DNB Working Paper

No. 314 / August 2011

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DNB Working Paper

De Nederlandsche Bank
Eurosysteem

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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

Working Paper No. 314

August 2011

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Sovereign and Bank Credit Risk during the Global Financial Crisis

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Abstract

This paper investigates the interaction of market views on the sustainability of sovereign debt and the perceived credit risk of banks. This interaction came into spotlight during the recent financial crisis, as government interventions in support of the financial sector were associated with increases in fiscal burden. I analyze and quantify the effect of government interventions in the domestic financial system on the default risks of the banking sector and sovereign borrowers. The paper focuses on the cases of Ireland and Spain, which experienced large public interventions in the domestic banking system and at a later stage highly volatile bond markets. For each country, I estimate a Vector Autoregression model to trace the interaction among sovereign CDS spreads, bank CDS spreads, and a measure of the business cycle over the sample period 2007-2011. I identify shocks by imposing sign restrictions on the impulse response functions. The results point towards a risk transfer from the financial to the sovereign sector, which generates an increase in the credit risk of the latter but only a temporary drop in that of banks.

JEL: C32, E44, H63

Keywords: Financial Crises, Sovereign Debt, VAR, Sign Restrictions

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I. Introduction

This paper investigates the interaction of market views on the sustainability of sovereign debt and the perceived credit risk of banks. This interaction came into spotlight during the recent financial crisis, as large-scale government interventions in support of the financial sector were associated with large increases in fiscal burden. In this paper I analyze and quantify the effects of bailouts on the default risks of both sectors and establish some of their implications. As pointed out by Acharya, Drechsler, and Schnabl (2011), financial rescue packages not only create moral hazard and incentives for excessive risk taking but also generate a higher exposure of the public sector to the private one.

The recent fiscal crisis in the euro area has highlighted the relevance of this analysis. Although the crisis has started in the financial sector, the turmoil also affected sovereign debt markets starting in 2010. Investors' increasing concern about the capacity of some of the euro area governments to meet their debt obligations is reflected in the recent marked increase of sovereign bond yield spreads (Attinasi, Checherita, and Nickel, 2009). This surge is visible especially from a historical point of view, as the sovereign risk premium differentials were much smaller immediately after the start of EMU (Sgherri and Zoli, 2009). One possible explanation for the deterioration in the sovereigns' creditworthiness could be governments' support of the domestic financial sector. The bailouts schemes adopted by some European countries created exposures of the public sector to the risks and weaknesses of the private one. The interaction between the weaknesses of the banking sector and fiscal fragility is at the center of policy discussions but has not yet been extensively researched, especially for the case of developed economies.

In this paper I look at the dynamic interaction between the market's assessments of sovereign credit risk, measured by sovereign credit default swap (CDS) spreads, credit risk of the banking system, measured by CDS spreads for banks, and the business cycle. In order to trace this interaction, I estimate a Vector Autoregression (VAR) model with sign restrictions over the sample period 2007-2011, using weekly data. I impose sign restrictions on impulse responses to identify a business cycle shock, a sovereign credit risk shock, and a shock emanating from the financial sector. The impulse response functions describe the dynamic responses of the term spread, bank CDS and government CDS spreads to the three identified shocks.

The study is based on the theoretical findings of Acharya et al. (2011), which are used to provide an identification scheme for capturing the three shocks in the VAR model, and extends the empirical evidence presented in that paper. In particular, we derive two identification restrictions from the model in Acharya et al. (2011). First, their paper investigates the interrelation of bank bailouts and sovereign credit risk, and shows that the announcements of bank rescue packages led to a widening of sovereign CDS spreads together with a decrease in the bank CDS spreads, due to a risk transfer from the financial sector to the government balance sheet. This distinctive evolution of the variables capturing the default risk of the government and banking sectors allows pinning down a bailout shock distinctly from a shock originating in the banking sector and from a macroeconomic shock.

Second, Acharya et al. (2011) predict 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 will lead to a reduction in the value of the already existing bonds. Since government bonds generally account for a significant part of the portfolios held by the financial sector, this dilution will directly affect the quality of banks' balance sheets. As a consequence, default risks of the public and the private sector become significantly interlinked after bailout announcements, which should be reflected in a co-movement of their CDS premiums.

In this empirical study, a VAR model has the advantage of allowing for endogeneity between the sovereign and banking sector-specific credit risk. Moreover, using a VAR with sign restrictions relies on assumptions that are less stringent compared to standard restrictions used in a structural VAR, such as imposing zero constraints on the contemporaneous impact matrix or on the long run effects of the identified shocks. I therefore use this approach to document more formally the mechanisms described above and to test the above identification scheme. In particular, I assess the patterns of the impulse response functions, and in addition plot the identified bailout shocks in order to observe how they fit actual bailout announcements dates. I then take the analysis one step further by comparing the effects of the identified shocks across two euro area countries. The purpose of this extension is twofold. First, it provides a robustness check for the main results. Second, it offers insights on how the link between sovereign and banking sector shocks can vary depending on policy responses and country-specific characteristics.

The results show that a bailout shock leads to a rise in the government credit risk and a temporary drop in the credit risk of the banking sector. This is consistent with the fact that bank rescue packages lead to a risk transfer from the financial sector to the sovereign. Moreover, a shock in the banking sector associated with a higher level of riskiness generates an increase in the sovereign credit risk. This can be interpreted as supportive evidence for the fact that the two sectors become interlinked and the governments become exposed to the vulnerabilities of the banking sector.

The remainder of the paper is organised as follows. The next section provides a brief overview of the relevant literature. Section 3 describes my data set. Section 4 presents the empirical model and the identification procedure. Section 5 illustrates the main results for Ireland and Spain. Section 6 summarizes the conclusions.

II. Literature Review

The literature that studies the effects of the interaction between fiscal and banking crises in industrial countries is still scarce. This link is addressed mainly in the context of emerging market crises.[1] Burnside, Eichenbaum, and Sérgio (2001), for example, document how the roots of the Asian crisis of the 1990s originated in the implicit bailout guarantees for the financial sector provided by governments in the Asian region and their impact on expected future deficits. The recent financial events provide an opportunity to analyze the effects of the rescue packages on both the banking sector default risk as well as the one of the sovereign countries.

