Bank Bailouts and Bank-Sovereign Risk Contagion Channels

Irina M. Stângă*

February 13, 2014

Abstract

Bank bailouts generate risk spillovers between the default risks of banks and governments. This paper quantifies the effects of bank bailouts and measures the interdependence risk between the banking sector and government for the U.S. and six European countries. The approach allows to distinguish two channels of contagion by identifying bailout and sovereign risk shocks and assessing their effects on the default risks of banks and governments. In contrast to Europe, a bailout shock generates a persistent decrease in the default risk of the U.S. banking sector. The bank-sovereign risk contagion is stronger in Europe relative to the U.S..

JEL: C32, E44, H63

Keywords: Bank Bailouts, Bank Default Risk, Sovereign Default Risk, Contagion, Vector Autoregression, Sign Restrictions

*Affiliation: University of Groningen; Economics, Econometrics and Finance department; PO Box 800; 9700 AV Groningen, the Netherlands. I would like to express my gratitude towards Gabriele Galati and Jan Jacobs for very helpful discussions. I benefited from seminar feedback received at De Nederlandsche Bank. In addition, I would like to thank for comments to Jakob Bosma, Lammertjan Dam, Renee Fry, Pierre Lafourcade and Vincent Sterk. All errors are my own.
1 Introduction

Government interventions in support of the banking sector generate risk spillovers between banks and governments, which take place through two main channels. First, bank rescue measures lead to a decrease in bank default risk and an increase in the fiscal burden of governments (IMF, 2009). Second, the deterioration of sovereign creditworthiness feeds back to banks because it negatively impacts the valuation of their bond portfolios and hence their ability to obtain funding (BIS, 2011). The first channel describes the risk transfer from banks to governments due to a bank bailout, while the second one captures the co-movement between the default risks of the two sectors. The aim of this paper is to quantify the effects of bank rescue measures on both the default risk of the banking sector and the default risk of governments. It proposes a framework to identify the effects of bank bailouts and deal with the endogeneity between the two default risks. Furthermore, the paper offers insights on the differences among the bank-sovereign contagion channels across countries in Europe and the United States.

The main contribution of the study consists of a new identification scheme which allows to distinguish these two channels of contagion and to evaluate them in a joint framework. The distinction between the two channels is achieved through the identification of bailout shocks and sovereign risk shocks and the assessment of their impact on the bank and government default risks. Therefore the empirical strategy in the paper allows to isolate the effects of bank bailouts and to measure the interdependence risk between banks and governments. The identification of bailouts does not rely on bailout announcement dates and these can therefore be used as a validation for the bailout shocks estimated by the model. The second contribution of the paper is to provide a comparison of the implications associated with bank bailouts
across countries. Results show a substantial degree of heterogeneity in their stabilization effects. The bank-sovereign contagion is more persistent in Europe relative to the US.

In order to evaluate the two channels, I trace the dynamic interaction among the default risk in the banking system, sovereign default risk, and the term spread in a Structural Vector AutoRegression (SVAR) model with sign restrictions.\(^1\) The default risk measures are defined by the Credit Default Swap (CDS) spreads on bank debt and CDS spreads on government debt. The term spread is included as a control for macroeconomic conditions that affect the evolution of the default risks such as the liquidity premium and monetary policy. I estimate VAR models at the individual country level over the sample period 2008-2010 and impose sign restrictions on impulse responses to identify a bailout shock, a sovereign risk shock and a business cycle shock. The estimation is done at the individual country level in order to allow the estimated coefficients to vary across countries.

The two contagion channels are described in the theoretical model of Acharya, Drechsler, and Schnabl (Acharya et al.) (hereafter ADS), which provides restrictions for the identification of the bailout shock and sovereign risk shock. Government interventions in support of the financial sector are associated with increases in fiscal burden and impair the sustainability of sovereign debt. As a consequence, bank rescue packages entail a risk transfer from the financial sector to the government balance sheet. This leads to an increase in sovereign CDS spreads together with a decrease in the CDS spreads of the banking sector. Therefore, the first sign restriction is given by the opposite evolution of these two variables that allows the identification of a bailout shock.

\(^1\) Sign restrictions were introduced by Faust (1998), Canova and Nicolo (2002) and Uhlig (2005) for the identification of a monetary policy shock. Their approach is extended by Peersman (2005) for the case of a larger number of shocks. See Fry and Pagan (2011) for a review.
The second channel captures the spillover effects between the default risks of the two sectors and it is characterized by a two-way feedback between the CDS spreads of banks and sovereign CDS spreads. The underlying idea is that bailouts are funded in the short term by issuing new debt, which leads to a reduction in the value of already existing bonds. Since government bonds generally account for a significant part of the portfolios held by the banking sector, this dilution will directly affect the quality of banks’ balance sheets. As a consequence, the default risks of the banking sector and government become significantly interlinked and this is reflected in a co-movement of their CDS premiums. This co-movement provides the identifying sign restriction for the sovereign risk shock.

One challenge in evaluating the implications of bank bailouts is to identify at which point in time the actual effects of bailouts take place. We would expect that on average the effects of bailouts materialize on the dates of actual announcements of bank rescue measures. However, this match may not always hold if bailout expectations ‘matter more’ than actual bailouts (Bernal et al., 2010; Dam and Koetter, 2012). Bailout announcements were not a one time event and they consisted of a series of measures implemented during the crisis. Therefore, after the first bailout announcements, the effects of further bailouts may materialize shortly before their announcement. In this case the use of bailout announcement dates to identify bailout effects leads to spurious results. The advantage of the adopted methodology is that it traces the effects of bailouts without relying on bailout announcements such that these effects can take place at any point in time. Thereafter, I assess the validity of the identification restrictions by the match between the bailout announcement dates and the bailout shocks identified by the model.

