of the bank, the internal model dummy (from January 1996). We control for firm effects (1 to 3) or country effects (3 to 6), CISS systemic stress, market capitalization, market investment opportunities proxied by the MSCI equity index and short-term interest rate proxy the country policy rates. The standard errors are clustered for banks (Parente et al. 2016).

positively to larger banks is not supported by the data.[28]

With respect to the policy rate we observe a highly significant and strongly negative effect throughout all of our specifications. This suggests that monetary policy does interfere with bank business models directly. Lower interest rates effectively increase risk exposure. This affects is larger for the upper quartile but strong throughout the distribution, both with and without cross-country fixed effects.

In summary, the intended consequences of the Basel regulation were achieved only for the safer banks, but ironically they were missed for the riskier banks. Obviously, banks' strategic incentives were not properly understood and the substitutability between capital rules and state guarantees was seriously underestimated throughout the various levels of the Basel process of capital regulation. Consequently, it was especially the systemic European banks that were ill prepared to deal with the subprime crisis in 2007 and even more in the subsequent European sovereign crisis.

4.6 Counterfactual Analysis and Diff-in-Diffs Results

By analysing the whole distribution of banks, we go a long way towards causal identification. The documented increase in risk exposure is concentrated on the upper quintiles of the risk distribution of banks, which happen to be the largest and internationally active banks. So the build-up of systemic risk is strongly correlated with the use of internal models, especially for credit risk. Smaller banks are less likely to invest in the costly process of setting up internal credit risk models, and, hence, as we document, build up less exposure to systemic risk. This observation excludes many alternative hypotheses about the increase in risk exposure, such as monetary policy, financial innovation and the role of derivatives. While all these developments undoubtedly influence the strategic choice of business models, our data suggest that it is particularly the large and internationally active banks that exploit those opportunities if at the same time they invest in setting up internal risk models.

In order to assess the contribution of the Basel process to the build-up of risk exposure, we provide a simple counter-factual analysis by asking the question of how would the evolution of risk exposure have occurred if internal models had not existed. In order to conduct this counter-factual experiment, we estimate the behavioural parameters in periods where internal models were not available and then trace the (hypothetical) evolution of systemic risk for the observed realizations of the risk factors in later periods. Thus we can identify the effect of changes in behaviour induced by the introduction of internal models.[29]

For conducting the counter-factual experiment we consider two sub-periods: i) the period before any internal models were available (prior to 1996) and ii) the period prior to the implementation of internal credit risk models (1996-2006).

Figure 15 shows the historical evolution of SRISK compared to the estimated forecasted SRISK in case of no changes in the regulatory environment. We present trajectories both for total exposure

[28]Even if the competitive effect of Hakenes and Schnabel (2011) is relevant at all, our evidence suggests that the direct (negative) implications for banks' risk management are dominant. However, our findings about the effects of internal models suggest that the assumption of an increase in resiliency or the largest banks due to the use of risk-models is not supported by the data. In this regard, also Colliard (2015) has investigated theoretically the impact of internal models on the risk-taking behaviour of banks.

[29]This approach follows Fuess et al. (2016).

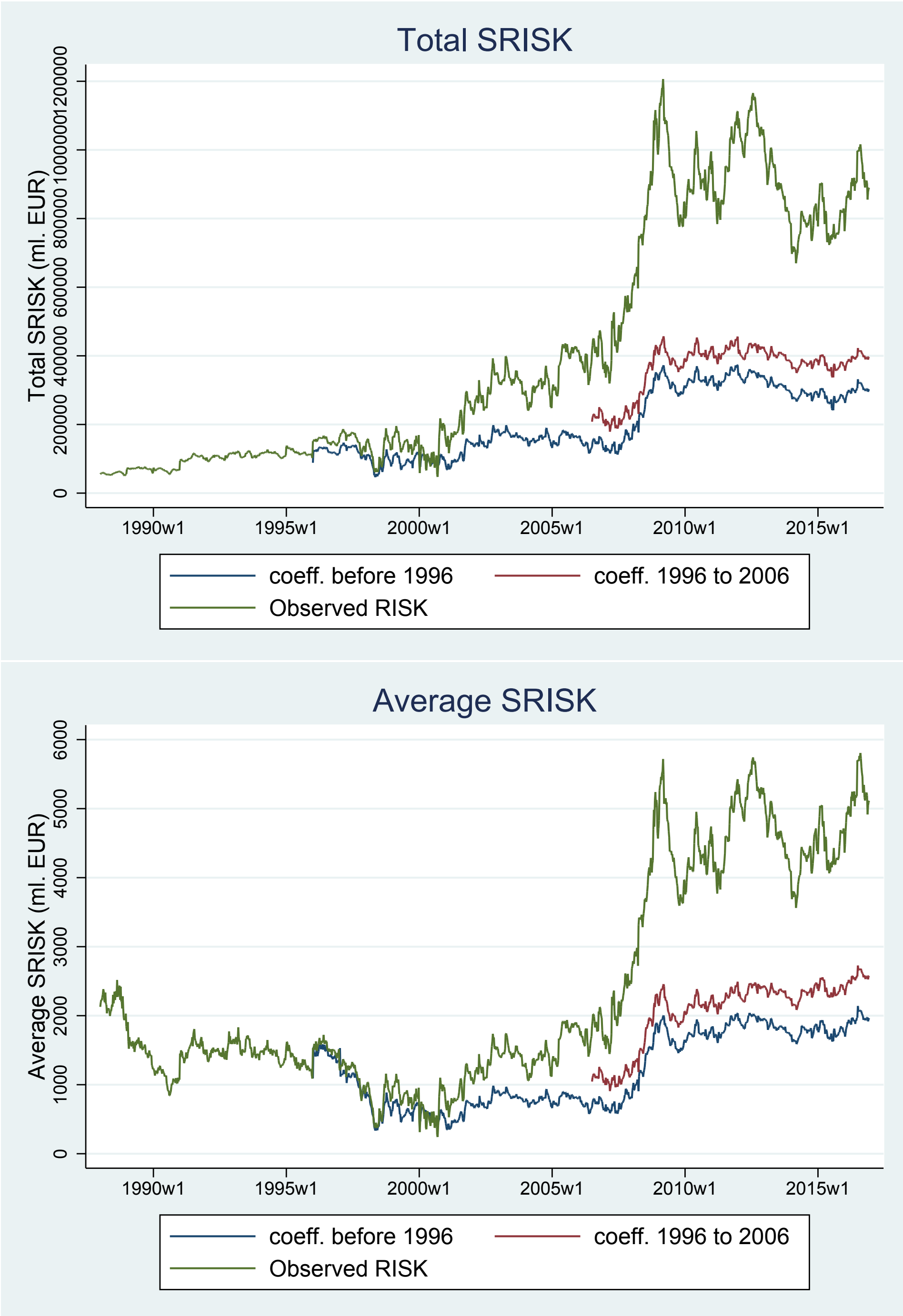

Figure 15: Evolution of historical total and average SRISK vs. counterfactual SRISK. The Figure presents the evolution of the historical average SRISK compared with the estimated forecasted SRISK in case of no Market Risk Amendment (blue line) and no Basel II accord (red line). We estimate SRISK using the dynamic two-stage model as Equation 11 in two sub-periods: i) before any internal models were available (prior to 1996) and ii) prior to the implementation of internal credit risk models (1996-2006).