The present empirical study is based on the model developed by Acharya et al. (2011), which provides testable hypotheses regarding the relation between financial sector bailouts and sovereign credit risk during the financial crisis. The paper shows that there is a two-way feedback between the default risk of the private and public sectors, which translates into a strong co-movement of bank and sovereign CDS spreads. In their model, a bailout is viewed as a risk transfer from the banking sector to the government's balance sheet, which triggers a decrease in bank CDS spreads and a rise in the sovereign ones. However, the rescue packages are funded through the issuance of new government bonds, therefore diminishing the value of the existing ones and the sovereign creditworthiness. Since a part of these bonds are held by the financial sector, its ability to borrow by using them as collateral is likely to be affected. As a consequence, the banking sector becomes sensitive to future sovereign shocks.

Acharya et al. (2011) provide empirical evidence on this link by regressing the CDS spreads of banks on sovereign CDS spreads and a set of control variables. The relation is found to be significant, indicating that changes in sovereign credit risk positively affect bank credit risk. The authors emphasize that bailouts create not only moral

[1] See Mishkin (2001) for an overview of this topic.

hazard incentives but also additional types of costs, which are reflected in a higher level of sovereign credit risk and a raise in the cost of borrowing.

Ejsing and Lemke (2011) also focus on the relation between the financial sector and sovereign default risk. They find that a large proportion of the variability in both sovereign and corporate CDS spreads can be explained by a common risk factor, measured by the iTraxx index of non-financial CDS premia.[2] This represents evidence for a significant co-movement between the private and public risk of default and closely resembles one of the results obtained by Acharya et al. (2011). In addition, the authors highlight the fact that the sensitivity of banks' risk premia to the common risk factor decreased after the announcement of bank rescue packages, while the one of the sovereign evolved in the opposite direction.

Attinasi et al. (2009) study the evolution of sovereign bond yield spreads with respect to Germany. They consider a country's fiscal position, international risk aversion and market liquidity risk as the main potential determinants of government bond spreads. The authors investigate the role played by government announcements of bank rescue packages in explaining the widening of sovereign bond yield spreads and the risk transfer between the financial and public sector. The paper concludes that all variables are relevant and highlights the size of the expected budget deficit relative to Germany as a key factor in explaining higher bond yield spreads. Furthermore, the study emphasizes that bank bailouts have indeed influenced investors' assessment of government default risk.

Following a similar line of research, Sgherri and Zoli (2009) analyze the movements in euro area sovereign spreads and link them to solvency concerns of the private and public sectors for each country. They find that sovereign risk premium differentials are driven by a common time-varying factor which reflects shifts in investors' risk

[2]The iTraxx non-financial CDS index includes 100 non-financial entities from the iTraxx Europe index. The index also covers credit derivatives markets outside the euro area.

preferences. The authors also provide evidence for an increase in the sensitivity of sovereign spreads to the projected evolution of debt since the onset of the crisis.

Dieckmann and Plank (2011) study the determinants of CDS spreads in advanced economies. They regress the first principal component of CDS spreads on several local, global, and risk premium variables and show that both the domestic and the world financial systems are relevant explanatory factors. Furthermore, they illustrate that the sensitivity of CDS spreads to local and global shocks is higher for EMU members, compared with countries outside EMU. They also provide evidence on the presence of a risk transfer from the private to the public sector, and quantify the channel through which the sovereign absorbs the risks of the financial sector. Moreover, the paper emphasizes the co-movement of sovereign CDS spreads across countries, which intensified after the start of the financial crisis.

A similar analysis is the one of Demirgüç-Kunt and Huizinga (2010), the main difference being the focus on the reverse channel, through which an increase in public debt affects the financial sector in a negative way. The authors study the effects of a country's public finances on banks equity prices and CDS spreads, and show that the burden of a high level of debt creates difficulties in providing support to the financial sector. The financial safety net consisting of subsidies to systemically important banks is weakened by a deteriorating state of public finances, and as a consequence large banks might become too big to be saved rather than too big to fail.

III. Data

The analysis is based on a 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 main source of the data is Thomson Reuters Datastream.

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).

There are two main differences between credit default swaps and typical insurance contracts. Firstly, the party who buys the CDS contract does not necessarily have to hold the assets that create the risk exposure. Secondly, CDS contracts are traded over the counter, whereas insurance contracts are generally not traded (Stulz, 2010). One advantage of using CDS spreads series is that they represent a more accurate measure for pricing default risk than bond prices, which to an important extent reflect also other forms of risk. The price of a CDS reflects the expected loss in case of default and it is less influenced by other factors such as liquidity (Blanco, Brennan, and Marsh, 2005).

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 computing simple averages across the 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 (Euribor rate). I use the term spread to capture the business cycle and account for other economic factors which might influence the joint evolution of CDS spreads over time. In contrast to other common business cycle indicators such as the output gap or GDP growth, the term spread has the advantage of being available at high frequency.

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. According to this hypothesis, the long term rates should be an average of the expected short term 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.[3]

The frequency of the data is weekly and it is justified by the fact that it should be high enough to still capture the high frequency movements in CDS spreads and low enough to minimize the noise. The data is transformed by computing weekly averages of the daily CDS spreads and interest rates series.

The sample period covers the period from January 2007 to March 2011. This captures the crisis and a short period before its onset, and provides the possibility to analyse the evolution of the shocks at different stages of the crisis. I do not include earlier data because the behaviour of CDS spreads before the crisis differs significantly compared to the crisis period.

The empirical analysis focuses on Ireland since this country provides an interesting case to study the interaction between sovereign and banking system risks, given that it is the first country from the euro area which implemented a comprehensive bailout of the domestic banking system. I then extend the empirical analysis to Spain in order to assess the fit of the identification scheme on a different country and to compare the results across them.