This paper relates to the literature that investigates connections between banking and sovereign debt crises. In light of the Global Financial Crisis, some studies aim
to explain the determinants of sovereign risk, either based on macroeconomic funda-
mentals (Beirne and Fratzscher, 2013) or by focusing on the risk spillovers with the financial sector. However, most studies focus on a single channel of contagion. One strand of literature investigates how risks in the financial sector determine the sovereign risk spreads. Attinasi et al. (2009) show that bank bailouts have led to a widening of sovereign bond yield spreads in EMU. Furthermore, Dieckmann and Plank (2012) document that the perceived risk transfer from the private sector de-
pends on the importance of a country’s financial sector. Another strand of literature focuses on the reverse channel and documents the impact of risk in the government sector on the default risk in the banking sector. The results of Demirgüç-Kunt and Huizinga (2013) indicate that the burden of a high level of debt creates difficulties in providing support to the financial sector. ADS find that changes in sovereign credit risk affect bank credit risk positively after bailout announcement dates, while there is no significant relationship before them.

The documented effects in the literature are unidirectional and the two contagion channels are not evaluated simultaneously. However, their coexistence gives rise to endogeneity and the effects of bank bailouts cannot be identified if the two channels are not differentiated. Furthermore, the identification of both channels is necessary in order to isolate the effects of bailouts on both the default risks of banks as well as the one of governments. The adopted methodology sets this paper apart from the literature by differentiating the two contagion channels in a dynamic context and allowing the effects associated with any of them to take place at a given point in time. In this sense the paper goes beyond documenting a relationship between the default risks of the two sectors and quantifies the effectiveness of bailouts in de-
creasing the default risks of banks as well as their negative effects on governments’ creditworthiness. Moreover, since the estimation is done at the individual country
level, it allows for a comparison of the effects of bailouts across countries.

The results show that the bailout shocks identified by the model match the announcement dates of bank rescue packages. This match validates the identification scheme and it indicates that bank bailouts entail a risk transfer from banks to governments. In contrast to Europe, the volatility of the estimated bailout shock for the US drops substantially after the crisis. This indicates a lower persistence of the risk transfer and a stronger stabilization effect. Furthermore, a bailout shock leads to a significant and persistent decrease in the banks’ default risk for the US but only to a temporary drop for the majority of the analyzed European countries. However, a bailout shock leads to a rise in the sovereign default risk across all countries.

2 Methodology

2.1 Empirical model

The methodology is based on a structural VAR (SVAR) model with sign restrictions and the motivation for this specification is twofold. First, a VAR model allows for endogeneity between the bank and sovereign CDS spreads such that causality between the two variables can run either way. Second, sign restrictions allow to disentangle the two channels of contagion and thus to identify the effects of bank bailouts on both the default risk of banks and governments. Given this purpose the standard short-run or long-run restrictions used in the VAR literature would not allow for the identification of the two main shocks of interest.

In particular, there is no motivation for using long-run restrictions as the effects of the shocks on all variables are expected to materialize in the short run and these types of restrictions would not allow for identification. The choice of a recursive
Identification is also not suitable since it assumes that some variables do not respond immediately to certain shocks. Since the CDS spreads of banks and sovereigns are financial variables, it is likely that they react immediately to a shock. Moreover, the impulse responses obtained from the recursive identification can be an outcome that is part of the distribution formed by the impulse responses consistent with the sign restrictions (Farrant and Peersman, 2006). As a consequence, the zero contemporaneous restrictions are not required but at the same time not excluded and the shocks are allowed to have no effect contemporaneously.

The general representation of a structural VAR($p$) model is the following:

$$A_0Y_t = A(L)Y_t + \varepsilon_t,$$  \hspace{1cm} (1)

where $Y_t$ is an $n \times 1$ vector, $n$ denotes the number of variables in the model and $t$ indexes the observations. Furthermore, $L$ denotes the lag operator and $A(L) = A_1L + \ldots + A_pL^p$ is a matrix polynomial of order $p$, $A_0$ is the $n \times n$ matrix of coefficients that reflect the contemporaneous relationships among the endogenous variables, and $\varepsilon_t$ is a vector of structural shocks with expectation zero and diagonal covariance matrix $\Sigma_\varepsilon$.

The endogenous variables of the VAR model are the term spread (T-spread), the bank’s CDS spread (Bank CDS) and CDS spread on sovereign debt (Sovereign CDS). I identify three types of shocks based on sign restrictions: a business cycle shock, a bailout shock and a sovereign risk shock: $\varepsilon'_t = [\varepsilon'^{bc}_t, \varepsilon'^b_t, \varepsilon'^{sr}_t]$. The sign restrictions imposed for identification and their economic motivation are presented in section 2.2.

In order to estimate (1) the model is expressed in reduced form. Each variable is determined by its own past values and the lagged values of the other variables. The
reduced form is obtained by premultiplying (1) with $A_0^{-1}$:

$$Y_t = B(L)Y_t + e_t,$$

where $e_t$ is a $n \times 1$ vector of errors with expectation zero and covariance matrix $\Sigma_e$.

The ordinary least squares estimation of (2) yields the estimates $\hat{B}(L)$, residuals $\hat{e}_t$ and their estimated covariance matrix $\hat{\Sigma}_e$. The model is estimated in levels and with a lag order of one based on the Schwarz Information Criterion. Since the data consists of financial variables with high frequency it is unlikely that it has high persistency. The purpose is to obtain the structural shocks, which represent the underlying economic shocks and compute the impulse response function of the three variables to these shocks.

