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Abstract

We construct a new data set of macroprudential policy announcements for the United Kingdom and estimate their effect on systemic risk, using a high-frequency identification approach. First, by examining a sample of the largest UK-listed banks, we identify macroprudential policy announcement shocks that were unanticipated by the financial markets. Second, we study the effects of market-based macroprudential policy surprises on systemic risk in a local projection framework. We find that tighter than expected macroprudential policy announcements contribute to a substantial reduction in perceived systemic risk in the short run, with effects persisting for several months. The reduction is mostly attributed to the reaction in equity and bond markets.

Key words: Macroprudential policy, systemic risk, high-frequency identification, policy announcements.

JEL classification: E58, G14, G18, G21.

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1 Introduction

Since the Great Financial Crisis (GFC), central banks and other financial authorities increasingly employed macroprudential policy tools to achieve financial stability. Unlike monetary policy and its target of price level stability however, macroprudential policy and its aim of achieving financial stability is a more elusive concept. First, the term macroprudential policy encompasses a wide range of different tools including measures to improve the solvency or liquidity of lenders, as well as measures to enhance the resilience of borrowers. Second, changes in the stance of macroprudential policy are less frequent, less traded in financial markets and potentially more anticipated than their monetary policy counterpart. Third, the term financial stability itself is multifaceted, with no particular target variable that captures all aspects of financial stability. It is therefore challenging to study how effective macroprudential policy measures are at achieving their goal. In this paper, we propose a solution that helps address some of these challenges by exploiting a high frequency identification approach.

Given that most macroprudential policy measures have been communicated to the financial markets in the form of speeches, publications, and financial stability reports, we focus on high-frequency macroprudential policy announcements and ask: (i) How are macroprudential policy announcements perceived by financial market participants? (ii) What is the impact of macroprudential policy surprises on systemic risk?

To address these questions we first collect a comprehensive list of daily macroprudential policy announcements made in the UK between 2009 and 2019. We then follow an event study approach and measure the change in equity prices and CDS spreads for the six largest UK regulated banks in a tight window around regulatory news. This enables us to isolate a series of plausibly exogenous macroprudential policy surprises, which we then employ in a local projection to study the impact of macroprudential policy surprises on systemic risk.

We find that tighter than expected unanticipated macroprudential policy announcements can reduce perceived systemic risk in the near term, specifically in the (financial) equity and bond markets. This result is consistent with the idea that 'tighter than expected' macroprudential policies limit the likelihood of large bank equity losses and therefore reduce perceived banks' riskiness. In addition, we find that 'tighter than expected' macroprudential policy announcements dampen down investor uncertainty and risk aversion. Our results are robust to a number of specifications and different market-based systemic risk measures.

We contribute to the literature in three ways. Firstly, we construct a new database of daily macroprudential policy announcements in the UK encompassing a wide range of policies announced by UK and international macroprudential authorities. Our database includes several macroprudential policy measures including capital, liquidity and housing measures and is available at a daily frequency.

Second, using an event study methodology, we identify a novel series of unanticipated macroprudential policy 'surprises', analogue to the monetary policy literature. This is in contrast to previous literature which often identifies macroprudential policy using a narrative approach (Richter et al. 2019) or simply runs dynamic panel regressions within a monthly frequency (Meuleman & Vennet 2020). While this identification scheme allows for a very wide range of macroprudential policy measures to be taken into account for a cross section of countries, our high-frequency identification approach ensures that the macroprudential shocks are (i) unexpected, (ii) uncorrelated with other shocks, and (iii) plausibly orthogonal not just to economic conditions (as in the case of Richter et al. (2019)), but also financial conditions. The identifying assumption is that within a narrow window around an announcement, changes in asset prices are unlikely to be affected by any other news of a non-macroprudential policy nature. To make sure this assumption holds, we cross-check our macroprudential policy announcement dates against digital news archives and filter out all dates that contain non-macroprudential policy information.

Finally, our paper presents new evidence on the impact of macroprudential policy shocks on systemic risk, a key financial stability measure (Allen & Carletti 2013). We use the Composite Indicator of Systemic Stress (CISS) by (Hollo et al. 2012), which is a market-based measure of systemic risk that incorporates risks and interlinkages within 5 different segments of financial markets (i.e. equity financials, equity non-financials, bond, money and FOREX markets).

Previous papers have explored a more narrow definition of systemic risk by focusing on bank risk specifically. For example, Meuleman & Vennet (2020) also examine the link between macroprudential policy and systemic risk, as measured by the individual bank's marginal expected shortfall (MES). Our work differs from theirs in three important dimensions. First, in contrast to the bank-specific MES our measure of systemic risk encompasses different dimensions of market stress, so that it can account for a broader effect on systemic risk beyond stress in bank equity markets. Secondly, while they use monthly data, our daily high-frequency approach alleviates endogeneity concerns to a maximum degree. Finally, rather than looking at an aggregate series of macroprudential policy announcements, our identification strategy carefully selects macroprudential policy shocks, which are unanticipated and exogenous to the state of the economy. Our results are also in line with other papers, like (Altunbas et al. 2018, Fernández-Gallardo et al. 2023), which also find that macroprudential policy, in particular when tightening, is effective in reducing bank risk or tail risk. However, while Altunbas et al. (2018) assesses effectiveness of macroprudential policy measures that were active at the time of the analysis and potentially anticipated, we focus on unexpected and exogenous macroprudential policy announcements.

Besides the few papers that looked at systemic risk, a larger fraction of papers have studied the role of macroprudential policies in terms of lending spreads (Meeks 2017), credit growth (Aiyar et al. 2014, Cerutti et al. 2017, Kuttner 2001) house price growth and macro outcomes (Richter et al. 2019). However, in those papers a macroprudential tightening is often associated with a drain on economic growth in the short-term as lending is temporarily reduced in response to an increase in capital, loan-to-value (LTV) or loan-to-income (LTI) requirements. Looking at systemic risk instead allows us to explore the benefits of macroprudential tightening and how effective it is in fulfilling its primary objective, financial stability.

Our paper also relates to the literature on central bank communication and the market reaction to specific macroprudential policy announcements. As we highlight in Section 2 only very few macroprudential announcements are actually unanticipated and can therefore be used to identify the effect of macroprudential policy. This is also confirmed by Flannery et al. (2017) who analyse the market reaction to stress test announcements and find no discernible effect, or Harris et al. (2019) who find no strong market reaction to financial stability reports and conclude that most information was already anticipated. Bruno et al. (2018) also find that markets did not react strongly if policies were not perceived to be binding.

The remainder of the paper is structured as follows: Section 2 lays out how we identify macroprudential policy 'surprises'. Section 3 explains our local projection methodology to assess the effect of a macroprudential announcement shock on systemic risk, and presents the results and several robustness checks. Finally, Section 4 concludes. Additional material is reported in the Appendix.

2 Identification of macroprudential policy surprises

This section employs high-frequency identification methods to construct a series of macroprudential policy surprises. Our approach involves four steps: First, we collect a comprehensive list of macroprudential policy announcements made in the UK between 2009 and 2019. Second, we conduct an event study on each announcement to determine which ones were not anticipated by market participants. Third, we use our event study findings to construct a series of exogenous macroprudential policy shocks. Finally, we present a stylised theoretical framework to explain the underlying mechanisms behind our event-study findings.

2.1 Macroprudential policy events

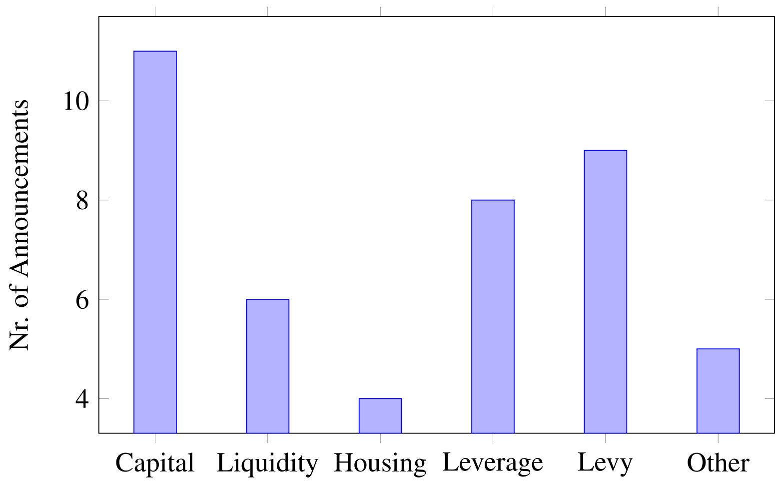
Unlike announcements related to monetary policy, there is no readily available measure of the macroprudential policy stance in the UK at a daily frequency. To overcome this challenge, we compile a macroprudential announcement dataset, which consists of 44 macroprudential policy measures that were taken from 1 January 2009 to 31 December 2019. We use the ECB's monthly Macroprudential Policies Evaluation Database or MaPPED, which provides details of more than 2000 macroprudential policy actions taken in 28 EU member states from 1995 to 2017. The dataset covers a large range of macroprudential policy instruments, including capital-based, asset-based or liquidity-based policy measures.

We expand this dataset along several dimensions: As MaPPED's coverage for the United Kingdom is only provided until the end of 2015, we update MaPPED so that it covers macroprudential policy announcements made post 2015. These announcements come from a range of sources, namely Financial Stability Reports, Prudential Regulation Authority Supervisory and Policy Statements, Financial Policy Committee Policy Statements, Basel III and European Banking Authority publications.

We also upgrade MaPPED from monthly to daily frequency, so we can identify shocks more precisely. This means we look at each announcement and pin down the exact date when they were first made public. Finally, the listed macroprudential policies are country-specific and therefore do not always contain macroprudential policy announcements that are common across all EU member states, for example the publication of Basel III or the assessment methodology and additional loss absorbency requirements that apply to Global Systemically Important Institutions (G-SII). We ensure that our database includes both country-specific as well as wider international announcements related to macroprudential policy in the UK.

In total, we collect 44 macroprudential policy announcements which we can categorise into different instrument types; i.e. capital, liquidity, housing, leverage, levy, or other macroprudential measures, as detailed in Figure 1. For example, 12 of the macroprudential policy announcements we collect pertain to capital measures (capital requirements, capital conservation buffers, countercyclical capital buffers) and 6 of the announcements concern liquidity measures (liquidity coverage ratio and net stable funding ratio).

Figure 1: Number of macroprudential policy announcements by instrument type



Notes: This bar chart categorises the macroprudential policy announcements in our dataset into instrument types. Capital-based macroprudential policy announcements concern instruments such as capital requirements, capital conservation buffers and countercyclical capital buffers. Liquidity-based macroprudential policy announcements concern measures such as LCR and NSFR. Housing tools cover macroprudential policy announcements related to LTI, LTV, DTI and mortgage affordability rates. Leverage instruments pertain to minimum leverage ratio requirements and countercyclical and G-SII leverage ratio buffers. Bank levy announcements refer to changes in tax rates on short-term and long-term chargeable bank equity and liabilities, which aim to encourage banks to reduce the use of wholesale finance. Other instruments contain announcements on ring-fencing, risk weights, limits on large exposures and concentration, adoption of IFRS9 standards and measures which aim to reduce financial risks from climate change.

2.2 High-frequency identification

For our identification strategy, we borrow from the monetary policy literature and turn to financial market data to identify macroprudential policy innovations unrelated to the state of the economy (Kuttner 2001, Gürkaynak et al. 2005, Gertler & Karadi 2015, Nakamura & Steinsson 2018, Jarociński & Karadi 2020, Cesa-Bianchi et al. 2020, Miranda-Agrippino & Ricco 2021). However, unlike in the monetary policy literature where monetary policy shocks are identified through high-frequency changes in the short term interest rate futures, there is no financial instrument that trades based on macroprudential policy. Nonetheless, to the extent that some of the macroprudential policy announcements in our dataset are unanticipated, they could still affect bank equity prices and credit default swap (CDS) spreads, which are closely related to expected bank profitability and default probability. Therefore, our event study compares market-based indicators of expected bank profitability and probability of default in the 'event window' versus an estimation window.

In particular, we look at the response of bank equity returns and CDS spreads in the aftermath of a macroprudential policy announcement, as shown in Figure 2. We designate the date of each macroprudential policy announcement as $\tau = 0$. Our estimation window spans from 261 days prior to the announcement to 2 days prior to the announcement. The event window brackets the day before and after the announcement. This window is kept short enough to exclude any news not related to macroprudential policy and long enough for the markets to fully assimilate the information.[1] Our estimation window is aligned with Bruno et al. (2018) and Armour et al. (2017).

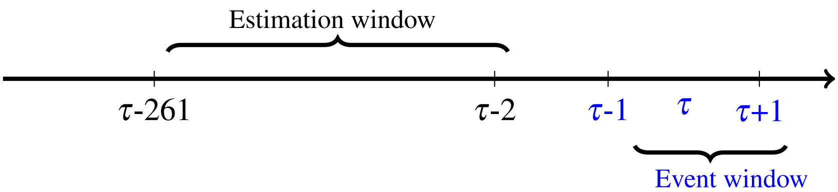


Figure 2: Event study timeline

Abnormal returns: To begin with, we start with a simple market model in the estimation window, where i indices an individual bank. The α_i and β_i coefficients are estimated from an ordinary least squares (OLS) regression of each bank's daily stock returns, $R_{i,t}$ on the daily returns of the market, $R_{m,t}$. The abnormal returns in the event window are computed as the difference between the realized stock returns and expected returns based on the market model:

$$\widehat{AR}_{i,t} = R_{i,t} - \underbrace{(\widehat{\alpha}_i + \widehat{\beta}_i R_{m,t})}_{\text{Expected Return}} \tag{1}$$

[1] We have included the day before the announcement in the event window, so that we can account for potential leakage of information the day before the press statement by regulators.

Our next step is to cumulate abnormal returns over the event window ($\tau - 1$, $\tau + 1$):

$$\widehat{CAR}_{i,t} = \sum_{t=\tau-1}^{\tau+1} \widehat{AR}_{i,t} \tag{2}$$

We then calculate the cumulative average abnormal returns across all banks in our analysis:

$$\widehat{CAAR}_t = \frac{1}{N} \sum_{i=1}^{N} \widehat{CAR}_{i,t} \tag{3}$$

And finally, we test (parametrically and non-parametrically) whether the cumulative average abnormal returns in the event window are significantly different from zero.

Abnormal change in CDS spreads: In a similar fashion to abnormal returns, we estimate abnormal changes to CDS spreads as the difference between realised and expected changes in CDS spreads based on the market model. We proceed by calculating the cumulative abnormal changes to CDS spreads over the event window following the same steps outlined in equations (1) to (3) and test their significance under the normality assumption. To proxy for the benchmark CDS spread, we use ITRAXX Europe, which is a credit default swap index that comprises of 125 investment grade entities.

Financial firms Our financial firms concern the six largest London Stock Exchange (LSE) listed banks. Namely, Barclays, HSBC, Lloyds Banking Group, NatWest Group (RBS), Santander UK and Standard Chartered. There are two main reasons why we focus on these six banks. First, they are the participating banks in the Bank of England's annual cyclical stress test and in 2018 (together with Nationwide Building Society) accounted for around 80% of the outstanding stock of PRA-regulated banks' lending to UK households and businesses.[2] Hence, we conjecture that these banks must be more directly affected by new macroprudential policy measures than other financial firms. Second, their shares tend to be very frequently traded and are more liquid than other financial securities.

Data on equity prices, volumes, market capitalisations and CDS spreads for these securities has been obtained from Bloomberg. Consistent with Gregory et al. (2013), the broad market index has been proxied by the FTSE All Share Index, which comprises around 600 companies that trade on the LSE. To address any endogeneity concerns, we have filtered out the returns of Barclays, Santander UK, Lloyds, RBS, Standard Chartered and HSBC from the FTSE All Share benchmark. This is done by re-weighting the daily returns of all other constituents of FTSE All Share by market capitalisation, so that the banks in our analysis are excluded from the benchmark. Consistent with Harris et al. (2019) our benchmark CDX is proxied by ITRAXX Europe, which is a credit default swap index that comprises of 125 investment grade entities.

[2]The Bank of England regulates and supervises financial services firms through the Prudential Regulation Authority (PRA).

