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Temi di discussione

(Working Papers)

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Number 1201 - November 2018

ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

Printed by the Printing and Publishing Division of the Bank of Italy

CONTAGION IN THE COCOS MARKET?
A CASE STUDY OF TWO STRESS EVENTS

by Pierluigi Bologna, Arianna Miglietta and Anatoli Segura*

Abstract

The post-crisis regulatory framework has fostered the development of the contingent convertible bonds (CoCos) market. These instruments permit banks to absorb losses as a going concern but their critics warn that they could have potentially destabilizing effects in stress situations. We analyse the dynamics of the European CoCos market during two stress episodes that occurred in 2016 and that were triggered by news of substantial unexpected losses faced by a European systemically important bank. Our econometric approach aims to disentangle the fundamental channel by which the contagion of such bank's distress spreads to the rest of the market from a possible CoCo-specific contagion channel. We find evidence of significant CoCo-specific contagion in the two stress episodes, which could be the result of investors' reassessment of the CoCos' riskiness or of uncertainty about their supervisory treatment. Moreover, we find that the CoCo-specific contagion was weaker in the second stress event, suggesting that as investors learn about the specific features of these instruments and their supervisory treatment the CoCos market becomes more resilient.

JEL Classification: G14, G21, G28.
Keywords: CoCos, Basel III, contagion.

Contents

1. Introduction 5
2. Related literature 7
3. The CoCos market and the two Deutsche Bank stress events 8
4. The transmission channels: fundamental and CoCo-specific contagion 13
5. Data 14
6. Empirical analysis 17
7. Further analysis and robustness 22
8. Conclusions and policy implications 30
References 32

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1. Introduction[1]

In the aftermath of the global financial crisis bank capital requirements have been significantly increased to enhance the resilience of the system. In a number of jurisdictions the new regulatory framework allows banks to satisfy part of the additional capital needs with contingent convertible bonds (CoCos). The CoCos are hybrid debt instruments that in adverse contingencies can be used to recapitalize the banks by writing down their principal or converting it into equity.[2] Such a privileged regulatory treatment has spurred the growth of the CoCos market, with 208 billion USD of global issuances between the first issuance in 2009 and September 2014 (Avdjiev et al., 2017).

The rationale for the introduction of CoCo bonds is related to their contingent debt-equity nature in two ways. First, they provide an equity injection when bank capital is needed and the bank is still in going concern, i.e. when the bank is close to a given (regulatory) threshold but still above the regulatory minima. Second, the debt feature, that prevails except in rare distress episodes, makes them appealing to both banks, as they carry a lower cost relative to equity, and fixed income investors. Defendants of CoCos argue that these two properties render these instruments optimal to increase the loss absorption capacity of banks without imposing an excessive burden on bank profitability that could in turn negatively affect lending to the real economy (Duffie, 2009; Squam Lake Working Group, 2009; Flannery, 2016; Vallee, 2015). CoCos may also be beneficial by inducing timely recapitalisation to avoid costly dilution of profits or loss of control (Pennacchi, 2011; Calomiris and Herring, 2013). However, these arguments are by no means shared by all academics and practitioners. Sceptics in fact argue that the double nature of CoCos introduces complexity and uncertainty that, should a CoCo be on the eve of conversion, may prove destabilizing for the issuer bank and could spillover to the rest of the market (Goodhart, 2010; Admati et al., 2013; Allen, 2012).

In this paper we shed light on the potential destabilising effect of these securities by focusing on two stress periods experienced by Deutsche Bank (DB) during 2016, that created significant concerns on the value of its 4.6 billion EUR CoCo issuances. The two stress periods, that started in January and September 2016 respectively and lasted for a few weeks each, were initially triggered by announcements of substantial legal costs to be faced by DB. During the two events the yield-to-maturity (YTM) of DB's senior bonds and CoCos peaked to historical maxima. The unfolding of these events was accompanied by great concerns from practitioners and commentators about DB's CoCos, and in particular about both the possibility that their coupons would not be paid and that the supervisory authority could mandate their conversion.

[1]Pierluigi would like to dedicate this work to Giovanni Abbate, a true mentor. The paper has benefited from a number of useful discussions with Piergiorgio Alessandri, Antonio Bassanetti, Nicola Branzoli, Luisa Carpinelli, Francesco Corsello, Fabio Panetta, Tommaso Perez, Enrico Sette, and Luigi Federico Signorini. The views expressed are those of the authors and should not be attributed to the Bank of Italy or the Eurosystem.

[2]Avdjiev et al. (2013) provide a description of the main design elements of CoCos.

The CoCos issued by the most important European banks also experienced severe tensions, especially during the January episode when their average YTM attained historical maxima. In that event, the YTM of the senior bonds issued by the same European banks also increased, although the level remained relatively contained. These dynamics could be the result of the contagion from a systemically important institution such as DB to other banks through "fundamental channels" stemming from, e.g., the network of interbank exposures or the possibility of fire-sales. Yet, the "overreaction" of the CoCo market relative to the behaviour of the senior bond market suggests that, in addition to fundamental distress propagation, the CoCo market could have been further destabilized by a broad reassessment of the riskiness of these instruments, ignited by the specific problems of DB's CoCos. Such a CoCo-specific contagion is precisely the type of concern raised by sceptics on these instruments and was frequently emphasized by commentators of these events. Our analysis of the two DB stress periods attempts at identifying whether or not there has been a CoCo-specific contagion beyond any fundamental distress propagation. By doing so, we investigate the potential unintended financial stability effects of a regulatory regime that encourages banks to issue CoCos.

In our empirical analysis we regress the daily YTM of the CoCos of European banks (excluding DB) on i) the institutions' stock return and the YTM of their senior bonds; and on ii) the YTM of DB's CoCos and its interaction with a dummy for each of the two events. The first set of controls aims at capturing the extent to which the CoCos YTM can be explained by the bank fundamental variables such as its solvency risk (proxied by the YTM of the bank's senior bonds) and its expected profitability (proxied by the bank's equity return). These variables allow us to control for the fundamental contagion from DB during the two distress episodes, and our specification thus captures how such contagion may have affected also CoCo prices. The second set of controls aims at capturing whether any inter-dependence between the Cocos of DB and those of other banks increased due to a Coco-specific contagion when DB was under distress.

Our results show strong evidence across all specifications on the existence of a CoCo-specific contagion channel in the propagation of the distress of DB to the rest of the European banks in the two episodes, which supports CoCos sceptics' claim that these instruments might be a source of financial instability when negative shocks occur. Moreover, we find that the behaviour of the CoCos issued by riskier banks does not significantly differ from those issued by safer institutions, which further suggests the existence of non-fundamental factors affecting the CoCo market dynamics in the two episodes. Yet, when comparing the CoCo-specific contagion between the two DB's events, we find that its magnitude was significantly weaker during the September episode. Such enhanced market stability could be consistent with investors' learning on the specificities of CoCos along time. The clarification by the European Banking Authority (European Banking Authority, 2016b) and the European Central Bank (European Central Bank, 2016a) on the supervisory treatment of these instruments, in particular with regard to the conditions that may call for the suspension of coupon payments, is also likely to have played a role in stabilizing the CoCos market during the second stress period of DB. The weakening of a CoCo-specific contagion mechanism suggests that the potential destabilizing role of these securities – claimed by CoCos sceptics – might be only transitory and/or could have been mitigated by regulators' intervention, but we are probably not yet able to say the last word. Authorities should hence keep on monitoring the development of this market and its dynamics in situations of distress.

The rest of the paper proceeds as follows. Section 2 briefly recalls the literature related to this paper. Section 3 describes the regulatory treatment of CoCos, the market development, and the two DB distress events. Section 4 discusses the two transmission channels of contagion: a fundamental and a CoCo-specific one. Section 5 describes the data. Sections 6 present the empirical analysis. Section 7 conducts some further analysis and robustness exercises. Section 8 provides the policy implications of our findings and concludes.