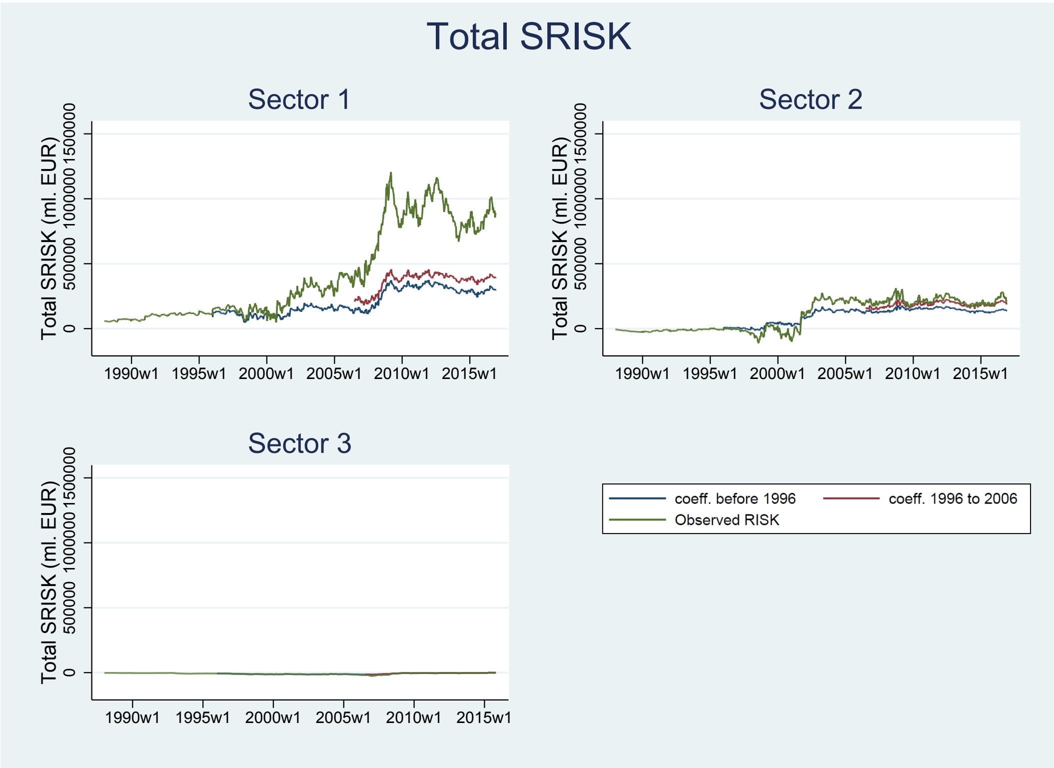

Figure 16: Evolution of historical total sectoral SRISK vs. counterfactual total sectoral SRISK. The Figure presents the evolution of the historical total SRISK compared with the estimated forecasted SRISK in case of no Market Risk Amendment (blue line) and no Basel II accord (red line). We average SRISK according to the financial sector: 1. banks and diversified institutions, 2. insurance companies, 3. real estates. We estimate SRISK using the dynamic two-stage model as Equation 11 in two sub-periods: i) before any internal models were available (prior to 1996) and ii) prior to the implementation of internal credit risk models (1996-2006).

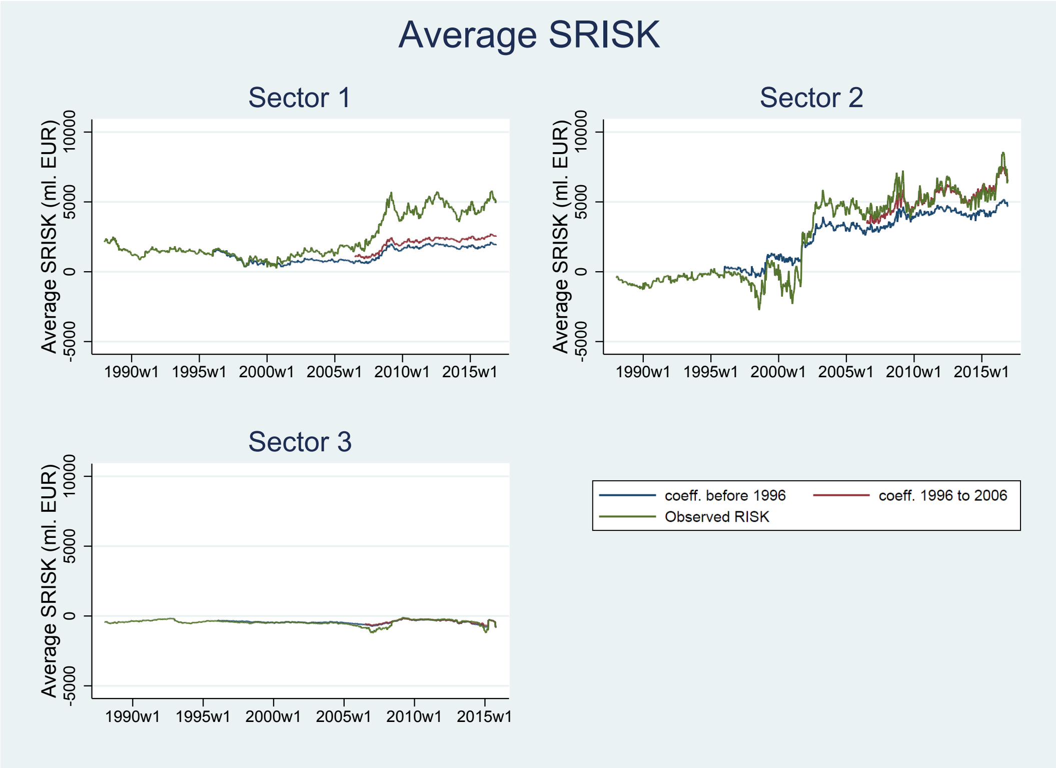

Figure 17: Evolution of historical average sectorial SRISK vs. counterfactual average sectorial SRISK. The Figure presents the evolution of the historical average SRISK compared with the estimated forecasted SRISK in case of no Market Risk Amendment (blue line) and no Basel II accord (red line). We average SRISK according to the financial sector: 1. banks and diversified institutions, 2. insurance companies, 3. real estates. We estimate SRISK using the dynamic two-stage model as Equation 11 in two sub-periods: i) before any internal models were available (prior to 1996) and ii) prior to the implementation of internal credit risk models (1996-2006).

and average exposure, since the number of banks in our dataset is not constant over time. The results of the mean panel regression suggest that the internal models for market risk did indeed reduce the risk exposure around the turn of the millennium, suggesting that the market risk amendment was in fact helpful in improving risk management for European banks on average.[30] These observations are in line with the original intentions of the Basel Committee even though they appear quantitatively small.

Most strikingly, however, our results suggest that in the run-up of Great Financial Crisis internal models contributed largely to the lack of resiliency of European banks. Our simulations suggest that internal models contributed largely to amplify the capital short-fall in in 2008-9 by a factor of two. In fact both, internal models for market risk and for credit risk did contribute to a massive amplification of exposure to systemic risk in the European banking system. After 2014, we observe a significant reduction in aggregate systemic risk, but well above the levels of the Great Financial Crisis. It remains worrisome though that despite improved supervision the capital shortfall remains at the levels of the Great Financial Crisis of an average of about 5 billions of Euros per bank. There is no indication of a normalization of the capitalization of European banks to pre-crisis levels.

How do the reported developments in the banking sector compare to other financial intermediaries, notably the insurance sector but also to real estate funds? Figures 16-17 provide the historical and estimated evolution of SRISK for the various financial sub-sectors: banks, insurance companies and real estates.

