EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

NO 1127 / DECEMBER 2009

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In 2009 all ECB publications feature a motif taken from the €200 banknote.

1 The views expressed in this paper are those of the authors and do not necessarily represent the views of the European Central Bank or its staff. We thank Maria Grazia Attinasi, Manfred Kremer, Diego Rodriguez-Palenzuela, Alexander Schulz, Christian Schumacher, an anonymous referee and a member of the Editorial Board for useful comments.

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ISSN 1725-2806 (online)

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Abstract

As the global banking crisis intensified in the fall of 2008, governments announced comprehensive rescue packages for financial institutions. In this paper, we put the joint response of euro area bank and sovereign CDS premia under the microscope. We find that the bank rescue packages led to a clear structural break in these premia's comovement, which had been rather tight and stable in the weeks preceding the intensification of the crisis. Firstly, the packages induced a decrease in risk spreads for banks at the expense of a marked increase in risk spreads for governments. Secondly, we show that in addition to this one-off jump in the *levels* of CDS spreads, the packages strongly increased the *sensitivity* of sovereign risk spreads to any further aggravation of the crisis. At the same time, the sensitivity of bank credit risk premia declined and became more sovereign-like, reflecting the extensive government guarantees of banking sector liabilities.

Keywords: Financial crisis, risk transfer, credit default swaps

JEL Classification: G15, G21

Non-technical summary

We analyse the joint dynamics of credit risk premia of euro area sovereign and bank debt from January 2008 to June 2009. As a first result, we find a strong comovement of weekly credit default swap (CDS) premia for the first half of our sample: a single common risk factor, the iTraxx index of non-financial CDS premia, explains a large proportion of the variability in sovereign and individual corporate (banks but also non-financial) CDS premia. The common factor captures the effects from a deteriorating macroeconomic outlook and changing risk aversion.

In early October 2008, euro area governments announced rescue packages for their national banking systems. In response, risk spreads of financial firms declined while sovereign spreads increased as investors perceived a 'credit risk transfer' from the banking sector to the government. Afterwards, however, both spreads re-widened as the crisis aggravated further.

As a second result, using regressions with breaks and time-varying parameters, we find that besides this one-off level effect, the credit risk transfer had a dynamic dimension. For bank CDS premia, the slope in the regression on the common risk factor decreased after the announcement of the packages. For the sovereign issuers, bearing the fiscal burden, the opposite effect occurred. Thus, the financial rescue packages apparently slowed down the increase of risk premia for banks, but at the considerable cost of increasing the sensitivity of sovereign risk premia to any further crisis aggravation.

1 Introduction

We analyse bank and government credit risk premia of ten major euro area countries between January 2008 and June 2009. As a first result, we find that a large proportion of CDS premia variation of both banks and sovereign issuers is explained by a single common factor. This common regressor for individual bank and sovereign CDS premia is chosen to be the iTraxx index of non-financial CDS premia.[1] We interpret it as a proxy for a 'common risk factor', capturing the effect stemming from a deteriorating macroeconomic outlook, but also from changing investors' risk aversion. This interpretation is supported by the fact that regressions of single-name non-financial corporate CDS premia on the iTraxx index tend to show high measures of fit as well. Moreover, the result is robust against using other natural candidates of common factors such as the first principal component of the standardised CDS premia or their simple median.

This strong comovement notwithstanding, the movements in risk spreads in mid-October deviated significantly from the previously observed pattern. In fact, for a short period, CDS premia of banks declined at the same time as sovereign spreads increased. This divergence resulted from the announcement by most euro area governments of various guarantee and rescue packages for the national banking systems. Hence, investors perceived this as a 'credit risk transfer' from the banking sector to the government, which led to a drop in financial spreads, and an increase in sovereign spreads.[2] Afterwards, however, both spreads picked up again as the overall state of the crisis aggravated further.

Besides this one-off level effect of risk transfer, did the introduction of governments' rescue packages also change the relative dynamics of bank and sovereign CDS premia? In other words, did the way in which these two groups of spreads comoved with the common risk factor change? We assess this question by allowing for a structural break as well as by running the regressions allowing for smoothly varying parameters using the Kalman filter. We find clear evidence that for bank CDS premia the slope in the regression on the common risk factor has decreased after the introduction of the rescue packages. For the sovereign issuer, bearing the fiscal burden of these packages, the opposite effect is observed.

Thus, as a second finding, the financial rescue packages have apparently been effective in slowing down the increase of risk premia for financial institutions, but came at the considerable cost of increasing the sensitivity of sovereign risk premia to changes in the

[1]The iTraxx non-financial CDS index comprises the 100 non-financial entities from the iTraxx Europe index, which includes also non-euro area firms. The included firms are divided into five broad sectors: Auto, Consumer, Energy, Industrial and Technology/Media/Telecommunications (TMT). The indices are rebalanced every six months, and for the index with the 'roll date' 29 September 2008, for instance, the five countries with most firms represented were: France (24), United Kingdom (24), Germany (20) and the Netherlands (8).

[2]See, e.g., European Central Bank (2009a).

overall severity of the financial crisis. The changed dependence on the common risk factor was not a short-lived phenomenon: at end-June 2009, the sensitivity of bank CDS premia was still below the magnitudes of mid-2008, while that of sovereign CDSs appeared to have settled on a markedly higher level.

Regarding related literature, Geyer, Kossmeier, and Pichler (2004) find marked co-movement of euro area bond spreads, as two latent factors explain the bulk of variation across issuing countries and maturities. Moreover, in a regression of the factor explaining long-maturity spreads on explanatory variables, they find that the EMU corporate bond spread comes out as a highly significant explanatory variable – a result in line with the findings of our study that there is a close relation between corporate and sovereign credit spreads. Beber, Brandt, and Kavajecz (2009) come to the conclusion that credit risk is a relevant determinant for bond spreads, but that liquidity is the pre-dominating factor in times of market stress. When relating this to our results it is important to note that we use CDS premia rather than cash bond spreads. Since positions in CDS contracts, contrary to positions in cash bonds, need no up-front funding, the information implied by these swaps is likely to have been less distorted by the simultaneous dry-up of both market and funding liquidity at the height of the crisis relative to cash instruments.[3] Moreover, the extent of the increase in CDS premia over the crisis does suggest by itself the relevance of increased credit risk premia. In addition, the results of Beber et al. (2009) are obtained for the period April 2003 to December 2004, and therefore do not cover periods of as extreme and prolonged market stress as in our analysis. Somewhat in contrast with the results of Beber et al. (2009), Codogno, Favero, and Missale (2003) conclude that yield differentials between euro area government bonds are to a large degree explained by international risk factors, which represent changes in perceived default risk of government bonds in the euro area. Liquidity factors play a more subordinate role. Likewise in line with our results, Favero, Pagano, and von Thadden (2008) emphasise that there is a common trend in euro area bond spreads, representing an aggregate measure of risk. In a similar vein, Bernoth, von Hagen, and Schuknecht (2004) find that global investors' attitude towards credit risk is one driving force for euro area sovereign bond spreads. Based on monthly data from 1999 to 2006, Manganelli and Wolswijk (2007) also find that a common factor is driving both sovereign bond spreads and corporate spreads in the euro area. However, they identify it as the short-term interest rate. In doing so, their interpretation differs from ours. They suggest that lower short-term rates spur institutional investors (endowed with rigid return targets) to take on more risk, eventually leading to a compression of risk premia.

The paper by Mody (2009) focuses like ours on the current turmoil and uses weekly data as well. However, the focus is solely on sovereign spreads, while we take a joint view

[3] A similar, funding-related divergence between different market-implied measures were seen, for example, in the markets for inflation-linked bonds and swaps, where the latter were clearly less affected by market distortions.

on sovereign and bank CDS premia. As one of his key results, Mody finds that "countries with the largest decline in competitiveness display a particularly strong link between the prospects of the financial sector and sovereign spreads". Mody identifies two turning points regarding euro area sovereign spread dynamics. The first is the rescue of Bear Stearns in March 2008. In fact, sovereign spreads in the euro area showed the first strong upsurge at this time. The second is the nationalisation of Anglo Irish in mid-January 2009. Interestingly, however, our analysis does not point to a marked change in the spread sensitivity with respect to the common risk factor associated with these dates. Recent work by Sgherri and Zoli (2009) points out that since October 2008, markets have evidently become more concerned about current and future fiscal positions as well as about financial-sector stability, when pricing euro area sovereign debt. Finally, when interpreting sovereign bond spreads during the financial crisis, Barrios, Iversen, Lewandowska, and Setzer (2009) emphasise the interaction between risk aversion and macroeconomic fundamentals. They find that the combination of elevated risk aversion and large current account deficits exacerbates the impact of deteriorated public finances on government bond spreads.