The first step is to obtain orthogonal shocks by computing an eigenvalue-eigenvector decomposition of the covariance matrix $\hat{\Sigma}_e$:

$$\hat{\Sigma}_e = PDP' = \tilde{P}\tilde{P}' ,$$

where $\tilde{P} := PD^{1/2}$, $P$ is a matrix of eigenvectors and $D$ is a diagonal matrix which contains the eigenvalues. The orthogonal shocks $\eta_t$ can be obtained as:

$$\eta_t = \tilde{P}^{-1}\tilde{e}_t.$$
composition of the covariance matrix can be written as:

\[ \hat{\Sigma}_e = \hat{P}Q\hat{Q}'\hat{P}', \]  

(5)

Therefore, \( \hat{P}Q \) is also an admissible decomposition which leads to a new set of candidate structural shocks \( \zeta_t \), that have the same covariance matrix as the initial ones but generate a different set of impulse responses:

\[ \zeta_t := (\hat{P}Q)^{-1}\hat{e}_t. \]  

(6)

For each choice of \( Q \) we obtain a different set of orthogonal shocks with associated impulse response functions. The choice of \( Q \) is done such as to systematically explore the space of MA representations (Canova, 2007). The selection of \( Q \) is based on Givens rotations by setting \( Q = Q(\theta) \), where \( \theta \) is an \( n \times 1 \) vector and \( \theta \sim U[0, \pi] \); there are \( \binom{n}{2} \) rotations for an \( n \) variable system and each matrix depends on the value of a rotation angle \( \theta_i \), where \( i \) indexes the number of matrices. In the context of the present model, the three possible rotations which form \( Q(\theta) \) are the following:

\[
Q(\theta_1, \theta_2, \theta_3) = \begin{bmatrix}
\cos(\theta_1) & -\sin(\theta_1) & 0 \\
\sin(\theta_1) & \cos(\theta_1) & 0 \\
0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
\cos(\theta_2) & 0 & \sin(\theta_2) \\
0 & 1 & 0 \\
-\sin(\theta_2) & 0 & \cos(\theta_2)
\end{bmatrix}
\times \begin{bmatrix}
1 & 0 & 0 \\
0 & \cos(\theta_3) & -\sin(\theta_3) \\
0 & \sin(\theta_3) & \cos(\theta_3)
\end{bmatrix}.
\]  

(7)

Intuitively, the base set of shocks is rotated to produce an alternative set of or-
orthogonal shocks. If we let \( m = 1, \ldots, M \) index a draw of \( Q(\theta) \), then for each draw \( Q^{(m)}(\theta) \) the contemporaneous impact matrix is computed together with the corresponding impulse response functions. The procedure for obtaining the impulse response functions is described in appendix 7.1. The next step consists of verifying whether the impulse response functions associated with a specific draw satisfy the sign restrictions and storing the draw if the correspondance is found. This is the case only if the responses of the variables to the shocks have the expected signs for the specified time length. The procedure is repeated until 1000 successful draws are obtained.

This approach leads to multiple sets of candidate structural shocks with different impulse responses, each corresponding to a specific draw. The outcome is a distribution of models, and a criterion is needed to identify a unique structural model. I apply the "median target" method suggested by Fry and Pagan (2011): identify a single structural model whose impulse responses are closest to the median model. This selection is achieved by minimizing a distance criterion from the median impulse responses. Note that the impulse responses obtained for each country might come from a different structural model, therefore the extent to which the magnitudes of the effects can be compared across countries is limited.

The last step consists in obtaining confidence bands for the impulse response functions. I employ a bootstrap procedure where the reduced form residuals are resampled in order to generate new data and obtain estimates of the sample distribution for the impulse response functions. The advantage of this approach is that it does not rely on the assumption that the error terms are Gaussian (Runkle, 1987). For every draw of the reduced form residuals, the above procedure of estimating the model and implementing the identification scheme is repeated. As a consequence, the median and the error bands are computed from all the impulse responses that
satisfy the sign restrictions, therefore reflecting both the sampling and model uncertainty. The number of bootstrap replications is set to 1000. In all figures, I report the optimal median of the impulse responses together with the 84th and 16th percentiles confidence bands as it is common in the literature that employs the VAR methodology.

2.2 Identification strategy

I briefly describe the set-up and implications of the theoretical model of ADS that are relevant for the identification scheme. Thereafter I discuss the sign restrictions imposed for the identification of the three shocks.

In the model of ADS the economy consists of a financial and a non-financial sector, a representative consumer and the government. The financial sector supplies financial services and maximizes expected profits. Their portfolio consists of government bonds and private sector assets. The non-financial sector decides upon the level of invested capital. The government aims at maximizing the economy’s output by addressing the debt-overhang problem of the financial sector. In this context, the debt-overhang is alleviated through the issuance of government bonds that are subsequently transferred to the balance sheet of the financial sector. This transfer increases the probability of solvency of the financial sector and therefore induces a raise in the supply of financial services.

The model emphasizes that a bailout represents a risk transfer between the financial and public sector, which results in a net reduction of the financial sector debt. Typically, the purpose of the guarantees is to prevent liquidation of the institutions in the financial sector. Therefore, the immediate effect of a bank bailout announcement is to lower the default risk of the banking sector and raise that of the government. However, a bailout is financed through the issuance of new govern-
ment debt, leading to a decrease in the value of the existing bonds. These assets are generally part of banks’ portfolios and represent a widespread form of collateral. As a result, the erosion in the value of the bonds can be viewed as a "collateral damage" which affects the ability of the banks to obtain funding and increases their risk exposure. Hence, any adverse sovereign risk shocks that increases the default risk of the government will negatively affect the creditworthiness of the financial sector. This translates into a co-movement between the default risk of the two sectors.

Based on these considerations, the sign restrictions imposed to identify the three shocks are summarized in Table 1.

<table>
<thead>
<tr>
<th>Structural shocks</th>
<th>Term-spread</th>
<th>Bank CDS</th>
<th>Sovereign debt CDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business cycle</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sovereign risk</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bailout shock</td>
<td>?</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Notes: A "+" ("-”) sign indicates that the impulse response of the respective variable to the corresponding positive shock is restricted to be greater or equal to zero (respectively smaller) for a certain number of weeks. A question mark indicates that no restriction is imposed. The restrictions are specified for 2 weeks on the main diagonal and one week for the rest.