2.3 Event study results: unanticipated announcements

Our tests show that banks' stock market returns and/or their CDS spreads were significantly affected in 19 out of 44 macroprudential policy event dates.[3] However, it would be naive to claim that all 19 of these responses were solely driven by macroprudential policy announcements and no other important economic news that could have been released on the day. To address this issue we rely on Factiva, which is a digital archive of global news that covers a great number of financial news sources worldwide. We provide Factiva with search words such as 'banks', 'financials', 'unemployment', 'monetary policy', 'earnings' and 'inflation' and check whether any other economic signals occurred on the same day as our macroprudential policy events.

We find that 11 of our macroprudential policy event dates have been contaminated by other financial news. For instance, while it is true that on 19 January, 2009 the Financial Service Authority made a statement announcing new rules on minimum core Tier 1 capital ratios, it is also true that all banking shares in the UK collapsed in the aftermath of RBS announcing the biggest corporate losses in history.[4] To the extent that these other economic events would render our macroprudential policy events endogenous, we exclude these dates from our sample of unanticipated macroprudential policy events.[5] Our final sample of 'pure' macroprudential policy shocks, as summarised in Table 1 and Table 2 for CAARs and CDS spreads, respectively:

Table 1: CAARs under 4 different event windows

Date	Event	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAR[0,0]
16 Dec 2010	Basel III	-4.3326%***	-1.6927%	-2.6153%**	0.0247%
		(0.0020)	(0.1355)	(0.0215)	(0.9753)
04 Nov 2011	G-SII Buffers	-2.9975%**	-1.6390%	-1.8067%	-0.4482%
		(0.0391)	(0.1654)	(0.1263)	(0.5902)
27 Jun 2013	CRD IV	-2.7029%**	-2.3429%**	-2.8696%***	-2.5096%***
		(0.0319)	(0.0232)	(0.0052)	(0.0006)
27 Oct 2014	PRA PS + EBA Stress Test	-3.1828%***	-1.0871%	-3.9078%***	-1.8121%***
		(0.0003)	(0.1273)	(0.0000)	(0.0004)
31 Oct 2014	Leverage ratio	1.6806%*	2.0174%***	1.9809%***	2.3177%***
		(0.0609)	(0.0061)	(0.0069)	(0.0000)
19 Feb 2016	O-SII Methodology + SSM	-2.4653%**	-2.9856%***	-0.3349%	-0.8553%
		(0.0121)	(0.0002)	(0.6741)	(0.1286)
29 Mar 2016	CCyB	-2.3971%**	-2.3222%***	-1.1828%	-1.1079%*
		(0.0258)	(0.0082)	(0.1769)	(0.0728)
25 Sep 2017	PRA Buffer	-2.0571%**	-1.7545%**	-1.6967%**	-1.3940%**
		(0.0440)	(0.0353)	(0.0415)	(0.0178)

Notes: This table presents the cumulative average abnormal returns (CAAR) from a portfolio of the 6 largest LSE-listed banks, following a macroprudential policy announcement. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 1 shows the cumulative average abnormal returns (CAAR) for each of the macropru-

[3] Table A.1 highlights all the announcements that were met by a significant CAAR response.

[4] 19 January 2009 was previously known as Blue Monday. RBS shares fell over 67% in a single day. Shares in all other British banks suffered heavy losses.

[5] See Table A.1 for a detailed account of the excluded macroprudential policy events.

dential policy announcements that generated a significant market reaction.[6] For more information on the CARs for each bank stock and each announcement date see Appendix B.1. As a robustness check, we also include the event study results under three other event windows. Namely, an event window that concerns one day before the announcement and the day of the announcement (-1,0), an event window that concerns the day of the announcement and one day after (0,1) and an event window that only takes into account the day of the announcement (0,0). The results show that the macroprudential policy announcements listed in Table 1 did provide new information to the financial markets and had a significant impact on expected future bank earnings and profitability. Moreover, the sign of the CAARs is negative in all but one announcement, suggesting that macroprudential policy measures were in general 'tighter' than expected.

Bank equity prices encompass information on both future bank profitability and default risk, as we explain later in Section 2.5. Since macroprudential policy could in principle affect not just expected bank profitability but also bank default expectations, we proceed by conducting event studies with respect to bank CDS spreads. The latter is thought to be a good proxy for perceived default probability. Table 2 shows the cumulative average abnormal changes in CDS spreads for each of the macroprudential policy announcements that generated a significant market reaction. The majority of the macroprudential policy events were met by a negative or an insignificant abnormal change in CDS spreads. This is consistent with the idea that tighter than expected macroprudential policies curb systemic risk, and as a result lower the likelihood of bank default. The exception here are the announcements of 31 October 2014, 19 February 2016 and 25 September 2017, where the cumulative abnormal change in CDS spreads goes in the opposite direction of the equity price responses in Table 1. We think of these announcements as announcements that contain Central Bank information effects, as discussed later in Section 2.5. Nevertheless, it is important to exercise caution when interpreting the findings from Table 2. Firstly, the CDS market, in comparison to equities, is relatively small, and trading activity in these derivatives can be sparse.[7] Consequently, minor idiosyncratic CDS transactions could disproportionately influence prices, potentially biasing the outcomes. Moreover, the benchmark index we use to estimate the abnormal CDS spreads contains the CDS spreads of the 6 UK banks we use in the event study, which may introduce an endogeneity issue in the estimation of the abnormal CDS spreads. While we mitigate this issue in Table 1 by excluding the equity returns of these banks from the FTSE All Share Index, data limitations prevent us from applying the same adjustment for ITRAXX Europe. For these reasons, we place a greater emphasis on the findings presented in Table 1.

[6] Section B.4 provides a comprehensive institutional background for each of the unanticipated announcements listed in Table 1.

[7] For instance, even for prominent companies, the average daily CDS trades can sometimes amount to single digits, as reported by data from the Depositary Trust & Clearing Corporation (DTCC).

Table 2: Cumulative abnormal changes in CDS spreads under 4 different event windows

Date	Event	CDS[-1,1]	CDS[-1,0]	CDS[0,1]	CDS[0,0]
04 Nov 2011	G-SII buffers	1.8670%	-0.6266%	3.4362%	0.9425%
		(0.6106)	(0.8294)	(0.2492)	(0.6406)
27 Jun 2013	CRD IV	-7.7589%***	-13.1495%***	1.4060%	-3.9845%***
		(0.0024)	(0.0000)	(0.4962)	(0.0066)
27 Oct 2014	PRA PS + EBA ST	-2.0662%	-4.9653%**	-0.9419%	-3.8411%***
		(0.3852)	(0.0109)	(0.6272)	(0.0053)
31 Oct 2014	Leverage ratio	0.9541%	1.8901%	-4.5427%**	-3.6067%***
		(0.6901)	(0.3326)	(0.0207)	(0.0092)
19 Feb 2016	O-SII Methodology + SSM	4.3065%	4.3722%**	4.8340%**	4.8998%***
		(0.1113)	(0.0476)	(0.0286)	(0.0018)
29 Mar 2016	CCyB	0.9544%	1.2960%	-1.0138%	-0.6722%
		(0.7324)	(0.5689)	(0.6559)	(0.6755)
25 Sep 2017	PRA Buffer	4.3234%**	3.8122%**	2.4711%	1.9600%*
		(0.0221)	(0.0133)	(0.1073)	(0.0705)

Notes: This table presents the cumulative average abnormal changes in CDS spreads from a portfolio of the 6 largest LSE-listed banks, following a macroprudential policy announcement. The announcement of 16 December 2010 is not included because our benchmark index ITRAXX Europe is only available from 2011 onward. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Robustness: We conduct a number of robustness checks to ensure that the shock series we identify are indeed true macroprudential surprises. Firstly, we check the robustness of the simple market model by comparing it to a Fama-French (1993) three-factor model:

$$R_{i,t} = R_{f,t} + \beta_i(R_{m,t} - R_{f,t}) + s_i SMB_t + h_i HML_t + \varepsilon_{i,t} \tag{4}$$

where $R_{f,t}$ is the risk-free rate of return and SMB_t and HML_t are, respectively, the size and value factors constructed by Gregory et al. (2013). The results from the three-factor specification are reported in Table B.10 and they are quantitatively and qualitatively very similar to the results reported in Table 1.

Secondly, to ensure that our $\hat{\alpha}$ and $\hat{\beta}$ estimates from the market model are consistent and the results are robust to different estimation windows, we consider two alternative estimation windows. Namely (-120, -30) in line with Linton (2019) and (-91, -11) in line with Harris et al. (2019). The results are very similar and are reported in Table B.11.

And lastly, we conduct the event studies under different test diagnostics. Campbell et al. (2010) argue that in multi-day windows nonparametric rank and generalized sign tests are more powerful than common parametric tests. Our results in Table B.12 are robust to both parametric (Patell 1976, Boehmer et al. 1991) and non-parametric (Wilcoxon 1945, Kolari & Pynnonen 2011) tests.

2.4 Macroprudential policy shocks series

We use the results in Table 1 to construct the macroprudential policy shock series.[8] More specifically, for every macroprudential policy announcement in Table 1 that generates a significant negative cumulative average abnormal return (CAAR), our ΔMaP_t^{shock} variable will take a value of 1. Analogously, for every macroprudential policy announcement that generates a positive financial market reaction, our ΔMaP_t^{shock} variable will take a value of -1. And finally, for all macroprudential policy announcements that were met by an insignificant financial market response, our ΔMaP_t^{shock} variable will take a value of 0.

$$\Delta MaP_t^{shock} = \begin{cases} 1, & \text{if } \widehat{CAAR}_t < 0 \,(\text{significantly}) \\ -1, & \text{if } \widehat{CAAR}_t > 0 \,(\text{significantly}) \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

Borrowing from the monetary policy literature, an alternative way of constructing our macroprudential policy shock series would be to scale ΔMaP_t^{shock} according to the CAAR responses bracketing the macroprudential policy event windows. This ensures that we take into account not only the occurrence of a financial market surprise, but also the degree to which the markets were surprised. Hence macroprudential policy events that were met by a stronger financial market reaction are attributed a higher ΔMaP_t^{scaled} index. Based on the results from Table 1, we proceed by constructing the following alternative macroprudential shock series:[9]

$$\Delta MaP_t^{scaled} = \begin{cases} 4.3326, & \text{if Date = 16 Dec 2010} \\ 2.9975, & \text{if Date = 04 Nov 2011} \\ 2.7029, & \text{if Date = 27 Jun 2013} \\ 3.1828, & \text{if Date = 27 Oct 2014} \\ -1.6806, & \text{if Date = 31 Oct 2014} \\ 2.4653, & \text{if Date = 19 Feb 2016} \\ 2.3971, & \text{if Date = 29 Mar 2016} \\ 2.0571, & \text{if Date = 25 Sep 2017} \\ 0 & \text{otherwise.} \end{cases}$$

In the scaled series, a one unit increase in ΔMaP_t^{scaled} reflects an unanticipated macroprudential policy measure that surprised the markets by 1pp. Similarly, a one unit decrease in ΔMaP_t^{scaled} reflects a looser-than-expected macroprudential policy announcement that 'positively' surprised financial markets by 1pp.

[8] We elaborate more on the nature of each surprise in Section B.4.

[9] These are based on the CAAR results from a portfolio of the 6 largest UK banks, bracketing a three-day event window (-1,1) around the macroprudential policy announcements.

We argue that our macroprudential policy shocks are orthogonal to the state of the economy and unrelated to contemporaneous macro-financial conditions. This is because changes in expectations about future bank profitability and default risk using a tight window around a macroprudential policy announcement should predominantly be driven by information about macroprudential policy. Assuming that financial markets and the central bank have the same information about the determinants of macroprudential policy, any news that arrives in this short window about the policy must be about the actions of policymakers given the state of the economy, rather than the state of the economy itself (Cesa-Bianchi et al. 2020). Moreover, since we have made sure that no other news of economic or financial importance has occurred on the same day as the identified macroprudential policy surprises, these surprises are pure macroprudential policy surprises and not contaminated by any information effects.

To empirically verify that our series of macroprudential policy surprises is 'unpredictable' by current macrofinancial conditions, we regress the unanticipated changes in macroprudential policy on contemporaneous and lagged financial conditions over different time horizons. Results in Table B.13 are nil, suggesting that financial conditions and/or market sentiment cannot forecast future unanticipated changes in macroprudential policy and that our identification assumption thus holds.

2.5 Interpretation

How can we interpret the response of banks to macropudential policy announcements? Since a tightening macroprudential policy could affect banks' equity prices, profitability, and default expectations via several mechanisms, we provide a stylized theoretical framework to explain the underlying mechanisms behind our event-study findings. We begin with a simplified Consumption CAPM asset pricing model. Suppose an investor can freely buy or sell a security, at a price p_t. Denote by x_{t+1} the payoff that this asset yields in period $t+1$. The investor's problem in a two-period model yields the following asset price formula:

$$p_t = E_t(m_{t+1}x_{t+1}) \tag{6}$$

where $m_{t+1} \equiv \beta \frac{u'(c_{t+1})}{u'(c_t)}$ denotes the stochastic discount factor. We separate all possible future events ('states of the world') into two sets. One set contains one single 'bank default' event (D), the other contains all other no-default events (ND). We denote the probability of bank default by $prob^D$. Let E^D and E^{ND} denote expectations conditional on the default and no-default events, respectively. We assume for simplicity that the investor's payoff in the case of bank default is some known constant, x^D_{t+1}.[10] We can now write the asset pricing Equation

[10]We assume $E^{ND}_t[x_{t+1}] > x^D_{t+1}$ (i.e. expected future payoff conditional on no default is greater than future payoff in the event of bank default).

in (6) as follows:

$$p_t = (1 - prob^D)E_t^{ND}(m_{t+1}x_{t+1}) + prob^D E_t^D(m_{t+1})x_{t+1}^D \tag{7}$$

Applying a simple covariance formula, yields the following expression:

$$p_t = (1 - prob^D)\left[E_t^{ND}(m_{t+1})E_t^{ND}(x_{t+1}) + Cov^{ND}(m_{t+1}, x_{t+1})\right] + prob^D E_t^D(m_{t+1})x_{t+1}^D \tag{8}$$

Assuming the conditional and unconditional risk-free rates are equivalent, Equation (7) can be decomposed into three terms:

$$\begin{aligned} p_t = \; & \underbrace{(1 - prob^D)\frac{E_t^{ND}[x_{t+1}]}{R_{t+1}^f}}_{\text{Discounted PV of future payoffs (ND)}} + \underbrace{(1 - prob^D)\; Cov^{ND}\left(m_{t+1}, x_{t+1}\right)}_{\text{-Risk premium (ND)}} \\ & + \underbrace{prob^D \frac{x_{t+1}^D}{R_{t+1}^f}}_{\text{Discounted PV of future payoffs (D)}} \end{aligned} \tag{9}$$

where R_{t+1}^f denotes the gross risk-free return at time t+1, (i.e. the inverse of the expected discount factor). We will focus on the first and third term in particular, i.e. the discounted present value of future payoffs in a no-default and default event, respectively.[11]

Tighter than expected macroprudential policy announcements can impact banks' asset prices p_t in two different ways. On the one hand, if policies such as capital and leverage requirements limit banks' ability to extend credit, this would affect banks' future profitability. All else equal, a fall in the present value of future payoffs in the absence of bank default (i.e. a lower $E_t^{ND}[x_{t+1}]$), would result in a reduction of bank equity prices. On the other hand, since macroprudential policies aim to reduce the probability and severity of future crises, they directly affect the probability of bank default (i.e. a lower $prob^D$). To the extent that tighter macroprudential policy may limit banks' risk-taking incentives, investors may perceive these banks as safer. Holding everything else equal, Equation (9) shows that a reduction in bank default probability has a positive effect on bank equity prices.

However, in some cases tighter than expected macroprudential policies can lead to an increase in bank profitability of default ($prob^D$). This occurs when policy announcements reveal information about the state of the economy and aggregate risks levels, which motivated the regulatory authority to act. In these instances, equity prices decline and bank probability of default goes up.

[11]For simplicity, we will ignore the effect that macroprudential policy announcements have on equity risk premia and only look at the effects of macroprudential policy announcements on future bank profitability and default probability.