As an immediate result, aggregate exposure to systemic risk in banking dominates the other sectors. However, on a per firm basis, the average exposure of the insurance sector is rising and after the Great Financial Crisis even exceeding the average exposure in the banking sector. Moreover, there is strong evidence that capital regulation in the banking sector spills over into the insurance sector, while no spill-overs into the real estate sector can be detected. Nevertheless, the dominant counter-factual effects of capital regulation are clearly identified within the banking sector. This holds both for total as well as average exposure.

Finally, despite a lot of regulatory action and despite the creation of the supervisory infrastructure of Banking Union, there is no tendency for exposure to systemic risk to decline back to pre-crisis levels relative to the Great Financial Crisis.

We conclude with a difference-in-differences analysis and report the results on the mean regression. The treated group comprises banks that did implement internal credit risk models after the regulatory option is made available by Basel II in June 2006. We first use propensity score matching (PSM) to weight observations such that the treated group reflects the distribution of covariates in the pre-Basel period. We report both the results for the probit regression for the PSM and the difference-in-differences estimation in Table 6. We choose the bank-characteristics we have used throughout the analysis to identify control banks by lagged SRISK, market beta, Zscore, market-to-book and market value. We see that all these characteristics importantly affect the choice of implementing internal models, in line with the probit regression results in frame A.

The PSM provides the weight for the weighted diff-in-diffs regression. The results strongly support our hypothesis that exposure to systemic risk is largely driven by the use of internal credit risk models. While there are no significant differences in SRISK between treatment and control groups

[30] This is in line with the short-lived reduction in SRISK after the implementation of the internal market risk models in 1996 (see Figure 7).

Table 6: PSM and Diff-in-Diff

A. Probit regression

IRBA01	Coef.	z	p-value
L.SRISK	-0.0000328***	-20.93	0.000
L.Beta	0.7261689***	30.59	0.000
Zscore	-0.0045197***	-4.93	0.000
Market-to-Book	-0.1658926***	-25.95	0.000
Market Value	0.0000749***	42.02	0.000
Constant	-0.4001053***	-15.69	0.000

Pseudo R2 = 0.2101

B. Difference-in-differences estimation

Outcome var.	SRISK	t	p-value
Baseline:			
Control	5892.937		
Treated	5275.271		
Diff (T-C)	-617.666	-0.22	0.83
Follow-up:			
Control	1684.41		
Treated	2.00E+04		
Diff (T-C)	1.80E+04	3.3	0.002***
Diff-in-Diff	1.90E+04	3.73	0.000***

[a] This table reports the results from the Propensity Score Matching and the following difference-in-differences analysis on banks with internal credit risk models (Advanced or mixed approaches) versus comparable banks without, before and after the regulatory change in 2006. Propensity Score is estimated via a probit regression, where the probability of implementing IRBA is explained by lagged SRISK, market beta, Zscore, Market-to-Book, and market capitalization. We report robust standard errors, clustered per firm. ***0.01; **0.05; *0.10.

prior to the implementation of Basel II standards, we find strong and significant differences in risk exposure after their introduction in 2006. In the follow-up period, we see that institutions that have chosen to implement credit risk models as either advanced or mixed approaches, have increased more than tenfold their exposure to systemic risk in the post-Basel II period compared to the peer group.

4.7 Robustness

Our results require a number of important modelling judgements that are open up for discussion. While the specific estimations will depend on these choices, the qualitative results remains remarkably robust. We only provide some of the most immediate request that might come to mind. One suggestion does concern the definition of the prudential capital ratio. While we chose k=8% in order to maintain comparability with other studies, we also run regression for the settings k=5.5% and k=3%. The latter may even open up another interpretation of our risk measure in terms of the leverage ratio under Basel III to which it corresponds. We cannot detect any qualitative modification to the previous discussion, concerning the impact of the Basel dummies and of the credit risk internal models approaches..

While time fixed effects do generate robust and consistent estimations, we also report regressions with country fixed effects instead. For this purpose, we estimate SRISK on the same previous set of regressors via use of OLS or random effects. Overall our results are confirmed with country fixed effects. Systemic risk particularly builds up for the larger more systemic banks.

Concerning monetary policy, again we find weakly destabilizing effect of low interest rates. The estimates are not that strong but again low interest rates reduce resiliency.

Moreover, without over-emphasizing, we find interesting country specific effects, reflecting differences in the supervisory attitudes.[31] Under the mentioned caveat, we find evidence that most countries take a more effective role in reducing SRISK with the notable and significant exception of France. The country effects are significantly lower for Germany and Spain; they are also lower for Italy but not significantly.

4.8 Delta CoVaR

We perform the same analysis above using the Delta CoVaR measure from Adrian and Brunnermeier. Following their approach, we use the dollar value of the systemic risk measure, defined as $\Delta^{\$}CoVaR_{it}(\alpha) = \Delta CoVaR_{it}(\alpha) * size_{it}$.

As we measure it, Delta CoVaR is the market VaR conditional on a bank being in distress, therefore it can be viewed as measuring an institution's contribution to systemic risk. It measures the contagion deriving from a bank being in distress and, hence, the likelihood of the banking system getting infected by such bank.

Performing a weekly panel regression again we find mixed evidence for the role of the various policy dummies of the Basel regulatory framework (Table 7). While Basel II essentially did succeed

[31] Given data availability and the fact that Banking Union only exists for about 2 years by now - Oct. 2016 - we have not - yet - controlled for a potential structural break in November 2014.

Table 7: Weekly Panel Regressions of $\Delta^{\$}$ CoVaR

$\Delta^{\$}$ CoVaR	(1)	(2)	(3)	(4)	(5)	(6)
Beta	60.15***	62.07***				
	(14.82)	(15.48)				
Cost of Equity			-138.5***	-140.3***		
			(33.32)	(33.82)		
SRISK					0.00246***	0.00270***
					(0.000527)	(0.000508)
Market to Book	-0.000139	-0.00294	-0.00522	-0.00803*	-0.00640	-0.00624
	(0.00385)	(0.00375)	(0.00376)	(0.00406)	(0.00467)	(0.00473)
CISS	99.00***	100.00***	45.62***	45.88***	84.53***	81.66***
	(24.83)	(25.49)	(13.62)	(13.81)	(22.60)	(21.51)
MSCI Europe return	-62.79	-51.23	151.9**	166.1**	-13.66	-24.93
	(55.62)	(54.36)	(65.48)	(65.48)	(55.91)	(52.69)
EU Policy rate	-438.4***	-414.9***	-842.4***	-828.7***	-498.3***	-498.7***
	(147.3)	(136.7)	(244.6)	(236.5)	(171.0)	(168.6)
Market Value	0.00847***	0.00758***	0.00846***	0.00763***	0.00842***	0.00872***
	(0.000467)	(0.000381)	(0.000467)	(0.000437)	(0.000483)	(0.000581)
1.IRBA Standardized #MV		-0.00118		-0.000989		-0.00173
		(0.00154)		(0.00204)		(0.00142)
2.IRBA Foundation #MV		-0.00196***		-0.00197**		-0.00310***
		(0.000622)		(0.000760)		(0.000529)
3.IRBA Mixed #MV		0.00214***		0.00200***		-0.000162
		(0.000394)		(0.000384)		(0.000652)
4.IRBA Advanced #MV		0.000498		0.000283		-0.00320
		(0.000367)		(0.000512)		(0.00228)
1.IRBA Standardized	-11.96	-9.722	-17.70	-15.90	-6.486	4.923
	(11.45)	(12.56)	(11.44)	(13.02)	(10.10)	(9.746)
2.IRBA Foundation	-21.74	-3.749	-24.13*	-6.156	-16.53	15.54
	(14.06)	(12.83)	(14.15)	(12.87)	(14.23)	(11.00)
3.IRBA Mixed	20.31	-13.13	33.21**	2.374	5.878	11.03
	(14.94)	(11.55)	(15.80)	(11.96)	(14.07)	(11.60)
4.IRBA Advanced	1.226	-4.177	-1.976	-5.034	-32.74	5.873
	(14.50)	(14.83)	(15.00)	(14.62)	(22.10)	(11.86)
intermodel	-32.19	-23.44	-56.32**	-48.45**	-54.57**	-63.91**
	(22.89)	(20.21)	(26.62)	(24.26)	(27.43)	(25.56)
basel3	15.89	15.81	6.622	6.318	10.40	8.407
	(10.54)	(10.48)	(9.102)	(8.874)	(9.875)	(9.824)
Year effects	yes***	yes***	yes***	yes***	yes***	yes***
(p-value)	(0.0018)	(0.0055)	(0.0008)	(0.0004)	(0.0024)	(0.0013)
Constant	-6.680	-12.46	62.77***	58.78***	36.99***	36.24***
	(11.09)	(10.89)	(16.50)	(15.04)	(13.31)	(12.69)
Observations	11,778	11,778	11,778	11,778	11,778	11,778
R-squared	0.538	0.551	0.530	0.542	0.565	0.573
Number of gvkey	100	100	100	100	100	100
rho	0.176	0.176	0.176	0.204	0.114	0.117
r2_b	0.919	0.933	0.958	0.966	0.952	0.951
r2_o	0.769	0.777	0.774	0.776	0.796	0.799
r2_a	0.537	0.550	0.529	0.541	0.563	0.571