Summing up, strong comovement among euro area sovereign bond spreads as in our study is identified by several studies in the literature, although with differing interpretations. Moreover, the fact that a common factor is also relevant for explaining corporate spreads has likewise been found in other studies. However, our study differs from other studies addressing euro area sovereign bond spreads in two dimensions. First, it uses a relatively high data frequency but is confined to a rather short period of time. This is because we are essentially putting CDS premia developments during the extreme market stress of 2008-09 under the microscope, rather than exploring structural relationships over longer periods as in previous studies. Such an approach may be seen as adequate, given the different magnitudes of sovereign CDS premia before and after 2008 and the clear corresponding break. In fact, from 2004, when most of the considered sovereign CDS premia became available, to 2007, these data showed a rather flat evolution most of the time, varying in a very narrow range and displaying extended periods of stale quotes. Second, our study takes a *joint* view on sovereign and single-name CDS premia, whereas most studies in the literature – if they include information on both types of issuers – use corporate-bond indices rather than firm-specific information.

The paper is structured as follows. The next section illustrates the relevance of the common risk factor by regressing individual CDS premia on the iTraxx index of non-financial CDS premia. The subsequent section allows for structural breaks in this relationship, and – complementarily – conducts these regressions with time-varying parameters. Both is intended to capture the change in risk exposure. The final section concludes.

2 Bank and sovereign risk spreads in the early phases of the turmoil: a common risk factor at work?

In the beginning of 2008, the financial crisis had already brought euro-area corporate bond spreads and respective CDS premia to highly elevated levels. Unlike the corporate spreads, their sovereign counterparts, referring to bonds issued by euro-area governments, had first remained fairly tight. However, in the first quarter of 2008, they increased markedly and did not revert to their pre-crisis levels thereafter, see Figure 1.

[Figure 1 about here]

Moreover, since that time corporate and sovereign bond spreads showed a distinct comovement, both within and between the respective families of CDS names. Such co-movement is meaningful since with the threat of intensifying macroeconomic repercussions both the corporate sector (decreasing profit expectation, rising risk of default) and the public sector (decreasing tax revenues, higher fiscal deficits and, ultimately, the threat of sovereign default) became increasingly distressed. An additional driving force affecting bond spreads from both groups of issuers is given by investors' risk aversion. In fact, investors' risk aversion and hence required risk compensation is likely to be countercyclical, hence increasing both corporate and sovereign bond spreads and CDS premia when the state of the macroeconomy is deteriorating.

We quantify the degree of comovement by measuring the proportion of variation in corporate and sovereign CDS premia that can be explained by a common factor. This factor is intended to capture the above-mentioned driving forces and will be referred to in the following as 'the common risk factor'. Our data set covers weekly averages of daily data on five-year senior CDS premia for corporate issuers and the government of ten euro area countries, namely Austria (AT), Belgium (BE), Germany (DE), Spain (ES), France (FR), Greece (GR), Ireland (IE), Italy (IT), the Netherlands (NL) and Portugal (PT). Using CDS premia instead of bond spreads comes with the advantages that we can focus on risk considerations (abstracting broadly from additional liquidity effects as discussed above) and also include Germany (which would otherwise serve as the reference with respect to which bond spreads were computed). The whole sample covers the period January 2008 to June 2009, i.e. 78 weeks overall. The 2007 part of the turmoil is not included as no significant reactions of sovereign bond risk premia were observable during this period. The size of the cross-section differs across countries: we considered all firms, for which CDS premia were available in Datastream and have traded sufficiently liquidly, which amounts to 141 firms in total for the ten countries. Viewed over all countries and issuers (both corporates and sovereigns), there are thus 151 CDS premia in the cross-section for each week.

As a measure of the common risk factor (F), we use the iTraxx index of non-financial CDS premia. As alternatives, we considered drawing the first principal component from the set of CDS premia of non-financial corporations, or simply the median of non-financial CDS premia. As Figure 2 shows, all three ways of constructing the common factor lead to very similar time series. They all clearly show the major episodes of the crisis: for instance, the upsurge in corporate spreads in 2008Q1, or the intensification of the crisis in 2008Q4 after the collapse of Lehman Brothers. All results in the paper are robust against using one of the two alternative measures as the common factor instead of the iTraxx index.

[Figure 2 about here]

Table 1 (upper panel) summarises the R^2s obtained by regressing each CDS premium in our sample on the common factor over the period January 2008 to mid-October 2008, i.e. 41 weeks preceding the announcement of the rescue packages in October 2008. For non-financial corporations, the common factor explains the bulk of variation for the majority of firms with the median R^2 reaching from 55% to 91%. For most of the countries, the proportion of bank CDS premia variation explained by the common factor ranges around 80%.[4] For sovereign issuers it ranges between 30% to 78%. As Table 1 (lower panel) shows, a considerable degree of comovement is also observed when the same analysis is conducted using weekly changes rather than levels.

[Table 1 about here]

Summing up, this initial analysis shows that during January 2008 to mid-October 2008 CDS premia displayed a common trend, probably reflecting a deteriorating macroeconomic outlook and increasing investor risk aversion. This common factor not only explained the bulk of variation in bank and sovereign CDS premia, which are the focus of analysis, but also that of non-financial CDS premia, lending support to our macroeconomic interpretation of the common factor.

[4] The number of banks in the respective countries, for which sufficiently actively traded CDS premia were available: AT (0), BE (1), DE (5), ES (2), FR (4), GR(0), IE (3), IT (4), NL (3), PT (2). We did not include CDS for the Belgian-Dutch group Fortis, as in October 2008 the Dutch banking activities were taken into the ownership of the Dutch state, and the remaining banking activities were eventually transferred to a large extent to BNP Paribas in May 2009. For Belgium, the only bank in the sample is Dexia, which was under particular stress before October 2008 (on 30 September 2008 Dexia received large-scale support from the Belgian, French and Luxembourg governments), hence the relatively low R^2. Irish banks were strongly affected by national factors.

3 The effect of government rescue packages on sovereign and bank CDS premia

3.1 Evidence from regressions with structural breaks

The relation between the common factor and sovereign CDS premia is depicted in the scatter plots in Figure 3. The blue circles represent the observation pairs (level of common factor, level of sovereign CDS premium) for the period January to mid-October 2008. Reflecting the relatively high R^2 levels, the individual observations are clustering close to the respective regression line.[5]

[Figure 3 about here]

Between end-September and mid-October, various euro area governments announced that they would engage in large-scale financial rescue packages. The support for banks came in the form of government guarantees for lending in the interbank market or for newly issued bank debt; of direct recapitalisation of financial institutions; of enhanced retail deposit insurance; and – especially later on – of asset relief schemes.[6] Besides implying some immediate government outlays, these measures most notably brought about the risk of deficit increases in the future. For instance, government guarantees constitute contingent liabilities and their expected impact on future deficits depends both on their overall size and the fraction of these guarantees that is expected to be eventually called. Overall, financial market participants perceived the packages as a 'risk transfer' from the financial sector to governments, which was reflected in the CDS of the former going up and the latter going down, see Figure 4.[7]

[Figure 4 about here]

Besides this *level effect* of increasing sovereign CDS premia immediately after the introduction of rescue packages, these measures also brought about a *slope effect*, i.e. a change in sensitivity to potential future aggravations of the crisis. As clearly visible in Figure 3, the relation between the common risk factor and CDS premia remained tight, but has steepened for all euro area sovereign issuers (red asterisks for the time mid-October

[5]In the charts, some regression lines look fairly horizontal, especially for countries with low CDS *levels* during this period (AT, DE, FR, IE, NL). However, the respective estimate of the slope parameter has been found to be positive and significantly different from zero (at the 5% level) for all countries considered, and for both regressions in levels and regressions in first differences.

[6]See European Central Bank (2009b). For a detailed overview of these measures in the individual countries, see Petrovic and Tutsch (2009).

[7]For a more detailed discussion of this episode, see European Central Bank (2009a).