Overall, the way in which macroprudential policy announcements affect equity prices will depend on which of these channels dominates. To differentiate between these channels empirically, we can examine the simultaneous reaction of bank equity prices and a market-based variable that proxies for the probability of bank default. Figure 3 shows the combined impact of a tightening macroprudential policy announcement on equity prices and the probability of bank default. Quadrant III contains announcements that are associated with a reduction in bank equity prices, as well as a reduction in bank default probability. This is the case when the reduction in expected future bank profitability (which has a negative impact on equity prices) exceeds the reduction in default probability (which positively impacts equity prices). Quadrant IV contains announcements that result in both a decrease in bank equity prices and an increase in the perceived risk of bank default. As explained above, this may occur if the announcement also includes information about the underlying risks that prompted regulatory auction. We think of these announcements as tighter than expected announcements that contain Central Bank information effects. Analogously, Quadrants I and II distinguish between looser than expected macroprudential policy announcements with and without Central Bank information effects.[12]

[12]We rule out the possibility that quadrant II may also contain tighter than expected MaP announcements, where the reduction in banks' probability of default exceeds the reduction in bank future expected profitability. If changed bank behaviour would reduce banks' default probability in a way that dominates the reduction in earnings in the no-default state, banks should have adopted this behaviour without policy coercion.

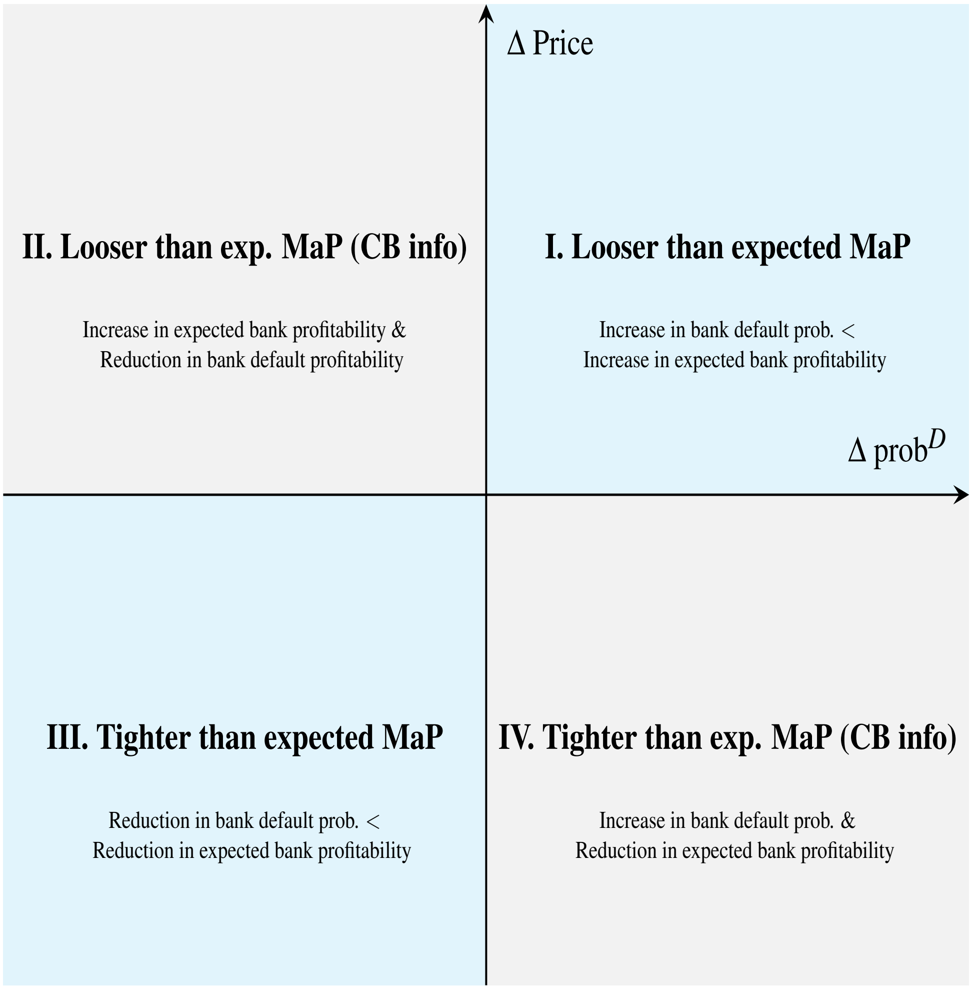


Figure 3: Equity price vs. default probability effects from a MaP announcement

We use CDS spreads as a proxy for bank default probability, since CDS spreads have been shown to be a relatively pure pricing measure of the underlying entity's probability of default and loss given default (Zhang et al. 2009). The joint effect of asset prices in Table 1 (proxied by bank equity returns) and bank default probability in Table 2 (proxied by changes in CDS spreads) places the majority of our announcements in Quadrant III of Figure 3 (i.e. tighter than expected macroprudential policy surprises). This implies that these macroprudential announcements are mostly linked to a perception of lower bank profitability. There are three notable exceptions. The first is the 31 October 2014 announcement in which the BoE increased the leverage ratio requirement, but markets did not consider the new requirement to be binding. On this date CAAR increased by approximately 1.68% on a (-1,1) window and CDS spreads fell significantly on the day of the announcement. Articles from financial news outlets suggest that analysts regarded this policy measure as 'looser' than expected.[13] Therefore, we think of this as a 'positive' macroprudential policy surprise and place it in Quadrant II of Figure 3. The other announcement that was met by a significant CDS spread response is that of 25 September

[13] "Credit Suisse estimates indicated that most UK banks were in a comfortable position to meet their requirements by the following year" (Article by Max Colchester and Jason Douglas, retrievable at Dow Jones Top News and Commentary, www.dowjones.com/professional/factiva)

2017. On this date the BoE warned that banks had been 'too' lax in provisioning for potential losses in consumer credit and should increase their capital buffers to 'protect' themselves (Financial Times).[14] One could argue that the bank equity response on this date can in principle be the result of both a reduction in the expected future bank profitability and an increase in the probability of bank default. In other words, the announcement of 25 September 2017 also contains Central Bank information effects. Our simple asset pricing equation places this announcement in Quadrant IV of Figure 3. Similarly, we place the announcement of 19 February 2016 in Quadrant IV of Figure 3, because this event led to a significant reduction in equity prices, but was simultaneously accompanied by an increase in CDS spreads.

3 Econometric Approach

In this section we test the hypothesis that macroprudential policy announcements affect systemic risk. Firstly, we employ local projection methods to estimate the dynamic causal relationship between macroprudential policy announcements and systemic risk, as measured by various indicators. Secondly, we delve deeper into the mechanisms behind this relationship by analysing the impact of macroprudential shocks on different components of systemic risk. Finally, we perform a series of robustness tests, where we consider a 'scaled' version of our macroprudential policy shocks and a number of placebo tests.

3.1 Empirical Specification

Since the effect of macroprudential policies on financial markets might take some time to be priced in, we estimate the dynamic effects using local projection methods in the spirit of Jordà (2005). The specification we use is as follows:

$$\Delta_h y_t = \alpha + \beta^h \Delta MaP_t^{shock} + \sum_{l=1}^{L} \delta_l^h y_{t-l} + \sum_{l=1}^{L} \beta_l^h \Delta MaP_{t-l}^{shock} + \sum_{k=1}^{K} \phi_k^h \Delta X_{t-k} + \varepsilon_{t+h} \tag{10}$$

where $\Delta_h y_t = y_{t+h} - y_t$ denotes the response variable of interest (i.e. the change in systemic risk between announcement day t and day t+h over varying prediction horizons h = 1,2,..., 60). ΔMaP_t^{shock} is a dummy variable defined from the event study results in Section 2.4. Note that different form the monetary policy literature, which identifies the transmission of monetary policy shocks to the real economy using an external instrument identification approach, we instead use the macroprudential policy surprise directly as a shock. We do this for two reasons. First, to the extent that our macroprudenial policy surprises represent instances when macroprudential policy announcements affect market participants' perceptions of bank risk, we expect

[14] Article by Chris Giles (Financial Times), retrievable at www.ft.com/content/c0f1eb7c-a1d2-11e7-b797-b61809486fe2

these surprises to have a direct impact on perceived systemic risk.[15] Additionally, while in the monetary policy literature changes in the monetary policy stance are captured by changes in the level of interest rates, it is not straighforward to think of a macroprudential policy variable that captures the stance of macroprudential policy in the UK. X are a set of one-day lagged controls (K = 1) including daily changes in the UK 1 year gilt, 10 year gilt, euro/pound and pound/dollar exchange rate and an economic policy uncertainty index from Baker et al. (2016). We include lagged changes in the UK 1 year gilt and 10 year gilt to account for changes in conventional and unconventional monetary policy in the UK. The latter could affect systemic risk through the risk-taking channel, but also trigger a change in macroprudential policy depending on the economy's risk environment. We control for exchange rate fluctuations in our baseline specification because in a small open economy like the UK, movements in the exchange rate are important determinants of monetary policy transmission, which could have implications for both financial stability and the conduct of macroprudential policy. Moreover, since our sample period contains episodes of elevated financial risk such as Brexit, movements in the euro/pound and dollar/pound exchange rate are likely to control for these events. Lastly, we control for economic policy uncertainty, since the latter is associated with greater stock price volatility and reduced investment and employment.[16]

Equation (10) allows us to gauge the effect of an unanticipated change in macroprudential policy on systemic risk. The coefficient β^h represents the cumulative average impact of a macroprudential policy surprise on systemic risk h days after the shock hit. Since we are using daily data we set L = 30 days. Including lags of both the independent and dependent variable does not only correct for serial correlation in the error terms, but also allows us to account for historical factors that might have influenced the dependent and independent variable. If our macroprudential policy surprises are exogenous then the inclusion of the lags will not affect the probability limit of our estimator $\hat{\beta}^h$, but will affect its standard error and the value it takes in finite samples.[17]

3.2 Composite Indicator of Systemic Stress

To assess the impact of macroprudential policy shocks on systemic risk in the UK, we use a daily market-based indicator of contemporaneous stress in the financial system named the Composite Indicator of Systemic Stress (CISS) developed by Hollo et al. (2012). CISS condenses the current level of frictions, stresses and strains in the financial system into a single statistic of systemic stress. Owing to its high-frequency nature, CISS mainly comprises of price based indicators with only a few exceptions (banks' emergency central bank lending and the finan-

[15]This would imply that although the macroprudential policy surprise itself is exogenous, it would not satisfy the exclusion restriction for it to be considered a valid external instrument.

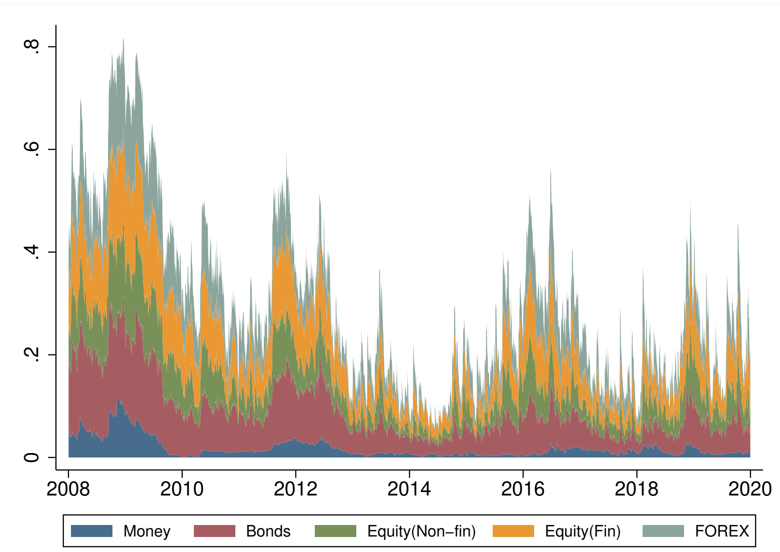
[16]To the extent that our macroprudential policy shocks are orthogonoal to financial conditions, the inclusion of additional controls should not affect our results. We confirm empirically that this is indeed the case.

[17]Our results are robust to different lag-length specifications and are quantitatively and qualitatively very similar to setting L = 0 days.

cial intermediaries' price-book ratio). Hollo et al. (2012) predominantly consider realised asset return volatilities and risk spreads for capturing the main symptoms of financial stress.[18] As such, the index is likely to capture investors' uncertainty about future fundamentals and/or the behaviour and sentiment of other investors.

We chose the UK CISS for several reasons. First, CISS is a composite indicator that combines market based financial stress measures coming from 5 different segments of the financial markets, as shown in Figure 4. Secondly, different from other financial conditions indices, CISS focuses on the systemic dimension of financial stress.[19] And thirdly, from a statistical point of view CISS has been shown to not suffer from look-ahead bias, which occurs when information that would not have been known during the period being analysed is used and can lead to inaccurate results. Additionally, CISS is sufficiently robust to outliers and can be updated on a daily basis (Chavleishvili & Kremer 2023). Figure 4 emphasises two important stylized facts. First, CISS is elevated in times of heightened financial distress, such as the GFC, European Sovereign Debt Crisis and Brexit. Secondly, different components of CISS are responsible for the observed variation in the composite indicator. For example, money market stress contributed almost 15% to the aggregate CISS in the height of the GFC, but represented only 4% of the aggregate CISS in December 2019.

Figure 4: Decomposition of CISS



Notes: This Figure plots the decomposition of the UK Composite Indicator of Systemic Stress by Chavleishvili & Kremer (2023). The contributions from 15 individual stress factors are aggregated into money, bond, equity (finanical and non-finanical corporations) and foreign exchange market contributions.

[18]For instance, to capture stress in bond markets Hollo et al. (2012) consider (i) the realised volatility of a benchmark 10-year Government bond index, (ii) the yield spread between A-rated non-financial corporations and government bonds, (iii) a 10 year interest rate swap, (iv) the yield spread between A-rated financial and non-financial corporations (7-year maturity).

[19]What makes CISS a systemic measure is the statistical methodology used in aggregating financial stress coming from all 5 of these segments, which assigns more weight on days were stress is elevated in several markets simultaneously.

3.3 Local Projection Results

Figure 5 shows the dynamic effects of an unexpected macroprudential policy announcement on systemic risk, as defined in Equation (10). The impulse response function indicates that in response to a tighter than expected macroprudential policy announcement, CISS in the UK falls by 0.48 standard deviations. As a point of reference, systemic risk in the UK as measured by CISS increased by around 3 standard deviations in the height of the Great Financial Crisis and by around 2 standard deviations on the week following the Brexit referendum.[20] Our results indicate that macroprudential policies are not just a regulatory cost banks have to meet, but have a substantial role to play in reducing perceived systemic risk. To the extent that CISS is a market-based indicator, which responds faster than the underlying fundamental, this IRF represents a reduction in markets' expectations of systemic risk. This is in line with the objective of macroprudential policy which is to pursue financial stability by ensuring banks are resilient enough to withstand financial shocks. It takes about 36 trading days for this effect to reach its peak, which is consistent with the idea that it takes time for market participants to adjust their view on systemic risk in the face of regulatory requirements.[21] This suggests that macroprudential policy announcements are indeed effective in reducing perceived systemic risk in the short run with effects persisting for several months.