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[a] This table reports the results from panel regressions with fixed effects of weekly median Delta CoVaR in dollar terms. We regress on, alternatively, market Beta, CAPM cost of equity, and SRISK. We include the bank-level IRBA dummies (categories 1 to 4) with and without interaction with the market capitalization of the bank. We also include as regressors the internal model dummy (from January 1996), the Basel II dummy (June 2006 to September 2008) and the Basel III dummy (from September 2008). We control for year effects, CISS systemic stress, market capitalization, MSCI index, and EU country policy rate. The standard errors are clustered for banks.

to reduce risk of contagion, the implications of the internal models are rather mixed. It turns out that the foundation approach did meet expectations and did contribute to reducing contagion risk especially for the larger banks. However, the mixed approach, which allows bank to apply internal models strategically, tends to contribute positively, and hence enhance, contagion risk. This finding parallels the results on SRISK showing that the strategic use of internal models especially for larger banks contributed to an increase in systemic risk, both for exposure to systemic risk as well as for contributing to systemic risk. Internal models for credit risk were used by larger banks in a way that contributed to enhance systemic risk, and thus reduce stability and soundness for the overall banking system.

Interestingly, the policy rate has strictly negative affects on the contribution to systemic risk, suggesting that a low-growth environment could be an incentive for risk-taking behavior at the level of individual banks.

5 Policy Role for Market-Based Risk Measures

An attractive feature of market based risk measures is the fact that they control for market feedback. Regulatory institutions and supervisors, however, typically focus on information about individual institutions and, hence, idiosyncratic risk such as possibly embodied in book values. Also the Basel capital regulation focuses on book rather than market values. This regulatory approach, while facilitating the analysis of single institutions by separating them from market developments, is not helpful in a system context, since the very foundations of systemic risk are tied to the notion of market feedback. Bank runs do occur because of depositors' (self-fulfilling) fears about other depositors running. Contagion effects occur, whenever insolvencies of single institutions cause knock-on insolvencies of connected, but otherwise healthy, financial institutions. Accordingly, discrepancies between book and market values may contain important systemic information to which supervisors (and regulators) should not cast a blind eye.

In order to illustrate the informational content of the market based capital shortfall measure SRISK, we provide a brief discussion of two systemic European banks that entered into different trajectories during the Great Financial Crisis, Deutsche Bank and Union Bank of Switzerland (UBS) (Figures 18). While UBS had to be rescued by the tax payers in 2007, Deutsche Bank succeeded to (narrowly) escape the need of government support in 2007-8. In the respective SRISK trajectories we identify similar pre-crisis developments. Both banks had accummulated a pre-crisis shortfall of about 60 bill. Euro according to our crisis definition. During the crisis the measure shot up to about 160 bill. Euro in the case of Deutsche Bank, while in the case of UBS the tax payer intervened and the measure only increased to about 100 bill. Euro. In 2010 the shortfall measures declined in both cases but remained considerable above pre-crisis level until the European Sovereign Crisis hit, increasing the short fall again for both banks. But even after 2013 in the case of Deutsche Bank the capital shortfall basically remained at level of 2009, considerably above the pre-crisis level of 2007. In contrast UBS succeeded in reducing capital shortfall to pre-crisis levels of 2007 and even below.

The troubles of Deutsche Bank after the leakage of hefty penalties in the United States in September 2016 are clear evidence that capital shortfall is strongly correlated with lack of investor confidence and a high degree of stock market volatility, essentially due to worries about the bank's resilience. Quite differently, UBS seems to stay out of trouble quite comfortably despite the realiza-