2008 to mid-January 2009).[8] A similar picture emerges for the analysis in first differences.[9]

In order to quantify this *slope effect*, we again regressed sovereign CDS premia on the common risk factor, now including data until mid-January 2009 and allowing for a break at mid-October 2008, i.e. the time around which most euro area countries announced their financial sector support measures.[10] We likewise ran this regression for the CDS premia of banks, which will be discussed below. Hence, the set of regression equations estimated reads:[11]

$$CDS(i,c,t) = \alpha_0(i,c) + \alpha_1(i,c) \cdot I(t > t^*) + [\beta_0(i,c) + \beta_1(i,c) \cdot I(t > t^*)] \cdot F(t) + u(i,c,t) \tag{3.1}$$

where:

$CDS(i,c,t)$:	average CDS premium of sovereign issuer ($i = 0$)
	or of bank i, $i = 1, \ldots, N_c$, in country c in week t
t^*:	week ending on 10 October 2008
$I(t > t^*)$:	dummy variable, equal to 1, if $t > t^*$, 0 before that time
α_0, α_1, β_0, β_1:	scalar parameters
$F(t)$:	common factor
$u(i,c,t)$:	residual

[8]The end of the second sub-sample (16 January 2009) corresponds to the week, when the Irish bank Anglo Irish has been nationalised. This date has been identified by Mody (2009) as marking a break for the analysis of sovereign CDS. In fact, after this event sovereign CDS jumped to the highest levels observed over the turmoil and stayed at those exceptional magnitudes for two months. Hence, when continuing our analysis with the focus on the slope beyond that date, we would at least have to allow for another break in the intercept after mid-January. However, for tracing the crisis sensitivity beyond mid-January, we refer to the analysis in the next sub-section, where we trace our slope parameter of interest in a continuous fashion, using regressions with smoothly time-varying parameters.

[9]Charts for first differences can be made available on request.

[10]The bulk of rescue messages was announced in the first half of October, whereas the Irish Government (which was the first to approve bank guarantees to safeguard all deposits and liabilities of the major Irish-owned financial institutions) announced its measures on 30 September. We let the first part of our sample end with the week ending on 10 October 2008. Choosing this as the break date for all countries considered is a sensible choice, as the Heads of State or Government of the euro area agreed on an action plan for bank support on their meeting on 12 October 2008. We abstain from taking into account country-specific events beyond that time (such as the introduction of asset protection schemes) as additional break dates. However, should these have sizeable effects, they would be picked up by the analysis based on smoothly time-varying parameters below.

[11]The set of equations (3.1) constitutes a SUR (seemingly unrelated regressions) structure, but with the same regressors for each equation. Hence, single-equation OLS is the efficient estimator, and is equal to GLS.

Analogous regressions were run for weekly changes[12]

$$\Delta CDS(i,c,t) = \delta_0(i,c) + [\gamma_0(i,c) + \gamma_1(i,c) \cdot I(t > t^* + 1)] \cdot \Delta F(t) + \tilde{u}(i,c,t),$$
$$t = 1, \ldots, t^*, t^* + 2, \ldots, T \qquad (3.2)$$

Table 2 quantifies the slope effect for sovereign issuers. For the regressions in levels, the crisis sensitivity increased at least by half (ES, PT) and for some countries (NL, IE, AT) it increased by a factor of five or more. The corresponding t-statistics on the add-on to the slope after the introduction of rescue packages – parameter β_1 in (3.1) – reflect a statistically significant increase for all sovereign issuers except Portugal (at the 5% level). Conducting the same analysis controlling for the lagged sovereign CDS level (not shown in Table 2) corroborates the results.[13] Finally, the results for the analogous analysis applied to weekly changes also give a very similar message (see the last four columns).

[Table 2 about here]

Before turning to the analogous results for bank CDS premia, it may be worthwhile to discuss the interpretation of the common risk factor in some more detail. The question we ask is whether and by how much the sensitivity of sovereign and bank CDS premia to aggravations of the crisis has changed after the introduction of financial rescue packages. One may wonder if the results are to some extent driven by the fact that the speed, at which the crisis was unfolding, has itself picked up considerably after September. However, what we are exploring here is the increase of our sovereign and bank CDSs *relative* to that factor. In other words, our measure of the common risk factor F_t, taken as the iTraxx non-financial index should rather be interpreted to act as a 'numeraire' relative to which the risk sensitivities of the two types of CDS premia (sovereign issuers and financial corporations) are measured.

Having shown that the introduction of rescue packages led to an increased risk sensitivity of sovereign issuers, the relevant question is whether these 'costs' have bought about not only a one-time level drop but also a decrease of risk sensitivity for banks. Figure 5 provides the counterparts to the results for the sovereign issuers reported in Figure 3 above. In fact, for all 24 banks in our sample, the relation with the common risk factor between mid-October 2008 and mid-January 2009 (red stars) is less steep than before this time (blue circles).

[Figure 5 about here]

[12]We consider (3.2) as a separate specification for first differences, ignoring, e.g., that (3.1) would imply a non-invertible MA(1) error term and no intercept. But we carry over the implication of (3.1) that observation $t^* + 1$ (the 'jump') is effectively dummied out.

[13]The change in slope is clearly positive for all countries. The t-statistic for Portugal increases to 1.7, but that for Ireland drops to 1.0.

These slope effects for banks are quantified in Table 3. The sensitivity to the common risk factor is considerably lower during the weeks following the introduction of the rescue packages. For the analysis in levels, the slope parameter has decreased for all banks in the sample, the decrease being significant for 17 of the 24 banks. Finally, the results for weekly changes of CDS premia convey a similar result.

[Table 3 about here]

3.2 Evidence from regressions with time-varying parameters

Have the apparent transfers of 'risk sensitivity' been working only temporary or have they been longer-lasting? In order to trace the evolution of crisis sensitivity further beyond mid-January 2009, we again regressed CDS premia on the common risk factor, but now allowing the parameters to continuously change over time rather than pre-imposing particular break dates. This will also act as a complement to our descriptive regression analysis with breaks shown above. Again, we may run the regression in levels or in first differences. However, the level analysis would come with the problem that – also owing to the relatively short sample – some residual variation would be falsely absorbed by the time-varying intercept.[14] Hence, we run the regression on weekly differences only:

$$\Delta CDS(i,c,t) = \gamma_t(i,c) \cdot \Delta F(t) + v(i,c,t), \quad v(i,c,t) \sim N(0, r(i,c)). \tag{3.3}$$

The symbols denote the same entities as in (3.2) above. We assume random walks for the evolutions of the slope parameters

$$\gamma_t(i,c) = \gamma_{t-1}(i,c) + w(i,c,t), \quad w(i,c,t) \sim N(0, s(i,c)). \tag{3.4}$$

This is a common assumptions in regression models with time-varying parameters.[15] Essentially, it represents an 'unconditional' view on the evolution of parameters, so that – via filtering – the parameter path conditional on the observed data (here the sequence of $\Delta CDS(i,c,t)$) can be backed out. The size of $r(i,c)$ governs the amount of variation in the idiosyncratic component of the respective CDS premium. The magnitude of the innovation variance $s(i,c)$ governs the amount of variation in parameters.

For each pair of equations (3.3)-(3.4), identified by (i,c), we use the corresponding state space model to construct the likelihood $\mathcal{L}\left(r(i,c), s(i,c); \{\Delta CDS(i,c,t), \Delta F(t)\}_{t=1,\ldots,T}\right)$, which is maximised to obtain estimates of $r(i,c)$ and $s(i,c)$.[16] Given these estimates, we

[14] This problem could be addressed by restricting the degree of variation of the time-varying intercept a priori or to set the degree of time variation equal to that of the slope parameter. Doing so generates results for the slope parameters (which we are interested in) that are very similar to those for the analysis in first differences.

[15] See, for example, the CAPM example in Zivot and Wang (2003) and the references given therein.

[16] In case the normality assumptions in (3.3)-(3.4) are not valid, the parameter estimates amount to so-called quasi maximum likelihood (QML) estimates.

then run the Kalman filter to obtain a sequence of estimated slope parameters $\left\{\hat{\gamma}_{t|t}\right\}_{t=1,\dots,T}$, where $\hat{\gamma}_{t|t} = E\left(\gamma_t \left| \{\Delta CDS(i,c,\tau), \Delta F(\tau)\}_{\tau=1,\dots,t}\right.\right)$.[17]

Figure 6 shows the median risk sensitivity of sovereign issuers and banks over time.[18] Sovereign CDS's risk exposure was fairly constant until September 2008. During early October, however, when governmental rescue packages were announced, their crisis sensitivity nearly quintupled and stayed around this level until mid-March 2009. This pattern corroborates our analysis using breakpoint regressions discussed above. Note that the nationalisation of Anglo Irish in mid-January, viewed as a relevant break point in Mody (2009), only gave rise to a minor increase in our estimated median crisis sensitivity. For mid-March to May 2009, the estimation identifies a period of further increases in risk sensitivity. This short episode of elevated 'steepness' underlines the symmetry of the concept of crisis sensitivity: essentially, it picks up the fact that during a period of improved market sentiment and overall declining risk aversion, sovereign CDS premia showed a faster decrease than their corporate counterparts. Finally, in June, the median estimated slope parameter falls back to a level somewhat higher than prevailing by end-2008. Summing up, after the announcement of rescue packages, the sensitivity of sovereign CDS premia to changes in the common risk factor has stayed around higher levels than up to September 2008.