2. Related Literature

Our paper belongs to a growing literature on CoCos starting with Flannery (2016) and Flannery (2005). The theoretical contributions initially dealt with how design features affect the valuation of these instruments (e.g. Posner, 2010; Pennacchi, 2011; Glasserman and Nouri, 2012). The possibility of multiple pricing equilibria for CoCos with market trigger and the ensuing manipulation incentives by the different stakeholders was uncovered in Sundaresan and Wang (2015), and subsequent contributions have identified design features that eliminate such pricing multiplicity (Calomiris and Herring, 2013; Pennacchi et al., 2014). Another strand of the theoretical literature has focused on how wealth transfers between the bank's stakeholders upon CoCo conversion may affect the ex-ante risk-taking decisions of the bank in a counter-productive way (Flannery, 2016; Hilscher and Raviv, 2014; Martynova and Perotti, 2018). Closer to the focus of our study, concerns that CoCos may not offer effective loss-absorption in times of distress have been raised by practitioners, academics and regulators (Pazarbasioglu et al., 2011; Delivorias, 2016).

The empirical literature on CoCos is scarce and has not addressed potential contagion problems associated with the conversion of these instruments. Berg and Kaserer (2015) investigate the impact of CoCos' issuances on banks' risk-taking using a sample of CoCo bonds issued by European banks over the period 2009-2013. The paper finds that some key-design features of CoCos, such as a too high conversion price lead the issuer bank to increase risk-taking. The literature has found mixed evidence on the effect of CoCos issuance on the riskiness of the issuer (Avdjiev et al., 2017; Goncharenko et al., 2017).

This paper is related also to the literature on contagion. The theoretical and empirical debate on what contagion means is far from conclusive, as emphasized by Pericoli and Sbracia (2003) and Forbes (2012). We interpret an increase in the comovement of CoCo prices after controlling for variations in the banks' fundamentals as evidence of CoCo-specific contagion. The notion of contagion as a transmission of shocks in excess of what can be explained by fundamentals is discussed in Claessens et al. (2001) and Forbes (2012), and has been adopted in the analysis by e.g., Calvo and Mendoza (2000), Bekaert et al. (2005) and Bekaert et al. (2014).

3. The CoCos market and the two Deutsche Bank stress events

3.1. CoCos market developments and regulatory treatment

The issuance of CoCos by European banks has grown steadily since the adoption of Basel III and its introduction in Europe by means of the Capital Requirements Directive IV (CRD IV) and the Capital Requirements Regulation (CRR).

Under Basel III, hybrid capital instruments, such as CoCos, are designed to absorb losses while the bank is still a going concern and are classified as Additional Tier 1 (AT1) capital. To qualify as AT1, CoCos must have, like common equity, a perpetual maturity and non-cumulative coupons, payable at the discretion of the issuer. They also need a loss-absorption trigger – activated when the CET1 capital ratio of the bank falls below a certain level – which allows the principal to be written down or converted to common equity without this event constituting a default of the issuer (Basel Committee for Banking Supervision, 2011). These features should enable to strengthen banks' capital position at a time when raising equity would otherwise be difficult.[3] Furthermore, allowing the issuer to miss coupon payments can reduce pressure on liquidity. Finally, in a resolution process, CoCos are senior only to common equity.

In the EU, the CRD IV and the CRR set the criteria for CoCos to qualify as AT1 capital. In addition to the above mentioned harmonized conditions, EU regulation requires i) the loss-absorption trigger in terms of CET1 not to be lower than 5.125 per cent of risk-weighted assets; and ii) the coupon distribution on CoCos to be conditional on the banks' meeting the Combined Buffer Requirement (CBR).[4] Should a bank not meet its CBR the amount of pay outs it can make in the form of dividends and coupon payments on AT1 instruments would be limited by the institution's Maximum Distributable Amount (MDA, CRD IV, Art. 141).

The favorable regulatory treatment of CoCos – combined with banks' need to strengthen their capital position during difficult market conditions for equity

[3] In addition to the automatic triggers, supervisory authorities can mandate the conversion or the write down of CoCos by discretionally activating the point of non-viability (PONV) triggers, if they believe that such action is necessary to prevent the bank from becoming insolvent (Delivorias, 2016).

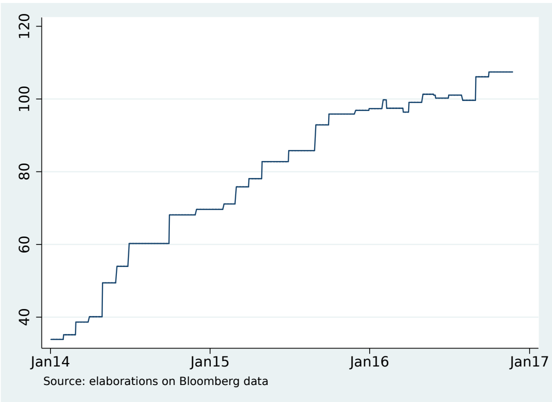
[4] According to Art. 128 of the CRDIV the CBR is the sum of the Capital conservation buffer requirement and, when applicable, the Countercyclical capital buffer requirement, the G-SII and O-SII buffer requirements, and the Systemic risk buffer requirement.

issuances[5] –, has spurred the development of the CoCos market in Europe. Based on Bank of America Merrill Lynch Contingent Capital Index (BAMLCCI), European banks have almost tripled their CoCo issuances, with the outstanding volume rising from 33.8 billion EUR to 107.4 billion EUR between January 2014 and November 2016 (Figure 1a).

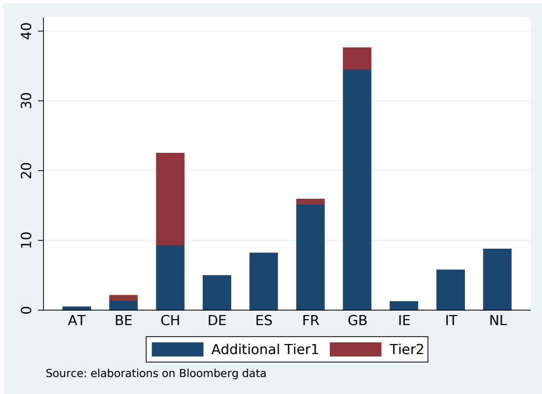
The regulatory incentive in the growth of CoCos is confirmed by the fact that the vast majority of issuances qualify as AT1 capital, with only a small fraction of the total eligible as Tier 2 capital (Figure 1b). It is also worth highlighting that the Tier 2 CoCos have mostly been issued in the early days of the new-born market well before the approval of Basel III.[6]

Figure 1: The market of Contingent Convertible Bonds (billion EUR)

(a) European banks CoCos outstanding issuances (January 2014 - November 2016)



(b) European banks CoCos outstanding by country and Basel III capital category (November 2016)



Despite this strong growth, towards the end of 2015 uncertainties emerged in the interpretation of the legal framework for the computation of the MDA trigger, i.e. the level of the capital requirements below which a bank would need to calculate the MDA and restrict its pay outs, including those on AT1 instruments. In particular, it was unclear whether the CBR would come in addition of the 8 % Pillar 1 minimum requirements only, or in addition of both the Pillar 1 and Pillar 2 requirements. To clarify this issue, in December 2015 the European Banking Authority (European Banking Authority, 2015) published an opinion in which it reaffirmed that both Pillar 1 and Pillar 2 requirements should be below the CBR when determining the MDA trigger. It was also recognized that, given the importance of the MDA trigger to investors in AT1 instruments, there should be full disclosure of the Pillar 2 requirements. In early 2016, the European Central Bank (2016b) endorsed the

[5]This has occurred in particular in the preparatory phase of the Single Supervisory Mechanism, with the Asset Quality Review completed in October 2014, and with its entry into force.

[6]The first CoCo was issued by Lloyds Banking Group in November 2009.

EBA opinion. Notwithstanding such a clarification, uncertainties yet remained, this time due to the possibility that some banks could have breached the MDA trigger not because of actual losses but rather because of potential losses arising from the adverse scenario of the supervisory stress test, that would have been carried out over the following months.

Issuances of CoCos abruptly halted in early 2016, contemporaneously to the first DB stress period analyzed in this paper.

3.2. The two Deutsche Bank stress events

In this section we discuss in more detail each of the two distress episodes experienced by DB in 2016.

Event 1

The first event took place at the beginning of 2016 after the announcement of negative earnings expectations for 2015 which came as a surprise for market participants.