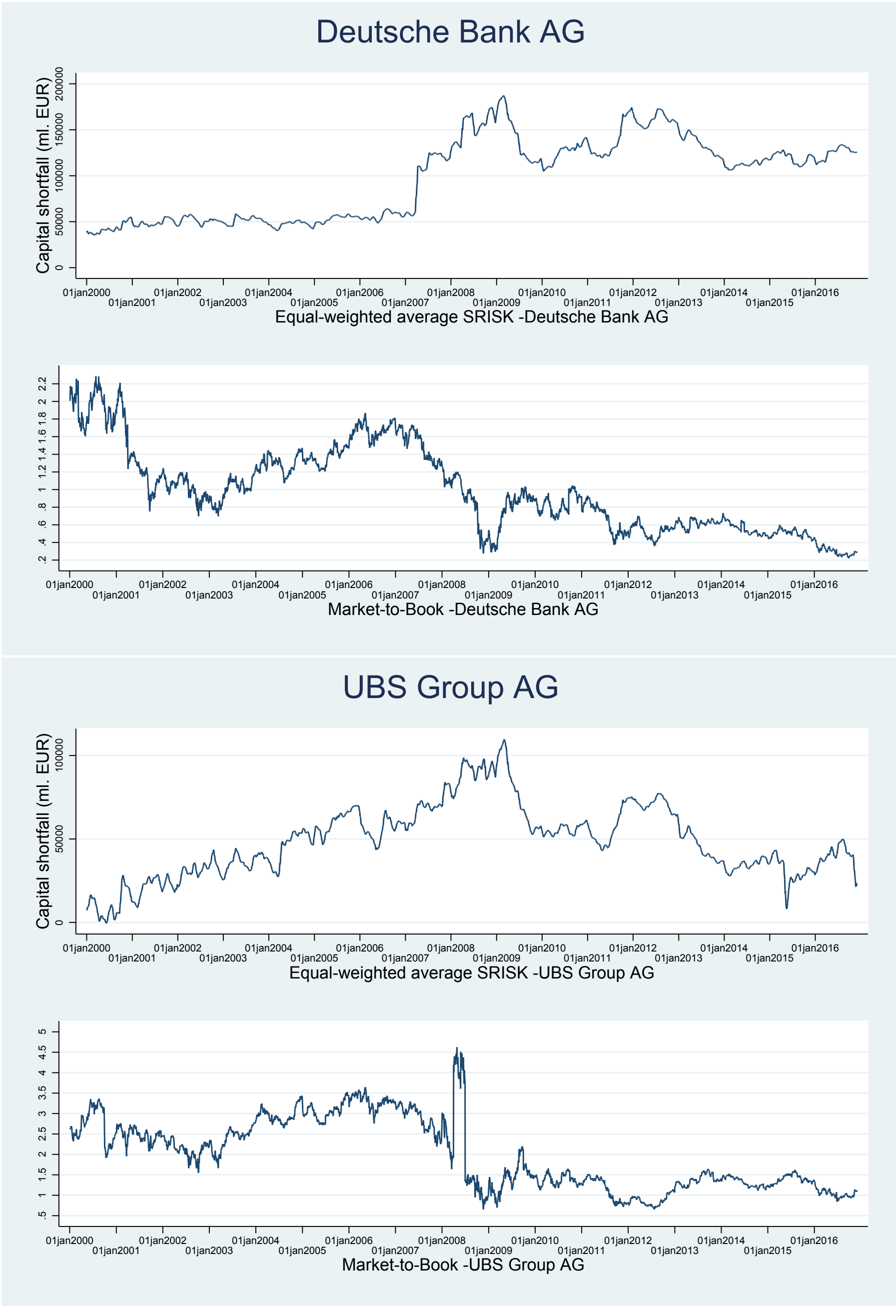

Figure 18: Cross-sector variation of systematic risk. The Figure presents the evolution of the SRISK and Market-to-Book of Deutsche Bank and UBS.

tions of operational risk also on their side.

European supervisors tend to take the view that markets may be over-reacting to bad news causing market-to-book values to be excessively depressed. They seem to be essentially satisfied by what they consider serious attempts of Deutsche Bank - and other systemic banks - to rebuild *book values* of regulatory tier-1 capital [32]. This lack of drive is somewhat surprising, since according to Gandhi et al. (2015, 2016) and Kelly et al. (2016) bank equity is cheap particularly for the large banks. Rather the ECB tends to be more concerned to harmonize supervisory procedures for smaller banks than to recapitalize the ailing systemic banks in Europe (see Gehrig et al. 2016).

The case of UBS is an interesting case study, since i) Switzerland is over-complying with Basel III standards, and ii) UBS is over-complying with Swiss standards. And in fact, market-to-book recovered for UBS to essentially normal values, while in the case of Deutsche Bank, market-to-book remains on a long run decline well below .5.[33] The case of UBS demonstrates that it is possible to rebuild market confidence and, thus, market valued capital, if the recapitalization is done seriously enough. Obviously, it is very costly to undo the massive stock repurchases in the run-up to the Great Financial Crisis, but rebuilding confidence requires serious and similarly massive commitment. Market values are important indicators of market confidence and trust, and, hence, relevant information also for supervisors.

6 Concluding Comments

We document a steady increase in the systemic risk exposure of European banks as measured by the capital shortfall measure SRISK within the past 30 years. The lion's share of the increase occurs in the highest quintile of the size distribution of banks. For almost half of the banks in our sample, and certainly for the lower two quintiles, the measure remains roughly constant over 30 years.

While the Basel process of capital regulation was designed to increase the stability and safety of the global banking system, our evidence suggests that it did not fully achieve this goal in its first three decades of operation, at least for European banks. From the perspective of systemic risk measures, the Basel process has been effective for smaller banks in our sample. But even there it did not significantly reduce systemic exposures or contagion risk. For the largest quantiles of banks, internal models might have provided strong incentives to carve out equity and, thus, reduce in-house resiliency. The evidence demonstrates that those incentives were exploited and the resiliency of large and especially systemic European banks was greatly impaired at the onset of the Great Financial Crisis. To the extent that all large banks did engage in this activity of reducing their capital buffers, overall bank capital also became scarce, generating systemic concerns for the whole banking sector. But even after 2008, and especially even after the start of the Banking Union in November 2014, most individual - and thus aggregate - SRISK scores did not retreat to levels of the 2007-8 crises or below.[34]

Controlling for bank balance sheet variables, the standard drivers of bank stock prices and macroeconomic indicators[35], our structural analysis of the drivers of SRISK strongly suggests that

[32]See e.g. Carney, 2016, Dombrovskis, 2016 and Nouy, 2016

[33]In September market-to-book for Deutsche Bank even fell as low as .10.

[34]This observation is consistent with attempts of ECB researchers (Homar, Kick, Salleo, 2016) trying to empirically validate the ECB policy of focusing on particular on the European ECB and EBA stress scenarios rather than focusing on individual and aggregate capital shortfall for the Euro area as suggested for example by Acharya, Engle and Pierret (2014).

[35]While we cannot completely rule out omitted variables, we make a large attempt to include all the known drivers of stock prices that crucially affect our endogenous variable SRISK plus additional country-specific macro-economic

internal risk models were chosen strategically (see Behn, Haselmann and Vig (2016) and Colliard (2015), but also Admati and Hellwig (2013)) resulting in an enormous depletion of bank equity. Ironically, these equity carve-outs were one way of increasing return on equity through extensive stock repurchases especially prior to the Great Financial Crisis and at a time when the cost of bank equity was actually low, and strengthening capitalization and resiliency would have been relatively cheap (in historical context).[36]. Of course, this observation may simply constitute a reflection of the leverage ratchet effect. (see Admati et al. (2016)).

On the basis of our analysis it is not necessarily that capital rules per se were insufficient; it is rather the possibility to reduce effective capitalization by means of complex risk models under supervisory approval that causes the lack of resiliency. Our findings accord well with Miles et al. (2012). They seem to contradict Jackson (2015) in the sense that simple models, even at sub-optimal levels in terms of efficiency, may be more suitable to limit risks and, hence, safeguard resiliency.

It is not evident that these outcomes should be viewed as unintended consequences of the Basel process of capital regulation. Rather public warnings about such outcomes had dutifully and rigorously been voiced by leading academic researchers. Notably Danielson et al. (2001) raise serious concerns that the neglect of endogeneity of systemic risk could turn into an unintended build-up of major systemic risk within the Basel II approach. However, the political economy of the Basel process might have succumbed too much to industry interests in reducing the bite of the standard approach by introducing generous options to determine regulatory capital with the help of their own internal models.

The current debate on Basel IV reflects a new perspective on this front, implicitly showing that regulators have become aware of the need to limiting the potential misuse of internal models. The Basel Committee's Consultative Document on credit risk models (Basel Committee on Banking Supervision, 2016) proposes to remove this self-regulatory option for exposures that do not allow for sufficiently reliable estimates, such as low-default exposures. The European evidence provided on our analysis strongly suggests curtailing the use of the mixed and the advanced IRBA-approaches in order to effectively reduce the exposure to systemic risk (SRISK). Surprisingly given the evidence, it is especially the European supervisors that were reluctant to cut back on internal models on what was to be the final decision on Basel III in November 2016 in Santiago de Chile.[37]

We also suggest that, by concentrating on formal fulfilment of regulatory rules based on book values, regulators missed a pro-social role in interpreting (negative) market feedback. Relying on rules based on book values only completely neglects social feedback and market expectations. However, trust and confidence are key in the banking industry, but they are notoriously difficult to measure and observe. Hence, market based risk measures are one simple step towards taking into account market reactions, trust and confidence, and hence systemic market feedback. This is potentially useful information and supervisors should be challenged to explain more when and why they disregard market information.[38] After all, supervision attains an important role to correct potential

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indicators. Moreover, the cross-sectoral heterogeneity does contribute importantly to identifying causal relationships between regulatory variables and SRISK. In addition we perform both a counter-factual simulation and a diff-in-diff analysis.