In a future extension of the analysis, I plan to look at the interaction between sovereign and banking sector CDS spreads and inflation expectations. Measures of

[3]Other key contributions include Harvey (1989), Stock and Watson (1989, 1993) and Hamilton and Kim (2002).

inflation expectations extracted from inflation swaps are available at high frequency, and provide an alternative way of capturing macroeconomic developments at weekly frequency. This would provide a robustness check for the results in this paper and at the same time enrich the analysis regarding the impact of bailout and banking sector-specific shocks.

IV. Methodology

This section first describes the empirical model and then the identification scheme together with the motivation for the choices of sign restrictions.

A. Empirical model

The methodology employed in this paper is based on a sign restricted VAR model. I use a VAR model to allow for endogeneity among the variables and illustrate their dynamic interactions. The impulse response functions (IRFs) indicate how the variables of interest respond to the identified shocks. Moreover, they provide information regarding the magnitudes of the effects and the time span between the occurrence of the shocks and the changes in the variables.

More formally, the general representation of a structural VAR(p) model is the following:

$$\boldsymbol{B}\boldsymbol{Y}_t = \boldsymbol{A}(\boldsymbol{L})\boldsymbol{Y}_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \boldsymbol{\Sigma}_\varepsilon) \tag{1}$$

where $\boldsymbol{A}(\boldsymbol{L}) = \boldsymbol{A}_1\boldsymbol{L} + ... + \boldsymbol{A}_p\boldsymbol{L}^p$ is a matrix polynomial of order p, $\mathbf{B}$ is the $n \times n$ matrix of coefficients that reflect the contemporaneous relationships among the endogenous variables, and ε_t is an $n \times 1$ vector of structural shocks with variance-covariance matrix $\boldsymbol{\Sigma}_\varepsilon$.

The endogenous variables of the VAR model are the term spread, the bank CDS spread and the sovereign debt CDS spread. The model is estimated in levels and the lag order is one, chosen according to the Schwartz information criterion. Within this VAR, I identify three types of shocks: a business cycle shock, a bank risk shock and a sovereign risk shock ("a bailout shock"): $\varepsilon_t\prime = [\varepsilon_t^{bc}, \varepsilon_t^{br}, \varepsilon_t^{sr}]$.

To estimate the model, it must be expressed in reduced form, where each variable is explained by its own past values, lagged values of all the other variables and an error term which is serially uncorrelated. The reduced form of the structural model is obtained by multiplying (1) with $\boldsymbol{B}^{-1}$ and has the following representation:

$$\begin{aligned} \boldsymbol{Y}_t &= \boldsymbol{\Pi}(\boldsymbol{L})\boldsymbol{Y}_{t-1} + \boldsymbol{e}_t, \quad \boldsymbol{e}_t \sim \mathcal{N}(0, \boldsymbol{\Sigma}_{\boldsymbol{e}}), \\ \boldsymbol{\Pi}(\boldsymbol{L}) &\equiv \boldsymbol{B}^{-1}\boldsymbol{A}(\boldsymbol{L}); \end{aligned} \tag{2}$$

where $\boldsymbol{e}_t$ is a $n \times 1$ vector of errors with mean zero and variance-covariance matrix $\boldsymbol{\Sigma}_{\boldsymbol{e}}$.

The parameters and residuals $\hat{\boldsymbol{e}}_t$ of the model are obtained from the OLS estimation of the reduced-form VAR. However, the purpose is to recover the structural shocks ε_t, which represent the underlying economic shocks. The relationship between the structural shocks ε_t and the VAR errors $\boldsymbol{e}_t$ is given by the matrix $\boldsymbol{B}^{-1}$:

$$\boldsymbol{Y}_t = \boldsymbol{B}^{-1}\boldsymbol{A}(\boldsymbol{L})\boldsymbol{Y}_{t-1} + \boldsymbol{B}^{-1}\varepsilon_t \Rightarrow \boldsymbol{e}_t = \boldsymbol{B}^{-1}\varepsilon_t. \tag{3}$$

In order to estimate the matrix $\boldsymbol{B}^{-1}$ and obtain the orthogonal shocks from the vector of the reduced form VAR residuals, an eigenvalue-eigenvector decomposition of the variance covariance matrix is computed:

$$\boldsymbol{\Sigma}_e = \boldsymbol{P}\boldsymbol{V}\boldsymbol{P}' = \tilde{\boldsymbol{P}}\tilde{\boldsymbol{P}}', \tag{4}$$

where $\boldsymbol{P}$ is a matrix of eigenvectors and $\boldsymbol{V}$ is a diagonal matrix which contains the eigenvalues. However, for any orthonormal matrix $\boldsymbol{Q}$, the decomposition can be written as:

$$\boldsymbol{\Sigma}_e = \tilde{\boldsymbol{P}}\boldsymbol{Q}\boldsymbol{Q}'\tilde{\boldsymbol{P}}', \tag{5}$$

with $\boldsymbol{Q}'\boldsymbol{Q} = \boldsymbol{Q}\boldsymbol{Q}' = \boldsymbol{I}$. Therefore, $\tilde{\boldsymbol{P}}\boldsymbol{Q}$ is also an admissible decomposition which leads to a new set of candidate structural shocks that have the same variance-covariance matrix as the initial ones but generate a different set of impulse responses.