On January 20, 2016 DB announced that it expected an extraordinary high net loss of about 6.7 billion EUR for 2015, due to unanticipated very high litigation charges and restructuring costs and to cyclical market conditions (which led in particular to a fall in revenues from the bank securities trading unit). When the news was published, DB's debt securities reacted negatively (Figures 2a and 2b). The situation worsened a few days later on January 28 when the CEO of DB, Mr. John Cryan, addressed a message to the bank's employees. In particular, he clarified that the yearly losses for 2015 (revised by then to 6.8 billion EUR) had been driven mainly by regulatory and litigation provisions (5.2 billion EUR) and impairments on goodwill and other intangible assets (5.8 billion EUR) while, differently from the previous announcement, little emphasis was given to the market conditions. The news about the loss, coupled with the uncertainty about the bank's capital position relative to the MDA trigger[7], raised dramatically the concerns on the capability of DB to meet the forthcoming payments on its CoCos (Glover, 2016). This in turn led the bank to take a number of initiatives to restore market confidence: on February 8, 2016, in a press release and in a message to the bank employees by the CFO of DB, Mr. Marcus Schenck, it was reaffirmed the bank cash availability to make the upcoming payments falling due on the CoCos.[8] Then on the following day another message to the employees was sent by the CEO who claimed that "Deutsche Bank remains absolutely rock-solid".[9] On February 12, 2016 the CFO announced a tender offer to

[7] The first CoCo was issued by Lloyds Banking Group in November 2009.

[8] $www.db.com/newsroom_news/2016/ir/deutsche-bank-publishes-updated-information-about-at1-payment-capacity-en-11391.htm$ and $www.db.com/newsroom_news/2016/ghp/a-message-from-marcus-schenck-deutsche-bank-s-additional-tier-1-at1-capital-en-11386.htm$

[9] $www.db.com/newsroom_news/2016/ghp/a-message-from-john-cryan-to-deutsche-bank-employees-0902-en-11392.htm$

buy back in the market some of the bank senior unsecured debt "taking advantage of market conditions to repurchase this debt, lowering its debt burden at attractive prices" and with "no impact on the bank's capacity to service coupons on its AT1 capital".[10] The buy-back operation was clearly aimed at proving the soundness of the bank to the markets. On February 29, 2016, the CFO announced the success of the operation, which was welcomed by the market.[11] Since then conditions began to improve. The stabilization of the CoCos market might have also benefited from the recognition by the ECB, in February 2016, of the need to reduce uncertainty on the supervisory treatment of these instruments, and, in particular, on the conditions that would lead to the suspension of coupon payments. After long debate, the ECB announced on July 29, 2016 changes in the methodology to calculate the banks' MDA trigger that would effectively reduce the likelihood that banks would not be allowed to make CoCo coupon payments (see Section 8 for more details).

Before the described event the price of DB's CoCos were essentially stable. However, at the beginning of 2016 the YTM started rising with a sudden spike of almost 200 basis points (Figure 2a). In particular, the YTM jumped from an average of around 660-670 basis points in mid-January 2016, to more than 850 basis points in mid-February. We set the start date of the first distress episode on January 28 when, after the profitability announcement and the first message by the CEO of DB, the YTM of the DB's CoCos spiked by more than 100 basis points. We set the end date on February 29 when, after the announcement of the successful completion of a debt buy back, the YTM substantially declined.[12]

Event 2

The second distress event of DB started on September 12, 2016 when a number of articles in the press announced that the bank had received a 14 billion USD fine by the U.S. Justice Department. The news came after a series of other bad news that involved the bank over the summer,[13] putting the institution under serious investors' scrutiny that was further exacerbated by the reports that the German government wouldn't help the ailing bank (Donahue, P., 2016). Both DB's CoCos and senior bonds yields took a hit, with the senior bonds almost reaching the pick observed in February 2016 (Figures 2a and 2b).

[10] $www.db.com/newsroom_news/2016/ghp/a-message-from-marcus-schenck-deutsche-bank-announces-a-public-tender-offer-to-buy-back-debt-en-11399.htm$

[11] $www.db.com/newsroom_news/2016/medien/deutsche-bank-announces-results-of-public-tender-offer-for-us-dollar-bonds-as-of-early-tender-date-en-11494.htm$

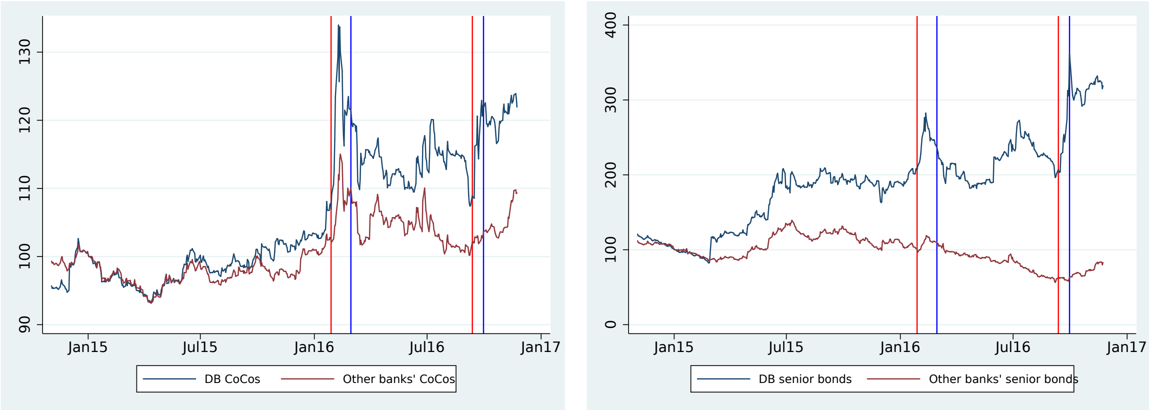
[12] The results presented in the following sections are robust to setting the beginning of the distress event to January 20, i.e. when DB announced for the first time the negative results.

[13] The most relevant are the following: i) in June the IMF stated that DB "appears to be the most important net contributor to systemic risks in the global banking system" (International Monetary Fund, 2016); ii) also in June the US subsidiary of DB failed for the second consecutive year the stress test performed by the Federal Reserve, as the regulator rejected the bank capital plan (Federal Reserve Board, 2016); iii) in July the rating agency Standard&Poor's lowered its outlook on the bank's rating; iv) again in July the bank passed the EU-wide stress test by a tight margin (European Banking Authority, 2016a); and v) in August the bank was removed from the Stoxx 50 index.

Figure 2: The CoCos and senior bond markets during Deutsche Bank's CoCos distress (yield-to-maturity; January 2, 2015=100)

(a) The CoCos market

(b) The senior bonds market



The rise in DB senior bonds and CoCos YTM started therefore on September 12, with an average increase on all issues by about 10 basis points in one day for both types of securities. Then other large one-day increases followed, particularly on September 16 when the news of the fine was confirmed – with the average YTM of DB senior bonds and CoCos increasing by 36 and 49 basis points respectively (Strasburg, J. (2016) and Davis, P.J. (2016)) – and on September 26 when the rumours about the government unwillingness to help the bank spread (Donahue, P., 2016) – with the average YTM of DB senior bonds and CoCos increasing by 22 and 29 basis points respectively. A number of interventions at the end of the September contributed to the recovery from this distress. In particular, on September 30 the CEO of DB reassured the market and the bank employees about the soundness of the bank's financial conditions;[14] on the same day the Eurogroup President Mr. Jeroen Dijsselbloem stated that the 14 billion USD fine to DB was excessive,[15] and unconfirmed reports claimed that the bank was about to agree on a reduction of the fine with the U.S. Department of Justice.[16] Taking this information into account, in our empirical analysis we set September 12 as the start date of the second distress event, and September 30 as the end date.

[14] $www.db.com/newsroom_news/2016/medien/media - reports - on - deutsche - bank - a - message - to - employees - from - john - cryan - en - 11702.htm$

[15] $euobserver.com/tickers/135321$

[16] The rumors were indeed confirmed by the facts, as an agreement had been found in December when the fine was almost halved to 7.2 billion USD.

4. The transmission channels: fundamental and CoCo-specific contagion

The sequence of news in January and September 2016 led to mounting concerns on the ability of DB to pay the coupons on its CoCos or even of a possible write-down of their notional value. This information also increased the insolvency risk of DB, as shown by the large increases in the YTM of its senior debt (and by the negative stock returns). As exhibited in Figures 3 and 4, the rest of the European banking sector experienced also some distress: the YTM of the senior bonds and of the CoCos of European banks increased (and their stock prices fell). Such a co-movement may be the result of a propagation mechanism based on two contagion channels: a *fundamental* and a *CoCo-specific* one.