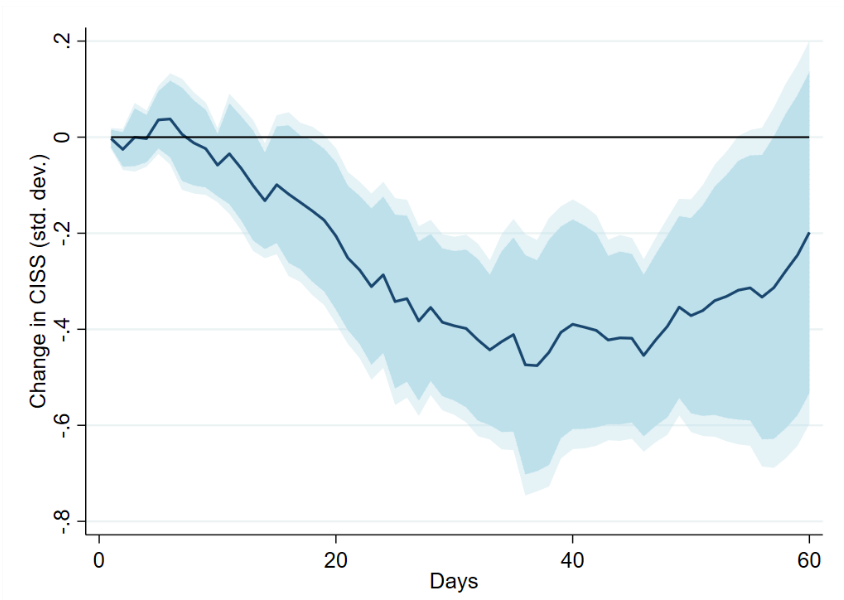
Additionally, a major advantage of our identification approach is that it provides insights into the importance of macroprudential 'surprises' by focusing on unanticipated announcements, therefore avoiding any confounding biases that might be present in a purely narrative approach. To demonstrate this, we offer a comparison: we compare the systemic risk response to macroprudential policy announcements that were expected (but not contaminated by other macrofinancial news) versus those that were unexpected.[22] Our prior is that anticipated macroprudential policy announcements should be already priced into systemic risk measures, and therefore unlikely to affect market outcomes. The resulting impulse response for the composite index of systemic stress to an anticipated macroprudential policy announcement is reported in Figure 6. In contrast to the baseline response, the impulse response shows a relatively mild reduction of systemic risk over a 60 day horizon. In particular, in response to an anticipated macroprudential policy announcement, CISS falls by only 0.15 standard deviations at its peak. This effect is over 3 times less pronounced than the baseline. Additionally, the impulse response supports our hypothesis that controlling for anticipation effects is crucial, as the IRF is statistically insignificant for the majority of the estimation period.

[20]These deviations in CISS are based on a horizon of 36 trading days.

[21]his could be related to the fact that it may take time for the information contained in macroprudential policy requirements to be fully assimilated by market participants.

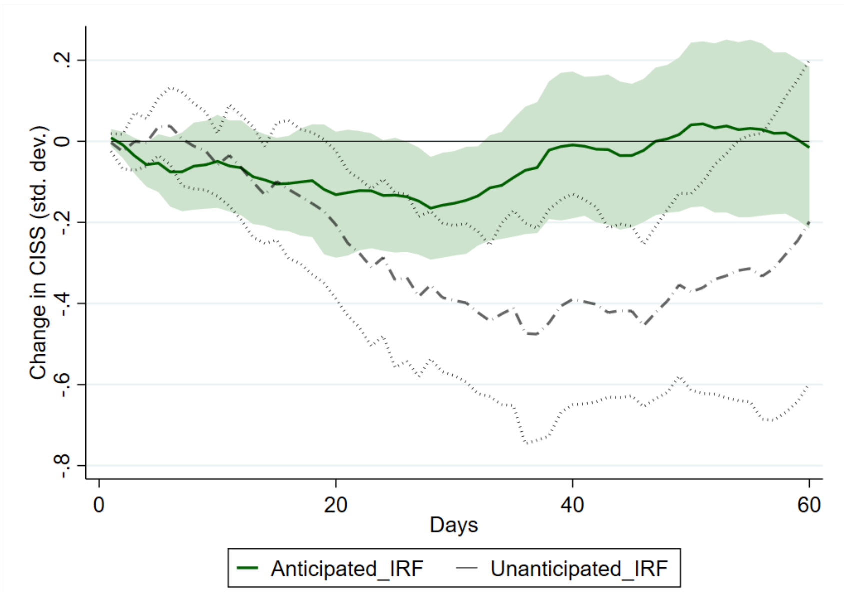
[22]By anticipated announcements we refer to macroprudential policy events that were not met by a significant reaction in banks' CARs and additionally were not confounded by macrofinacial press releases. See Table A.1 for a detailed list of these announcements

Figure 5: The effect of macroprudential policies on systemic risk



Notes: In line with local projection methods, each horizon is estimated separately. The blue solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h CISS^{UK}$, over the horizons considered. The independent variable is $\Delta \text{MaP}^{shock}$. The light blue shaded areas denote the 95% and 90% confidence intervals around point estimates constructed with robust standard errors.

Figure 6: The effect of 'anticipated' macroprudential policies on systemic risk



Notes: In line with the local projection methods, each horizon is estimated separately. The green solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h CISS^{UK}$, over the horizons considered. The independent variable is $\Delta \text{MaP}^{Anticipated}$, which takes a value of 1 on macroprudential policy dates, which did not significantly affect banks' CAARs. The light green shaded area denotes the 95% confidence interval around point estimates constructed with robust standard errors. The gray dashed line denotes the $\{\beta^h\}_{h=1}^{60}$ estimates with $\Delta \text{MaP}^{shock}$ as an independent variable. Area bound by the gray dotted lines is the corresponding 95% confidence interval.

3.4 Disaggregated Results

Our next question is on which dimension of systemic risk do macroprudential polices have the strongest effect. In other words is the reduction in systemic risk coming from the money markets, bond markets, equity markets or foreign exchange markets? To address this question we make use of the daily decomposed CISS subindices for the UK and estimate Equation (10) with the dependent variable being one of the systemic stress subindences.[23]

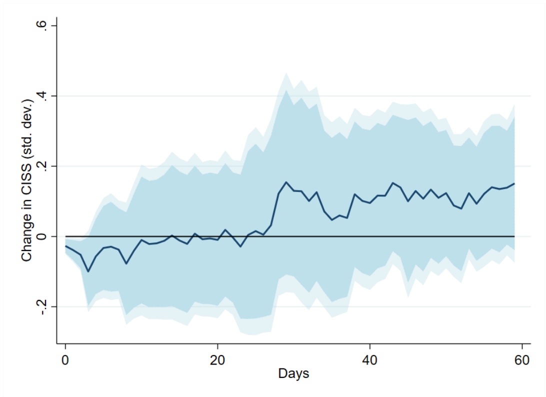
Figure 7(b) shows that a considerable reduction in overall systemic risk is attributed to a significant reduction in bond market stress or instability. A reduction in bond market stress is usually associated with containment of credit default and liquidity risk. There are three main reasons why macroprudential policies may have contributed to a reduction in bond market stress. First, the supervised banks issue large amounts of debt themselves. A tighter than expected capital/leverage requirements reduces the perceived riskiness of these banks and leads to a redistribution of value from shareholders to creditors. This would be reflected in a reduction in the yield spreads between A-rated financial and non-financial corporations, which is one of the determinants of the bond market CISS subindex. Secondly, by enhancing the resilience of the financial system macroprudential policies may dampen down investor uncertainty and risk aversion, which would improve market sentiment and reduce bond market stress. And thirdly, by limiting banks' ability to lend to risky borrowers (in an effort to improve credit quality), macroprudential polices may reduce the pool of risky borrowers in the economy, which would also be reflected in a reduction in counterparty credit risk.

Additionally, Figure 7(c) show that macroprudential policies may have also contributed to a reduction in perceived stress for non-financial corporations, potentially pointing to spillover effects from the financial sector to the non-financial sector. This effect is however statistically significant only for a few estimation horizons.

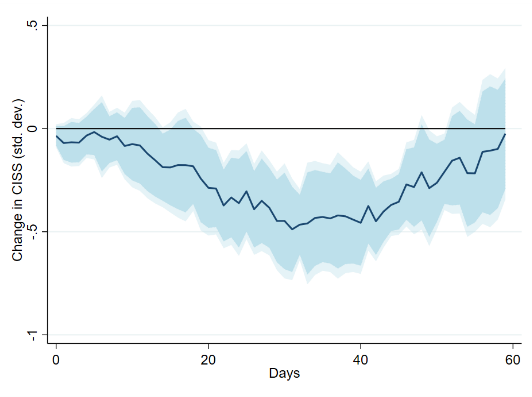
As expected, a significant reduction in systemic risk occurs in the equity markets and more particularly in the financials group. The result in Figure 7(d) is consistent with the idea that macroprudential policy shocks reduce the likelihood of large bank equity losses. This effect is indicative of macroprudential polices contributing to an improvement in financial sector stability as is shown in Figure 7.

[23]See Chavleishvili & Kremer (2023) for more information on the statistical framework used for constructing the daily CISS subindices.

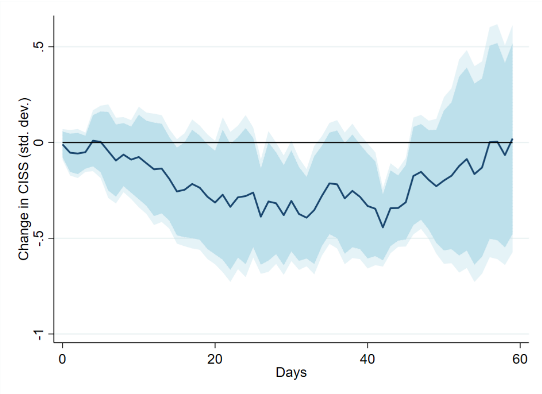
Figure 7: Disaggregated Impulse Response Functions



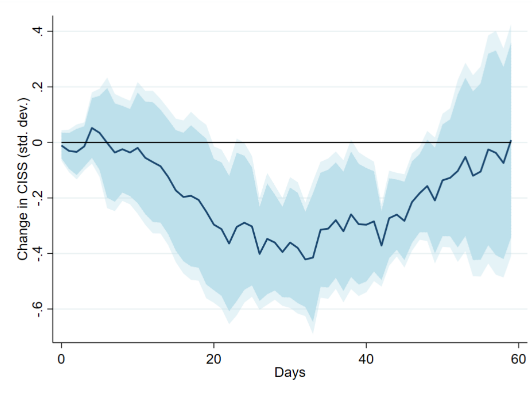
(a) Money Markets



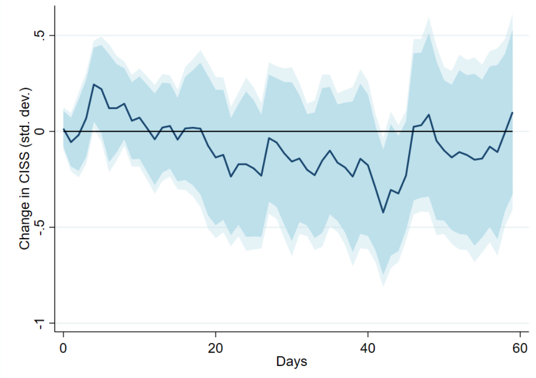
(b) Bond Markets



(c) Equity (non-financials)



(d) Equity (financials)



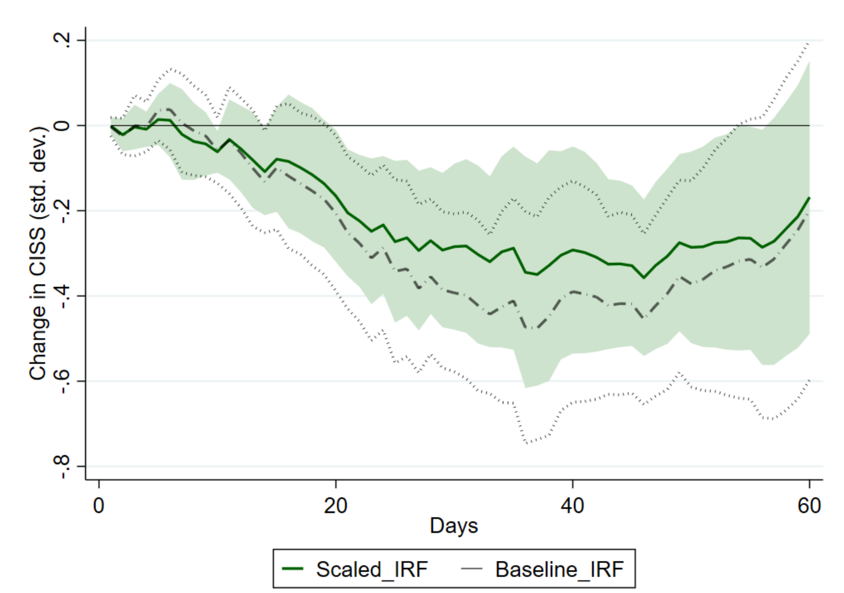
(e) FOREX

Notes: In line with local projection methods, each horizon is estimated separately. The blue solid lines represent the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable in panels (a), (b), (c), (d) and (e) is the change in the CISS subindex in the money markets, bond markets, equity (non-financials), equity (financials) and foreign exchange markets respectively, over the horizons considered. The independent variable across all panels is $\Delta \text{MaP}^{shock}$. The light blue shaded areas denote the 95% and 90% confidence intervals around point estimates constructed with robust standard errors.

3.5 Robustness

Scaled shocks Additionally, we assess the systemic risk response to macroprudential policy shocks scaled by the degree to which the markets were surprised. In other words, we assign a higher weight to the announcements that led to a stronger CAAR response, to account for the perceived tightness of the macroprudential policy measure. The IRF in Figure 8 shows that in response to a tighter than expected macroprudential policy announcement that negatively surprised the market by 2.3pp, the composite indicator of systemic stress in the UK fell by around 0.38 standard deviations.[24] This response is similar to the baseline estimation depicted in the dashed gray line, both in magnitude and persistence. Similar to before, the peak effect is reached around 36 days after the shock.

Figure 8: The effect of 'scaled' macroprudential policies on systemic risk



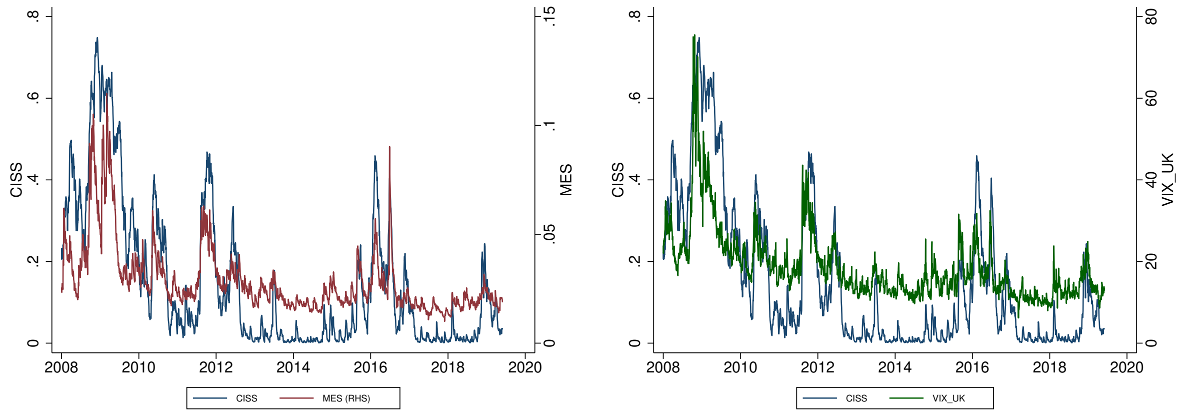
Notes: In line with local projection methods, each horizon is estimated separately. The green solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h CISS^{UK}$, over the horizons considered. The independent variable, $\Delta\text{MaP}^{scaled}$ is scaled according to the CAAR responses bracketing the macroprudential policy event window, as defined in Section 2.4. The light green shaded area denotes the 95% confidence intervals around point estimates constructed with robust standard errors. The gray dashed line denotes the $\{\beta^h\}_{h=1}^{60}$ estimates with ΔMaP^{shock} as an independent variable. Area bound by the gray dotted lines is the corresponding 95% confidence interval.

Alternative financial instability indices Since CISS is not the only indicator of systemic stress provided at a daily frequency, as a robustness check we also test our results against another popular market-based indicator of systemic risk. Namely, the Marginal Expected Shortfall (MES) developed by Acharya et al. (2017). MES measures an individual bank's marginal contribution to the overall tail risk in the banking system. Formally, the MES of a financial

[24] An average macroprudential policy surprise was associated with a 2.3pp reduction in bank equity prices, and so we scale the impulse response to a 1pp shock 2.3 times for better comparability with the original binary MaP shock.

institution represents the expected equity loss of a bank's stock price conditional on a large shock to the financial system (what is known as a tail event).