The selection of the $\boldsymbol{Q}$ matrix is based on Givens rotations; there are $\binom{n}{2}$ rotations for an n variable system and each matrix depends on the value of a parameter θ_i, which represents the rotation angle. The common approach in the literature is to multiply all the matrices in order to obtain a $n \times n$ matrix $\boldsymbol{Q}$. In the context of the present model, the three possible bivariate rotations which form the $\boldsymbol{Q}$ matrix are the following:

$$\boldsymbol{Q}(\theta_1, \theta_2, \theta_3) = \begin{bmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 \\ \sin(\theta_1) & \cos(\theta_1) & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \cos(\theta_2) & 0 & \sin(\theta_2) \\ 0 & 1 & 0 \\ -\sin(\theta_2) & 0 & \cos(\theta_2) \end{bmatrix}$$
$$\times \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta_3) & -\sin(\theta_3) \\ 0 & \sin(\theta_3) & \cos(\theta_3) \end{bmatrix}. \tag{6}$$

In order to explore the space of the MA representations, the rotation angles θ_1, θ_2 and θ_3 are drawn from a uniform $[0, \pi]$ distribution. For each draw of the rotation matrix the contemporaneous impact matrix is computed together with the corresponding impulse response functions. Intuitively, the base set of shocks is rotated to produce an alternative set of orthogonal shocks.[4]

The next step of the procedure consists of verifying whether the impulse response

[4]For further information regarding the methodology see Canova (2007) and Peersman (2005). Fry and Pagan (2010) provide a review of the sign restrictions approach.

functions associated with a specific draw are in line with the imposed sign restrictions and keeping the draw if the correspondence 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. If there is at least one single discrepancy, the model is discarded. The algorithm 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 final outcome consists of a distribution across models, hence a criterion is needed to identify a unique structural model. In order to summarize the information provided by the set of the impulse responses for each shock, I apply the "median target" method suggested by Fry and Pagan (2010). Their approach consists in identifying a single structural model whose impulse responses are as close as possible to the median values. This selection is achieved by minimizing a distance criterion from the median impulse responses.

The final step consists in constructing confidence bands for the impulse response functions based on bootstrapping. The number of bootstrap replications is set to 800. In all figures, I report the optimal median of the responses together with the 84th and 16th percentiles confidence bands. The median and the error bands are computed from all the impulse responses that satisfy the sign restrictions, therefore reflecting both the sampling and modeling uncertainty.

B. Identification strategy

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. The identification strategy employed in this paper follows that of Peersman (2005) and consists of imposing short run sign restrictions on the impulse responses.

Identification schemes based on short run or long run parametric restrictions are less useful in the context of the present model. In particular, the identification method based on the Choleski decomposition assumes that some variables do not respond contemporaneously to certain shocks. Since the CDS spreads of banks and sovereigns are financial variables, it is unlikely that they are contemporaneously exogenous and do not react immediately to a risk shock. The alternative of imposing long-run restrictions is also difficult to justify as the effects of the shocks are expected to materialize in the short run.

Note that the impulse responses obtained from the traditional recursive identification can be considered to be one possible outcome of the distribution formed by the responses which are consistent with the sign restrictions (Farrant and Peersman, 2006). In this context, the key advantage of the sign restrictions approach is that these zero constraints on the contemporaneous impact matrix are not required and at the same time not excluded.

The empirical specification is inspired by the theoretical model of Acharya et al. (2011) and is meant to provide an illustration of the mechanism that underlies their model. In what follows, I will briefly describe the set-up and implications which are relevant for the proposed empirical identification scheme.

In the model of Acharya et al. (2011), 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 payoff. Their portfolio consists of government bonds and other types of assets. The non-financial sector decides upon the level of invested capital. The government aims to maximize 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 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 guarantees' purpose is to prevent liquidation of the financial sector's institutions. Therefore, the immediate effect of a rescue package announcement is to lower the banking sector's credit risk and raise that of the government. However, in the short term, a bailout is financed through the issuance of new government 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 will negatively affect the private sector. Ultimately, this will induce a post-bailout 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 the following table:

TABLE I
Sign restrictions used for identification

	VAR variables		
Structural shocks	Term-spread	Bank CDS	Sovereign debt CDS
Business cycle	+	-	-
Bank risk	?	+	+
Government risk	?	-	+

Notes: A "+" ("-") sign indicates that the impulse response of the respective variable to the corresponding 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 positive restrictions on the diagonal are imposed for 3 weeks, while the remaining ones are specified for 2 weeks.

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 risk shock defines an increase in the level of credit risk for the respective sector. Hence, the positive risk shock represents an adverse shock and is associated with a deterioration in creditworthiness.

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. The preference for this type of constraint is justified by the fact that the effects of the business cycle or bank risk shock might not materialize immediately.

I select only the decompositions (rotations) which produce impulse responses consistent with all the specified restrictions. The restrictions on the diagonal of the matrix are imposed for a time length of three weeks after the shocks. All the other constraints are specified to hold for two weeks.

The sign restrictions on the impulse responses are imposed such that an appropriate identification of a bailout shock is obtained. This shock is associated here with a a positive sovereign risk shock and 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 bank risk shock is associated with an increase in both the CDS spreads of the banks and the government. An increase in the credit risk of the banks leads to an immediate raise in the banking sector CDS index. However, the sovereign CDS spreads might not react on impact or widen if the financial markets expect a bank rescue package associated with an increase in fiscal burden.

A favorable business cycle shock should create a positive response in the term spread and a decrease in the bank and sovereign CDS spreads. The latter effect can be explained by the fact that a positive economic outlook lowers the level of riskiness of the public and private sector. This shock has the role of capturing the economic conditions that trigger the same responses in both the bank and sovereign risk. The co-movement between these two variables might be caused also by macroeconomic fundamentals which affect the private and public level of riskiness in similar directions. The business cycle measure represents a proxy for these factors, so that the direct feedback channel between bank and sovereign CDS spreads is properly captured through the two identified risk 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 bank risk shock and the business cycle shock still need to be disentangled because the two sets of sign restrictions are not mutually exclusive and therefore do not uniquely identify them. In order to distinguish these two shocks, I follow an approach similar to that of Peersman (2005) and impose a size restriction. In particular, the response of the term spread to a business cycle shock is constrained to be larger in absolute value than its response to a bank risk shock.