First, DB is a global systemically important institution whose financial difficulties may spillover to other institutions. This could result from the losses that DB's counterparties would suffer directly in case of insolvency of the institution, and indirectly from the exposure to other institutions through a loss cascade propagated by the network of interbank exposures. The distress of a systemic institution with important trading activities such as DB may also lead to substantial fire sales that would depress asset values and negatively affect the capitalization of banks with similar assets in their trading portfolio. Negative spillovers on the economy could also arise due to second round general equilibrium effects following the failure of a systemic institution. For example, it could reduce or make more costly the access to credit for banks' customers, that may as a response cut down investment or hiring; this in turn could depress the rest of the economy and, through this channel, the quality of other banks' assets. We refer to all these propagation mechanisms as "fundamental". They may explain all or part of the price evolution of banks' liabilities, including their CoCo instruments.

Second, both in January and September 2016, the news that DB may face substantial losses due to fines and legal charges immediately brought the attention to the institutions' capability to satisfy the coupon payments of its CoCos and to the possibility that supervisors would prohibit the bank from paying their coupons. More generally these events led to statements by practitioners and commentators alike on a broad reassessment of the riskiness of CoCos, and to concerns that their design and their debt-like features during normal times could have led investors to misunderstand these instruments. During these stress episodes, investors' uncertainty about CoCos could have led to adverse price dynamics extending from DB's CoCos to the CoCos issued by other institutions, well beyond what would be explained by fundamental factors (e.g. banks' credit risk, profitability, etc. . .). We refer to such a propagation as "CoCo-specific contagion".

The European banking sector was affected by the difficulties of DB in the two stress episodes, albeit to a different extent. While the severity of the distress of DB, as proxied by the change in the YTM of its senior bonds, was of a similar intensity in the two periods, the magnitude of the movements in the other European banks' senior bonds and CoCos YTM was significantly smaller in the second event.

In the first event, the yield of the senior bonds of the major European banks experienced a short-lived increase, within the range of variation observed in the previous 12 months. This suggests a – possibly weak – fundamental contagion from DB to the other major European banks. In contrast, the European banks' CoCos yield hit an all-time high, which constitutes suggestive evidence of a CoCo-specific contagion.

In the second event, instead, the senior bond yield of the European banks remained essentially unchanged, which we can interpret as evidence of a very weak or even lack of fundamental contagion. The CoCos yields nevertheless significantly increased (although their maximum level remained below that attained in the first event), which suggests again the possibility of CoCo-specific contagion. The lower magnitude of the movements in the CoCos market during the second stress episode relative to the first could be the result of a lower fundamental contagion and/or a lower CoCo-specific contagion. A less intense contagion through the Coco-specific channel could be due to an ameliorated understanding by investors of the mechanisms and risks underlying these instruments following the January episode. Furthermore, the actions taken by the ECB during the summer, namely the reduction of the capital ratio below which coupon payments would not be allowed by regulators, could have contributed as well to mitigate volatility transmission through this channel.

In the next sections we investigate whether the described anecdotal evidence on both a fundamental and a CoCo-specific contagion, as well as their relative magnitude across the two events, can be confirmed by the empirical analysis.

5. Data

The main dataset used is provided by BAMLCCI. This index tracks on a daily basis the performance of contingent capital bonds publicly issued in the major markets. This dataset has been augmented with additional data at issuer level. In particular, for each bank we have selected all senior unsecured bonds from the Merril Lynch index ER00 and the daily (closing) data on equity prices from Bloomberg.[17]

For our purposes, we have selected data on securities issued by European banks between January 2014 and November 2016. Overall we have a sample of 102 CoCos issued by 22 banks located in 10 European countries (Table 1).[18]

[17]This matching procedure has led to a reduction of the original panel of banks from the BAMLCCI index.

[18]Information on issuers is aggregated at group level if the holding bank is represented in our sample. The banks included in our sample are the following: Erste Group (Austria), KBC Bank (Belgio), SocietÃľ Generale, Credit Agricole and BNP Paribas (France), Aareal Bank and Deutsche Bank (Germany), Bank of Ireland (Ireland), Intesa SanPaolo and Unicredit (Italy), ABN Amro and Ing Group (the Netherlands), Banco Bilbao Vizacaya Argentaria, Bankinter, and Banco Santander (Spain), Credit Suisse and UBS (Switzerland), Barclays Plc., HSBC, Lloyds Banking Group, Royal Bank of Scotland, Standard Chartered (United Kingdom).

Table 1: Summary Statistics of Cocos Issuances

	Number of daily observations	Number of Issues	Number of issuers	Volume outstanding (billion EUR, November 2016)
Austria	105	1	1	0.5
Belgium	1,432	2	1	2.1
France	7,538	15	3	15.9
Germany	2,945	5	2	5.0
Ireland	364	1	1	0.8
Italy	3,096	6	2	4.5
The Netherlands	1,110	3	2	3.1
Spain	4,421	9	3	7.5
Switzerland	9,009	16	2	20.6
United Kingdom	16,571	44	5	35.9
Total	46,591	102	22	95.9

Table 2: Summary Statistics of Cocos Issuances by Loss Absorption Mechanism

	Number of issues				Volume outstanding (billion EUR, November 2016)			
	Temporary write-down	Permanent write-down	Equity conversion	Total	Temporary write-down	Permanent write-down	Equity conversion	Total
Austria	1	-	-	1	0.5	-	-	0.5
Belgium	1	1	-	2	1.4	0.7	-	2.1
France	14	1	-	15	15.2	0.7	-	15.9
Germany	5	-	-	5	5.0	-	-	5.0
Ireland	1	-	-	1	0.8	-	-	0.8
Italy	6	-	-	6	4.5	-	-	4.5
the Netherlands	1	-	2	3	1.0	-	2.1	3.1
Spain	-	1	8	9	-	1.0	6.4	7.5
Switzerland	-	15	1	16	-	20.6	-	20.6
United Kingdom	-	2	42	44	-	3.1	32.8	35.9
Total	29	20	53	102	28.4	26.2	41.4	95.9

The UK and the Swiss banking systems are the most represented in our sample, with both the largest number of issuances (44 and 16 issues respectively) and the highest volume outstanding (about 36 and 21 billion EUR respectively as of November 2016). Securities in the dataset are denominated in EUR, USD and GBP. In addition to daily closing market data (e.g. price, YTM, spread, and duration), information from BAMLCCI includes a large number of variables describing the main securities features (e.g. maturity date, rating, amount outstanding, issuance currency and whether the instrument is classified as AT1 or T2 capital). Additional information on CoCo instruments is obtained from Bloomberg. In particular, for each bond we have collected the main contractual characteristics, such as the loss absorption mechanisms (principal write-down/equity conversion), the type of write-down (temporary, permanent), the underlying trigger variable (e.g. Tier1 ratio, CET1) and the trigger level. Tables 2, 3, and 4 present more detailed summary statistics about this additional information for the selected sample of CoCos.

Statistics by country of the average daily YTM of the CoCos and the senior bonds as well as the average returns of equity prices are provided in Table 5.

Table 3: Summary Statistics of Cocos Issuances by Trigger Variable

	Number of issues				Volume outstanding (billion EUR, November 2016)			
	CET1 ratio	Core Tier1 ratio	Total risk-based capital ratio	Total	CET1 ratio	Core Tier1 ratio	Total risk-based capital ratio	Total
Austria	1	-	-	1	0.5	-	-	0.5
Belgium	2	-	-	2	2.1	-	-	2.1
France	15	-	-	15	15.9	-	-	15.9
Germany	5	-	-	5	5.0	-	-	5.0
Ireland	1	-	-	1	0.8	-	-	0.8
Italy	4	-	2	6	4.0	-	0.5	4.5
the Netherlands	3	-	-	3	3.1	-	-	3.1
Spain	9	-	-	9	7.5	-	-	7.5
Switzerland	16	-	-	16	20.6	-	-	20.6
United Kingdom	25	19	-	44	35.9	-	-	35.9
Total	81	19	2	102	95.4	0.0	0.5	95.9

Table 4: Summary Statistics of Cocos Issuances by Trigger Level

	Number of issues				
	Low-trigger			High-trigger	Total
	5%	5,125%	6%	7%	
Austria	-	1	-	-	1
Belgium	-	1	-	1	2
France	-	14	-	1	15
Germany	-	4	-	1	5
Ireland	-	1	-	-	1
Italy	-	4	2	-	6
the Netherlands	-	1	-	2	3
Spain	-	8	-	1	9
Switzerland	7	4	-	5	16
United Kingdom	19	-	-	25	44
Total	26	38	2	36	102