Figure 9: CISS vis-à-vis other Financial (In)stability Indicators



Notes: This Figure plots the Composite Indicator of Systemic Stress (CISS) vis-à-vis two other financial stability indicators. Namely, the Marginal Expected Shortfall (MES) by Acharya et al. (2017) and the FTSE100 Implied Volatility Index (VIX). The frequency of the time series for CISS and MES and VIX is daily from 1 January 2008 to 30 June 2019.

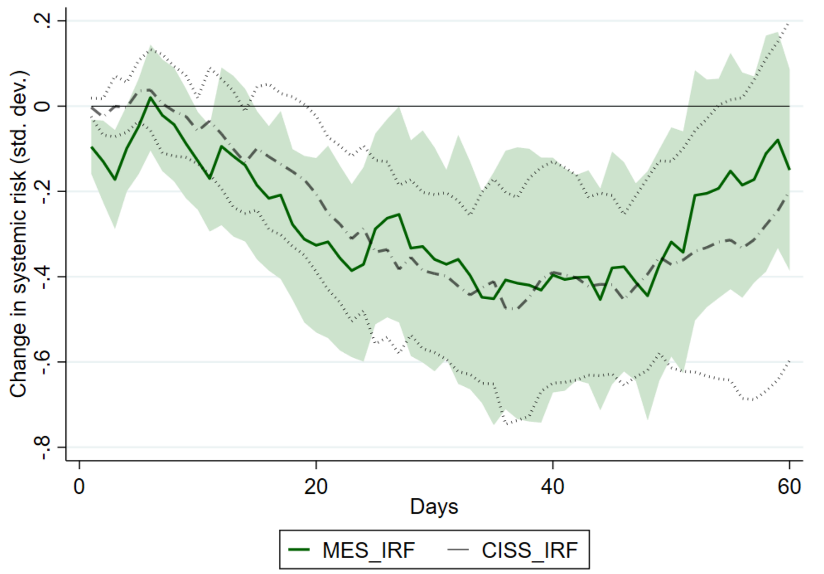
We proceed by computing the MES measure for each of the 6 individual banks in our analysis (see Appendix C.1 for more details). We then take a weighted average of the estimated MESs, with weights assigned according to banks' market capitalisation. The left panel of Figure 9 plots the weighted average MES estimate over time together with the CISS. MES is elevated in times of well-known financial stress periods such as the Great Financial Crisis, the European Sovereign Debt crisis and Brexit. Moreover, the left panel of Figure 9 shows that there is a great degree of co-movement between CISS and MES, thus indicating that MES is a good systemic risk proxy.[25] However, while MES moves similarly to CISS during times of economic stress, the time series can be quite different outside of peak crisis times. The contemporaneous differences are a reflection of the fact that while MES only captures systemic stress in the banking sector, CISS encompasses a much broader structure of financial markets, which accounts for stress in bond and FOREX markets as well.

Figure 10 reconfirms that the unanticipated macroprudential policy measures implemented in the post-GFC period led to a substantial reduction in systemic risk as measured by the MES measure. The IRF in Figure 10 depicted by the green solid line is remarkably similar both in shape and magnitude to the IRF we obtained previously using CISS as an indicator of systemic risk. The results indicate that in the aftermath of a macroprudential policy shock, the average UK bank's contribution to overall downside risk in the financial markets falls down by approximately 0.5 standard deviations. This is again in line with the notion that tighter macroprudential policy is beneficial in reducing systemic risk and in particular risks emanating from the banking

[25]The full sample correlation coefficient between CISS and MES is 0.862.

system, as banks become more resilient to external shocks. The result is also consistent with Meuleman & Vennet (2020) who showed that the introduction of tightening macroprudential policies have a downward effect on banks' MES within a one-month horizon.

Figure 10: The effect of macroprudential policies on systemic risk

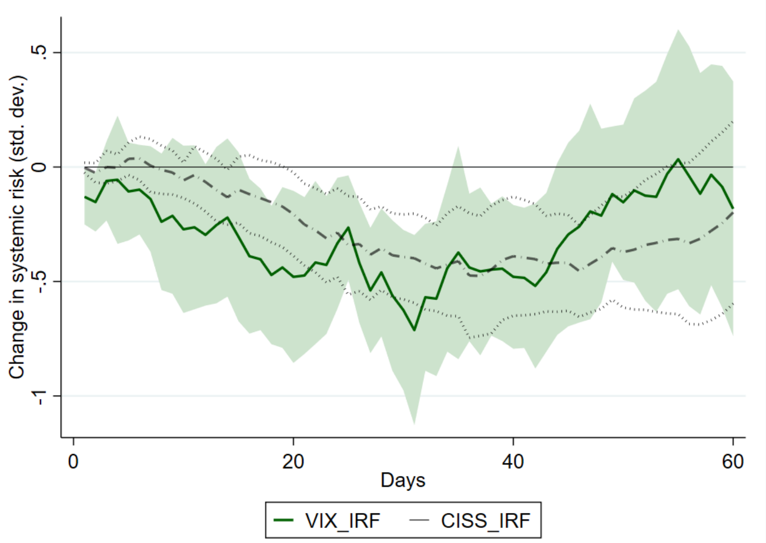


Notes: In line with local projection methods, each horizon is estimated separately. The green solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h MES^{Banks}$, over the horizons considered. The independent variable is ΔMaP^{shock}. The light green shaded area denotes the 95% confidence intervals around point estimates constructed with robust standard errors. The gray solid line denotes the $\{\beta^h\}_{h=1}^{60}$ estimates with $\Delta_h CISS^{UK}$ as a dependent variable. Area bound by the gray dotted lines is the corresponding 95% confidence interval.

Additionally, we conduct robustness checks against another well-known financial conditions indicator, namely the FTSE100 Implied Volatility Index, VIX^{UK}. While VIX^{UK} is not a systemic risk measure, it is often seen as a way to gauge market sentiment, and in particular the degree of risk aversion and uncertainty among stock market participants. To the extent that the level of risk aversion in the stock markets tends to be high in periods of elevated systemic risk as shown on the right panel of Figure 9, we think of VIX^{UK} as a suitable financial instability/stress variable for our analysis.[26] However, unlike CISS, which is a composite financial instability measure, VIX^{UK} measures the options-implied volatility in equity markets and does not consider other financial markets, such as the interbank, bond and FOREX markets. Moreover, since VIX measures the options-implied volatility of FTSE100 returns, it is more susceptible to global shocks that affect the large international companies that make up this index. For these reasons we do not think of VIX as a substitute for systemic risk in the UK, but rather as a complementary indicator of financial instability.

[26]The FTSE100 Implied Volatility Index Series (30 day) is available on Bloomberg.

Figure 11: The effect of macroprudential policies on VIX



Notes: In line with local projection methods, each horizon is estimated separately. The green solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h VIX^{UK}$, over the horizons considered. The independent variable is ΔMaP^{shock}. The light green shaded area denotes the 95% confidence intervals around point estimates constructed with robust standard errors. The gray solid line denotes the $\{\beta^h\}_{h=1}^{60}$ estimates with $\Delta_h CISS^{UK}$ as a dependent variable. Area bound by the gray dotted lines is the corresponding 95% confidence interval.

The results in Figure 11 show that 30 days after an unanticipated macroprudential measure VIX reduces by approximately 0.7 standard deviations. This result lends support to the idea that by making the financial system safer, macroprudential policies may improve investors' sentiment and reduce market uncertainty.

Placebo Tests: We next want to ensure that the macroprudential shocks we identified are not just global shocks but specific to the UK macroprudential policy. We construct a quasi-placebo test with our dependent variable being the h-horizon change of the composite indicator of systemic stress in China as opposed to the UK. The reason why we choose China as a counterfactual is twofold. First, UK and/or European specific macroprudential policy shocks (like the ones in our sample) are unlikely to affect systemic stress in Chinese financial markets. Second, in sharp contrast to some major jurisdictions, the Chinese Banking Regulatory Commission (CBRC) enthusiastically embraced the adoption of Basel III reforms. In fact, Knaack (2017) and Xi (2016) argue that China subjected itself to tougher regulatory standards compared to Basel III and aimed to implement them ahead of the international schedule. One could argue that since Chinese banks were subject to stricter domestic regulatory requirements, the two Basel announcements that are part of our macroprudential policy shock series are unlikely to be binding. For these reasons we do not expect unanticipated UK macroprudential policy shocks to affect systemic risk in China. The insignificant impulse response function indicated by the green solid line in Figure C.2 confirms our hypothesis.

Our next robustness step concerns a placebo test, where we simulate at random 8 macroprudential policy shocks days and investigate the effect of these placebo dates on systemic risk.[27] Furthermore, we condition the placebo announcements to be drawn from a sample of random days when the CAAR response of a portfolio that consists of UK's 6 biggest banks is (i) significantly different from zero, (ii) of a similar magnitude to the event study results described in Section 2.3 and (iii) excludes the 8 surprises in Table 1.[28] We do this to ensure that the shock series contains valuable information, not just random noise. We repeat this exercise 1000 times and we expect the 'placebo treatment' to not have an effect on systemic risk in the UK. Finding an effect would indicate an important flaw in our study. Figure C.3 verifies that the placebo treatment does not have any effect on systemic risk. The IRF obtained from the placebo test (in solid green) oscillates around zero, with quite wide confidence bounds around the mean effect. The 'true' IRF on the other hand reports tight bands around a mean effect that is statistically different from zero. This result gives us confidence that the reductions in systemic risk in response to unanticipated macroprudential policy announcements (indicated in solid gray) are not pure coincidences and that our sample does not yield similar results for randomly selected shock dates, even after conditioning on the cumulative abnormal returns.

Outliers: Finally, we test for existence of 'outlier' macroprudential policy shocks dates i.e. the possibility that one of our macroprudential announcements is driving the majority of the results. Results of Figure 5 are robust to dropping one macroprudential policy surprise at a time, thus indicating that the effect of macroprudential policy shocks on systemic risk is not driven by an outlier macroprudential policy event (see Table C.1 for details).

4 Conclusion

We have shown that macroprudential policy announcements can reduce systemic risk, specifically in the (financial) equity and bond market. In order to conduct this analysis, we have developed a database of daily macroprudential policy announcements encompassing a wide range of UK and international macroprudential authorities. Using high frequency techniques to ensure we identify true macroprudential 'surprises', we were able to test the impact of these shocks on systemic risk. Throughout all the rigorous robustness checks, our main result still holds: tighter than expected macroprudential policies can reduce markets' perception of systemic risk. Our main explanation for this results stems from the fact that macroprudential tightening is often associated with an increase in the resilience of banks to withstand shocks in the future i.e. by having higher capital ratios, more liquidity, less risky portfolios.

[27] In essence we randomly generate seven dates (without replacement) for which our placebo macroprudential policy shock variable will take a value of 1 and one day for which our macroprudential policy shock variable will take a value of -1.

[28] We restrict the magnitude of the CAAR's response to be between -4.5 and - 2.0 for seven of the Placebo announcements and between 1.5 and 2.0 for one of the Placebo announcements.

Our results could be extended along several dimensions. Firstly, while the 8 UK surprise dates gave us sufficient information to identify macroprudential shocks, the vast majority of UK announcements were well anticipated and potentially priced in by the markets in advance. Therefore, in order to extend our information set, cross-country information would add another richer dimension on which to judge the impact of macroprudential policy.

Secondly, it would be interesting to investigate the real economy impact of macroprudential policy and the effect on lending decisions. As macroprudential policy can involve a trade-off between ensuring financial stability in the longer-term versus higher credit growth in the near-term, an analysis incorporating this would be very insightful, e.g. by using GDP-at-risk vs GDP growth as a way of measuring the trade-off.

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A Data

A.1 List of macroprudential policy announcements

Table A.1: Macroprudential policy announcements

Date	Macroprudential policy announcement
17 Dec 2009	Basel II: Raising the quality, consistency and transparency of the capital base.
19 Jan 2009	FSA stated that it expected the banks participating in the recapitalisation scheme maintain core Tier 1 capital of at least 4% after applying stress tests.
05 Oct 2009	Under the FSA Policy Statement (09/16) on 'Strengthening Liquidity Standards', a subset of banks are required to hold a sufficient stock of HQLA.
22 Jun 2010	Bank levy: The rate for 2011 will be 0.05 per cent for ST liabilities and 0.025 per cent for LT liabilities.
16 Dec 2010	Publication of Basel III package.
23 Mar 2011	An increase in the bank levy to 0.078% rate for short-term liabilites.
04 Nov 2011	Basel III: Assessment methodology and the additional loss absorbency requirement for G-SIIIs.
29 Nov 2011	Bank levy is being raised from 0.078% to 0.088% from 1 January 2012.
01 Dec 2011	A recommendation by the FPC that major UK firms disclose their leverage ratios in accordance with Basel III.
21 Mar 2012	Short-term liabilities rate and long-term liabilities rate increase to 0.105 and 0.0525%, respectively.
05 Dec 2012	Bank Levy will increase to 0.130 per cent from 1 January 2013.
07 Jan 2013	Basel III: LCR will be introduced as planned in 2015, but the minimum requirement will be set at 60% and rise in equal annual steps to reach 100% in 2019.
20 Mar 2013	Bank levy Short-term liabilities rate and long-term liabilities rate increase to 0.142 and 0.071, respectively.
27 Mar 2013	FPC: PRA should take steps to ensure that, by the end of 2013, major UK banks and building societies hold capital resources equivalent to at least 7% of their RWA, have credible plans to meet the significantly higher targets for capital and leverage ratio that will come into effect in 2019 and the trading book review and surcharge for G-SIIs.
26 Jun 2013	FPC: PRA should provide an assessment to the FPC of the vulnerability of borrowers and financial institutions to sharp upward movements in long-term interest rates and credit spreads in the current low interest rate environment.
27 Jun 2013	CRD IV was published in the official journal of the European Union on 27 June 2013. CRD IV consists of a directly applicable EU Regulation, and an EU Directive which must be reflected in national law.
29 Nov 2013	PRA issued SS3/13 on capital and leverage ratios for major UK banks and building societies (SS3/13). The PRA set a 3% leverage ratio expectation for 8 major UK firms.
05 Dec 2013	Under Finance Act 2014, the bank levy rate had been increased to 0.156% for short term liabilities (and 0.078% for long terms equity and liabilities) from 2014.
14 Jan 2014	Basel III: Market risk minor revisions to (i) boundary between banking and trading book, (ii) internal models approach, (iii) standardised approach.
26 Jun 2014	FPC: FCA should ensure that mortgage lenders do not extend more than 15% of new residential mortgages at LTI ratios at or greater than 4.5. CCyB set at 0%. When assessing affordability, mortgage lenders should apply an interest rate stress test that assesses whether borrowers could still afford their mortgages if, at any point over the first five years of the loan, the Bank Rate were to be 3 pp higher than the rate at origination.
02 Oct 2014	FPC recommends that HM Treasury to exercise its statutory power to enable the FPC to direct the PRA and FCA to require regulated lenders to place limits on residential mortgage lending.
27 Oct 2014	EBA Stress Test results and PRA (PS10/14) on 'CRD IV: updates for credit risk mitigation, credit risk, governance and market risk'.
31 Oct 2014	FPC published its final review setting out proposals for the design of the leverage ratio framework, including its views on the calibration of the framework.
18 Mar 2015	Bank levy: Further increases the rate of the bank levy to 0.21% for short term liabilities from 1 April 2015 (and 0.105% for long term liabilities).
26 Apr 2015	The recast Banking Consolidation Directive (recast BCD) includes a revised framework for the risk weighting of credit risk in the banking book, including the standardised approach. Exposures secured by mortgages on residential property are to be weighted by 35% risk weight.