V. Results

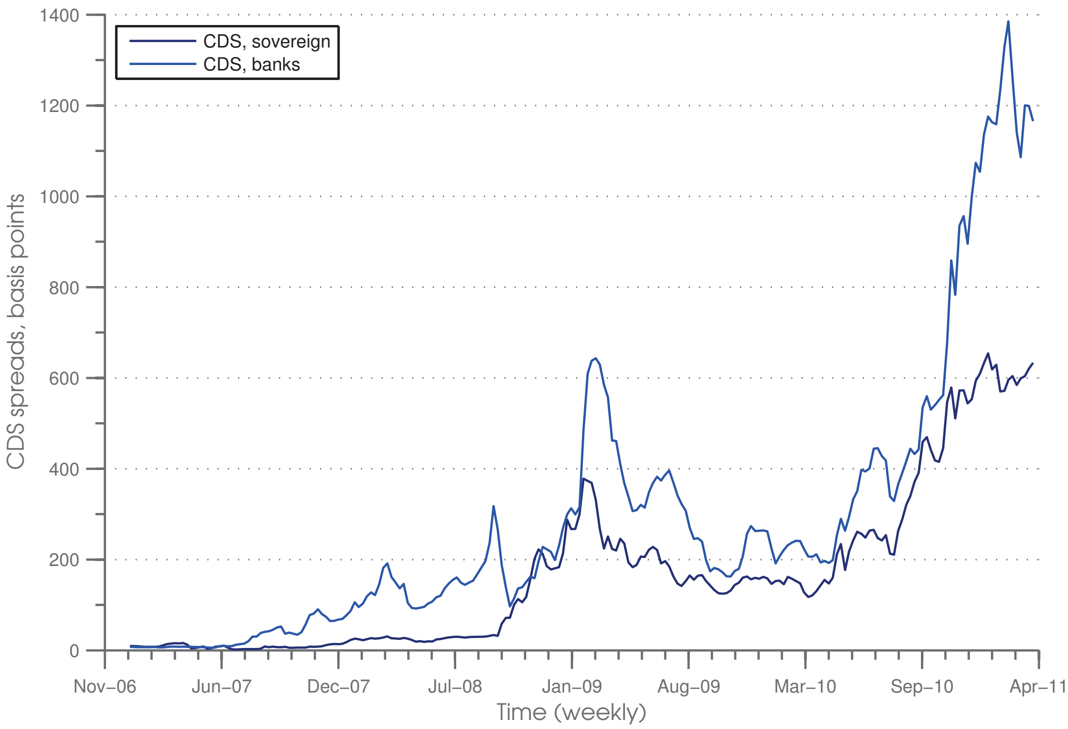
A. The case of Ireland

The focus of this section is on Ireland, which was the first country from the euro area to implement a bank rescue package. An analysis of Spain is presented in the next section.

Figure 1 illustrates the evolution of the bank and sovereign CDS spreads around the recent crisis. In the period before the first announcement of government support for the domestic banking system in the autumn of 2008, there is no apparent connection between the two series. The government CDS premium is low and stable, while the one associated with the banking sector starts to increase in June 2007, around the beginning of the financial crisis. In the autumn of 2008, the two series start to co-move closely and converge to similar levels. However, at the beginning of 2009, the CDS spreads of the banking sector surge and remain significantly above sovereign spreads. The gap between the two spreads becomes even more pronounced after the fall of 2010.

FIGURE 1

Evolution of bank and sovereign CDS spreads - Ireland



The co-movement of sovereign and banking sector CDS spreads for the case of Ireland is documented more formally in Figure 2, which shows the optimal medians of the impulse response functions, together with the 16th and 84th confidence bands.[5] The responses of the three variables to the business cycle, bank risk and bailout shocks

[5]The optimal median indicates the structural model with the least overall distance from the median responses.

are plotted for a time span of 24 weeks. Note that the interpretation regarding their signs is valid only for the period throughout which the restrictions are not imposed (i.e. after three or respectively two weeks), while the signs for earlier periods are driven by the identifying assumptions.

The impulse response functions highlight several interesting results. First, on average the number of draws necessary to obtain a set of responses in line with the imposed sign restrictions is modest, suggesting that these are a good description of the data. On average, 18.5 draws are needed in order to obtain a set of responses which is in line with the imposed sign restrictions.[6]

Second, the bottom row of Figure 2, which illustrates the dynamic transmission of the sovereign risk shock to the three variables, highlights that this shock generates in the short run a significant decrease in the bank index CDS spread and an increase in the government CDS spread. The response of the banking sector CDS premium remains negative for only one week and becomes positive afterwards. This positive movement is quite pronounced and reaches a magnitude of 20 basis points after seven weeks. This pattern is in line with the theoretical predictions and suggests that following a government intervention in the domestic banking sector with an associated rising debt burden, the banks' credit risk decreases only temporarily and then increases in tandem with sovereign CDS spreads.

Third, a shock emanating from the banking sector leads to higher sovereign CDS spreads. The reaction of the government CDS spread is persistent, with a median impact of around 13 basis points. Its response is both statistically and economically significant.

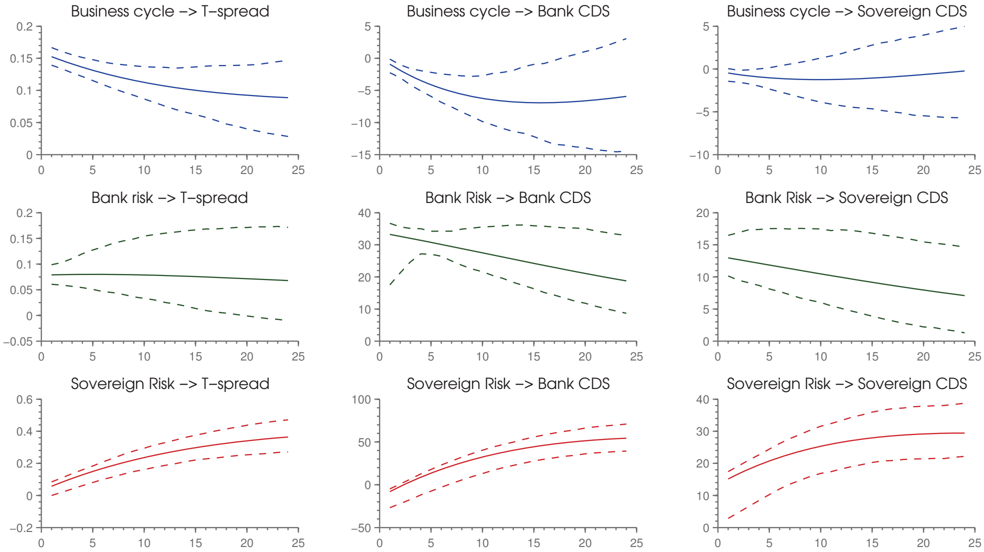
I also find that a favourable business cycle shock leads to a decrease in both the bank CDS spread index and the sovereign CDS spread. The response of the bank CDS

[6] Fry and Pagan (2010) suggest that this provides an indication for the fit of the identification scheme based on sign restrictions.

premium is small immediately after impact and becomes more pronounced over time, indicating a decline in the perceived riskiness of the banking sector. However, the fall in the government CDS premium is of negligible size.