Table 5: Summary Statistics of Cocos Issuances by Trigger Level

	CoCo bonds (average ytm, basis points)			Senior bonds (average ytm, basis points)			Stocks (average return, basis points)		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Austria	-	-	853	-	-	137	-	-	0.27
Belgium	611	595	601	72	104	105	0.04	0.09	0.01
France	682	665	685	170	135	92	-0.04	0.03	0.02
Germany	615	652	742	167	179	219	-0.13	-0.04	-0.12
Ireland	-	711	739	-	107	61	-	-0.05	-0.21
Italy	720	711	771	187	117	94	-0.01	0.01	-0.31
the Netherlands	-	621	610	-	111	87	-	-0.07	0.04
Spain	720	693	746	114	113	82	-0.03	-0.14	-0.03
Switzerland	528	535	550	92	62	61	-0.06	0.02	-0.12
United Kingdom	649	610	664	187	145	117	-0.02	-0.05	-0.01

6. Empirical analysis

6.1. Set-up

In order to disentangle fundamental from CoCo-specific contagion, we define the following baseline model:

$$Y_{i,j,t} = \alpha_{i,j} + \beta Y_{i,j,t-1} + \sum_{k=1,2} \gamma_k X_{k,j,t} + \delta Y_{DB,t} + \sum_{s=1,2} \varphi_s Y_{DB,t} Dummy_{s,t} + \theta Z_{i,j,t} + \varepsilon_{i,j,t}. \quad (1)$$

The dependent variable, $Y_{i,j,t}$, is the daily YTM of CoCo i, issued by a European bank j other than DB, at time t. We include as a regressor one lag of the dependent variable, $Y_{i,j,t-1}$, to account for serial correlation in yields. The pair of bank specific controls $X_{k,j,t}$, with $k = 1, 2$, consists of the daily average YTM of the senior bonds ($k = 1$) issued by bank j and of the daily stock return ($k = 2$) of bank j, both at time t. By using these controls we aim to capture the variation in the CoCos YTM that can be explained by the changes in bank fundamental conditions such as its solvency (proxied by the YTM of the bank's senior bonds) and its expected profitability (proxied by the bank's equity return). To the extent that there is a fundamental contagion from DB to the other banks' CoCos YTM during the two distress episodes, it should be reflected by these variables.

The variable $Y_{DB,t}$ is the daily average YTM of the CoCos issued by DB which we use to control for the possible co-movement between the CoCos of DB and those of the other banks. In particular, the coefficient of $Y_{DB,t}$ in the baseline regression would capture the average inter-dependence in the YTM of CoCos, along all the sample and time span considered, which could result from unobserved variables that affect the pricing of all CoCos, but not that of the other banks' securities. We also interact $Y_{DB,t}$ with the dummy variables $Dummy_{s,t}$, with $s = 1, 2$, which identify the two DB stress periods as previously defined. The coefficients of the interactions aim to capture whether there has been a change in the inter-dependence between the CoCo of DB and those of other banks when DB was under distress (and investors spotted the riskiness of its CoCos).

Finally, $Z_{i,j,t}$ is a vector of CoCo-specific variables that includes the type of action upon conversion (principal write-down or equity conversion), the type of write-down (temporary or permanent), the regulatory treatment of the instrument (AT1 or Tier 2), the trigger level (high or low[19]), the possibility for the supervisory authority to suspend coupon payments, and the size of the issue.

We use the baseline regression to test the two following hypothesis:

[19] We follow Avdjiev et al. (2013) and define a high (low) trigger CoCo bond as one having a trigger level above (below) 6 per cent of the ratio between Common Equity Tier 1 capital and Risk-weighted assets (CET1/RWA). The results of the analysis do not change to setting a threshold at 5.125 per cent, the regulatory minima for a CoCo to qualify as AT1.

Hypothesis 1: *Existence of CoCo-specific contagion in the first and/or the second stress period*

We say that there is evidence of CoCo-specific contagion in the stress period s if the coefficient of $Y_{DB,t}Dummy_{s,t}$ is statistically significant and positive. Our definition of contagion is consistent with that of Forbes and Rigobon (2002) that consider contagion to be an increase in cross-dependence across markets during crises periods. Note that since we control for the banks' equity and senior unsecured debt price, the potential fundamental contagion from DB to the other banks' CoCos should be transmitted through the effect of DB's distress on these variables. Our baseline pricing model does not capture the potential non-linearities that can be especially important when banks financial position is eroded and the pricing of their CoCos becomes more information sensitive. We conduct a robustness exercise in Section 6.2 to address this issue.

Hypothesis 2: *Reduction in CoCo-specific contagion in the second stress period relative to the first one*

Conditional on the existence of CoCo-specific contagion in both periods, we say that there is evidence of a reduction of contagion from the first to the second period if the interacted coefficient of $Y_{DB,t}Dummy_{2,t}$ is lower than that of $Y_{DB,t}Dummy_{1,t}$. Since the yields' volatility may change during the two stress periods, we look at the coefficients' economic significance which we compute by normalizing each coefficient by the standard deviation of the YTM of DB's CoCos observed in each corresponding stress period.

6.2. Estimation

Equation (1) is first estimated using a Generalized Least Square (GLS) estimator with random effects, to control for the issue-specific characteristics of the CoCos. We estimate the model by clustering the standard errors by bank and time and by allowing for intragroup correlation (i.e. relaxing the usual assumption that the observations are independent), since the null hypothesis of no serial correlation in the residuals is rejected by the Wald test discussed in Wooldridge (2002) and for which Drukker et al. (2003) shows the good size and power properties.

In addition, as the Likelihood Ratio test shows that there is heteroscedasticity across groups, we also run a Feasible GLS (FGLS) estimation with heteroskedastic error structure across panels and a panel-specific AR(1) process within panels.

Finally, although the time dimension of our panel is relatively large (746 days) and hence we could expect a priori the dynamic panel bias of GLS and FGLS estimations to be small, we check their results against the generalized method of moments (GMM) estimator proposed by Blundell and Bond (1998), also known as System GMM. The latter framework accounts for endogeneity, controls for unobserved heterogeneity, and deals with the biases and inconsistencies typical of least square estimations, provided that the model is not subject to serial correlation of order two and the instruments used are valid. We estimate the System GMM with a two-step estimator robust to panel-specific autocorrelation and heteroscedasticity.

6.3. Results

The results from the estimation of equation (1) are shown in Table 6, with the GLS estimation reported sub (i), the FGLS sub (ii), and the System GMM sub (iii). The three estimates confirm that the CoCo YTM is characterised by an AR(1) process, as shown by the very large and significant coefficient of the autoregressive term. The results also confirm, as expected, that the CoCo YTM is inversely related with the bank stock returns, as shown by the significance of the stock return variable, and that it positively co-moves with the senior bonds YTM. For the latter variable the evidence is however somewhat less robust due to its low significance, observed in two estimations only (GLS and GMM). These findings show that there is a close relationship between the banks' fundamental conditions and the pricing of their CoCos. Any effect of the two DB events on the other banks' CoCos resulting from the fundamental contagion channel previously described should therefore be captured by the significance of the senior bond and stock return variables. Table 6 shows also that there is limited evidence of co-movement between the CoCos of DB and those of the other banks over the entire time-span as the DB's CoCos variable is significant only under the FGLS estimation sub (ii). Such significance could be due to unobservable variables that affect all CoCos and that might bias our estimates. We analyse therefore the robustness of our results to the possibility of omitted variables in section 6.3.

As for the variables of direct interest to test the CoCo-specific contagion hypotheses described in the previous paragraph, we find that the two interacted variables $Y_{DB,t}Dummy_{s,t}$ are both positive and very significant across the three alternative estimations. This confirms Hypothesis 1 about the existence of CoCo-specific contagion during the two stress episodes. We also observe that the size of the interacted variable is larger in the first episode, which suggests a lower intensity of the CoCo-specific contagion in the second event. In order to confirm that this is indeed the case, we assess the economic significance of the coefficients and take into account the volatility observed during the two events, as a higher volatility in the second event could have been in principle the reason for the lower estimated coefficients. However, we find that this is not the case. After adjusting the coefficients of $Y_{DB,t}Dummy_{s,t}$ for the standard deviation of the $Y_{DB,t}$ during each event (89 and 65 basis points, respectively), we find that the relative magnitude of the coefficient for the first event is more than four times larger than that for the second event. We conclude therefore that Hypothesis 2 about a reduction of the CoCo-specific contagion between the first and the second distress period is validated by the data.