[Figure 6 about here]

Heuristically, the fact that the sovereigns' risk sensitivity has increased after the introduction of rescue packages can be interpreted against the background of a standard Merton-type bond pricing model, originally developed for pricing corporate debt and equity.[19] In this model, corporate bond spreads (closely related to CDS spreads) depend positively on the firm value's volatility and leverage, i.e the debt-to-firm-value ratio. Moreover, the sensitivity of the bond spread with respect to volatility is in turn an increasing function of leverage.[20] Our observed pattern for sovereign debt squares well with this theoretical result: as the governments' (contingent) liabilities increased, the sensitivity of their bond risk premia vis-á-vis the common risk factor (broadly parallel to the volatility in the Merton model) was likewise increasing. However, while appealing as a theoretical analogue, the applicability of considerations of corporate bond pricing to sovereign debt is of course somewhat limited.

[17] The initial state for the filter, i.e. $\hat{\gamma}_{0|0}$, is set to the OLS estimate using the first 30 observations.

[18] That is, for each week t, it displays $\underset{\text{all banks}}{median}\left\{\hat{\gamma}_{t|t}(i,c)\right\}$ and $\underset{\text{all sovereigns}}{median}\left\{\hat{\gamma}_{t|t}(i,c)\right\}$, respectively.

[19] We are grateful to a member of the Editorial Board for pointing out this perspective.

[20] It is straightforward, to derive an analytical expression for the derivative of the bond yield with respect to volatility, using e.g. the relations expounded in chapter 2.2 in Lando (2004). For plausible parameter ranges, this derivative is in turn an increasing function of the debt-to-asset ratio.

Figure 7 displays the evolution of estimated sensitivities for the individual countries. For most of them, the time pattern shows the same dynamics as the median. Moreover, there is no systematic relation between the estimated sensitivities to the absolute magnitudes of the CDS premia (see Figure 1 again).[21] This confirms that the results from the regressions with time-varying parameters are not an artefact in the sense of just reflecting level changes in disguise. Regarding individual country patterns, the most striking feature is the surge of the estimated Austrian crisis sensitivity during the week ending 20 February 2009. During this week, market commentators were pointing to a rebound of investors' risk aversion, triggered in part by a report by Moody's, which stressed the exposure of Western European banks to Eastern Europe. This induced sovereign but also corporate CDS premia in the euro area to rise markedly. Compared to the recent past, the increase in sovereign CDS has been disproportionately strong, hence the (moderate) increase in the median estimated sensitivity parameter, see Figure 6 again. For Austria, however, the significant exposure of its banking system vis-à-vis Eastern Europe – and in turn the increased expected fiscal burden for the governments to support the financial system – led to a surge of government bonds' CDS premia. From the viewpoint of the time-varying regression model, this did not only trigger a strong increase in sensitivity for that particular week, but the Austrian risk exposure stayed high until end-April.[22]

[Figure 7 about here]

The behaviour of the sensitivity of bank CDS premia in Figure 6 roughly provides the mirror image of the sovereign pattern. Again the crisis sensitivity remained roughly constant, around 1.0, until mid-September. Unlike for the sovereigns, it then showed a short-lived increase associated with the collapse of Lehman Brothers. With the introduction of the rescue packages, the crisis sensitivity decreased and ranged between 0.7 and 0.8 from November 2008 to March 2009 before increasing somewhat in the second quarter of 2009 to a magnitude of around 0.9. Thus, according to the median outcome, banks' risk exposure after the introduction of governmental support packages has overall remained below its pre-October-2008 level.

This result holds also for most individual banks in our sample (not shown). For all 24 banks, the crisis sensitivity dropped in the first half of October. For 20 of them, the

[21] In particular, there is no clear *positive* correlation between estimated parameters and CDS levels, neither before nor after the introduction of rescue packages. Leaving out the 'transition period' of the first two weeks of October, one obtains correlations between parameters and CDS levels that range from -0.6 (FR) to 0.5 (NL) for the sub-sample January 2008 to end-September 2008; correlations for the time after mid-October 2008 are likewise in this range, but the extremes correspond to different countries (PT: -0.4; AT: 0.5).

[22] Note that we have not included any Austrian bank in our group of banks, as there were too many stale quotes in the respective series of CDS premia.

crisis sensitivity at the end of the sample (end-June 2009) was estimated to range below the corresponding pre-October magnitude. Hence, from this perspective, the transfer of risk sensitivity has been enduring.

4 Conclusion

Since the beginning of 2008, sovereign and corporate CDS premia showed a broad co-movement. The bulk of variation in these credit risk measures between January and mid-October 2008 can be explained by one common risk factor, the iTraxx index of nonfinancial corporations' CDS premia. With the introduction of governments' rescue packages for the financial system around early October 2008, the levels of bank CDS premia decreased shortly, while those of sovereign issuers surged. This was widely considered as reflecting a 'risk transfer' from the private financial to the public sector.

The empirical analysis in this paper has shown that in addition to this one-off level effect, the perceived risk transfer from the banking sector to governments also had a dynamic dimension in the following sense. After the introduction of financial rescue packages, i) the sensitivity of bank CDS premia to further aggravations of the crisis was lower than before, ii) while the sensitivity of sovereign CDS premia to movements in the common risk factor became higher.

In this sense, the rescue packages have been effective in *slowing down* the increase of bond risk premia for financial institutions, but this benefit came at the considerable cost of increasing the sensitivity of sovereign bond risk premia to further aggravations of the financial crisis. However, there is no obvious way how these two opposing effects can be weighted against each other, rendering an overall 'welfare' evaluation infeasible.

Like all regression analyses with breaks or time-varying parameters, it cannot be excluded that movements in parameters (here the changing sensitivity to the common risk factor) is masking the omittance of additional explanatory variables. In principle, this view can be brought in line with our analysis in a relatively straightforward fashion. The regression with breaks and the regression with smoothly time-varying parameters both suggest that parameters changed more-or-less in a step-wise fashion. Hence, alternatively, a regression with our common risk factor and another regressor that is a product of this factor and a 'step-shaped' variable would bring about a constant-parameter specification. However, in absence of a readily available observable and interpretable variable of this type[23], the approach chosen here arguably offers a more direct and economically intuitive interpretation.

The analysis in this paper has been largely descriptive, focusing on one important

[23] Conceptually, fiscal variables relating to expected deficits would be natural candidates. However, while they may help explaining cross-sectional patterns, they are not available at a high-frequency basis, and thus cannot be used directly within our regressions with weekly data.

aspect of the financial crisis, namely the changing sensitivity of sovereign and bank CDS premia to overall aggravations of the crisis. To be aware of and being able to quantify such time-varying risk sensitivity can be relevant as a tool for macro-prudential analysis, and can help to detect when a particular financial institution's risk sensitivity is beginning 'to take off'. Moreover, it may be helpful in portfolio analysis or risk management, e.g. when hedging a portfolio containing bank and/or sovereign credit risk exposure.

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A Tables and figures

Table 1: Proportion of variance of CDS premia (R^2) explained by common factor

Results are based on regressing individual CDS premia on the iTraxx index of non-financial CDS premia, using average weekly data from 4 January 2008 to 10 October 2008. Upper panel: levels; lower panel: first differences. The number of banks in the countries: AT (0), BE (1), DE (5), ES (2), FR (4), GR(0), IE (3), IT (4), NL (3), PT (2).