[36] Baron and Xiong (2014) provide a behavioural explanation based on over-optimism.

[37] While this version of the paper is being written, there still does not exist consensus on a final Basel III accord.

[38] This argument is not saying that there is no mispricing in markets. However, under normal conditions mispricing should be a short term problem. In the long run markets should converge to fair valuations. For example, a market-to-book anomaly may occur for short periods; but when it persists for years or decades, the underlying sources of the

misbehavior only in market economies. This argument assumes the existence of a sufficiently high degree of trust in the operation of markets after all. If this trust cannot be assured for normal periods, why not economize on bureaucracy and centralize the whole banking system?

Our analysis also uncovers disconcerting effects of monetary policy on banks' contribution to systemic risk. We can motivate this result considering that a low-growth environment might create incentives for excessive risk-taking, and, therefore, increase both, contagion risk and contribution to systemic instability of the sector. This effect can be observed throughout the whole distribution of banks. Accordingly, under the current regulatory framework, Quantitative Easing, through its effect on interest rates, might tend to contribute to undermining the stability and soundness of the European banking system.[39]

There are even wider implications of the Basel process of capital regulation beyond the banking industry on the whole financial sector (Gehrig, Iannino, 2016). For example, the build-up of systematic risk in the insurance sector, while not as dramatic as in the banking sector, also significantly moves upwards with a structural break around 1996. Possibly these developments also exhibit unintended consequences across markets and industries: long-term lending is increasingly given up by banks[40] and taken over by the insurance sector. Hence, a final evaluation of the welfare consequences of the Basel process of capital regulation requires an analysis whole financial sector in order to not only account for market feedback, both in the regulated as well as the unregulated segments, but also for substitution effects and their implications on complementary activities. We leave this for future research.

We leave for future research also the interaction between capital regulation and Banking Union. It is too early for a final judgement of Banking Union on the most systemic banks. However, at this stage we cannot detect any decline in the systemic risk scores for the banks under direct ECB supervision. Certainly, their SRISK remain well above the 2008 levels still in 2016.

Similarly, the implications of Brexit on financial stability are too early to assess. While for a final judgement the process of Brexit still needs to be properly defined, early market reactions do suggest a slight increase in systemic risk only. This seems to reflect an increase in risk premia due to heightened uncertainty. Due to the fact that systemic risk of the most systemic European banks has not been checked effectively up to date under Banking Union, Brexit implications for the stability of the European banking system may still be formidable and serious.

We end with the observation that the build-up in systemic risk in the financial sector entails considerable tail risk for the macro economy, which has been identified as one likely channel for seculiar stagnation (e.g. Kozlowksi, Veldkamp, Venkatesvaran, 2015).[41] To the extent that one subscribes to this argument, it is true that the Basel process has contributed to permanently enhancing tail risk. Thus, under this view, real effects of the resulting equity carves out in European and global banking systems can be seen contributors to the decline in long-term investment growth. The *missing recovery* after the Great Depression (Summers, 2016, Teulings Baldwin, 2014), unfortunately,

anomaly may be important to remedy.

[39] This finding suggests that Quantitative Easing would require complementary supervisory instruments to control adverse risk-taking incentives. In the case of Europe such complementary control was not effective for the period of our study.

[40] On the shortening of banks' planing horizon see also Boot and Ratnovski (2016).

[41] Kozlowski et al. (2015) argue that rare event realizations of tail risk have changed long term beliefs and expectations. Analysing credit spreads Füss et al. (2016) find similar evidence of changing risk perceptions in the U.S. corporate debt market.

correlates strongly with high levels of systemic risk, particularly for the largest, and, presumably, most efficient financial institutions worldwide.

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8 Appendix

Table 8: Large Sample Statistics

Sector	SRISK				Beta	ΔCoVaR	MV
	< 1996	1996-2006	2006-2008	> 2008			
Banks	2280.471	2890.016	7079.194	11388.29	.7360346	.0074475	7817.312
Diversified	727.5312	420.9213	1044.786	1904.564	.6127794	.0068244	1792.487
Insurers	-547.8529	1906.837	4677.732	5647.29	.8018688	.0086705	8925.343
Real Estates	-394.7499	-517.7924	-876.4478	-287.987	.5446723	.0047947	1121.411

[a] This table reports the summary statistics of the financial institutions in our whole sample. by financial subsector, we report average SRISK (in the four subperiods of interest), market Beta, Delta CoVaR and market capitalization.