In terms of CoCo-specific characteristics, there is little evidence of their role in explaining the YTM of CoCos. All but one of the variables capturing the different features of the CoCos are in fact not significant in all three estimations. The variable controlling for the possibility of the regulator to cancel interest payments is significantly related to the CoCos YTM in sub (i), while the issue-specific subordination (AT1 vs Tier 2) is marginally significant in sub (iii). The negative sign of the coefficient of the former variable indicates that those CoCos that allow the discretionary suspension of interest payments by the regulator have lower YTM (higher prices), a somewhat counterintuitive result. The negative sign of the coefficient of the issue-specific subordination variable indicates that the more senior the CoCo the lower its YTM (the higher its price). Overall, this evidence suggests that in the pricing of a CoCo – undoubtedly a complex instrument to price – its contractual features do not seem to play a significant role.

Table 6: Fundamental and Coco-specific Dependence of Cocos Yield-to-matuirty During DB Events

VARIABLES	(1) GLS RE	(2) FGLS	(3) System GMM
Lag CoCo ytm	0.996***	0.998***	0.995***
	(0.001)	(0.000)	(0.001)
Senior bond ytm	0.004**	0.001	0.009*
	(0.002)	(0.001)	(0.005)
Stock return	-0.726***	-0.608***	-1.074***
	(0.057)	(0.012)	(0.197)
Coco DB	0.001	0.002***	0.002
	(0.001)	(0.001)	(0.002)
Coco DB x event1	0.113***	0.116***	0.146***
	(0.012)	(0.003)	(0.024)
Coco DB x event2	0.028***	0.022***	0.046***
	(0.006)	(0.006)	(0.006)
Event1	-86.926***	-88.677***	-113.181***
	(9.420)	(2.436)	(18.174)
Event2	-20.557***	-16.328***	-33.541***
	(4.685)	(4.264)	(4.007)
Cocos characteristics			
Subordination type	-0.738	-0.156	-1.356**
	(0.473)	(0.110)	(0.600)
Equity conversion	-0.237	-0.056	-0.343
	(0.269)	(0.099)	(0.315)
Permanent write-down	0.035	-0.125	0.330
	(0.209)	(0.112)	(0.481)
Cancellation by regulators	-0.172*	-0.092	-0.270
	(0.093)	(0.072)	(0.244)
Trigger level	-0.216	-0.120	-0.269
	(0.196)	(0.083)	(0.295)
Size	0.160	-0.064	0.313
	(0.190)	(0.077)	(0.275)
Constant	1.163	-0.033	1.333
	(1.501)	(0.491)	(1.656)
Observations	30512	30512	30512
Hansen test			82.29
p-value			0.149
Arellano Bond test for AR(1)			-1.691
p-value			0.0909
Arellano Bond test for AR(2)			1.489
p-value			0.136
Number of instruments			85

Estimates of the yield to maturity of the Cocos issued by European banks, excluding DB. Random effect estimations is shown sub (1); Feasible GLS estimation with heteroskedastic error structure across panels and a panel-specific AR(1) process within panels is reported sub (2); Blundell-Bond system GMM estimates are shown sub (3). For the GMM, Hansen, AR(1), and AR(2) tests are provided. Robust standard errors are in parentheses. *** p<0.01,** p<0.05, * p<0.1.

7. Further analysis and robustness

In the previous section, we have found compelling evidence on the existence of CoCo-specific contagion during the DB distress episodes that is not explained by the dynamics of banks' fundamental risk. In this section, we conduct some further analysis and robustness exercises to check the validity of our results.

7.1. Bank riskiness and CoCo dynamics

To further explore the interaction between fundamental and CoCo-specific contagion we augment the baseline model in equation (1) by the triple interaction $Y_{DB,t}Senior_{j,t}$ $Dummy_{s,t}$, i.e. between the average YTM of DB's CoCos, the average YTM of the bank j's senior unsecured bonds, and the event dummies. A positive coefficient on this triple interaction would mean a higher sensitivity of the price of the CoCos issued by the riskier banks to the developments of DB. Such type of behaviour would be the one to expect if the dynamics of CoCos were entirely driven by fundamentals, as the CoCos issued by riskier banks are more likely to suffer MDA restrictions on coupon payments or a potential conversion. In contrast, a non-significant coefficient would show that the interdependence between European banks' CoCos and those issued by DB does not depend on the riskiness of the issuer. This in turn would provide evidence of non-fundamental factors driving the co-movements in CoCos prices and would constitute additional evidence of CoCo-specific contagion. The results of the robustness analysis are presented in Table 7. The non-significance of the interactions in all but one case provides suggestive evidence on the disconnection between the CoCos market dynamics and the fundamental risk of the issuing banks and further points towards the existence of CoCo-specific contagion during the DB stress periods.

7.2. Non linearities in CoCo prices during stress events

As an additional robustness exercise, we test the validity of our results against the possible role of non-linearities between bank risk and the price of CoCos during the two DB distress periods. We do so by estimating equation (1) augmented by the interactions $Senior_{j,t}Dummy_{s,t}$ and $Stock_{j,t}Dummy_{s,t}$, that is, between the two dummy events and the senior bond YTM of bank j and the stock return of bank j, respectively. The results shown in Table 8 confirm the validity of our findings as the magnitude and significance of the coefficients of $Y_{DB,t}Dummy_{s,t}$ are essentially unchanged relative to their values in Table 6.

Table 7: Fundamental and Coco-specific Dependence of Cocos Ytm During DB Events: Bank Risk and Cocos YTM Robustness

VARIABLES	(1) GLS RE	(2) FGLS	(3) System GMM
Lag CoCo ytm	0.996***	0.998***	0.994***
	(0.001)	(0.000)	(0.001)
Senior bond ytm	0.003*	0.001	0.014**
	(0.002)	(0.001)	(0.006)
Stock return	-0.727***	-0.609***	-0.614***
	(0.057)	(0.012)	(0.154)
Coco DB	0.001	0.002***	0.002
	(0.001)	(0.001)	(0.003)
Coco DB x event1	0.110***	0.114***	0.120***
	(0.013)	(0.003)	(0.029)
Coco DB x event2	0.028***	0.022***	0.048***
	(0.006)	(0.006)	(0.006)
Event1	-85.810***	-88.047***	-93.102***
	(9.425)	(2.442)	(21.941)
Event2	-20.814***	-16.465***	-36.246***
	(4.679)	(4.265)	(4.241)
Senior bond x event1 x CoCo DB	0.000	0.000***	0.000
	(0.000)	(0.000)	(0.000)
Senior bond x event2 x CoCo DB	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Cocos characteristics			
Subordination type	-0.731	-0.159	-1.493**
	(0.472)	(0.110)	(0.715)
Equity conversion	-0.231	-0.053	-0.253
	(0.269)	(0.099)	(0.349)
Permanent write-down	0.028	-0.125	0.537
	(0.208)	(0.112)	(0.556)
Cancellation by regulators	-0.176*	-0.094	-0.290
	(0.093)	(0.072)	(0.303)
Trigger level	-0.211	-0.120	-0.042
	(0.196)	(0.083)	(0.307)
Size	0.145	-0.069	0.399
	(0.187)	(0.077)	(0.313)
Constant	1.430	0.120	0.475
	(1.488)	(0.493)	(1.873)
Observations	30512	30512	30512
Hansen test			82.55
p-value			0.145
Arellano Bond test for AR(1)			-1.652
p-value			0.0985
Arellano Bond test for AR(2)			1.373
p-value			0.170
Number of instruments			87

Estimates of the yield to maturity of the Cocos issued by European banks, excluding DB. Random effect estimations is shown sub (1); Feasible GLS estimation with heteroskedastic error structure across panels and a panel-specific AR(1) process within panels is reported sub (2); Blundell-Bond system GMM estimates are shown sub (3). For the GMM, Hansen, AR(1), and AR(2) tests are provided. Robust standard errors are in parentheses. *** $p<0.01$,** $p<0.05$, * $p<0.1$.