	Sovereign	Non-financials			Banks
		Min	Median	Max	Median
AT	0.31	0.73	0.76	0.80	
BE	0.48	0.91	0.91	0.91	0.33
DE	0.35	0.14	0.66	0.94	0.73
ES	0.62	0.23	0.63	0.85	0.79
FR	0.46	0.34	0.65	0.90	0.83
GR	0.78	0.55	0.55	0.55	
IE	0.30	0.46	0.59	0.72	0.39
IT	0.60	0.46	0.72	0.76	0.72
NL	0.39	0.25	0.74	0.85	0.83
PT	0.64	0.63	0.74	0.86	0.81

	Sovereign	Non-financials			Banks
		Min	Median	Max	Median
AT	0.18	0.53	0.67	0.80	
BE	0.17	0.81	0.81	0.81	0.17
DE	0.15	0.08	0.71	0.84	0.49
ES	0.36	0.52	0.75	0.88	0.58
FR	0.26	0.18	0.67	0.89	0.48
GR	0.30	0.65	0.65	0.65	
IE	0.10	0.53	0.56	0.59	0.24
IT	0.31	0.34	0.67	0.70	0.57
NL	0.13	0.21	0.70	0.89	0.62
PT	0.32	0.76	0.78	0.81	0.51

Table 2: Regression of sovereign CDS on common factor allowing for structural break in mid-October 2008

Results are based on estimated regressions (3.1) for levels and (3.2) for weekly changes, using average weekly data from 4 January 2008 to 16 January 2009. The Latin letters b and g denote the estimates of the parameters β and γ in (3.1) and (3.2), respectively. t(.) denotes the t-statistic based on HAC-consistent estimates of standard deviations of these parameter estimates.

	Levels				Weekly changes			
	b_0	$b_0 + b_1$	$(b_0 + b_1)/b_0$	$t(b_1)$	g_0	$g_0 + g_1$	$(g_0 + g_1)/g_0$	$t(g_1)$
AT	0.1	1.3	10.8	11.5	0.1	0.8	7.7	8.1
BE	0.2	0.6	3.3	8.3	0.1	0.4	3.0	3.4
DE	0.1	0.3	3.2	5.5	0.1	0.2	2.8	3.7
ES	0.3	0.5	1.6	2.1	0.2	0.5	2.1	3.5
FR	0.1	0.3	2.7	5.6	0.1	0.3	2.3	4.9
GR	0.5	2.0	4.2	7.1	0.3	0.9	3.2	3.8
IE	0.3	1.7	6.7	7.1	0.2	0.8	4.8	4.4
IT	0.4	1.3	3.6	9.3	0.3	0.9	3.3	4.2
NL	0.1	0.8	7.6	11.8	0.1	0.5	5.7	3.8
PT	0.3	0.5	1.4	1.5	0.2	0.5	2.1	3.0

Table 3: Regression of bank CDS on common factor allowing for structural break in mid-October 2008

The included banks are – **in alphabetical order**: ABN Amro Bank, Allied Irish Bank, Anglo Irish Bank, Banca M.d.P. di Siena, Banca Ppo. Italiana, Banco Bilbao Vizcaya, Banco Comr. Portugues, Banco Espirito Santo, Banco Stdr. Ctl. Hisp., Bank of Ireland, Bayer. Hypo, BNP Paribas, Commerzbank, Credit Agricole, Deutsche Bank, Dexia Group, Dresdner Bank, ING Bank, Intesa Sanpaolo, Natixis, Rabobank, Societe Generale, Unicredito Italiano and WestLB. **In the table the banks are sorted w.r.t the relative change in slope in the level regressions.** See also notes of Table 2.

	Levels				Weekly changes			
	b_0	b_0+b_1	$\frac{b_0+b_1}{b_0}$	t(b_1)	g_0	g_0+g_1	$\frac{g_0+g_1}{g_0}$	t(g_1)
Bank 1	1.4	-0.0	-0.0	-9.8	1.3	0.2	0.1	-5.4
Bank 2	2.2	0.4	0.2	-2.9	1.1	0.5	0.4	-1.8
Bank 3	1.1	0.2	0.2	-10.0	1.0	0.3	0.3	-3.0
Bank 4	1.5	0.4	0.3	-5.1	1.3	0.3	0.2	-4.9
Bank 5	1.1	0.3	0.3	-9.5	1.2	0.4	0.3	-3.6
Bank 6	1.3	0.4	0.3	-6.4	1.0	0.6	0.5	-2.0
Bank 7	1.0	0.3	0.3	-6.3	1.0	0.4	0.4	-2.8
Bank 8	1.2	0.4	0.3	-5.3	1.2	0.9	0.7	-1.1
Bank 9	0.9	0.3	0.4	-5.2	0.9	0.6	0.6	-1.4
Bank 10	1.0	0.4	0.4	-5.3	1.1	0.8	0.7	-1.2
Bank 11	0.8	0.3	0.4	-7.3	0.8	0.3	0.4	-3.2
Bank 12	3.2	1.2	0.4	-1.8	1.1	0.3	0.3	-0.7
Bank 13	1.1	0.4	0.4	-4.6	1.0	0.5	0.5	-2.1
Bank 14	2.5	1.2	0.5	-1.3	1.5	0.3	0.2	-1.7
Bank 15	1.1	0.5	0.5	-6.4	1.0	0.6	0.6	-2.2
Bank 16	0.9	0.5	0.5	-3.1	1.0	0.7	0.7	-1.5
Bank 17	1.0	0.5	0.5	-4.4	1.0	0.8	0.8	-1.1
Bank 18	1.0	0.5	0.5	-2.0	0.9	0.5	0.5	-2.7
Bank 19	1.1	0.8	0.7	-1.0	1.1	0.4	0.4	-2.6
Bank 20	0.8	0.7	0.8	-1.4	1.0	0.7	0.7	-1.4
Bank 21	1.6	1.3	0.9	-0.5	1.2	0.5	0.4	-1.3
Bank 22	0.8	0.7	0.9	-0.8	0.9	0.9	0.9	-0.4
Bank 23	0.9	0.9	1.0	-0.1	0.7	0.4	0.6	-1.5
Bank 24	1.6	1.6	1.0	-0.0	1.2	0.5	0.4	-1.3

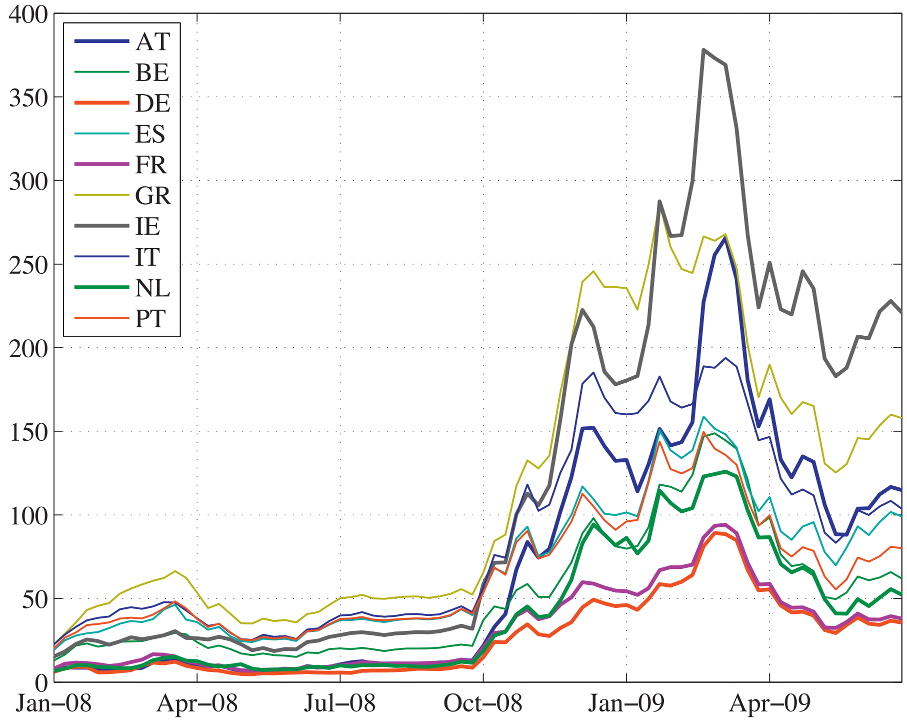

FIGURE 1: FIVE-YEAR EURO AREA SOVEREIGN CDS PREMIA

Weekly averages of five-year CDS premia in basis points. Source: Datastream.