The sign restrictions indicate the responses of the variables to positive shocks. A positive business cycle shock is related to an improvement in the economic conditions, while a positive sovereign risk shock defines an increase in the level of default risk for the government. Hence, the positive risk shock represents an adverse shock and is associated with a deterioration in creditworthiness. A positive bailout shock is associated with a decrease in the default risk of the banking sector and an increase in the sovereign default risk.

The restrictions are imposed for a time length of two weeks on the main diagonal of the table and one week otherwise. The motivation for the specification of constraints in the short run is justified by the fact that the effects of default
risk shocks materialize immediately. Furthermore, the restrictions are imposed as smaller (larger) or equal to zero ($\leq$ or $\geq$), therefore the responses of the variables are not forced to be different from zero. This allows for the contemporaneous effect of a shock to be zero and provides a more flexible framework than the standard short-run zero restrictions used for identification in VAR models.

The last row of the table denotes the sign restrictions imposed such that a bailout shock is identified. A positive bailout shock is associated with the first contagion channel and it is identified based on a simultaneous increase in the sovereign CDS spread and decrease in the banking sector CDS spread. The bailout shock is uniquely identified because it is the only type of shock that triggers an opposite movement in the CDS spreads of the public and private sector. A positive sovereign risk shock is associated with the second channel and it is identified based on an increase in both the CDS spreads of banks and the government.

A favorable business cycle shock is identified based on a positive response of the term spread and a decrease in the bank and sovereign CDS spreads due to the fact that a positive economic outlook lowers the perceived level of riskiness of the public and private sector. This shock has the role of capturing the macroeconomic fundamentals which affect the private and public level of riskiness in similar directions. The identification of a business cycle shock represents a proxy for these factors, so that the direct feedback channel between bank and sovereign CDS spreads is properly captured through the other two identified shocks.

The directions of the responses of the term spread to the bank and sovereign risk shocks are a priori uncertain, therefore I do not impose any restrictions and let the data determine the sign of the responses. However, the lack of restrictions implies that the sovereign risk shock and the business cycle shock still need to be disentangled because the two sets of sign restrictions are not mutually exclusive. I
follow an approach similar to that of Peersman (2005) and impose the size restriction that the response of the term spread to a business cycle shock is larger in absolute value than its response to a sovereign risk shock.

3 Data

The analysis is based on a weekly data set on CDS spreads of banks and governments at the individual country level. Additionally, the empirical model includes the term spread as a proxy for real economic activity. The source for this data is Thomson Reuters Datastream. The data for the government announcements of bank rescue packages is taken from ECB (2009), Panetta (2011), King (2009) and Panetta et al. (2009) and it is used as a robustness check for the validation of the estimated bailout shocks.

A credit default swap (CDS) is a contract which provides insurance for the buyer in the event of a loan default. The party who buys the contract pays an insurance premium (CDS spread) to the seller until either the contract expires or the specified credit event occurs. In the latter case, the buyer is entitled to receive the par value of the assets to which he is exposed or an amount equal to the difference between the par value and the market value (Stulz, 2010). The data for CDS spreads are for senior contracts with a maturity of five years, as these are frequently traded and liquid (BBA, 2006). For each country in the sample, a bank CDS index is constructed by calculating simple averages across the main banks which have the headquarters in the respective country.

The term spread is computed as the difference between the interest rate on government bonds with a maturity of ten years and the money market interest rate with a maturity of three months. I use the term spread to account for other eco-
nomic factors which might influence the joint evolution of CDS spreads over time such as liquidity premium, monetary policy and the economic cycle. There is a large body of literature that documents the forecasting power of the term spread for future real activity, which is usually explained by the expectations theory of interest rates. Estrella and Hardouvelis (1991) find that the spread can predict changes in real economic activity at least four quarters ahead. Adrian, Estrella, and Shin (2010) provide a rationale based on the balance sheet channel of the financial sector. In their paper, a reduction in the term spread decreases the net interest margin and therefore induces a contraction in the supply of credit and a dampening in real activity.\(^2\)

The data is transformed by computing weekly averages of the daily CDS spreads and interest rates series. The sample period spans January 2008 through November 2010 and covers the period of the Global Financial Crisis in which the majority of bank bailouts were announced and implemented. Since the main purpose of the study is to identify the effects of bank bailouts and the wave of bailouts started around September 2008 and continued for approximately one year thereafter, it is not necessary to extend the sample. Furthermore, the level and volatility of the CDS spreads were much lower before 2008, therefore the sample is chosen such as to avoid breaks in the series of the CDS spreads and preserve the stability of the models.

The results section focuses on the US, Ireland and Germany. I then extend the empirical analysis to four other European countries: France, Italy, Spain and the United Kingdom. The purpose of the extension is twofold. First, it provides the possibility to compare the patterns in the effects of shocks across countries. Second, it allows for a further validation of the identification scheme and provides a robustness check for the results.

\(^2\)Other key contributions include Harvey (1989), Stock and Watson (1989, 1993) and Hamilton and Kim (2002).
4 Results

The empirical method allows to distinguish bailout shocks from sovereign risk shocks and assess their effects on the default risks of banks and governments. I first discuss the evolution of the bailout shocks and their match with the actual announcements of bank rescue packages in order to document the validity of the identification scheme and assess the magnitude of the risk transfer from the banking sector to the governments. Thereafter, I present the impulse response functions as a means to analyze the effects of the identified shocks on the evolution of default risks in the financial and sovereign sectors.

4.1 Bailout shocks

The series of bailout shocks and actual bailout announcements (depicted as vertical lines) are plotted in Figure 1 for the US, Figure 2 for Ireland and Figure 3 for Germany. A bailout shock corresponds to positive values and it is associated with an increase in the sovereign default risk and decrease in the banking sector default risk. The vertical lines indicate government announcements of bank rescue packages which are described in appendix 7.4. The graphs for other countries are presented in Appendix 7.2.