Table 8: Fundamental and Coco-specific Dependence of Cocos YTM During DB Events: Non-linearities in the Price of Bank Risk

VARIABLES	(1) GLS RE	(2) FGLS	(3) System GMM
Lag CoCo ytm	0.996***	0.998***	0.994***
	(0.001)	(0.000)	(0.002)
Senior bond ytm	0.003*	0.001	0.014**
	(0.002)	(0.001)	(0.006)
Stock return	-0.649***	-0.564***	-1.604***
	(0.064)	(0.013)	(0.243)
Coco DB	0.001	0.002***	0.005*
	(0.001)	(0.001)	(0.003)
Coco DB x event1	0.111***	0.114***	0.151***
	(0.012)	(0.003)	(0.017)
Coco DB x event2	0.028***	0.022***	0.032***
	(0.006)	(0.006)	(0.006)
Event1	-86.970***	-88.436***	-117.181***
	(9.475)	(2.412)	(12.384)
Event2	-21.154***	-16.727***	-24.092***
	(4.754)	(4.297)	(4.288)
Senior bond x event1	0.013	0.009***	0.002
	(0.011)	(0.003)	(0.005)
Senior bond x event2	0.007	0.004	0.011
	(0.008)	(0.008)	(0.010)
Stock return x event1	-0.529***	-0.374***	0.781***
	(0.180)	(0.036)	(0.159)
Stock return x event2	-0.169	-0.072	0.691***
	(0.171)	(0.114)	(0.241)
Cocos characteristics			
Subordination type	-0.730	-0.141	-1.441**
	(0.471)	(0.108)	(0.706)
Equity conversion	-0.218	-0.071	-0.320
	(0.268)	(0.100)	(0.431)
Permanent write-down	0.032	-0.137	0.489
	(0.208)	(0.110)	(0.533)
Cancellation by regulators	-0.178*	-0.094	-0.290
	(0.093)	(0.072)	(0.320)
Trigger level	-0.210	-0.124	-0.097
	(0.196)	(0.082)	(0.393)
Size	0.138	-0.068	0.441
	(0.186)	(0.077)	(0.350)
Constant	1.475	0.111	-1.286
	(1.497)	(0.491)	(2.746)
Observations	30512	30512	30512
Hansen test			82.95
p-value			0.688
Arellano Bond test for AR(1)			-1.768
p-value			0.0770
Arellano Bond test for AR(2)			1.717
p-value			0.0859
Number of instruments			109

Estimates of the yield to maturity of the Cocos issued by European banks, excluding DB. Random effect estimations is shown sub (1); Feasible GLS estimation with heteroskedastic error structure across panels and a panel-specific AR(1) process within panels is reported sub (2); Blundell-Bond system GMM estimates are shown sub (3). For the GMM, Hansen, AR(1), and AR(2) tests are provided. Robust standard errors are in parentheses. *** p<0.01,** p<0.05, * p<0.1.

7.3. Omitted variables

In two out of the three estimations presented in Table 6 the DB CoCo variable is not a significant driver of other banks' CoCo YTM under normal market conditions, as we expected. However, in the estimation sub ii) it turned out to be significant. Even though it is so only in one out of three estimations we suspect that its significance might be due to a possible omitted variable problem, which is to say that omitted or unobservable variables might drive both DB's and other banks' CoCos YTM, hence the significance of the DB's CoCos in Table 6.

In order to test for this possibility we perform a four-steps procedure which aims to separate the effect of any omitted variable from any DB-specific effect. The procedure is the following. First, we run a principal component analysis (PCA) on the dataset of CoCos YTM, which includes both the CoCos issued by DB and those issued by the other banks. By means of the PCA, we aim to identify those components that capture the CoCos co-movements. As such, they should also reflect the effect of any unobserved variable that affect all CoCos similarly. Second, we select the components that together explain a significant proportion of the overall variance of our CoCos dataset; in particular, we consider the first three components that together account for about 84 per cent of the variance. Third, we use them as regressors to explain the DB's CoCos YTM; the resulting residuals are stored as they constitute the "purely" idiosyncratic part of the DB's CoCos YTM which remains unexplained from the regression. Fourth, with an approach similar in spirit to the forecasting method proposed by Stock and Watson (2002), we study the CoCo YTM running again the FGLS estimate of equation (1), but instead of including the DB CoCo YTM and its interactions with the two stress events, we use as regressors: i) the first three principal components selected in the previous step; and ii) the stored DB-specific residuals, which we also interact with the two DB stress events. Following this procedure we should be able to isolate any true DB-specific effect from the effect that may be due to any omitted or unobservable variable.

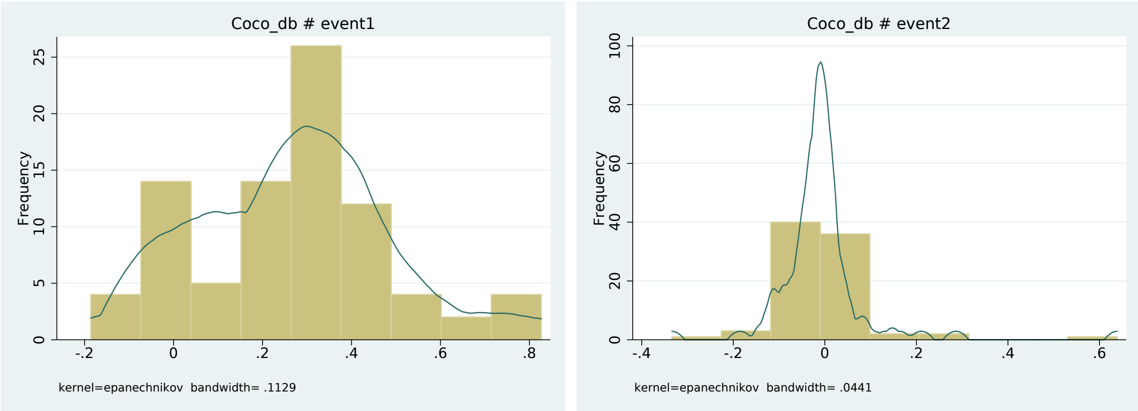
The results of the FGLS regression, which are comparable to those presented in Table 6 sub (ii), are shown in Table 9. They confirm our hypothesis that the significance in normal times of the DB CoCos evidenced in Table 6 sub (ii) is more likely to be due to an omitted variable problem rather than to a DB-specific role in explaining other banks' CoCos YTM. In fact, results show that the DB-specific variable (DB residuals) is not significant in explaining other banks' CoCos YTM in normal times, once we control for possible omitted variables with the principal components (significant in two cases). These results also strengthen our argument about the existence of a CoCo-specific contagion channel from DB to other banks during the two stress events, as the interactions of the DB residuals variable with the stress event dummies are both very significant.

Table 9: Controlling for Omitted Variables

VARIABLES	(1) FGLS
Lag CoCo ytm	0.997***
	(0.000)
Senior bond ytm	0.002
	(0.001)
Stock return	-0.731***
	(0.016)
Component 1	0.426
	(0.275)
Component 2	1.035*
	(0.579)
Component 3	0.298**
	(0.131)
DB residuals	-0.042
	(0.030)
Event1	-54.725***
	(3.374)
Event2	-71.830***
	(12.914)
DB residuals x event1	0.074***
	(0.004)
DB residuals x event2	0.095***
	(0.017)
Cocos characteristics	
Subordination type	-0.251
	(0.174)
Equity conversion	-0.040
	(0.159)
Permanent write-down	-0.188
	(0.171)
Cancellation by regulator	-0.122
	(0.111)
Trigger level	-0.172
	(0.131)
Size	-0.151
	(0.118)
Constant	31.992
	(21.310)
Observations	16719

Feasible GLS estimation of the yield to maturity of the Cocos issued by European banks, excluding DB. Robust standard errors in parentheses. The estimation allows for heteroskedastic error structure across panels and a panel-specific AR(1) process within panels. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure 3: Cross-sectional distribution of the estimated CoCo x DB interacted coefficients



7.4. Heterogeneity in CoCo-specific contagion

The results discussed so far describe the average features of our sample of CoCos issued by European banks. An interesting question is how "representative" these numbers are: does the CoCo-specific contagion during the DB events differ significantly and systematically across CoCo issues? The large-T nature of our panel allows us to answer this question by estimating issue-specific models and scrutinizing the cross-sectional distributions of the coefficients.