FIGURE 2

Impulse response functions - Ireland

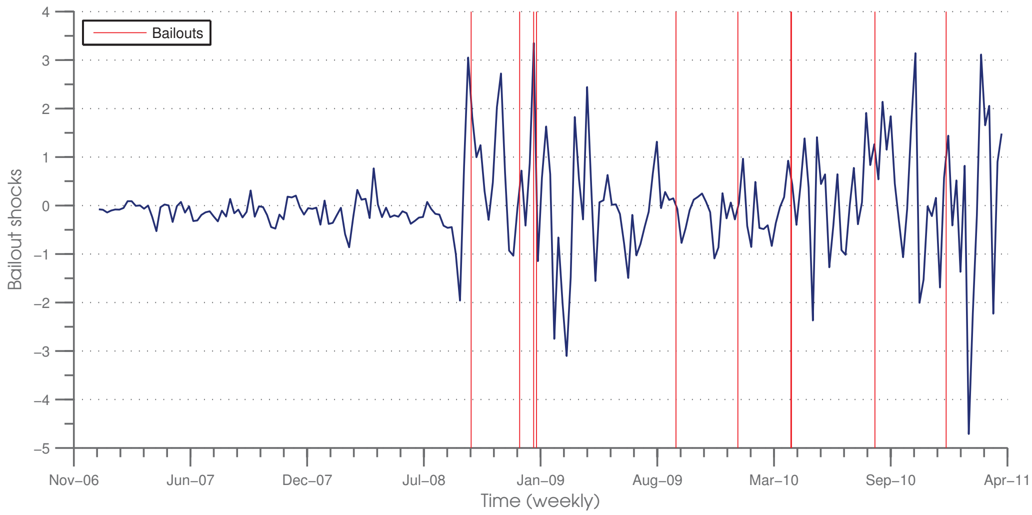


Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 800 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.

In sum, the impulse response functions indicate that in the case of Ireland, sovereign credit risk shocks associated with bailouts appear to play an important role for developments in both the banking and sovereign sectors. In particular, a positive sovereign risk shock generates an increase in the government credit risk and a transitory drop in the credit risk of the banks. This indicates that bailout shocks only temporarily transfer risk from the financial sector to fiscal authorities.

The time series of the bailout shocks and actual bailout dates (depicted as vertical lines) are plotted in Figure 3. The graph highlights a close match between positive shocks (i.e. shocks associated with an increasing fiscal burden and decreasing bank riskiness) identified by the model and bailout dates. This supports the identification assumptions that were chosen and the interpretation that a bailout event triggers a movement in opposite directions of the CDS spreads of banks and governments in the short-run.

FIGURE 3
Evolution of sovereign credit risk shocks - Ireland



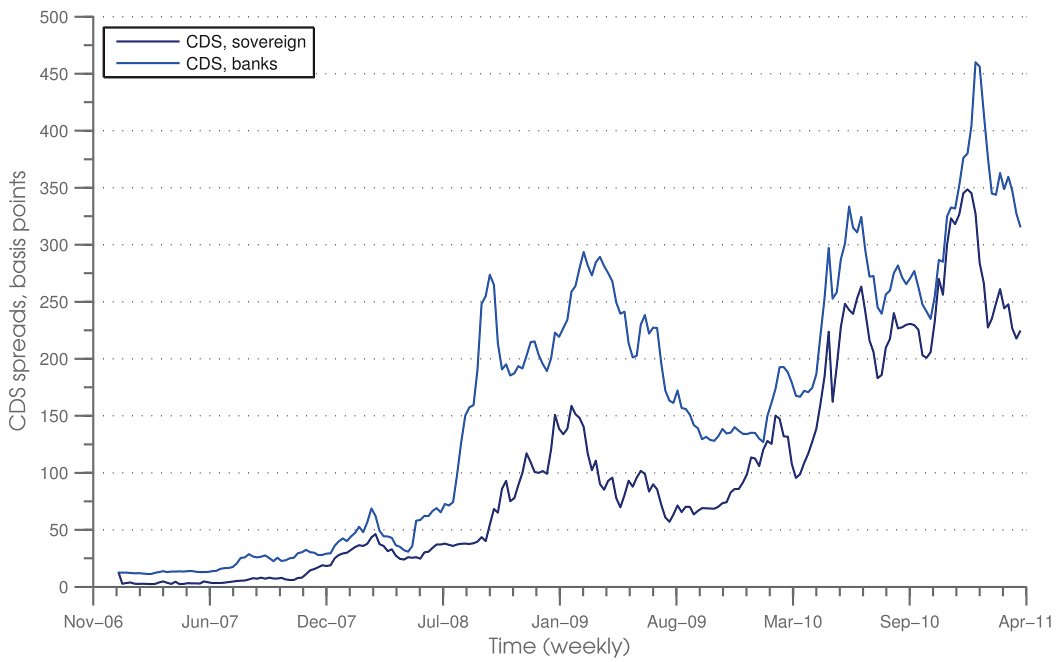
Notes: The graph illustrates the shock associated with the optimal medians of the IRFs. Positive values indicate an adverse risk shock (i.e. an increase in the credit risk of government debt.