Date	Macroprudential policy announcement
27 May 2015	PRA PS on (i) legal structure arrangements of banking groups subject to ring-fencing, (ii) governance arrangements of ring-fenced bodies and (iii) arrangements to ensure continuity of services and facilities to ring-fenced bodies.
01 Jul 2015	The FPC directs the PRA to require major banks to (i) satisfy a minimum leverage ratio of 3%, (ii) countercyclical leverage buffer rate of 35% of its institution-specific CCyB and (iii) G-SII additional leverage ratio buffer of 35% of its G-SII buffer rate.
08 Jul 2015	Bank levy: the short and long term rates were reduced to 0.18 and 0.09 % respectively, effective from January 2016. Alongside these cuts, the Government introduced an 8% corporation tax surcharge for banks.
15 Dec 2015	PRA disclosed the 2015 list of UK headquartered GSIIs and their respective sub-categories. Applicable buffers are: HSBC Holdings Plc 2.5%, Barclays Plc 2%, RBS 1%, Standard Chartered Plc 1%.
19 Feb 2016	PRA set out the criteria and scoring methodology it proposed to use to identify O-SIIs.
	The Single Supervisory Mechanism ordered the biggest Eurozone banks to boost their capital levels by 0.5pp
24 Mar 2016	From 21 March 2016 second and subsequent charge mortgage contracts fell under the definition of a regulated mortgage contract.
	PRA PS(11/16) rules that LTI flow limits automatically apply to second and subsequent charge mortgage contracts.
29 Mar 2016	FPC: Consistent with the Committee's assessment of the current risk environment, and its intention to move gradually, the Committee has decided to increase the UK countercyclical capital buffer rate from 0% to 0.5% of RWA.
05 Jul 2016	In light of the Brexit referendum results, the FPC reduced the UK countercyclical capital buffer rate from 0.5% to 0% of banks' UK exposures with immediate effect.
04 Aug 2016	The FPC recommends to the PRA that, when applying its rules on the leverage ratio, it considers allowing firms to exclude from the calculation of the total exposure measure those assets constituting claims on central banks where they are matched by deposits accepted by the firm that are denominated in the same currency and of identical or longer maturity.
27 Feb 2017	PRA PS: Amendments to the loan to income (LTI) ratios in mortgage lending. PRA sets out the final rules for the LTI flow limit to operate on a four-quarter rolling basis.
27 Jun 2017	FPC increased the CCyB rate to 0.5%, from 0%. When assessing affordability, mortgage lenders should apply an interest rate stress test that assesses whether borrowers could still afford their mortgages if, at any point over the first 5 years of the loan, their mortgage rate were to be 3 pp higher than the 'reversion' rate.
06 Jul 2017	PRA PS sets out final rules intended to update regulatory reporting requirements, and expectations, in light of the introduction of International Financial Reporting Standard 9 (IFRS 9) from 1 January 2018.
25 Sep 2017	FPC set out its view on the appropriate loss rate on consumer credit in the Bank's 2017 annual stress test of major UK banks. It judged that, in the first three years of the severe stress test scenario, the UK banking system would, in aggregate, incur consumer credit losses of around £30 billion, representing 150 bps of the aggregate common equity Tier 1 capital ratio of the UK banking system.
28 Nov 2017	The FPC is raising the UK countercyclical capital buffer rate from 0.5% to 1%, with binding effect from 28 November 2018.
07 Dec 2017	Basel III : Revisions to help restore credibility in the calculation of RWA by: (i) enhancing the robustness and risk sensitivity of the standardised approaches for credit risk and operational risk, (ii) constraining the use of internally modelled approaches, (iii) complementing the risk-weighted capital ratio with a finalised leverage ratio, a leverage ratio buffer for G-SIIs and a revised and robust capital floor.
16 Mar 2018	FPC agreed to the hurdle rates for the 2018 stress test evolving from those used in earlier years. The Bank would hold G-SIIs to higher standards each participating bank would now be assessed against single risk-weighted capital and leverage hurdle rates, which would now include for the first time, capital buffers for domestic, as well as global, systemic importance.
15 Apr 2019	PRA PS(11/19) on "Enhancing banks' and insurers' approaches to managing the financial risks from climate change".
11 Jul 2019	The 2019 biennial exploratory scenario will examine the implications of a severe and broad-based liquidity stress affecting major UK banks simultaneously. This exercise will explore how the reactions of banks and authorities to the stress would shape its impact on the broader financial system and the UK economy.
16 Dec 2019	The FPC judges a 2% UK CCyB rate to be appropriate for the current standard risk environment. It is therefore raising the CCyB rate from 1% to 2%. This will take effect in one year.

Notes: This table presents the 44 macroprudential policy announcements in our dataset. The announcements in dark green are days that generated a significant market response at the 1%, 5% or 10% significance level, around an event window of (-1, 1) days before and after the announcement. However, news coverage revealed that the dates in dark green were 'contaminated' by other macro-financial news and/or bank specific announcements that were not of a macroprudential nature. The announcements in bright blue depict our macroprudential policy 'surprises'. In other words, they are the days when financial markets were significantly surprised in the aftermath of a macroprudential policy announcement and were not affected by any other news.

B Event Study Results

B.1 Individual event studies

Table B.1: Event Study Results - 16 December 2010

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	-4.4146%	-0.5273%	-3.1364%	0.7509%
	(0.2621)	(0.8693)	(0.3281)	(0.7399)
Standard Chartered	-1.1480%	-0.1069%	-0.6385%	0.4026%
	(0.6729)	(0.9615)	(0.7732)	(0.7968)
HSBC	-2.3707%	-1.2731%	-0.8214%	0.2761%
	(0.2199)	(0.4185)	(0.6015)	(0.8036)
Santander	-4.8010%	-2.5669%	-2.8996%	-0.6655%
	(0.1779)	(0.3762)	(0.3176)	(0.7450)
Barclays	-4.4500%	-2.8017%	-0.8228%	0.8255%
	(0.2033)	(0.3253)	(0.7725)	(0.6811)
RBS	-8.9539%**	-2.9273%	-7.4882%**	-1.4616%
	(0.0355)	(0.3973)	(0.0310)	(0.5492)
Portfolio (6 securities)	-4.3326%***	-1.6927%	-2.6153%**	0.0247%
	(0.0020)	(0.1355)	(0.0215)	(0.9753)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.2: Event Study Results - 4 November 2011

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	-5.5840%	-3.2214%	-2.7748%	-0.4122%
	(0.1940)	(0.3577)	(0.4279)	(0.8674)
Standard Chartered	-2.5286%	-1.6302%	-1.7139%	-0.8155%
	(0.2848)	(0.3975)	(0.3735)	(0.5483)
HSBC	-1.6553%	-1.0480%	-0.4458%	0.1615%
	(0.3549)	(0.4724)	(0.7596)	(0.8752)
Santander	-2.1256%	-2.4961%	-3.4023%	-3.7728%*
	(0.5630)	(0.4050)	(0.2564)	(0.0751)
Barclays	-1.9393%	-0.2423%	-1.5970%	0.1000%
	(0.6405)	(0.9429)	(0.6370)	(0.9666)
RBS	-4.3484%	-1.3546%	-1.0321%	1.9618%
	(0.2979)	(0.6906)	(0.7615)	(0.4140)
Portfolio (6 securities)	-2.9975%**	-1.6390%	-1.8067%	-0.4482%
	(0.0391)	(0.1654)	(0.1263)	(0.5902)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.3: Event Study Results - 27 June 2013

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	-0.4983%	-1.2407%	-0.8829%	-1.6253%
	(0.8633)	(0.6008)	(0.7076)	(0.3305)
Standard Chartered	-1.2204%	-1.0282%	-1.4935%	-1.3013%
	(0.6883)	(0.6798)	(0.5460)	(0.4583)
HSBC	-1.0241%	-1.3164%	-0.8047%	-1.0970%
	(0.4610)	(0.2475)	(0.4760)	(0.1712)
Santander	-1.4238%	-0.8353%	-3.9955%	-3.4071%*
	(0.6716)	(0.7613)	(0.1441)	(0.0793)
Barclays	-5.8077%*	-3.6555%	-5.8458%**	-3.6936%*
	(0.0837)	(0.1833)	(0.0325)	(0.0565)
RBS	-6.3663%*	-6.0798%*	-4.2630%	-3.9765%*
	(0.0961)	(0.0525)	(0.1701)	(0.0715)
CAAR group 1 (6 securities)	-2.7029%**	-2.3429%**	-2.8696%***	-2.5096%***
	(0.0319)	(0.0232)	(0.0052)	(0.0006)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.4: Event Study Results - 27 October 2014

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	-3.8273%*	-0.5798%	-4.8262%***	-1.5786%
	(0.0632)	(0.7293)	(0.0042)	(0.1822)
Standard Chartered	-8.9431%***	0.4581%	-10.9098%***	-1.5086%
	(0.0000)	(0.7523)	(0.0000)	(0.1412)
HSBC	-1.0472%	-1.0095%	-1.0850%	-1.0473%
	(0.4148)	(0.3355)	(0.3004)	(0.1569)
Santander	-2.1158%	-3.0572%*	-3.0144%*	-3.9558%***
	(0.2903)	(0.0617)	(0.0653)	(0.0007)
Barclays	-1.1674%	-0.8611%	-1.9790%	-1.6727%
	(0.6179)	(0.6521)	(0.3002)	(0.2147)
RBS	-2.3998%	-1.5190%	-2.0195%	-1.1387%
	(0.4207)	(0.5321)	(0.4060)	(0.5065)
Portfolio (6 securities)	-3.1828%***	-1.0871%	-3.9078%***	-1.8121%***
	(0.0003)	(0.1273)	(0.0000)	(0.0004)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.5: Event Study Results - 31 October 2014

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	2.5166%	2.2322%	1.7984%	1.5140%
	(0.2289)	(0.1920)	(0.2912)	(0.2106)
Standard Chartered	-5.1792%**	-6.0457%***	-0.2617%	-1.1282%
	(0.0123)	(0.0004)	(0.8758)	(0.3429)
HSBC	-0.4550%	0.7778%	-0.4644%	0.7684%
	(0.7213)	(0.4561)	(0.6550)	(0.2978)
Santander	0.6352%	0.6259%	0.4405%	0.4312%
	(0.7563)	(0.7085)	(0.7917)	(0.7156)
Barclays	7.0928%***	7.8126%***	6.3291%***	7.0489%***
	(0.0027)	(0.0001)	(0.0010)	(0.0000)
RBS	5.0819%*	6.3288%***	3.7824%	5.0294%***
	(0.0885)	(0.0097)	(0.1195)	(0.0037)
Portfolio (6 securities)	1.6806%*	2.0174%***	1.9809%***	2.3177%***
	(0.0609)	(0.0061)	(0.0069)	(0.0000)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.6: Event Study Results - 19 February 2016

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	0.1415%	-0.6594%	0.0982%	-0.7027%
	(0.9420)	(0.6774)	(0.9506)	(0.5297)
Standard Chartered	-2.2242%	-5.4420%**	2.1601%	-1.0577%
	(0.5043)	(0.0458)	(0.4266)	(0.5808)
HSBC	-2.8832%*	-0.3773%	-1.8672%	0.6388%
	(0.0771)	(0.7760)	(0.1601)	(0.4948)
Santander	-2.9159%	-5.9567%***	0.3813%	-2.6595%*
	(0.2823)	(0.0074)	(0.8630)	(0.0887)
Barclays	-2.1193%	-2.4095%	0.7762%	0.4860%
	(0.3144)	(0.1610)	(0.6512)	(0.6881)
RBS	-5.0440%**	-3.1793%*	-3.7433%**	-1.8786%
	(0.0255)	(0.0836)	(0.0420)	(0.1469)
Portfolio (6 securities)	-2.4653%**	-2.9856%***	-0.3349%	-0.8553%
	(0.0121)	(0.0002)	(0.6741)	(0.1286)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.7: Event Study Results - 29 March 2016

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	-1.9733%	-0.0961%	-2.1243%	-0.2471%
	(0.3960)	(0.9596)	(0.2635)	(0.8533)
Standard Chartered	-0.6917%	-5.7695%**	4.7129%	-0.3649%
	(0.8459)	(0.0476)	(0.1057)	(0.8585)
HSBC	-2.8469%*	-2.0891%	-2.2676%*	-1.5097%
	(0.0786)	(0.1133)	(0.0862)	(0.1047)
Santander	-3.9000%	-2.6730%	-3.2233%	-1.9963%
	(0.1867)	(0.2669)	(0.1815)	(0.2397)
Barclays	-3.2559%	-1.6876%	-2.7411%	-1.1728%
	(0.1859)	(0.4001)	(0.1728)	(0.4069)
RBS	-2.0036%	-1.7350%	-1.6367%	-1.3682%
	(0.4081)	(0.3799)	(0.4081)	(0.3262)
Portfolios (6 securities)	-2.3971%**	-2.3222%***	-1.1828%	-1.1079%*
	(0.0258)	(0.0082)	(0.1769)	(0.0728)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table B.8: Event Study Results - 25 September 2017

SECURITY	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
Lloyds	-4.1747%**	-2.8637%*	-2.9770%*	-1.6661%
	(0.0453)	(0.0919)	(0.0794)	(0.1637)
Standard Chartered	-3.1059%	-3.4265%*	-1.5090%	-1.8296%
	(0.2195)	(0.0972)	(0.4636)	(0.2084)
HSBC	-1.0758%	-0.9070%	-1.1431%	-0.9743%
	(0.5529)	(0.5396)	(0.4391)	(0.3501)
Santander	-2.2195%	-1.9488%	-2.6206%	-2.3499%
	(0.4030)	(0.3680)	(0.2259)	(0.1242)
Barclays	-1.6789%	-1.1005%	-1.6448%	-1.0664%
	(0.5118)	(0.5980)	(0.4303)	(0.4686)
RBS	-0.1251%	-0.3086%	-0.3058%	-0.4892%
	(0.9680)	(0.9034)	(0.9041)	(0.7848)
Portfolios (6 securities)	-2.0571%**	-1.7545%**	-1.6967%**	-1.3940%**
	(0.0440)	(0.0353)	(0.0415)	(0.0178)

Notes: This table presents the cumulative abnormal returns of each individual bank stock following a macroprudential policy announcement, as well as the CAAR of an equally-weighted portfolio that contains these 6 securities. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

B.2 Additional event study results

We extend our event studies in 2 dimensions. First, we assess whether in addition to the abnormal equity returns our macroprudential policy events also generated an abnormal trading volume response. We do this because existing literature concludes that trading volumes spike up if new disclosure of information affects investors' prior beliefs. Second, as a robustness check to ensure that the abnormal equity returns we obtained in Table 1 only apply to banks and no other company that is not PRA-regulated, we compute abnormal stock returns for 6 LSE-listed pharmaceutical companies. This exercise could be thought of as a counterfactual experiment.

Abnormal Trading Volumes: Analogously to abnormal stock returns, we measure abnormal volumes as deviations of trading volumes in the event window compared to ‘normal times.

$$AV_{i,t} = Volume_{i,t} - \overline{Volume_{i,t}} \tag{11}$$

where $Volume_{i,t}$ is the number of shares of bank i traded on day t divided by the number of outstanding free-floating shares and $\overline{Volume_{i,t}}$ is the average of Volume for firm i over the estimation window (-261, -2) associated with each macroprudential policy announcement. We proceed by calculating abnormal volumes over the event window in a similar fashion to equations (2) and (3) and test their significance under the normality assumption.

Abnormal equity returns for pharmaceutical companies: As a counterpart to our bank CAAR, we assess whether a non-PRA regulated group of LSE-listed companies is similarly affected by the macroprudential policy announcements that we study. The companies that we select for this counterfactual exercise are the top 6 pharmaceutical companies in the UK by market capitalization.[29] Since they are not subject to micro-and-macroprudential regulatory requirements, these companies should not react similarly to banking shares on the day of the macroprudential policy announcements.

Table B.9 shows that the majority of the macroprudential policy events were met by an increase in trading activity. However these results are statistically significant for only two of our macroprudential policy event dates.[30] In line with our conjecture, the last column of Table B.9 shows that pharmaceutical companies did not react in a similar fashion to Banks following macroprudential policy announcements.[31]

[29]These companies include GlaxoSmithKline, Astrazeneca, Sinclair Pharma, Hikma Pharmaceuticals, Dechra Pharmaceuticals PLC and Vectura Group PLC.

[30]We think that the lack of statistical significance for other events could be an outcome of the specification chosen in equation (7). We are working on a different market model specification.

[31]The two significant CAARs with respect to Pharmaceuticals go in the opposite direction of Bank CAARs.