The results confirm the findings of the panel estimation. Figure 3 shows the distribution of the coefficients of $Y_{DB,t}Dummy_{s,t}$ obtained from OLS estimates of equation (1) performed at Isin level. The pooled estimates appear to be a good summary of the data as the banks' CoCo YTM are indeed positively correlated with the YTM of the DB CoCos both in the first and in the second event. Coherently with the panel estimates, the distribution of the estimated coefficients for the first turbulent period is upward shifted, albeit with a higher dispersion, relative to that for the second period, which is more centred around zero. The key message is therefore that our panel estimations provide a good description of most CoCo issues in the sample.

Table 10 confirms the validity of these results by showing the share of significant coefficients of $Y_{DB,t}Dummy_{s,t}$ across the OLS estimates of equation (1) performed at Isin level. The estimated coefficients (at either 1 or 5 percent level) are significant in a very high number of CoCo issues across the two events (74 and 84 per cent respectively) and for almost all issuers (90 per cent). Interestingly, in the second event the significance is also more concentrated at the 1 per cent level.

7.5. Banks' business model and CoCo-specific contagion

To further explore the nature of the CoCo-specific contagion in the two events, we consider the possible role of the banks' business model. In other words, we want to

Table 10: Significance of Coco-specific Contagion Across Issue-specific OLS Regressions

Estimated significant coefficients (share of total estimates)		
Significance level	CoCo DB x event1	CoCo DB x event2
1 percent	0.55	0.80
5 percent	0.19	0.04
Total	0.74	0.84

investigate whether banks with a business model closer to that of DB, i.e. investment banking, might have experienced higher contagion. Using information from banks' balance-sheet at the end of 2016, we consider a bank to be "Investment bank" (IB) if its trading assets account for more than 30 per cent of total assets. We then define a dummy variable IB_j which captures whether a bank j's business model is IB or not, and estimate again equation (1) augmented by IB_j and its interaction with $Y_{DB,t}Dummy_{s,t}$.

The results in Table 11 show that investment banks might face on average a higher CoCo YTM (sub (iii)). More importantly in the context of the analysis, they also indicate that being an investment bank, i.e. having a business model closer to that of DB, might have implied a more severe CoCo-specific contagion during the first DB distress event, given the significance of the coefficient of the triple interaction $IB_jY_{DB,t}Dummy_{s,t}$ (sub ii)).

Table 11: Fundamental and Coco-specific Dependence of Cocos YTM During DB Events: the Role of Bank Business Model

VARIABLES	(1) GLS RE	(2) FGLS	(3) System GMM
Lag CoCo ytm_level_coco	0.996***	0.998***	0.992***
	(0.001)	(0.000)	(0.002)
Senior bond ytm	0.004*	0.001	0.015**
	(0.002)	(0.001)	(0.006)
Stock return	-0.725***	-0.608***	-0.574***
	(0.057)	(0.012)	(0.146)
Coco DB	0.001	0.002***	0.003
	(0.001)	(0.001)	(0.003)
Coco DB x event1	0.113***	0.115***	0.110***
	(0.012)	(0.003)	(0.030)
Coco DB x event2	0.028***	0.022***	0.049***
	(0.006)	(0.006)	(0.006)
Event1	-87.106***	-88.730***	-85.072***
	(9.382)	(2.435)	(22.728)
Event2	-20.625***	-16.327***	-35.698***
	(4.656)	(4.263)	(4.179)
IB	0.207	0.084	3.427***
	(0.161)	(0.082)	(1.243)
IB x event1 x CoCo DB	0.003	0.002***	0.001
	(0.002)	(0.000)	(0.002)
IB x event2 x CoCo DB	0.000	0.000	0.001
	(0.001)	(0.001)	(0.001)
Cocos characteristics			
Subordination type	-0.823*	-0.187*	-2.439*
	(0.492)	(0.112)	(1.391)
Equity conversion	-0.157	-0.026	0.659
	(0.264)	(0.101)	(0.746)
Permanent write-down	0.131	-0.072	1.822
	(0.236)	(0.117)	(1.170)
Cancellation by regulator	-0.251**	-0.118	-1.097
	(0.099)	(0.074)	(0.778)
Trigger level	-0.145	-0.108	0.891
	(0.183)	(0.083)	(0.715)
Size	0.125	-0.079	0.166
	(0.185)	(0.077)	(0.583)
Constant	1.352	0.025	0.350
	(1.496)	(0.491)	(2.350)
Observations	30512	30512	30512
Hansen test			81.90
p-value			0.177
Arellano Bond test for AR(1)			-1.652
p-value			0.0985
Arellano Bond test for AR(2)			1.376
p-value			0.169
Number of instruments			89

Estimates of the yield to maturity of the Cocos issued by European banks, excluding DB. Random effect estimations is shown sub (1); Feasible GLS estimation with heteroskedastic error structure across panels and a panel-specific AR(1) process within panels is reported sub (2); Blundell-Bond system GMM estimates are shown sub (3). For the GMM, Hansen, AR(1), and AR(2) tests are provided. Robust standard errors are in parentheses. *** p<0.01,** p<0.05, * p<0.1.

8. Conclusions and policy implications

Our empirical analysis provides evidence of, on the one hand, the existence of a CoCo-specific contagion channel in the propagation of the distress of DB to the rest of the European banks in the two stress episodes considered, and on the other hand, the fact that such a contagion channel seems to have weakened in the second episode.

From a financial stability perspective, the widespread turbulence in the CoCos market in front of idiosyncratic shocks not totally explained by fundamentals supports the idea of CoCo sceptics that these instruments might prove destabilizing. In fact, in the aftermath of the January-February turmoil some senior bank executives complained that the rules for CoCos are too complicated and could undermine a bank's financial position rather than strengthen it in a crisis (Arnold and Hale, 2016). Concerns regarding these instruments were compounded by the uncertainties surrounding the interaction between the results of the EU wide stress test and the Pillar 2 requirement, together with the direct consequences of this interaction on the level of the MDA trigger point, i.e. the capital level below which a bank faces restrictions on the amount of distributable profits, including in the form of coupon payments on CoCos.

The ECB (European Central Bank, 2016b) clarified its position on July 29, 2016, in apparent coordination with the simultaneous publication of the stress test results by the EBA (European Banking Authority, 2016a). It announced that one element of the quantitative results of the stress test (that is the potential capital shortfall under adverse scenario) would be an input of the non-binding Pillar 2 guidance, a newly introduced element of the SREP process that, as opposed to Pillar 2 requirements, does not contribute to the determination of the MDA trigger. By doing so, the ECB not only reduced uncertainty on the supervisory framework in a dimension that is crucial for investors to understand the repayment behaviour of CoCos, but also de facto increased the protection of CoCos' investors by making it less likely that banks would face restrictions on the payment of coupons on AT1 instruments. In the European Central Bank (2016a) own words with "...the introduction of the component of Pillar 2 guidance, the capital requirements of a bank in terms of Pillar 1 plus Pillar 2 requirements will be reduced – all things being equal. As a result, the trigger for the Maximum Distributable Amount (MDA) will go down – also all things being equal...".

Both the reduction in uncertainty and the enhancement of protection are likely to have played a role in the weakening of the CoCo-specific contagion in the second DB stress period identified in our empirical analysis. In addition to that, the weakening could also result from a "learning process" from the part of investors spurred by the market disruption during the first stress period that made agents more aware of the riskiness of these instruments at the time of the second stress event, thereby rendering CoCos' prices less volatile in front of idiosyncratic shocks. More market stability in stressed periods is certainly reassuring regarding the convenience of CoCos as a substitute of costlier common equity for the purpose of increasing banks' loss absorption capacity.

We conclude the paper with a final comment. One of the most appraised features of CoCos is that of enabling the recapitalization of an institution as a going concern, that is, ahead of resolution. This property distinguishes CoCos from other AT2 instruments such as subordinated debt or the yet to be introduced bail-in eligible liabilities (MREL) that allow for the bank recapitalization as a gone concern, that is, in a resolution process. Yet, the supervisory actions described above went in the direction of relaxing the conditions that may lead to automatic restrictions on the payment of CoCos' coupons, thereby reducing the ability of these liabilities to provide for additional capital as a going concern, and rendering them de facto closer to AT2 instruments. While the ECB actions might have been justified (and the need for a reduction on uncertainty on supervisory treatment was uncontroversial), neither supervisory authorities nor investors should interpret them as an implicit recognition that "whatever it takes" will be done to stabilize CoCos markets. These instruments will only be useful if they achieve in practice what they are supposed to do by their design, namely the recapitalization of an institution as a going concern in a smooth manner that does not disrupt neither the institution itself nor the rest of the system.

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2018

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