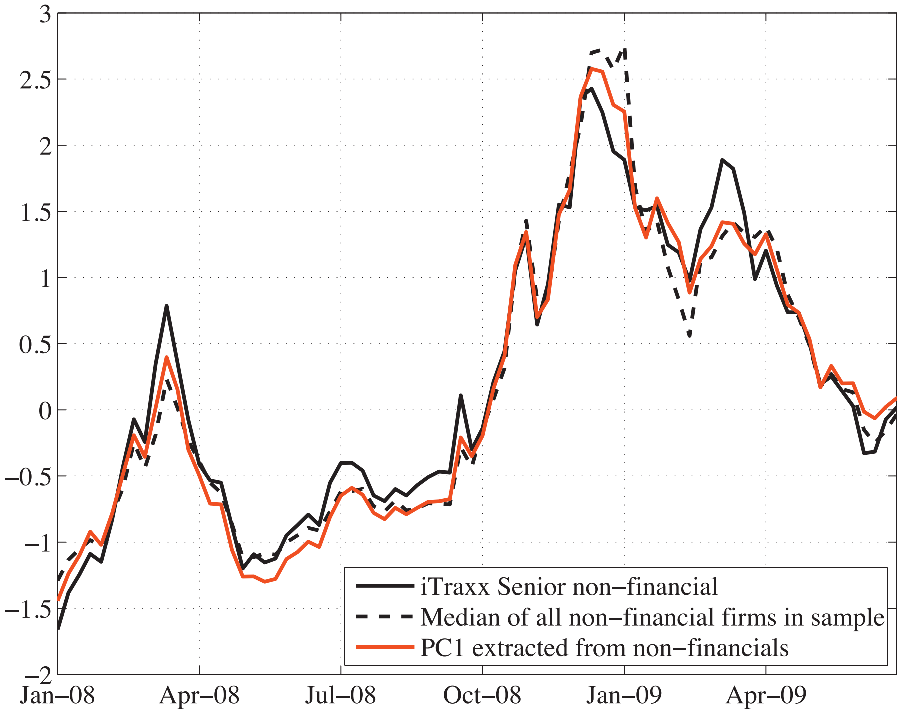

FIGURE 2: DIFFERENT MEASURES OF 'COMMON RISK FACTOR'

PC1 denotes the first principal component.

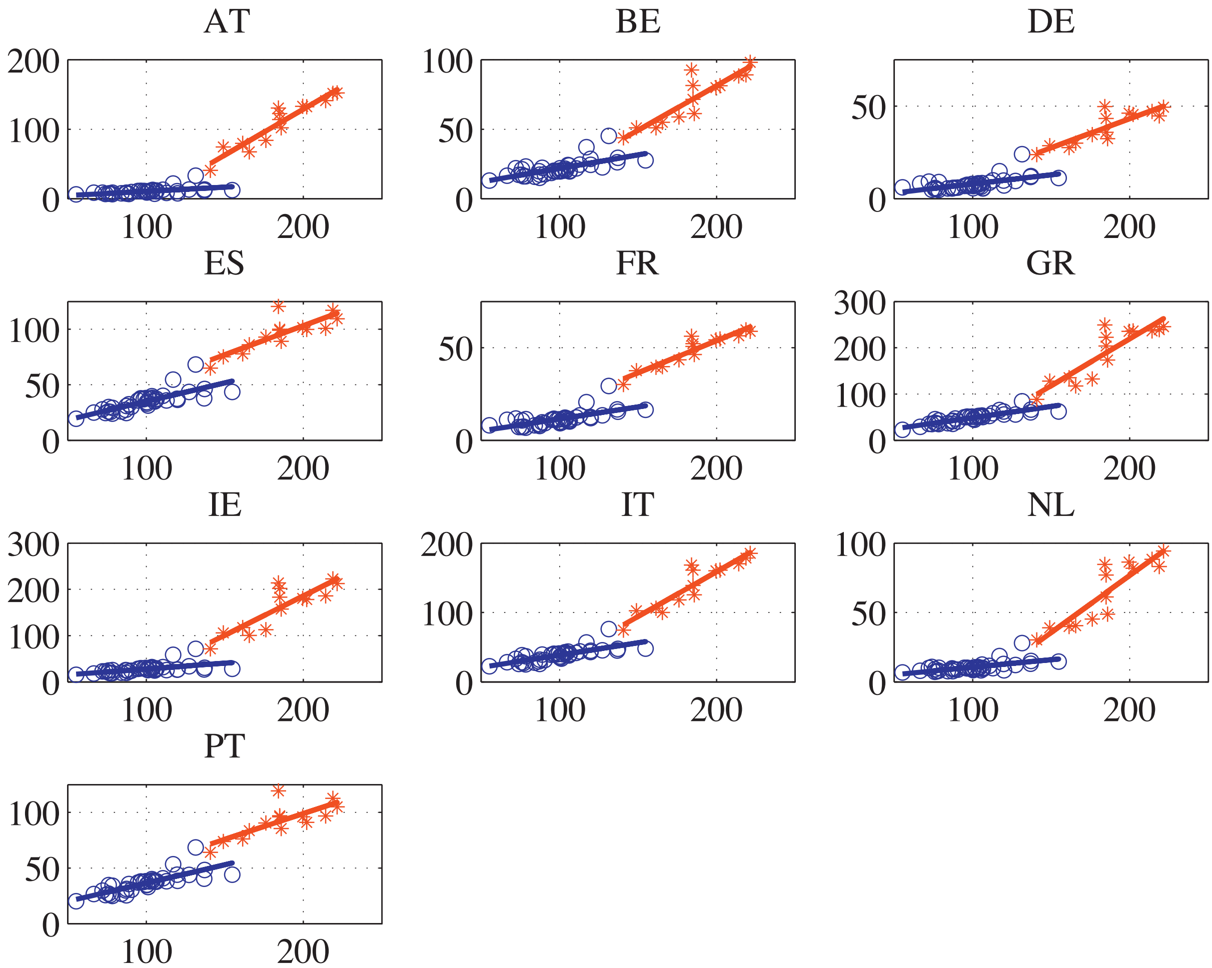

FIGURE 3: RELATION BETWEEN COMMON RISK FACTOR AND INDIVIDUAL SOVEREIGN CDS PREMIA, LEVELS.

Blue circles represent data pairs (CDS of country, iTraxx non-financial index) for the period 4 January 2008 to 10 October 2008; red asterisks for the period 17 October 2008 to 16 January 2009. Solid lines are based on regressions of individual CDS on the common factor within the respective time period.

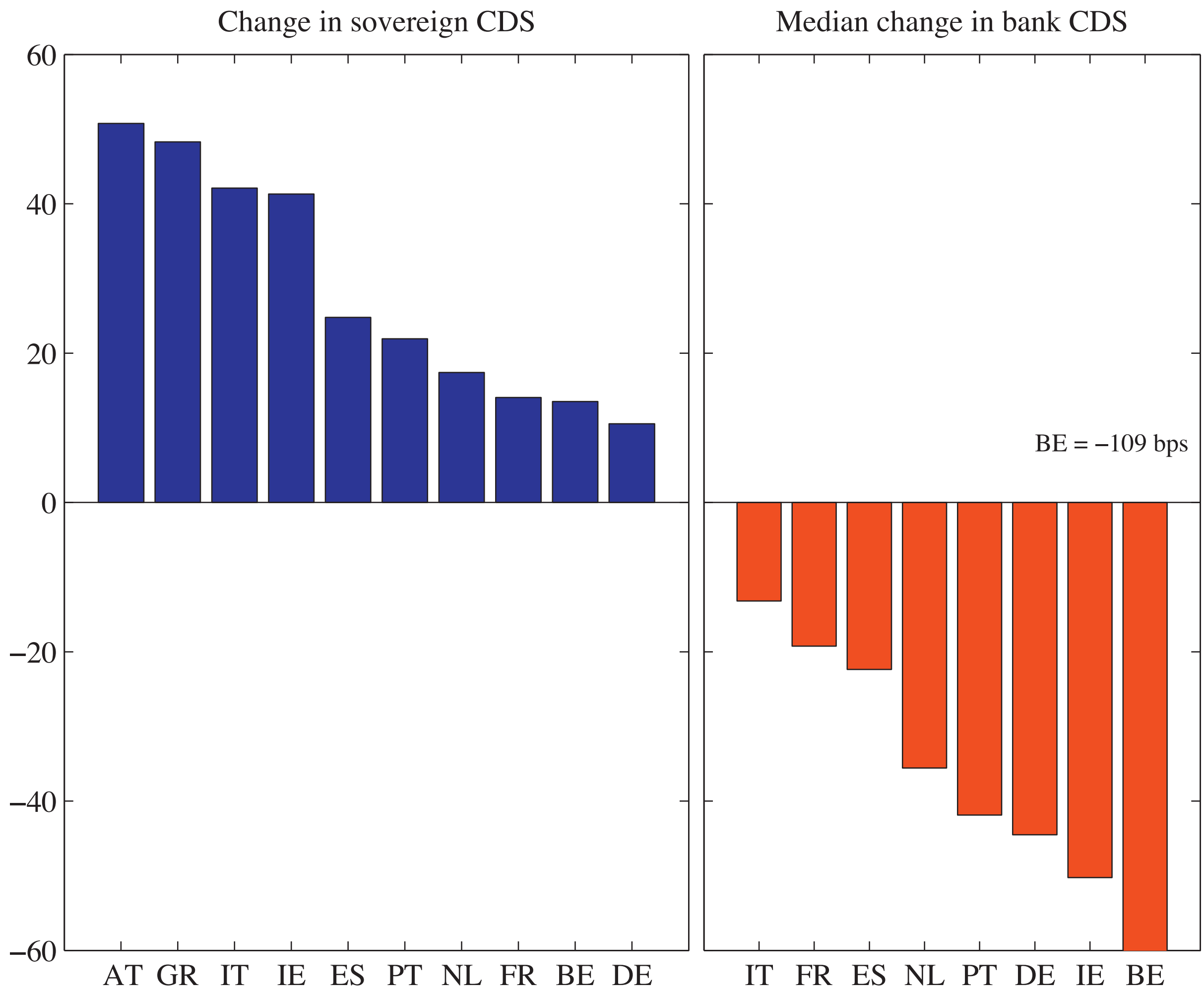

Figure 4: Change of sovereign and bank CDS premia upon the introduction of rescue packages

Bars denote the changes (in basis points) of the average CDS premia from the week ending 10 October 2008, representing the period immediately before the introduction of rescue measures, to the week ending 17 October 2008, representing the time immediately after these measures. For the number of banks in the respective countries, see Table 1.