Table B.9: Cumulative average abnormal values for different macroprudential policy events

Date	Event	Bank returns [-1,1]	Volumes [-1,1]	CDS spreads [-1,1]	Pharma returns [-1,1]
16 Dec 2010	Basel III	-4.3326%***	-0.0287%		-0.8756%
		(0.0020)	(0.7420)		(0.4565)
04 Nov 2011	G-SII Buffers	-2.9975%**	0.0392%	1.8670%	1.2458%
		(0.0391)	(0.4923)	(0.6106)	(0.2426)
27 Jun 2013	CRD IV	-2.7029%**	0.0460%	-7.7589%***	0.9539%
		(0.0319)	(0.5597)	(0.0024)	(0.2856)
27 Oct 2014	EBA Stress Testing	-3.1828%***	0.1861%***	-2.0662%	0.6863%
		(0.0003)	(0.0010)	(0.3852)	(0.5065)
31 Oct 2014	Leverage ratio	1.6806%*	0.4790%***	0.9541%	-0.5058%
		(0.0609)	(0.0000)	(0.6901)	(0.6272)
19 Feb 2016	O-SII Methodology + SSM	-2.4653%**	0.0266%	4.3065%	1.9874%**
		(0.0121)	(0.8105)	(0.1113)	(0.0447)
29 Mar 2016	CCyB	-2.3971%**	0.0431%	0.9544%	1.4996%
		(0.0258)	(0.6987)	(0.7324)	(0.1373)
25 Sep 2017	PRA Buffer	-2.0571%**	-0.1874%**	4.3234%**	2.0776%**
		(0.0440)	(0.0308)	(0.0221)	(0.0381)

Notes: This table presents the cumulative average abnormal values from a portfolio of the 6 largest LSE-listed banks, following a macroprudential policy announcement. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

B.3 Event study robustness

Table B.10: Event studies under Fama-French 3 Factor Model

Date	Event	CAAR[-1,1]	CAAR[-1,0]	CAAR[0,1]	CAAR[0,0]
16 Dec 2010	Basel III	-3.9001%***	-1.2701%	-2.7253%***	-0.0953%
		(0.0020)	(0.0251)	(0.2140)	(0.8949)
04 Nov 2011	G-SII Buffers	-1.8824%	-0.8685%	-1.1039%	-0.0899%
		(0.1489)	(0.4141)	(0.2994)	(0.9048)
27 Jun 2013	CRD IV	-2.4214%**	-1.8176%**	-2.6157%***	-2.0120%***
		(0.0326)	(0.0494)	(0.0048)	(0.0022)
27 Oct 2014	PRA PS + EBA Stress Test	-2.8295%***	-3.8655%***	-3.4751%***	-1.5401%***
		(0.0007)	(0.0007)	(0.0000)	(0.0014)
31 Oct 2014	Leverage ratio	1.4602%*	1.4602%*	1.7403%**	1.9692%***
		(0.0852)	(0.0852)	(0.0123)	(0.0001)
19 Feb 2016	O-SII Methodology + SSM	-3.3029%***	-2.9803%***	0.1574%	-0.8606%
		(0.0129)	(0.0000)	(0.8330)	(0.1038)
29 Mar 2016	CCyB	-2.1497%**	-2.0447%**	-0.9899%	-0.8848%
		(0.0333)	(0.0133)	(0.2285)	(0.1283)
25 Sep 2017	PRA Buffer	-1.6744%*	-1.5180%**	-1.4225%*	-1.2662%**
		(0.0676)	(0.0425)	(0.0572)	(0.0169)

Notes: This table presents the cumulative average abnormal returns (CAAR) from a portfolio of the 6 largest LSE-listed banks, following a macroprudential policy announcement.The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively. The event study results for 04 Nov 2011 are statistically significant at the 1% significance level under a Wilcoxon test (1954) test (not shown here).

Table B.11: Event studies with different estimation windows

Date	Event	(1)	(2)	(3)
16 Dec 2010	Basel III	-4.3326%***	-4.1918%***	-3.6734%***
		(0.0020)	(0.0009)	(0.0014)
04 Nov 2011	G-SII Buffers	-2.9975%**	-2.9128%*	-3.0544%*
		(0.0391)	(0.0721)	(0.0829)
27 Jun 2013	CRD IV	-2.7029%**	-1.9763%*	-1.8976%
		(0.0319)	(0.0865)	(0.1016)
27 Oct 2014	PRA PS + EBA Stress Test	-3.1828%***	-3.3330%***	-3.3623%***
		(0.0003)	(0.0002)	(0.0002)
31 Oct 2014	Leverage ratio	1.6806%*	1.5363%*	1.4556%
		(0.0609)	(0.0683)	(0.1033)
19 Feb 2016	O-SII Methodology + SSM	-2.4653%**	-2.2122%**	-1.8855%*
		(0.0121)	(0.0203)	(0.0785)
29 Mar 2016	CCyB	-2.3971%**	-2.0829%*	-2.1717%
		(0.0258)	(0.0683)	(0.1085)
25 Sep 2017	PRA Buffer	-2.0571%**	-1.8545%*	-1.6151%*
		(0.0440)	(0.0519)	(0.0569)

Notes: This table presents the cumulative average abnormal returns (CAAR) from a portfolio of the 6 largest LSE-listed banks, following a macroprudential policy announcement, with an event window (-1,1). The estimation windows are (-261, -2), (-120, -30), (-90, -30) in columns (1), (2) and (3) respectively. p-values in parenthesis are obtained under the normality assumption. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively. The results in column (3) become statistically significant when changing the event window to (0,1) for the announcements of 27 Jun 2013 and 31 Oct 2014 and (-1,0) for the CCyB announcement of 29 Mar 2016 (not shown here).

Table B.12: Event studies with different test diagnostics

Date	Event	(1)	(2)	(3)	(4)	(5)
16 Dec 2010	Basel III	-4.3326%***	-4.3326%***	-4.3326%***	-4.3326%**	-4.3326%**
		(0.0020)	(0.0022)	(0.0000)	(0.0277)	(0.0170)
04 Nov 2011	G-SII Buffers	-2.9975%**	-2.9975%**	-2.9975%***	-2.9975%**	-2.9975%**
		(0.0391)	(0.0284)	(0.0000)	(0.0277)	(0.0214)
27 Jun 2013	CRD IV	-2.7029%**	-2.7029%**	-2.7029%***	-2.7029%**	-2.7029%*
		(0.0319)	(0.0365)	(0.0020)	(0.0277)	(0.0906)
27 Oct 2014	PRA PS + EBA Stress Test	-3.1828%***	-3.1828%***	-3.1828%**	-3.1828%**	-3.1828%
		(0.0003)	(0.0000)	(0.0159)	(0.0277)	(0.1080)
31 Oct 2014	Leverage ratio	1.6806%*	1.6806%	1.6806%	1.6806%***	1.6806%
		(0.0609)	(0.1697)	(0.4704)	(0.0000)	(0.5295)
19 Feb 2016	O-SII Methodology + SSM	-2.4653%**	-2.4653%***	-2.4653%***	-2.4653%***	-2.4653%*
		(0.0121)	(0.0064)	(0.0008)	(0.0000)	(0.0613)
29 Mar 2016	CCyB	-2.3971%**	-2.3971%**	-2.3971%***	-2.3971%**	-2.3971%**
		(0.0258)	(0.0105)	(0.0000)	(0.0277)	(0.0230)
25 Sep 2017	PRA Buffer	-2.0571%**	-2.0571%**	-2.0571%***	-2.0571%**	-2.0571%*
		(0.0440)	(0.0289)	(0.0011)	(0.0277)	(0.0917)

Notes: This table presents the cumulative average abnormal returns (CAAR) from a portfolio of the 6 largest LSE-listed banks, following a macroprudential policy announcement. The estimation window is chosen to be (-261, -2). p-values in parenthesis are obtained under the normality assumption in column (1). p values in Columns (2), (3), (4) and (5) are obtained under a Patell (1976), Boehmer, Musumeci and Poulsen (1991), Wilcoxon (1945) and a GRANK test diagnostic, respectively. *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

B.4 Institutional Background to the Macroprudential Policy Events

16 December 2010: Publication of Basel III.

This document represents the initial phase of the Basel III reforms, which focused on strengthening the existing regulatory framework. The new rules proposed higher levels of capital requirements and enhanced risk capture by revising risk-weights to accurately reflect market risk, credit risk and securitisation. Additionally, new macroprudential instruments such as the countercyclical capital buffer and leverage ratio were added. This event was covered by major financial news sources. Article by Dow Jones News Wires has the headline: "Banks Need Extra EUR577B Capital Under Basel III". This rough-and-ready estimate is derived from a comprehensive impact study by the BIS, based on results from 263 of the world's largest banks, and represents the first time that the BIS has put a price on its new minimum capital requirements. At the same time, the BIS published final, official texts of its new rules on liquidity, which analysts said hinted at some worrying deficiencies at some banks, especially in Europe.

4 November 2011: G-SII assessment and additional loss absorbency requirement.

At the Cannes Summit, the G20 Leaders endorsed the implementation of an integrated set of policy measures to address the risks to the global financial system from systemically important financial institutions (SIFIs), and the timeline for implementation of these measures. The list of initial UK Banks required to hold additional buffers includes the Royal Bank of Scotland

PLC (RBS), Lloyds Banking Group PLC (LLOY.LN), Barclays PLC (BCS) and HSBC Holdings PLC (HBC). Article by Dow Jones News Wires reported that from banks' perspectives, the surcharges would restrict their ability to lend to the economy, as well as distort competition with their rivals.

26-27 June 2013: BoE affordability test + CRD IV
The BoE said in its biannual financial-stability report on the 26th of June 2013 that it has asked Britain's finance-sector supervisors to report back in September with an assessment of the vulnerability of borrowers and financial firms to any sharp increases in borrowing costs. Additionally, on the same day Wall Street Journal reported that BoE's governor at the time (Sir Mervin King) accused senior British politicians of inappropriately lobbying regulators on behalf of banks that were trying to water down stringent capital requirements. We view both of these announcements as indicative of a tightening macroprudential policy stance.

On the 27th of June 2013 the Capital Requirements Directive IV, which covers prudential rules for banks, building societies and investment firms was published in the official journal of the European Union. Additionally, on the same day a final agreement on bail-in rules were agreed by EU finance ministers. The new rules were designed to force shareholders, bondholders and some depositors to contribute to the costs of bank failure. Insured deposits under €100,000 were exempt and uninsured deposits of individuals and small companies were given preferential status in the bail-in pecking order. Moreover, on this day after many months of dispute, officials at the Fed, Federal Deposit Insurance Corp. and the Office of the Comptroller of the Currency agreed to increase US banks' leverage ratios and comply with Basel III rules. To the extent that prudential regulation tends to be internationally coordinated, we think of these announcements as 'tightening' macroprudential policy events.

27 October 2014: EBA Stress Test Results.
On this day, 24 out of 123 financial institutions subjected to stress tests failed to meet the threshold for a 5.5% capital buffer under an exercise by the European Banking Authority on how they would cope in the event of a crisis. Lloyds Banking Group barely passed this test and had the weakest score in the group of 30 biggest European Union banks by market capitalisation. Financial news sources revealed that the test's assessment did not account for overall level of bank borrowing, which was likely to come to focus later on that week with Bank of England's imposition of a new leverage ratio. Huw Pill, chief economist at Goldman Sachs, said: "The market is now thinking about capital in a fully-loaded Basel III way. This is a process that has a log way to go - there are a broad range of banks that still need to raise capital as a result in order to meet those requirements".

31 October 2014: Bank of England: Increase in the leverage ratio requirement.

On this day the Bank of England proposed an increase in the leverage ratio requirement for UK banks, to 4.05% by 2019. However, an article by Wall Street Journal suggests that this increase was smaller than expected. Analysts doubted the new rules would have a significant impact on banks' operations or the supply of loans to the UK economy as most banks' leverage ratios would meet their new requirement by the following year, according to estimates from Credit Suisse. Additionally, analysts from Citigroup said "The majority of UK banks already satisfy this requirement". Barclays PLC, which was viewed as the most vulnerable to an increase in the leverage ratio, said it was 'very confident' it would exceed the requirements set out with its existing plans.

19 February 2016: SSM: Europe's banks ordered to boost capital.
The Single Supervisory Mechanism (SSM), established in late 2014 as part of Europe's efforts to head off its debt crisis, warned in a report that the overall risk for the roughly 130 large eurozone banks it supervises have 'not decreased compared to 2014'. The eurozone banks need to boost their core tier 1 capital ratios by 0.5% from last year and set aside an additional 0.2% of capital as buffer against the risk posed by systemically important institutions. The report showed that five banks did not have enough capital to meet the current requirements, including one that fell significantly short. It did not name the banks. Additionally, the PRA published a policy statement which detailed the approach to identifying and designating as O-SIIs those firms whose distress or failure would have a systemic impact on the UK or the EU economy or financial system due to size, importance (including substitutability or financial system infrastructure), complexity, cross-border activity, and interconnectedness.

29 March 2016: Bank of England : CCyB increases from 0% to 0.5%.
The Bank of England published a set of proposals on buy-to-let lending following a review of the sector by its supervisory arm, the Prudential Regulation Authority. The proposed new rules would require lenders to put would-be-buy-to-let borrowers through income checks and to test whether they could still afford repayments at higher interest rates. "The proposals aim to prevent a marked loosening in buy-to-let underwriting standards and to curtain inappropriate lending for excessive credit losses". Additionally, the Financial Policy Committee of the Bank of England judged that the outlook for financial stability in the United Kingdom had deteriorated since it last met in November 2015. Consistent with the Committee's assessment of the risk environment at the time, and its intention to move gradually, the Committee decided to increase the UK countercyclical capital buffer rate from 0% to 0.5% of risk-weighted assets and raise the bar for banks to pass its annual stress test.

25 September 2017: Bank of England: Increase in PRA Buffers.
The Bank of England warned banks on Monday that they had been too lax in provisioning for potential losses on consumer credit and should increase their capital buffers by £10bn to

protect themselves. This warning was part of a fuller assessment of bank risks, which the BoE was going to publish on Nov. 28. Because the level of consumer debt and its riskiness varies across UK lenders, the BoE did not increase aggregate capital buffers but said it would raise the level of capital individual banks need in November when it publishes its annual stress tests. The extra 10 billion pounds is small in the context of the 280 billion pounds of core capital held by British lenders, but the BoE said it expected banks to take the greater risks into account in their future lending plans. In the same announcement the BoE said it still intended to raise a separate counter-cyclical risk buffer to 1 percent in November from 0.5 percent.

B.5 Can macro-financial conditions forecast macroprudential policy shocks?

Table B.13: Unpredictability of the macroprudential policy shock series

	(1) MaP shock	(2) MaP shock	(3) MaP shock
Lagged changes in systemic risk			
One-day effect	-.0324	-.0032	.0047
	(.0236)	(.0049)	(.0031)
Two-day effect	-.0156	-.0038	.0022
	(.0084)	(.0039)	(.0033)
Five-day effect	-.0038	0.0000	.0013
	(.0068)	(.0020)	(.0034)
Ten-day effect	.0022	.0016	0.000
	(.0037)	(.0016)	(.0016)
Twenty-day effect	.001	-.0003	-.0002
	(.0026)	(.0016)	(.0011)
Thirty-day effect	.0018	.0006	-.0026
	(.0023)	(.0019)	(.0018)
Forty-day effect	.0028	.0015	.0005
	(.0028)	(.0013)	(.0014)
Fifty-day effect	.0029	.0019	-.0002
	(.0017)	(.0013)	(.0013)
Sixty-day effect	.0029	.0017	.0003
	(.0018)	(.0011)	(.0013)
Controls	Yes	Yes	Yes

Notes: In line with the local projection methods, each horizon is estimated separately, the outcome of which is presented in a separate row. The dependent variable in all 3 columns is the macroprudential policy shock. The independent variables in columns (1), (2) and (3) are the standardised differences in CISS, MES and VIX respectively, over the horizons considered. Controls include one-day lags of the daily differences in the 1 year and 10 year gilts, euro/pound and dollar/pound exchange rate and the economic policy index by Baker et al. (2016). Standard errors in parentheses were obtained using robust standard errors.