Table 9: Small Sample Statistics

Name	Country	SRISK < 1996	SRISK 1996-2006	SRISK 2006-2008	SRISK > 2008	Beta	ΔCoVaR	MV
Bank Fuer Kaernten Und Steiermark	AUT	14.22134	-59.75613	-46.33916	43.12871	.2143777	.0065933	486.8625
Bank Fuer Tirol Und Vorarlberg	AUT	14.81701	-32.93632	141.5505	320.8975	.282841	.005198	490.1185
Erste Group Bank	AUT		4639.103	5917.598	10963	1.087557	.0125299	13243.07
Oberbank	AUT	107.6971	279.0604	181.6947	256.8992	.3012121	.0066912	987.3725
Raiffeisen International Bank Holding	AUT		-950.7543	-1573.622	6417.921	1.468486	.0137832	12022.19
Unternehmens Invest	AUT		-51.19232	-51.56719	-51.31037	.3092515	.0029117	82.14931
KBC Group	BEL	2446.67	5421.85	8437.08	15684.56	1.016361	.0096414	19903.96
Bank Coop	CHE	175.2317	164.858	-151.8836	313.4363	.1865398	.0047486	697.6836
Bank Linth LLB	CHE		35.2001	-24.73893	68.91928	.1967701	.0039515	262.3995
Edmond de Rothschild (Suisse)	CHE		-28.87809	-396.6915	257.5472	.3697498	.0064649	778.4694
St.Galler Kantonalbank	CHE		245.5587	-372.9412	309.5656	.3811617	.0099404	1909.731
UBS Group	CHE	8945.425	29101.2	72145.35	52753.51	1.078454	.0136245	56299.92
Valiant Holding	CHE		54.74283	-657.2963	291.9383	.2967349	.0059943	1764.552
Vontobel Holding	CHE	-218.2216	-618.8327	-446.8082	4.905521	.7540862	.0104863	1731.418
Zuger Kantonalbank	CHE	198.8947	72.12868	-109.2551	-155.2904	.2331743	.004816	750.4201
Bank of Cyprus Public Co Limited	CYP		-535.4931	-1486.459	1524.285	.5952032	.0068917	3565.318
Hellenic Bank	CYP		72.59184	-30.18251	421.175	.5971429	.0063062	479.5079
USB Bank	CYP		-7.056847	-.4129192	15.75585	.25283	.0008707	48.87632
Aareal Bank	DEU		2474.119	2387.432	2919.631	1.230744	.012334	1458.186
Adcapital	DEU		-69.72336	-124.8044	-71.45582	.3933429	.0045961	156.3118
Allerthal-Werke	DEU		-6.4114	-10.55832	-10.79959	.2690846	.0034523	12.72925
Baader Bank	DEU		-121.6808	-108.3948	-41.39077	.907278	.0078801	228.4999
Bayerische Hypo- Und Vereinsbank	DEU	6729.773	28506.13	13442.02	10060.16	.748991	.0067074	27546.18
Berlin-Hannoversche Hypothekenbank	DEU		2461.578	1056.194	1872.675	.2635079	.0023275	1901.139
Berliner Effektengesellschaft	DEU		-165.7096	-66.82896	-60.9642	.5656877	.0052909	175.7353
C.J.Vogel AG Fuer Beteiligungen	DEU	-49.96786	-71.97611	-74.48666	-117.618	.291241	.0007484	128.2511
Cash.life	DEU		-97.87551	-69.46162	3.133747	.594883	.0016734	142.0449
Comdirect Bank	DEU		-458.8782	-189.1062	253.5582	1.023382	.0106205	1525.255
Commerzbank	DEU	6696.523	22928.54	39000.36	48154.37	1.256342	.0109968	13713.74
DVB Bank	DEU		423.7643	65.28961	758.4427	.2986232	.0056905	841.345
Dab Bank	DEU		-199.127	-15.37433	103.1377	.9586043	.0074795	640.6317
Deutsche Balaton Aktiengesellschaft	DEU		-68.63236	-76.548	-79.75017	.5070966	.0049941	139.02
Deutsche Bank	DEU	8547.679	41662.42	104853.8	133273.4	1.278272	.0129767	40618.15
Deutsche Beteiligungs	DEU	-28.99577	-146.0597	-183.7969	-174.2623	.726984	.009179	271.7828
Deutsche Boerse	DEU		-2692.741	-1771.02	10573.49	.9898442	.0145578	14595.99
Deutsche Effecten & Wechsel	DEU	-238.4844	-179.8211	-25.62209	-16.26192	.4095766	.0043568	174.8968
Dresdner Bank	DEU	7902.26	17869.69			.9917994	.0075181	14734.96
Euwax AG	DEU		-76.24123	-167.4498	-234.5873	.4110111	.0057634	278.3155
Greenwich Beteiligungen	DEU		-4.318142	-6.369004	-3.948963	.2740479	.0026623	8.175117
Grenke	DEU		-174.6113	-182.9152	-530.8815	.7963759	.0094718	754.023
HSBC Trinkaus & Burkhardt	DEU		-801.3498	-693.9661	-219.7322	.346467	.0038639	2524.88
Heidelberger Beteiligungsholding	DEU		-44.8445	-16.04624	-13.45492	.3052562	.0014765	29.86555
IKB Deutsche Industriebank	DEU	595.7852	1390.092	3008.386	2020.156	.7378272	.0041683	1357.097
ING BHF-Bank	DEU	825.2952	1312.058			.6204178	.0053418	2326.243
KST Beteiligungs	DEU		-21.33921	-27.09604	-6.682449	.5044104	.0062016	36.81924
Kali-Chemie	DEU		-786.9916	-811.3713	-449.1126	.1865147	-.0002971	1014.859
MLP	DEU		-1308.865	-750.0582	-302.7297	.8290849	.0071374	1288.598
Mistral Media	DEU		-28.38215	-16.30481	-1.618629	.4273933	.0033758	25.30354
Mpc Muenchmeyer Petersen Capital	DEU		-227.8456	-344.7596	-36.41208	.7924116	.0067718	455.1406
Oldenburgische Landesbank	DEU		-539.2755	-271.5159	492.8164	.2508443	.0041538	1279.855
Peh Wertpapier	DEU		-22.0874	-43.38097	-28.75606	.5145887	.0054311	59.19286
RM Rheiner Mgmt	DEU		-1.992213	-5.685099	-3.806445	.2816036	.0020169	6.381972
Schnigge Wertpapierh.	DEU		-7.752105	-8.976514	-6.852736	.802636	.0019292	15.29016
Sparta.	DEU		-16.60778	-11.63445	-31.43882	.7058983	.0035152	34.91
U.C.A..	DEU		-49.74316	-21.48834	-5.995719	.5221826	.0050043	43.00204
Value Management & Research	DEU		-16.08503	-22.89594	-4.615294	.4677733	.0020844	26.37955
Vereins- Und Westbank.	DEU	369.938	383.6347			.4374557	.003478	1186.686
mwb fairtrade Wertpapierh.	DEU		-12.85357	-16.18547	-7.82211	.6310511	.0052266	24.16495
Banco De SAbadell	ESP		-350.9346	138.2247	7087.081	.8638371	.011291	8535.663
Banco Popular Espanol.	ESP	-166.9554	-2303.011	-1191.385	7613.467	.9713836	.0104589	10354.23
Banco Santander	ESP	1061.09	6811.238	22332.05	61398.66	1.159763	.0135965	61993.45
Bankinter.	ESP	8.397855	84.79258	1352.359	2403.317	1.020771	.0110242	3703.003
Credit Industriel Et Commercial	FRA		8132.779	12142.85	15087.85	.403918	.0092354	7577.139
CRCAM Centre Loire	FRA		430.7095	606.6389	819.0302	.1937384	.0012693	115.0459
CRCAM De Normandie Seine	FRA		439.3432	490.913	754.7281	.3618958	.0080081	114.9045
CRCAM De La Loire-Haute	FRA		277.6884	414.1352	614.9683	.2660342	.0057979	65.28481
CRCAM De La Touraine Et Du Poitou	FRA		309.5782	461.2311	674.665	.2966325	.0069781	98.0285
CRCAM Sud Rhone Alpes	FRA		479.8578	599.6129	950.4944	.3095156	.0066899	128.097
Compagnie De Financement Foncier	FRA	3055.729	3103.208			.6378412	.0031951	1297.015
Natixis	FRA	1045.217	6121.349	27366.57	34619.48	1.036197	.009896	10347.47
Societe Generale Group	FRA	10748.98	26454.56	55677.48	83356.53	1.338951	.0123765	34903.11
Arbuthnot Banking Group	GBR	-50.64982	-49.93948	-40.66502	-21.64422	.3672112	.0045149	125.9428
Barclays	GBR	9082.476	20830.12	99186.35	118115.8	1.261973	.0115427	46398.81
Close Brothers Group	GBR	-106.7236	-736.9025	-538.2259	-499.9091	.7713308	.009164	1641.322
Lloyds Banking Group	GBR	1178.638	-771.1953	15965.05	57274.5	1.136583	.0104569	43142.57
National Westminster Bank	GBR	8486.962	7116.575			1.107512	.0069997	18878.66
Santander UK	GBR	3072.288	9902.597			.9693451	.0080595	13253.14
Standard Chartered	GBR	1679.307	-44.88692	1603.6	16096.51	1.175097	.0108749	26860.11
Alpha Bank	GRC		-1033.565	-1553.479	3291.017	.9137462	.006317	5614.999
Attica Bank	GRC		-84.15314	-29.28466	198.1517	.910203	.004848	445.1873
Eurobank Ergasias	GRC		-1859.822	-2140.136	4799.101	1.02484	.0059927	7975.478
National Bank of Greece	GRC	1451.062	-211.0251	-3937.022	5777.132	.9803826	.0070634	9900.895
Piraeus Bank	GRC		-302.4399	-1281.319	4040.998	1.104049	.0064252	5138.382
Allied Irish Banks	IRL	609.0481	-673.1892	5118.931	-5464.812	1.047109	.0055791	16650.03
permanent tsb Group Holdings	IRL		283.8755	3401.602	3421.3	.927671	.0050396	2716.178
Banca Carige	ITA		-567.0531	-893.8699	1857.153	.7505962	.0095197	3560.437
Banca Finnat Euramerica	ITA	-7.016263	-51.33689	-192.2224	-39.21368	.6551871	.0060871	205.9743
Banca Mediolanum	ITA		-2043.448	-224.8292	1160.893	1.278085	.0128272	4921.9
Banca Monte Dei Paschi Di Siena	ITA		4663.851	6330.839	14045.51	1.110277	.009073	9554.885
Banca Popolare Di Spoleto	ITA		22.81744	26.01397	175.5701	.4906583	.0069308	187.3839
Banco Di Desio E Della Brianza	ITA		-42.62405	26.17808	470.1185	.6959628	.0091319	730.8828
Bper Banca	ITA		375.9536	504.1497	3331.753	.6614867	.0075182	2868.38
Credito Valtellinese Scarl.	ITA		297.1067	339.6009	1544.763	.6673743	.0083212	886.1056
Mediobanca	ITA	-849.5527	-1892.105	-3492.968	2496.675	1.099595	.010301	8941.688
Unicredit	ITA	3197.653	3316.829	31622.27	58034.22	1.143645	.0111054	38805.31
Unione Di Banche Italiane	ITA		1571.623	802.2977	7131.468	1.052218	.0114269	8758.752
Van Lanschot NV	NLD		[illegible]81.521	654.1196	822.1409	.4807536	.00918	1069.654