Overall, the results highlight a good match between the bailout shocks identified by the model and the dates when bailouts were announced by the government. This match is strong especially for the first bailout announcements. For all countries, we can notice that the first bailout announcements correspond to spikes in the volatility of the bailout shocks. This match supports the identification assumption that bailout events triggered in the short run an opposite movement in the CDS spreads of banks and governments due to the risk transfer from the financial sector to the
government. The match is presented here in terms of graphs since they provide an intuitive interpretation for the magnitude and volatility of the risk transfer between banks and governments. The overall fit is assessed also statistically in section 5.

The magnitude of the bailout shocks at these dates provides a quantification of the risk transfer between the two sectors. The persistence of the shock throughout the sample indicates the extent to which banks and sovereigns remain linked in terms of the risk transfer. The variances of the bailout shocks have become larger after the onset of the financial crisis and their magnitudes reach the highest peaks at the beginning of the crisis. For all countries, the largest shocks occur around the autumn of 2008, when the first bank rescue packages were announced.

There is a major difference between the path and volatility of the shock for the US and the ones corresponding to the other countries. In contrast to the volatilities of the bailout shocks for the European countries, the volatility of the US bailout shock decreases rapidly after January 2009 and the path remains stable and without major spikes thereafter. For most of the European countries, the volatility of the shock remains high even after January 2009 relative to the period before. This result shows that the risk transfer from banks to governments is stronger and more persistent in Europe than in the US. This might be explained by the fact that the value of banks’ assets as a percentage of fiscal revenues are higher for countries in Europe.

U.S. – Figure 1 documents the evolution of the bailout shocks in the US. Only one very large bailout shock is identified by the model towards the end of September 2008. This spike in the volatility of the bailout shock matches the bailout announcement on September 19, 2008, when the US Treasury announced the proposal to purchase illiquid assets from banks under the Troubled Asset Relief Program (TARP). The fund of $700 billion aimed to increase the liquidity in the financial sector and to prevent a freeze on the credit markets.
The next bailout shock is much smaller in size and corresponds to a recapitalization of the banks under the Temporary Liquidity Guarantee program on October 14, 2008. The US government announced another series of measures to strengthen the stability on the markets. The first bailout shocks are followed thereafter by a relatively stable path, with no other major surges in volatility. This suggests that the risk transfer from the financial sector to the government was successful in creating stability on the markets and no further major interventions were required. This stable path is in strong contrast with the evolution of the bailout shocks for most of the European countries.

Figure 1: Evolution of bailout shocks - US

Notes: The graph illustrates the shock associated with the optimal median of the IRFs. Positive values indicate a bailout shock.

Ireland – The bailout shocks for Ireland are illustrated in Figure 2. The estimates indicate that the first large shock took place at the end of September 2008. This shock fits with the first announcement of bank rescue packages in Ireland and the news related to the approval of bank liability guarantees. The plan consisted of
guarantees to deposits and debts of Irish banks. Furthermore, the model indicates another large shock on 15 January 2009, when the Irish government announced the emergency nationalization of the Anglo-Irish Bank.

Figure 2: Evolution of bailout shocks - Ireland

![Graph]

Notes: The graph illustrates the shock associated with the optimal median of the IRFs. Positive values indicate a bailout shock.

**Germany** – The bailout shocks for Germany are illustrated in Figure 3. The first two bailout announcements have a good match with the spike in the volatility of the bailout shock. These dates correspond to the announcement of the emergency credit facility to Hypo Real Estate Group and the system wide recapitalization of the banking sector. A second increase in the volatility of the shock occurs in January 2009 and it matches with the bailout of Commerzbank, when the German government bought preferred shares of the bank. The high volatility persists until the beginning of 2009, after which it decreases and becomes more stable. However, it does not reach the same level of stability as the bailout shocks in the US.

The bailout shocks for the other four countries are presented in Appendix 7.2.
The paths of the bailout shocks are very similar with the ones of Ireland and Germany, suggesting a similarity across the European countries regarding the inter-linkage between the banking sector and the governments. In contrast to the US, the evolution of the shocks for the European countries remains highly volatile even after the autumn of 2009. The volatilities of the first bailout shocks are especially high for Spain and France, indicating a seizable risk transfer from the financial sector to the sovereign for these countries. Note that in the case of Italy and Spain there is a large shock towards the end of the sample (June and August 2010) which is not matched by a bailout announcement. This is a limitation of the data on bailout announcements since this dataset does not document bailout events towards the end of the sample. Most bailouts documented in the literature are the ones belonging to the wide scale bank rescue measures which took place between September 2008 and September 2009.
Overall, the match of the identified bailout shocks and the bailout announcement dates remains robust across countries. The overlap is especially strong for the first bailout announcement dates. For later announcements, few cases occur when the bailout dates do not match with the positive bailout shocks. For example, in the case of the US, the announcement of a second round of help to AIG does not correspond to a positive shock. Furthermore, the last two bailout dates are around the shock, rather than falling precisely on its peak.

The decrease in the fit can be explained by bailout expectations and the noise around the bailout announcements that took place at later stages. After the first announcements of bank rescue packages, any further bailout events might be incorporated in the expectations of investors and therefore the bailout shock would occur slightly before the announcement. Moreover, while the bailout data provides clear information regarding the novelty of the announcements for the first bailout dates, the uncertainty about the novelty of the announcements corresponding to later dates is higher. However, the overall fit of the bailout dates and bailout shocks is statistically significant, as illustrated in section 5.

4.2 Impulse response functions

In this section I present the impulse response functions, which describe the dynamic responses of the term spread, bank CDS spreads and government debt CDS spreads to the three identified shocks. The central results are the responses of the CDS spreads in the banking and sovereign sectors to a positive bailout shock and a positive sovereign shock respectively.