C The effect of macroprudential policy shocks on systemic risk

C.1 Marginal Expected Shortfall

A commonly used approach to modelling systemic risk in the banking sector is the Marginal Expected Shortfall (MES) by Acharya et al. (2017). MES measures an individual bank's marginal contribution to the overall tail risk in the banking system. Formally, the MES of a financial institution represents the expected equity loss of a bank's stock price conditional on a large shock to the financial system (what is known as a tail event). First, following Brownlees and Engle (2010) the bivariate process of bank and market returns is represented by:

$$r_{i,t} = \sigma_{i,t}\rho_{i,t}\varepsilon_{m,t} + \sigma_{i,t}\sqrt{1-\rho_{i,t}^2}\varepsilon_{i,t} \quad (12)$$

$$r_{m,t} = \sigma_{m,t}\varepsilon_{m,t} \quad (13)$$

where $r_{i,t}$ and $r_{m,t}$ are the individual bank and market return, respectively.[32] $\sigma_{m,t}$ and $\sigma_{i,t}$ are volatilities of the market and the bank i at time t, respectively. $\rho_{i,t}$ is the correlation between $r_{i,t}$ and $r_{m,t}$ at time t. The disturbances $(\varepsilon_{m,t}, \varepsilon_{i,t})$ are assumed to be iid with mean zero and unit variance. The MES can be written more explicitly as a function of correlation, volatility and the tail expectations of the standardised innovations distributions:

$$MES_{i,t} = E_{t-1}(r_{i,t}|r_{m,t} < C) \quad (14)$$

$$MES_{i,t} = \sigma_{i,t}\rho_{i,t}\underset{t-1}{\mathbb{E}}\left(\varepsilon_{m,t}|\varepsilon_{m,t} < \frac{C}{\sigma_m, t}\right) + \sigma_{i,t}\sqrt{1-\rho_{i,t}^2}E_{t-1}\left(\varepsilon_{i,t}|\varepsilon_{m,t} < \frac{C}{\sigma_{m,t}}\right) \quad (15)$$

In line with Acharya et al. (2017), we set the threshold C that defines a crisis such that $Pr(r_{m,t} < C_{0.05}) = 0.05$. In other words, C represents the **most** the market as a whole stands to lose with confidence 95%. If we assume $\varepsilon_{i,t}$ and $\varepsilon_{i,t}$ are iid at time t, MES becomes equivalent to:

$$MES_{i,t} = \frac{\sigma_{i,t}}{\sigma_{m,t}}\rho_{i,t}E_{t-1}(r_{m,t}|r_{m,t} < C) \quad (16)$$

$$MES_{i,t} = \frac{\sigma_{i,t}}{\sigma_{m,t}}\rho_{i,t}ES_{m,t} \quad (17)$$

where $E_{m,t}$ denotes the Expected Shortfall of the market and reflects the expected loss of the market when the market experiences a shock greater than the threshold C. We can see that

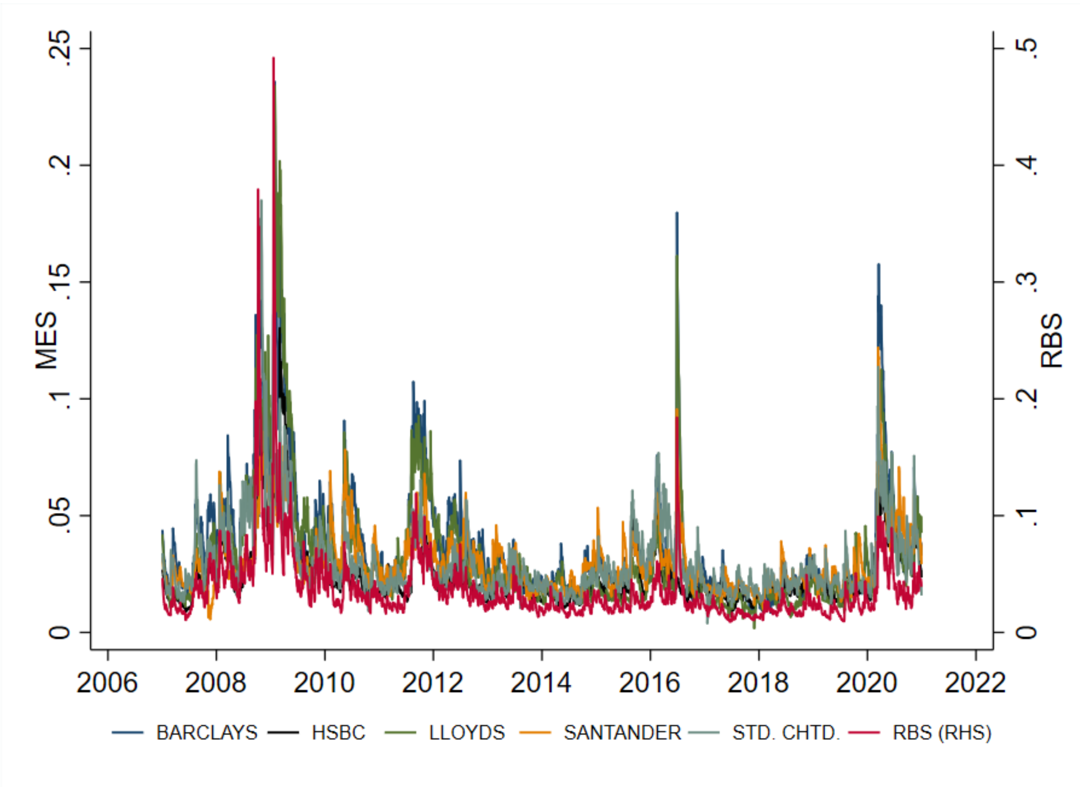
[32] In line with Gregory et al. (2013) we use the daily returns on FTSE All Share to approximate the market returns in the UK.

the MES is proportional to the tail $\beta_{i,t}$:

$$MES_{i,t} = \beta_{i,t} ES_{m,t} \tag{18}$$

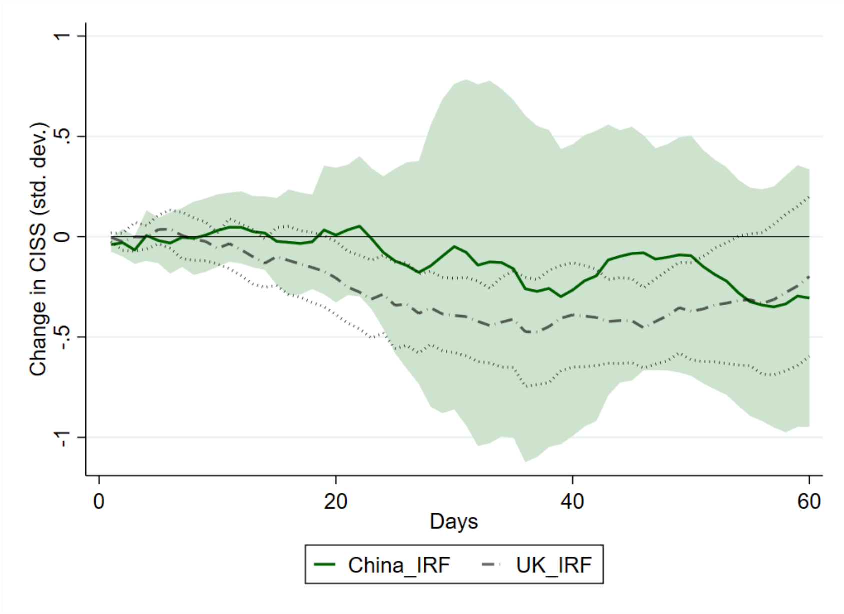
where $\beta_{i,t} = \frac{Cov(r_{i,t})}{Var(r_{m,t}} = \rho_{i,t}\frac{\sigma_{i,t}}{\sigma_{m,t}}$ denotes the time-varying conditional beta for bank i at time t and ES_t is the expected shortfall of the market. The expected shortfall of the return on the financial system is invariant across banks i which implies that the dispersion in MES can be only attributed to cross-sectional differences in $\beta_{i,t}$. We proceed by computing the MES measure for each of the 6 individual banks in our analysis.[33] Figure A.2. plots the MES for six UK-listed banks in our analysis. MES spikes in times of well-known financial stress periods such as the Great Financial Crisis, the European Sovereign Debt crisis, Brexit and more recently the Covid-19 crisis.

Figure C.1: Marginal Expected Shortfall by Bank



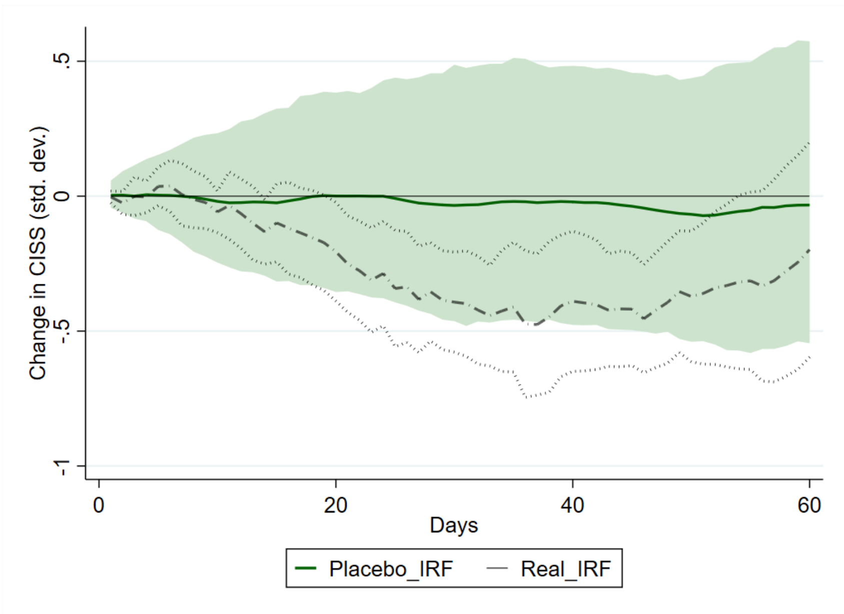
[33]To construct the series of the time-varying conditional betas, the expected shortfall of the market and the marginal expected shortfall for each of the banks in our analysis, we make use of the systemic risk toolbox by Tomasso Belluzo (2022). See `www.mathworks.com/matlabcentral/fileexchange/62482-systemic-risk` for more detail.

Figure C.2: The effect of UK macroprudential policies on systemic risk in China



Notes: In line with the local projection methods, each horizon is estimated separately. The green solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h CISS^{China}$, over the horizons considered. The independent variable is ΔMaP^{shock}. The light green shaded area denotes the 95% confidence interval around point estimates constructed with robust standard errors. The gray solid line denotes the $\{\beta^h\}_{h=1}^{60}$ estimates with $\Delta_h CISS^{UK}$ as a dependent variable. Area bound by the gray dotted lines is the corresponding 95% confidence interval.

Figure C.3: The effect of a placebo treatment on systemic risk



Notes: In line with the local projection methods, each horizon is estimated separately. The green solid line represents the $\{\beta^h\}_{h=1}^{60}$ estimates in standard deviation units. The dependent variable is $\Delta_h CISS^{UK}$, over the horizons considered. The independent variable is ΔMaP^{Placebo}. The light green shaded area denotes the 95% confidence intervals around point estimates. The gray solid line denotes the $\{\beta^h\}_{h=1}^{60}$ estimates with ΔMaP^{shock} as an independent variable. Area bound by the gray dotted lines is the corresponding 95% confidence interval.

Table C.1: Robustness with respect to macroprudential policy shock outliers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	h = 1	h = 5	h = 10	h = 15	h = 20	h = 25	h =30	h = 35	h = 40	h = 45	h =50	h = 55	h = 60
Full sample	-0.000444	0.00545	-0.00882	-0.0150	-0.0312*	-0.0519**	-0.0595***	-0.0623***	-0.0591**	-0.0635***	-0.0563**	-0.0476	-0.0300
	(0.00169)	(0.00548)	(0.00596)	(0.0112)	(0.0141)	(0.0167)	(0.0143)	(0.0186)	(0.0201)	(0.0162)	(0.0187)	(0.0254)	(0.0308)
Excl. 16 Dec 2010	-0.00115	0.00983	-0.00725	-0.0185	-0.0359*	-0.0580**	-0.0688***	-0.0701***	-0.0627**	-0.0656***	-0.0608**	-0.0496	-0.0393
	(0.00159)	(0.00550)	(0.00661)	(0.0122)	(0.0153)	(0.0180)	(0.0147)	(0.0203)	(0.0230)	(0.0188)	(0.0214)	(0.0290)	(0.0336)
Excl. 4 Nov 2011	0.000586	0.00431	-0.0105	-0.0226*	-0.0318*	-0.0483**	-0.0607***	-0.0559**	-0.0479**	-0.0526***	-0.0404**	-0.0267	-0.00569
	(0.00167)	(0.00627)	(0.00600)	(0.0103)	(0.0156)	(0.0172)	(0.0157)	(0.0192)	(0.0185)	(0.0125)	(0.0133)	(0.0198)	(0.0272)
Excl. 27 June 2013	-0.000447	0.00513	-0.00491	-0.00412	-0.0155	-0.0398*	-0.0481***	-0.0527**	-0.0505*	-0.0574***	-0.0510*	-0.0410	-0.0200
	(0.00195)	(0.00642)	(0.00694)	(0.00995)	(0.00950)	(0.0166)	(0.0128)	(0.0192)	(0.0212)	(0.0172)	(0.0209)	(0.0280)	(0.0337)
Excl 27 October 2014	-0.00105	0.00776	-0.00238	-0.00517	-0.0213	-0.0418	-0.0496**	-0.0632***	-0.0609**	-0.0598**	-0.0575**	-0.0474	-0.0295
	(0.00188)	(0.00563)	(0.00836)	(0.0133)	(0.0180)	(0.0228)	(0.0168)	(0.0168)	(0.0218)	(0.0194)	(0.0198)	(0.0285)	(0.0343)
Excl. 31 October 2014	-0.000715	0.00515	-0.0130*	-0.0187	-0.0341*	-0.0571**	-0.0559***	-0.0553**	-0.0589**	-0.0630***	-0.0543**	-0.0504	-0.0385
	(0.00180)	(0.00552)	(0.00539)	(0.0122)	(0.0154)	(0.0176)	(0.0157)	(0.0199)	(0.0227)	(0.0185)	(0.0210)	(0.0284)	(0.0334)
Excl. 19 Feb 2016	-0.000671	0.00265	-0.00967	-0.0157	-0.0347*	-0.0453**	-0.0567***	-0.0559**	-0.0493*	-0.0604***	-0.0559**	-0.0411	-0.0218
	(0.00177)	(0.00488)	(0.00539)	(0.0121)	(0.0147)	(0.0152)	(0.0144)	(0.0191)	(0.0218)	(0.0178)	(0.0200)	(0.0280)	(0.0349)
Excl. 29 March 2016	-0.000832	0.00115	-0.0134**	-0.0194	-0.0406**	-0.0639***	-0.0645***	-0.0673**	-0.0681**	-0.0748***	-0.0656**	-0.0739***	-0.0620**
	(0.00185)	(0.00493)	(0.00502)	(0.0119)	(0.0137)	(0.0154)	(0.0153)	(0.0205)	(0.0212)	(0.0154)	(0.0205)	(0.0210)	(0.0238)
Excl. 25 Sep 2017	-0.000108	0.00720	-0.00849	-0.0151	-0.0330*	-0.0566**	-0.0667***	-0.0691**	-0.0648**	-0.0693***	-0.0633**	-0.0508	-0.0288
	(0.00199)	(0.00635)	(0.00675)	(0.0127)	(0.0160)	(0.0186)	(0.0157)	(0.0214)	(0.0229)	(0.0179)	(0.0209)	(0.0285)	(0.0349)
Observations	2748	2744	2739	2734	2729	2724	2719	2714	2709	2704	2699	2694	2689

Notes: In line with local projection methods, each horizon is estimated separately, the outcome of which is presented in a separate column. The dependent variable is $\Delta_h CISS^{UK}$ over the horizons considered. The independent variable is $\Delta \text{MaP}^{shock}$. Standard errors in parentheses were obtained with robust standard errors. The asterisks denote statistical significance (*** for p < 0.001, ** for p < 0.01, * for p < 0.05).