Furthermore, we can notice that the magnitude and variance of the bailout shock have become significant only after the onset of the crisis. The largest shocks occur around the autumn of 2008, when the first rescue packages were announced in Ireland. More specifically, the model indicates that the first large shock took place at the beginning of October 2008, immediately after the first bailout news – the approval of bank liability guarantees – was released by the Irish government on 29 September 2008. Moreover, the largest shock took place in January 2009, when the Irish Parliament approved the emergency nationalisation of Anglo-Irish Bank. The graph also reveals a rise in size and volatility of bailout shocks in early April 2010. This coincides with the announcement of a "bad bank" plan aimed at removing "toxic assets" held by the domestic banking system.

B. The case of Spain

In this section I extend the analysis to the case of Spain and check whether the identification strategy is further supported. Figure 4 shows the developments in the sovereign and bank CDS spreads markets. The patterns of the series resemble those of Ireland. We can notice a surge of the bank index CDS premia in the summer of 2008, followed by a temporary drop a few months later. This fall is accompanied by an increase in sovereign CDS spreads and occurs around the first bailout announcement in Spain. The two series seem to evolve in parallel after the autumn of 2008.

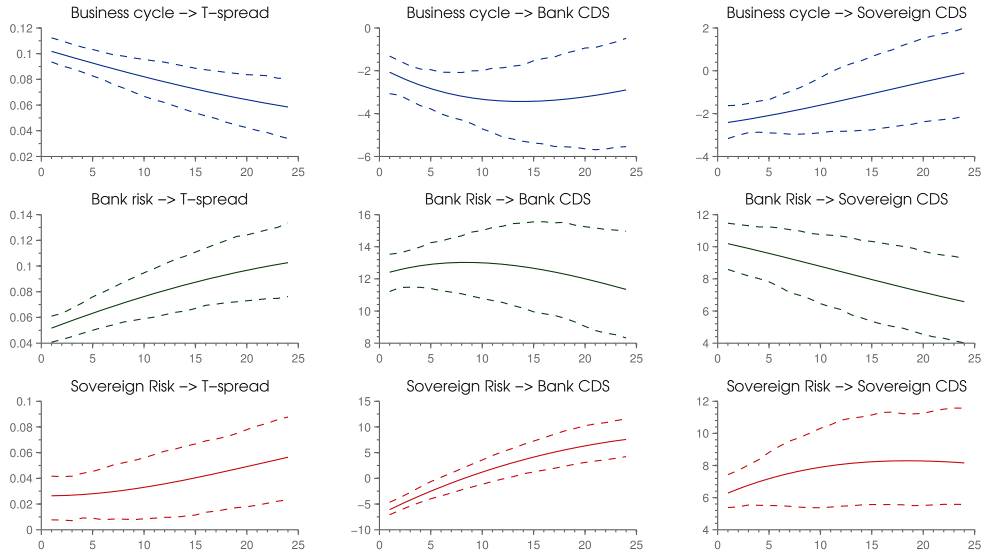
FIGURE 4
Evolution of bank and sovereign CDS spreads - Spain



The impulse response functions of the three variables are presented in Figure 5. Their directions and shapes are comparable with those of the benchmark model, indicating that the dynamic interactions between the bank and sovereign credit risk have analogous effects. Specifically, an adverse sovereign risk shock generates a short term decrease in the bank CDS spreads, followed by a return to positive values. The main difference with respect to the result for Ireland is that the fall in the bank level of riskiness is more persistent. The second similar finding is the increase in the sovereign CDS spreads as a result of a positive bank risk shock. This confirms the previous conclusion regarding the exposure of the government towards the financial sector and the co-movement of the two CDS spreads series.

FIGURE 5

Impulse response functions - Spain

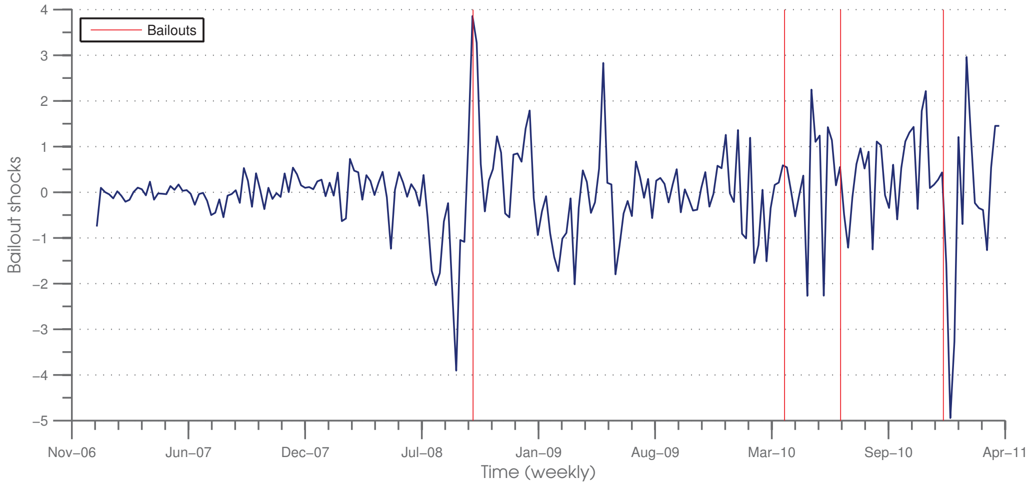


Notes: The solid lines denote the optimal medians of the impulse responses, which are estimated from a sign restricted VAR with 1000 draws. The confidence bounds represent the 16th and 84th percentiles of the distribution obtained from 800 bootstraps. The term spread is expressed in percentage terms, while the CDS spreads are in basis points. The horizontal axis denotes weeks.

The evolution of the sovereign risk shock over the sample period is presented in Figure 6. The variance of this shock is small before the onset of the financial crisis and peaks in July and August 2008. This negative shock is linked with a sudden increase in the bank index CDS spread and is associated with the release of data on non-performing loans from the Bank of Spain. The first vertical bar indicates the date on which the first bank rescue package was announced in Spain, namely 7 October 2009. The event coincides with the first and largest positive bailout shock identified by the model. This provides additional evidence on the robustness of the identification assumptions for the sovereign risk shock and for the fact that a bailout decision leads to a risk transfer from the financial sector to the government.