An important result to highlight based on the impulse responses is that the stabilization effects of bailouts in the US are stronger than in Europe. A bailout shock leads to a persistent decrease in the default risk of the banking sector in the US, but
only to a temporary decline for most of the European countries. This finding complements the results based on the evolution of the bailout shocks, which indicate that the contagion between banks and governments is stronger and more persistent in Europe. Furthermore, results show across all countries that a bailout shock increases the default risk of government and a sovereign risk shock also leads to a rise in the default risk of the banking sector.

**United States** – The impulse response functions for the US are documented in Figure 4, which shows the optimal medians of the impulse response functions, together with the 16th and 84th confidence bands. The responses of the three variables to the business cycle, sovereign risk and bailout shocks are plotted for a time span of 36 weeks. Note that the signs of the responses for the first week and respectively the first two weeks on the diagonal are driven by the identifying assumptions.

The dynamics of the bank and government CDS spreads following a bailout shock is illustrated on the bottom row of Figure 4 and their responses to a sovereign risk shock is shown on the middle row. These graphs highlight several results regarding the contagion between the banking sector and the US government.

First, a bailout shock leads to a strong decrease in the bank CDS spread. The decline in the spread is of approximately 25 basis points and it persists for 18 weeks. The significant drop in the CDS spread indicates that the financial rescue packages are successful in reducing the likelihood of default in the banking sector. This result together with the stable path of the bailout shocks in the aftermath of the crisis suggest that the bailout measures adopted by the US government are successful in terms of bringing financial stability on the markets.

Second, the effect of the bailout shock on the government CDS premium is positive and reaches a maximum of 1.5 basis points after 10 weeks. The bailout shock leads to a decrease in the creditworthiness of the government and the effect vanishes
out gradually. The magnitude of this effect is not high, indicating that the bailout measures in the US did not have a strong positive effect on the default risk of the public sector.

Third, a sovereign risk shock leads to a significant and persistent rise in the bank CDS spreads. This result illustrates the contagion from the government sector to the banks, through which a higher default risk of the government affects negatively the creditworthiness of the banking sector.

Overall, the results for the US show a strong stabilization effect of the bank rescue packages despite the fact that they lead to an increase in the sovereign CDS premium. Moreover, the latter effect is not strong in magnitude and therefore the
weaknesses of the financial sector associated with the bank rescue packages do not substantially affect the perceived solvency of the government.

**Ireland** – The impulse response functions for Ireland are presented in Figure 5. We can notice that the response of the banking sector CDS premium to a bailout shock is negative only for a very short period and this effect is driven by the identifying assumption. Thereafter, the effect becomes significantly positive and reaches a magnitude of 35 basis points at the peak. This pattern suggests that following a government announcement of a bailout measure, the default risk of the banking sector decreases only temporarily and therefore the stabilization effects of the intervention are limited. The effects of a bailout shock on the likelihood of default in the banking sector differ across the US and Ireland. One explanation for this contrast is that banks’ assets as a percent of government taxes are much higher in Ireland compared to the US and therefore the government deals with a higher burden for rescuing the banking sector (Merler and Pisani-Ferry, 2012).

Similarly to the US, the bailout shock leads to an increase in the sovereign CDS premium. The effect is statistically significant and it reaches a peak of approximately 26 basis points. Furthermore, a sovereign risk shock also leads to higher bank CDS spreads. These effects confirm the previous findings that bailout shocks transfer risk from the financial sector to fiscal authorities and the two sectors become mutually exposed. However, the contagion channel from banks to sovereign is stronger for Ireland than for the US.

**Germany** – The impulse response functions for Germany are presented in Figure 6. The results are similar to the ones for Ireland. The response of the default risk in the banking sector to a bailout shock becomes significantly positive immediately after the shock occurs. Furthermore, the bailout shock leads to a significant increase

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3 For the first week the response of the bank CDS premium to a bailout shock is restricted to be smaller or equal to zero, see Table 1.
Figure 5: Impulse response functions - Ireland

Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 1000 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.
in the CDS spreads on government debt, and a positive sovereign shock generates an increase in the CDS spreads of the banking sector. These results also indicate a stronger contagion channel between the public and private sector and a persistent interplay between the riskiness associated with the two sectors.

Figure 6: Impulse response functions - Germany

Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 1000 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.

European Countries – The impulse response functions for the other European countries are presented in Appendix 7.3. Their directions and shapes indicate that the effects of the shocks are similar across them. For most of the European countries except Spain, the bailout shocks generate a transitory drop in the bank CDS spreads, followed by a return to positive values. This rise in the bank CDS spread indicates a limited stabilization effect and it is in contrast with the US, where the bank rescue
packages managed to restore the creditworthiness of the banking system.

A second robust finding is the increase in the sovereign CDS spreads as a result of a positive bailout shock. This effect is strong for Ireland, Italy and Spain and it indicates that for these countries the rescue of the banking sector has a higher burden and impairs the sustainability of the sovereign debt. Finally, a positive sovereign risk shock leads to a significant decrease in the creditworthiness of the banking sector across all countries. The effect is pronounced in magnitude for France, Italy and Spain and highlights a high vulnerability of the banking sector towards the default risk of the government for these countries.

The results indicate that the inter-linkage between the state and the financial system is stronger and more persistent in Europe relative to the US. This contrast might be explained by the European sovereign debt crisis and the implicit risks and uncertainties associated with the creditworthiness of the European governments. As Goodhart (2011) documents, the connection between the government and the financial sector in Europe is much more complex than in the US. His paper indicates two relevant differences between the structures of the systems.

