THE GRADUATE INSTITUTE GENEVA

INSTITUT DE HAUTES ÉTUDES INTERNATIONALES ET DU DÉVELOPPEMENT
GRADUATE INSTITUTE OF INTERNATIONAL AND DEVELOPMENT STUDIES

Graduate Institute of
International and Development Studies Working Paper No:
16/2014

The risk of self-protection: the role of bank bailout guarantees in channelling sovereign credit risk internationally

Filippo Gori
Graduate Institute of International and Development Studies

This paper investigates the role of banks' foreign asset holdings in transmitting credit risk internationally. Foreign exposure in risky assets might severely affect the solvability of credit institutions. Credit risk, in turn, transfers from banks to public accounts as a consequence of implicit or explicit bailout guarantees to distressed banking systems. This paper articulates this mechanism with a simple model where governments choose to fill banks' capital gaps to self-protect from the severe economic consequence of a banking sector default. Referring to the existing literature on the determinants of sovereign yield spreads in the second part of the paper, I present empirical evidence of the link between banks' foreign claims and countries' credit risk. Results for the eurozone identify banks' foreign exposure as a major determinant of sovereign default probability. Also, governments' vulnerability to credit risk spill over decreases with banks' capitalisation and sovereigns' fiscal soundness.

The risk of self-protection: the role of bank bailout guarantees in channelling sovereign credit risk internationally

Filippo Gori

November 30, 2014

Abstract

This paper investigates the role of banks foreign asset holdings in transmitting credit risk internationally. Foreign exposure in risky assets might severely affect the solvability of credit institutions. Credit risk, in turn, transfers from banks to public accounts as a consequence of implicit or explicit bailout guarantees to distressed banking systems. This paper articulates this mechanism with a simple model where governments choose to fill banks' capital gaps to self-protect from the severe economic consequence of a banking sector default. Referring to the existing literature on the determinants of sovereign yield spreads in the second part of the paper, I present empirical evidence of the link between banks foreign claims and countries' credit risk. Results for the eurozone identify banks' foreign exposure as a major determinant of sovereign default probability. Also, governments' vulnerability to credit risk spill over decreases with banks' capitalisation and sovereigns' fiscal soundness.

JEL Codes: G15; F36; G28.
Keywords: Banks, sovereign credit risk, international spill over.

1 Introduction

Banking integration is perhaps the most notable achievement of the economic consolidation process of the European Union. During the 2010 debt crisis however, banks' exposure to troubled European countries represented a significant channel for credit risk transmission across euro-area sovereigns. In this paper, I illustrate, first theoretically and then empirically, how credit risk transmits internationally to sovereigns via banking sector foreign claims.

The research presented in this paper extends the broad literature on the determinants of sovereign credit risk and contributes to the literature on the role of credit intermediaries in channelling shocks internationally. The former focuses traditionally on macroeconomic fundamentals, such as fiscal balance and public debt, market conditions, such as risk aversion and liquidity, and global shocks. This paper, on the other hand, shifts attention to banks' balance sheets. The economic channel linking banks' foreign risky claims and governments' credit risk relies on the implicit or explicit back-up guarantees of sovereigns on their banking institutions. Building on the framework proposed by Ehrlich and Becker (1972), in the first part of the paper, I articulate this channel in a simple model where governments choose to fill banks' capital shortfalls to *self-protect* against significant economic losses in case of a banking sector default. Such commitment, in turn, affects sovereigns' default risk. If a countrys banking system has significant exposure in foreign assets, then a potential default on those assets could severely affect the solvency of its financial sector. In this case, and if financial intermediaries cannot access financial markets to raise new capital, sovereigns might rely on bailout plans, committing significant resources to re-establish financial stability. Bailout plans of this kind drain relevant resources from national budgets, widening sovereign prospective deficits, thus causing the government's credit risk to increase.