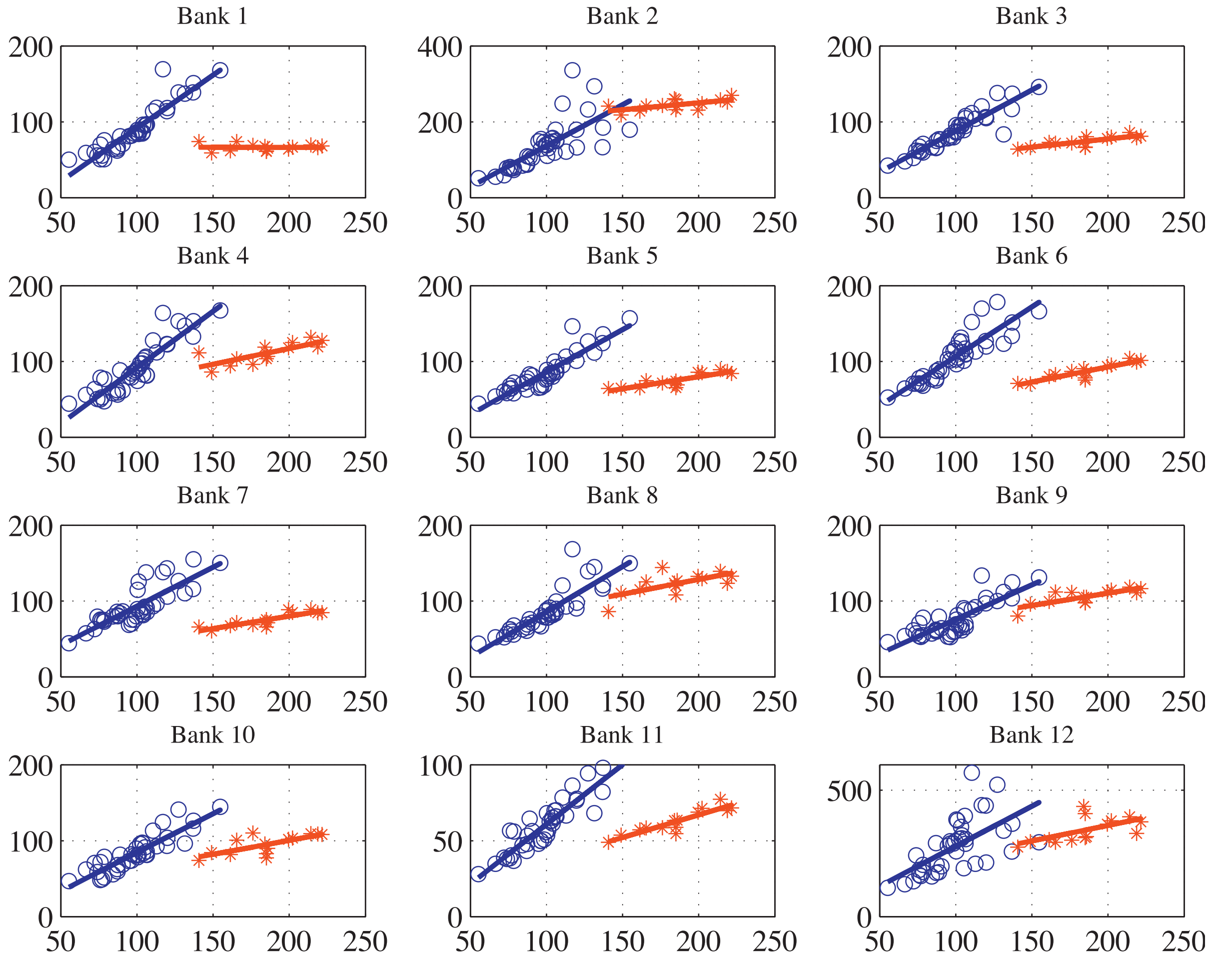

FIGURE 5: RELATION BETWEEN COMMON RISK FACTOR AND INDIVIDUAL BANK CDS PREMIA, LEVELS

Data pairs represent (iTraxx non-financial index, CDS of bank). The ordering is the same as in Table 3. See also the notes of Figure 3.

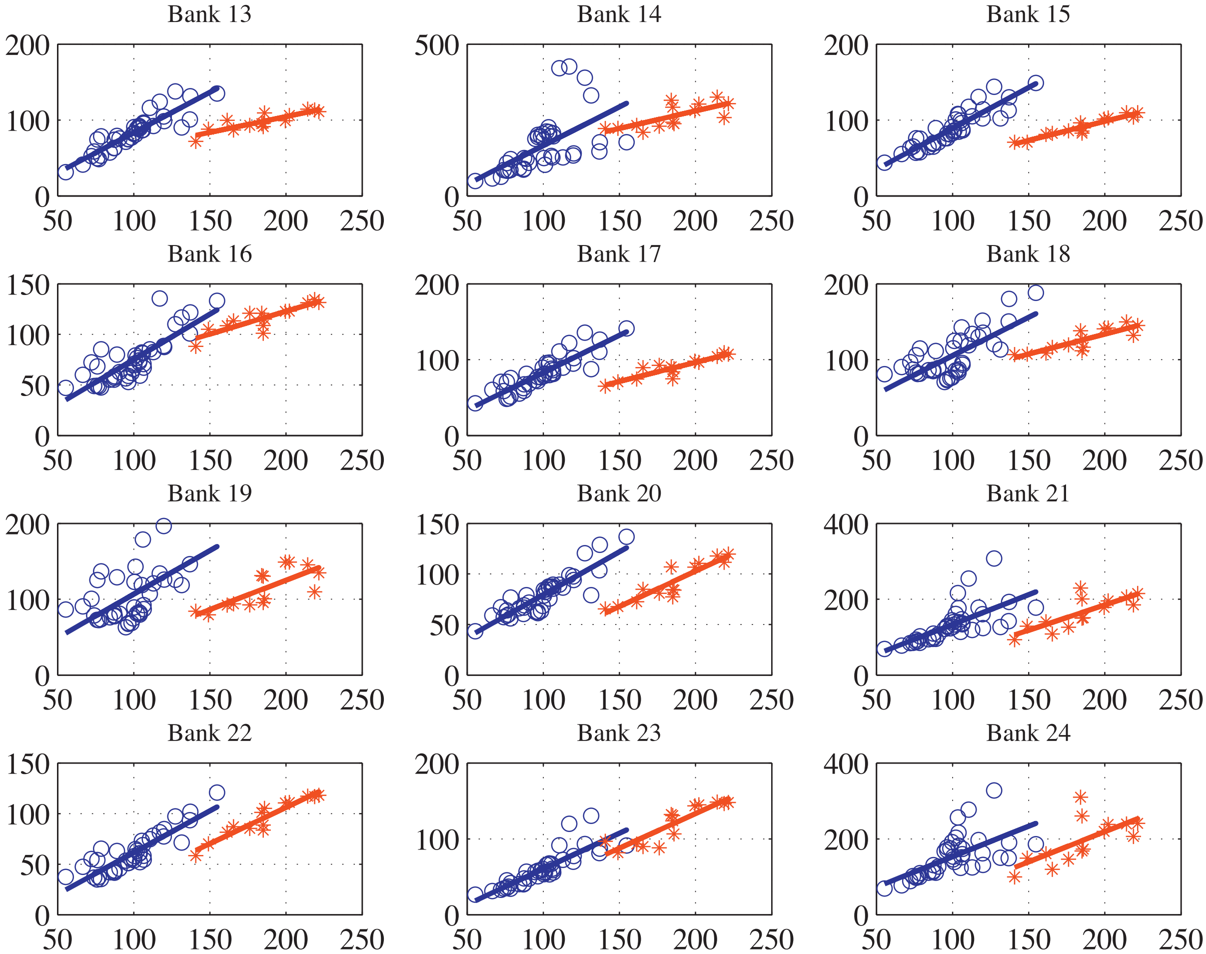

FIGURE 5: (CONT'D)