A first important difference is that the default of a US state would have less negative consequences and spillovers due to the existence of a federal center. Second, the financial intermediaries in the US operate on a much wider scale than in Europe and therefore these institutions hold a much more diversified portfolio of state bonds. As a consequence, the failure of a particular state would not strongly affect their default risks. In contrast, a failure of an European government would most likely have a significant impact on the creditworthiness of its financial sector. These differences highlight the relevancy of searching for policies that aim at balancing the sovereign and financial risks in Europe.
5 Robustness checks

5.1 Validation of bailout shocks

The graphs that illustrate the evolution of the bailout shocks (Figures 1-3 and 7-10) show a good match between the bailout shocks estimated by the VAR model and the actual bailout announcement dates for all countries. In this section I conduct a formal test to assess whether the relationship between the bailout shocks and bailout announcement dates is indeed positive and statistically significant. I estimate logit regressions with the bailout announcement dates as the dependent variable (0, no announcement; 1, announcement) and the bailout shocks as the explanatory variable.

The first two columns of Table 2 provide the regressions results based on the bailout shocks obtained from the VAR model estimated with one lag, while columns three and four present the results for the bailout shocks obtained from the VAR model with two lags. The table reports marginal effects associated with the bailout shocks on bailout announcements.
The results in Table 2 indicate that the marginal effects are positive and statistically significant at the 1% level. These results show that across all countries there is a match between the bailout shocks and the bailout announcement dates and therefore provide support to the identification scheme used for identifying the bailout shocks.

### 5.2 Results based on two lag estimation

The results based on the estimation of the VAR models with two lags are presented in the supplementary appendix. The match of the bailout shocks and bailout announcement dates remains robust to this specification, as it can be noticed in section 7.5 in the supplementary appendix. The graphs indicate the same contrast between the volatility of the bailout shocks after January 2009 for the European countries versus the one for the US. The regression results in Table 2 show that the marginal effects are positive and statistically significant at the 1% level in the regressions based on the bailout shocks obtained from the VAR models with two lags.
The impulse response functions in section 7.6 in the supplementary appendix indicate similar effects of the bailout shocks and sovereign risk shocks. For the US the effects are unchanged, in the sense that a bailout shock leads to a persistent decrease in the default risk of the banking sector and an increase in the default risk of the government. For many European countries, a bailout shock decreases the default risk temporarily and thereafter the effect becomes positive and significant. The main difference with the previous results is that the initial negative effects are more pronounced for the UK and Ireland. Furthermore, the effects of a bailout shock on the banks’ default risk for France and Spain are not statistically significant. The effects of a positive sovereign risk shock are robust across countries and consist of an increase in the default risk of the banking sector.

6 Conclusion

This paper investigates the interaction between the sustainability of sovereign debt and the default risk of banks that came into spotlight due to government interventions in support of the banking sector. I distinguish two channels of contagion by identifying bailout and sovereign risk shocks and estimating their effects on the default risks of the banking sector and governments. In order to identify these shocks and explore the implications of the financial rescue packages I estimate VAR models with sign restrictions. The validity of the identification scheme for the bailout shocks is assessed by their match with the dates of actual announcements of bank rescue packages.

The results illustrate a good match between the bailout shocks identified by the model and the actual announcements of bank rescue packages. This match validates the identification scheme and it indicates that bank rescue packages generated a
risk transfer from banks to governments. The persistence of this risk transfer and therefore the strength of the bank-sovereign contagion varies across countries in Europe and the US. For the European countries the volatility of the bailout shocks remains high throughout the sample.

The impulse response functions indicate that a bailout shock leads to a strong decrease in the default risk of the banking sector for the US. For most of the European countries the decline in the banks’ CDS spreads is transitory and thereafter becomes positive. However, the increase in the sovereign CDS spreads following a bailout shock is uniform across all countries. Furthermore, an adverse risk shock in the sovereign sector also generates an increase in the banks’ default risk. This effect is high in particular for France, Italy, and Spain and it indicates a higher vulnerability of the banking sector towards the weaknesses of the government. Overall, the results show a stronger contagion between the public and the private sector for Europe in comparison to the US. The patterns of the bailout shocks indicate a strong stabilization effect only for the US.

References


7 Appendix

7.1 Impulse response procedure

The moving average (MA) representation of the VAR can be written as:

\[ Y_t = \hat{C}(L)\hat{e}_t, \]  
\[ \hat{C}(L) := [I_n - \hat{B}(L)]^{-1}. \]  

Therefore the MA representation of the VAR in terms of orthogonal shocks is:

\[ Y_t = \hat{C}(L)\tilde{P}\eta_t, \]

and the general class of representations of \( Y_t \) in terms of the rotation matrix \( Q(\theta) \):

\[ Y_t = \hat{C}(L)\tilde{P}Q(\theta)\zeta_t = \hat{F}(L)\zeta_t \]
\[ = \sum_{h=0}^{\infty} \hat{F}_h \zeta_{t-h}, \]

where \( \hat{F}(L) \equiv \hat{C}(L)\tilde{P}Q(\theta) \) and \( \theta \sim U[0, \pi] \). Note that the covariance matrix of \( \zeta_t \) is:

\[ \mathbb{E}(\zeta_t\zeta_t') = \mathbb{E}\{[\tilde{P}Q(\theta)]^{-1}e_t e'_t [Q(\theta)' \tilde{P}']^{-1}\} \]
\[ = [\tilde{P}Q(\theta)]^{-1} \Sigma_e [Q(\theta)' \tilde{P}']^{-1} = I_n \]

The impulse response functions are defined as:

\[ \frac{\partial Y_{t+h}}{\partial \zeta_t} = \hat{F}_h, \]
where $h = 1, \ldots, H$ denotes the horizon of the response function to a shock at time $t$. If we let $i = 1, \ldots, n$ denote the rows of $\hat{F}_h$, and $j = 1, \ldots, s$ denote its columns, where $n$ is the number of variables and $s$ is the number of shocks, then the entry $F_{ij}$ of matrix $\hat{F}_h$ identifies the effect of a unit increase in $\zeta_{j,t}$ at date $t$ for the value of the $i^{th}$ variable $Y_{i,t+h}$ at time $t+h$. Note that for each draw of $Q^{(m)}(\theta)$, $m = 1, \ldots, M$ we obtain a new set of impulse response functions $\hat{F}^{(m)}_h$, $h = 1, \ldots, H$.