[a] This table reports the list of banks with internal models information. We report country, average SRISK (in the four subperiods of interest), market Beta, Delta CoVaR and Market capitalization of each bank.

Table 10: Drivers of SRISK (quarterly panel regression) - A robustness check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.Beta	-104.6	-51.20	-108.7	-53.94	-154.4	-37.21	-160.8	-41.55
	(145.3)	(157.1)	(146.8)	(159.2)	(204.3)	(222.6)	(212.0)	(231.9)
L.SRISK	0.974***	0.974***	0.973***	0.973***	0.734***	0.737***	0.732***	0.734***
	(0.0260)	(0.0260)	(0.0264)	(0.0263)	(0.0650)	(0.0644)	(0.0653)	(0.0648)
Total Loans	-0.00991	-0.0140	-0.0109	-0.0147	-0.0663**	-0.0680**	-0.0672**	-0.0690**
	(0.0184)	(0.0188)	(0.0184)	(0.0188)	(0.0285)	(0.0284)	(0.0278)	(0.0277)
NPA	0.0448**	0.0430**	0.0438**	0.0420**	-0.000353	-0.00234	-0.000104	-0.00144
	(0.0200)	(0.0198)	(0.0197)	(0.0195)	(0.0908)	(0.0942)	(0.0911)	(0.0944)
Equity Securities	-0.00108	-0.00161	-0.00220	-0.00274	-0.0249	-0.0302	-0.0250	-0.0301
	(0.0888)	(0.0886)	(0.0890)	(0.0888)	(0.105)	(0.105)	(0.105)	(0.105)
Fixed Income Securities	-0.00699	-0.00784	-0.00654	-0.00735	-0.00468	-0.00382	-0.00470	-0.00401
	(0.0160)	(0.0160)	(0.0160)	(0.0160)	(0.0200)	(0.0198)	(0.0200)	(0.0198)
Market Value	0.0533*	0.0540**	0.0538*	0.0545**	-0.133*	-0.126*	-0.138*	-0.131*
	(0.0271)	(0.0272)	(0.0271)	(0.0273)	(0.0738)	(0.0726)	(0.0746)	(0.0736)
Leverage	88.44	90.68*	106.2*	107.1*	-9.609	29.61	-19.46	18.98
	(56.61)	(54.43)	(63.12)	(60.91)	(79.15)	(77.54)	(81.14)	(78.93)
L.CISS	-1,792***	-1,190**	-1,789***	-1,203**	-1,280**	-1,030**	-1,276**	-1,028**
	(661.4)	(476.9)	(662.5)	(475.4)	(617.8)	(467.9)	(616.4)	(464.6)
L.GDP growth	-22.10	-8.491	-21.88	-8.522	-22.54	-13.36	-22.45	-13.60
	(21.77)	(25.49)	(21.80)	(25.50)	(21.38)	(25.85)	(21.33)	(25.73)
L.Unemployment	-42.84*	-56.27**	-40.81*	-54.35**	-28.54	-42.30**	-27.72	-44.21**
	(23.13)	(21.61)	(23.48)	(21.78)	(26.09)	(19.99)	(25.66)	(20.13)
L.Share Prices growth	1.724	-1.720	1.699	-1.774	1.012	-1.981	1.009	-1.941
	(2.063)	(2.138)	(2.069)	(2.141)	(2.007)	(2.070)	(1.999)	(2.054)
Market Risk Amendment	150.7*	8.809	137.1*	-0.193	621.5**	480.8**	1,541***	768.1**
	(84.35)	(62.50)	(81.72)	(69.59)	(250.2)	(208.8)	(484.3)	(306.5)
Market Risk Amend. # Bank			33.87	24.90			-709.8**	-804.7**
			(40.93)	(40.93)			(277.1)	(314.5)
Basel 2	-80.71	200.3	-141.8**	105.9	-53.63	315.8*	-85.83	256.3
	(57.31)	(171.6)	(61.27)	(155.0)	(51.58)	(179.1)	(58.68)	(174.1)
Basel 2 # bank			143.2**	184.0***			78.18	123.4**
			(57.36)	(61.73)			(55.22)	(56.45)
Basel 3	526.4***	292.4**	522.2***	267.9*	456.5***	384.0***	476.6***	391.6**
	(120.1)	(144.8)	(122.4)	(153.5)	(125.2)	(145.8)	(124.7)	(152.0)
Basel 3 # bank			45.31	52.47			-20.39	-7.475
			(77.49)	(77.70)			(92.51)	(98.93)
Constant	197.3	367.5*	171.8	346.6*	579.8**	553.4***	0	684.0***
	(212.4)	(193.6)	(223.2)	(199.8)	(255.4)	(201.1)	(0)	(216.5)
Year Effects	yes	no	yes	no	yes	no	yes	no
Country Effects	yes	yes	yes	yes	no	no	no	no
Firm Effects	no	no	no	no	yes	yes	yes	yes
Observations	8,973	8,973	8,973	8,973	8,973	8,973	8,973	8,973
R-squared	0.951	0.951	0.951	0.951	0.663	0.659	0.664	0.660
Number of groups	249	249	249	249	249	249	249	249

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[a] This table reports the results from the quarterly panel regressions of SRISK with firm or country fixed effects and year dummies. We regress the SRISK measure on CISS (indicator of systemic stress in the European system, Hollo et al, 2012), market Beta , an internal model dummy from January 1996 and two Basel dummies, Basel II from June 2006 to September 2008, and Basel III from September 2008. The Beta is estimated from a GJR-DCC Garch model between the bank stock returns and the MSCI Europe index. The CAPM cost of equity is the return required by the market applying the time-varying beta to the annual risk premium required on the market return, as Equation 9: $CostEquity_{it} = R_{ft} + \widehat{beta}_{it} * (R_{mt} - R_{ft})$. We use the yield on German Bund as risk-free rate. Moreover, we include bank-level drivers as previous quarter median SRISK, non-performing assets, other investment in equity and fixed income securities, market capitalization and leverage, and macro-variables as GDP growth, unemployment rate, equity share prices growth by country.