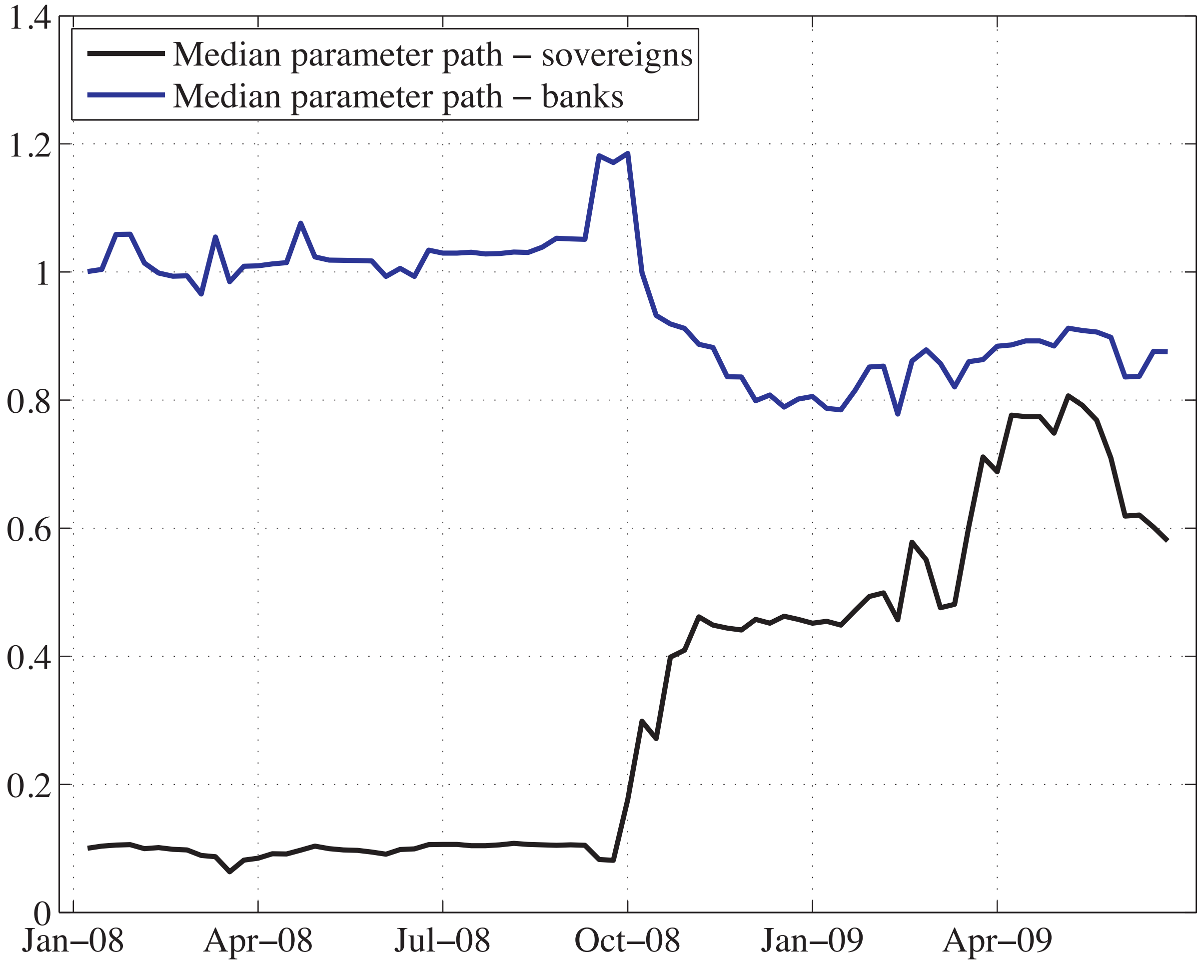

FIGURE 6: MEDIAN OF ESTIMATED RISK SENSITIVITY OF SOVEREIGN ISSUERS AND BANKS OVER TIME

For each week, the figure displays the median (across banks or countries, respectively) of estimated time-varying $\hat{\gamma}_{t|t}(i, c)$ in equation (3.3).

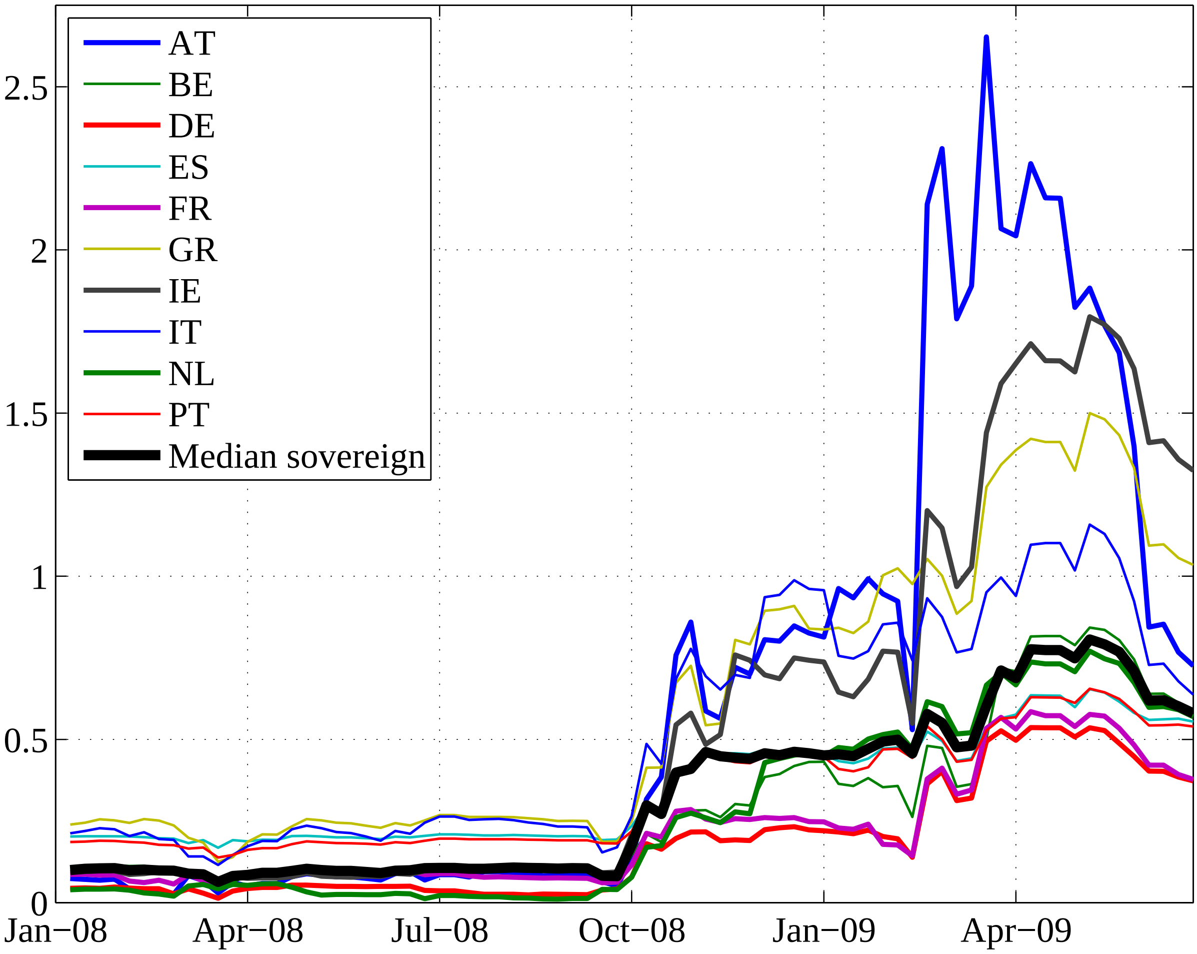

Figure 7: Estimated risk sensitivity of individual sovereign issuers

For each week, the figure displays the estimated time-varying $\hat{\gamma}_{t|t}(0, c)$, in equation (3.3).

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