7.2 Evolution of bailout shocks

Figure 7: Evolution of bailout shocks - France

Notes: The graph illustrates the shock associated with the optimal median of the IRFs. Positive values indicate a bailout shock.
Figure 8: Evolution of bailout shocks - Italy

Notes: The graph illustrates the shock associated with the optimal median of the IRFs. Positive values indicate a bailout shock.

Figure 9: Evolution of bailout shocks - Spain

Notes: The graph illustrates the shock associated with the optimal median of the IRFs. Positive values indicate a bailout shock.
Figure 10: Evolution of bailout shocks - UK

Notes: The graph illustrates the shock associated with the optimal median of the IRFs. Positive values indicate a bailout shock.
7.3 Impulse response functions

Figure 11: Impulse response functions - France

Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 1000 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.
Figure 12: Impulse response functions - Italy

Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 1000 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.
Figure 13: Impulse response functions - Spain

Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 1000 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.
Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 1000 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.
### 7.4 Bailout dates

Table 3: Announcements of bank rescue measures

<table>
<thead>
<tr>
<th>Date</th>
<th>Country</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-9-2008</td>
<td>US</td>
<td>Emergency credit line to AIG</td>
</tr>
<tr>
<td>19-9-2008</td>
<td>US</td>
<td>US Treasury announces purchase of illiquid assets under TARP</td>
</tr>
<tr>
<td>3-10-2008</td>
<td>US</td>
<td>US Congress approves the revised TARP</td>
</tr>
<tr>
<td>13-10-2008</td>
<td>US</td>
<td>The government announces Capital Purchase Program</td>
</tr>
<tr>
<td>14-10-2008</td>
<td>US</td>
<td>Announcement of the Temporary Liquidity Guarantee Program</td>
</tr>
<tr>
<td>10-11-2008</td>
<td>US</td>
<td>Second round of help to AIG</td>
</tr>
<tr>
<td>23-11-2008</td>
<td>US</td>
<td>US Treasury buys preferred shares Citigroup</td>
</tr>
<tr>
<td>24-11-2008</td>
<td>US</td>
<td>US Treasury provides Citigroup protection on asset losses</td>
</tr>
<tr>
<td>16-1-2009</td>
<td>US</td>
<td>US Treasury provides Bank of America protection on asset losses</td>
</tr>
<tr>
<td>10-2-2009</td>
<td>US</td>
<td>The government announces a new plan to support the financial sector</td>
</tr>
<tr>
<td>30-9-2008</td>
<td>FR</td>
<td>France and Luxembourg - Dexia capital injection</td>
</tr>
<tr>
<td>9-10-2008</td>
<td>FR</td>
<td>BE, FR, LX debt guarantee for Dexia</td>
</tr>
<tr>
<td>13-10-2008</td>
<td>FR</td>
<td>Capital injections and debt guarantees (system wide)</td>
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<tr>
<td>20-10-2008</td>
<td>FR</td>
<td>French government announces plan to buy subordinated debt of six banks</td>
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<tr>
<td>14-11-2008</td>
<td>FR</td>
<td>Guarantees to Dexia</td>
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<td>6-10-2008</td>
<td>DE</td>
<td>German government provides emergency credit facility to Hypo Real Estate Group</td>
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<td>13-10-2008</td>
<td>DE</td>
<td>Capital injections and debt guarantees (system wide)</td>
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<td>3-11-2008</td>
<td>DE</td>
<td>German government buys preferred shares in Commerzbank</td>
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<td>8-1-2009</td>
<td>DE</td>
<td>German government buys second round preferred shares Commerzbank</td>
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<tr>
<td>13-5-2009</td>
<td>DE</td>
<td>Facility to transfer toxic assets, in exchange for government guaranteed bonds</td>
</tr>
<tr>
<td>Date</td>
<td>Country</td>
<td>Remark</td>
</tr>
<tr>
<td>------------</td>
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<tr>
<td>29-9-2008</td>
<td>IR</td>
<td>First announcement of bank rescue packages</td>
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<tr>
<td>30-9-2008</td>
<td>IR</td>
<td>Irish Government enacts legislation on bank liability guarantees</td>
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<td>22-12-2008</td>
<td>IR</td>
<td>Irish Government injects funds into 3 largest Irish Banks</td>
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<td>15-1-2009</td>
<td>IR</td>
<td>Irish government nationalises Anglo-Irish Bank</td>
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<td>8-10-2008</td>
<td>IT</td>
<td>Recapitalization of banks is approved by law</td>
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<td>13-10-2008</td>
<td>IT</td>
<td>National government approves capital injection and debt guarantees</td>
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<td>28-11-2008</td>
<td>IT</td>
<td>The government approves a law to inject capital into sound banks</td>
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<td>7-10-2008</td>
<td>SP</td>
<td>First announcement of bank rescue packages</td>
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<tr>
<td>13-10-2008</td>
<td>SP</td>
<td>Debt guarantees and capital injection</td>
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<td>29-9-2008</td>
<td>UK</td>
<td>Bradford &amp; Bingley is nationalised by the UK government</td>
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<tr>
<td>8-10-2008</td>
<td>UK</td>
<td>UK government announces capital injections and debt guarantees for banks</td>
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<tr>
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<td>UK</td>
<td>UK announces recapitalisation for 3 banks</td>
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<tr>
<td>19-1-2009</td>
<td>UK</td>
<td>UK announces asset protection plan</td>
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<td>26-2-2009</td>
<td>UK</td>
<td>UK Asset Protection Scheme extended</td>
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<td>7-3-2009</td>
<td>UK</td>
<td>Lloyds Banking Group participation in Asset Protection Scheme</td>
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