FIGURE 6

Evolution of sovereign credit risk shocks - Spain



Notes: The graph illustrates the shock associated with the optimal medians of the IRFs. Positive values indicate an adverse risk shock (i.e. an increase in the credit risk of government debt.

VI. Conclusion

In this paper I investigate the interaction of market views on the sustainability of sovereign debt and the perceived credit risk of banks during the recent crisis. The focus is on two euro area countries where this interaction has come into spotlight – Ireland and Spain. The market's assessments of sovereign credit risk are measured by sovereign credit default swap (CDS) spreads, and the perceptions of credit risk of the banking system by the CDS spreads for banks. The business cycle fluctuations are captured by the term spread. I employ a vector autoregressive (VAR) model with sign restrictions for each of the two countries to explore the effects of financial rescue packages ("bailout events") during the recent financial crisis. I identify a bank risk shock and a sovereign risk shock by imposing short run sign restrictions on the impulse response functions derived from Acharya et al. (2011). In order to ensure a robust identification of these two shocks, I control for other relevant economic factors by identifying also a business cycle shock.

The results illustrate that the evolution of bank and sovereign credit risk was significantly affected by the government measures in support of the banking sector. In particular, the announcement of these bank rescue packages generated a temporary decline in banks' level of riskiness and a rise in the sovereign default risk. The resulting mutual exposure of the two sectors led to a co-movement of the prices that reflect their default probabilities. This linkage is evident from the positive response of government CDS spreads to an adverse bank risk shock. I find that the impulse response functions for Ireland and Spain look similar, the differences consisting mainly in the timing of the reactions.

In future research, I intend to extend my analysis to other economies that were recently hit by turmoil in sovereign bond markets, and also investigate the interaction between banks' CDS spreads and sovereign CDS spreads within multi-country models.

References

Acharya, V. V., I. Drechsler, and P. Schnabl, 2011, A Pyrrhic victory?- Bank Bailouts and Sovereign Credit Risk, *NBER Working Paper* 17136.

Adrian, T., A. Estrella, and H. S. Shin, 2010, Monetary Cycles, Financial Cycles, and the Business Cycle, *Federal Reserve Bank of New York Staff Reports* 421.

Attinasi, M. G., C. Checherita, and C. Nickel, 2009, What Explains the Surge in Euro

Area Sovereign Spreads during the Financial Crisis of 2007- 09?, *ECB Working Paper* 1131.

BBA, 2006, Credit Derivatives Report, Technical report, British Bankers' Association.

Blanco, R., S. Brennan, and I. W. Marsh, 2005, An Empirical Analysis of the Dynamic Relationship between Investment-Grade Bonds and Credit Default Swaps, *Journal of Finance* 60, 2255–2281.

Burnside, A. C., M. Eichenbaum, and R. Sérgio, 2001, On the Fiscal Implications of Twin Crises, *C.E.P.R. Discussion Papers* 2918.

Canova, F., 2007, Methods for Applied Macroeconomic Research (Princeton University Press, Princeton).

Canova, F. and G. De Nicolo, 2002, Monetary Disturbances Matter for Business Fluctuations in the G-7, *Journal of Monetary Economics* 49, 1131–1159.

Demirgüç-Kunt, A. and H. Huizinga, 2010, Are Banks Too Big to Fail or Too Big to Save? International Evidence from Equity Prices and CDS Spreads, *World Bank Policy Research Working Paper* 5360.

Dieckmann and Plank, 2011, Default Risk of Advanced Economies: An Empirical Analysis of Credit Default Swaps during the Financial Crisis, *Review of Finance* 15, in print.

Ejsing, J. and W. Lemke, 2011, The Janus-headed Salvation: Sovereign and Bank Credit Risk Premia during 2008-2009, *Economics Letters* 110, 28–31.

Estrella, A. and G. Hardouvelis, 1991, The Term Structure as a Predictor of Real Economic Activity, *Journal of Finance* 46, 555–576.

Farrant, K. and G. Peersman, 2006, Is the Exchange Rate a Shock Absorber or a Source of Shocks? New Empirical Evidence, *Journal of Money, Credit, and Banking* 38, 939–961.

Faust, J., 1998, The Robustness of Identified VAR Conclusions about Money, *Carnegie-*

Rochester Conference Series in Public Policy 49, 207–244.

Fry, R. and A. Pagan, 2010, Sign Restrictions in Structural Vector Autoregressions: A Critical Review, *Journal of Economic Literature* forthcoming.

Hamilton, J.D. and D.H. Kim, 2002, A Re-Examination of the Predictability of Economic Activity Using the Yield Spread, *Journal of Money, Credit and Banking* 34, 340–360.

Harvey, C. R., 1989, Forecasts of Economic Growth from the Bond and Stock Markets, *Financial Analysts Journal* 45, 38–45.

Mishkin, F. S., 2001, Financial Policies and the Prevention of Financial Crises in Emerging Market Countries, *NBER Working Paper* 8087.

Peersman, G., 2005, What Caused the Early Millennium Slowdown? Evidence based on Vector Autoregressions, *Journal of Applied Econometrics* 20, 185–207.

Sgherri, S. and E. Zoli, 2009, Euro Area Sovereign Risk during the Crisis, *IMF Working Paper* 222.

Stock, J. and M. Watson, 1993, A Procedure for Predicting Recessions with Leading Indicators: Econometric Issues and Recent Performance, in Business Cycles, Indicators and Forecasting (National Bureau of Economic Research, Inc), 95–156.

Stock, J. H. and M. W. Watson, 1989, New Indexes of Coincident and Leading Economic Indicators, in NBER Macroeconomics Annual, volume 4 (National Bureau of Economic Research, Inc), 351–409.

Stulz, R. M., 2010, Credit Default Swaps and the Credit Crisis, *Journal of Economic Perspectives* 24, 73–92.

Uhlig, H., 2005, What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure, *Journal of Monetary Economics* 52, 381–419.

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