The subsequent empirical analysis explores the role of banks' foreign claims in the international transmission of credit risk to sovereigns. Two empirical results are established, representing important additions to the literature on the determinants of sovereign default risk and shedding new light on the role of financial intermediaries in transmitting shocks internationally. First, banks' foreign exposure significantly affects sovereign default probability. To the extent banks' expected losses on foreign assets directly impact governments' prospective solvability, intermediaries' foreign claims represent a major source of international transmission for credit risk. Second, banks' capitalisation and a sound fiscal position are able to reduce the transmission of risk from intermediaries to sovereigns. From a policy standpoint, a well-capitalised banking sector and solid fiscal balances represent effective backstops to this channel of international shocks transmission. This result is supportive of normative interventions aimed at increasing banks' capital requirements to reduce the international spill over of financial shocks.

The remainder of the paper is organised as follows. In the next section, I review the relevant literature on the determinants of sovereign credit risk. Then, I present a simple theoretical framework where the sovereign's decision to offer banks bailout guarantees is the consequence of self-protecting behaviour by national authorities aimed at reducing the risk of banks' insolvency. In the next section, I move to empirics, estimating a panel in which euro area sovereign bond spreads are regressed on banks' foreign claims and a number of controls. The subsequent sections are devoted to presenting the results and conclusions.

2 Related literature

This paper relates to and extends two streams of literature: the first concerns the extensive research on the determinants of sovereign credit risk. This literature focuses on fundamentals, such as fiscal variables (as in Edwards (1986), Poterba and Rueben (1999), Afonso and Strauch (2007), Faini (2006) and Laubach (2009)), market characteristics such as liquidity (Gómez-Puig (2006), Favero and Giavazzi (2000), Favero et al. (2010)) and risk aversion (Fama and French (1993), Codogno et al. (2003), Manganelli and Wolswijk (2009), Favero et al. (2010)) and international or global factors (Arora and Cerisola (2001), Eichengreen et al. (2001)). This paper's contribution to this literature specifically concerns the empirical characterisation of a role for bank expected capital gaps as a determinant of sovereign default risk. The empirical evidence provided here suggests that bank foreign claims represent a significant factor in explaining sovereigns' default probability. This is consistent with a transfer of credit risk from banking intermediaries to sovereigns in cases of public bailout plans, as documented by a relatively new line of research: Zoli and Sgherri (2009), Attinasi et al. (2009) Attinasi et al. (2009), Ejsing and Lemke (2011), Alter and Schüler (2012) and Mody and Sandri (2012). Similarly, Demirgüç-Kunt and Huizinga (2013) perform a descriptive analysis on equity prices and credit default swaps (CDSs) around banks bailouts, and Dieckmann and Plank (2012) analyse the relationship between sovereign CDSs and the national banking sector after the collapse of Lehman Brothers. Even if revamped during the recent financial crisis, this idea is not entirely new: the transfer of credit risk from private to public accounts has been cited as a primary cause of the 1997 Asian currency crisis by Burnside et al. (1998), when contemplating the effect of bailouts guarantees on future domestic deficits.

The second stream of literature that is related to this work studies the role of intermediaries in channelling shock internationally. This research field is particularly vast: some authors have stressed the role of common lenders in affecting the real economy (Calvo and Mendoza (1997) and Kaminsky and Reinhart (1999)), others focused on the pivotal capacity of global financial institutions or investors to affect local intermediaries via financial linkages (Chan-Lau et al. (2007), Gai and Kapadia (2010), Cifuentes et al. (2005)), or portfolio rebalancing (Schinasi and Smith (2001), Goldstein and Pauzner (2004)). This paper adds to this literature presenting evidence of a direct role for bank expected international losses in the cross-country transmission of credit risk.

From a theoretical standpoint, this paper connects to the research of Acharya et al. (2011), who designed a model in which financial sector bailouts affect sovereign spreads, and Guerrieri et al. (2012) that present a model where financial integration, through cross-country exposure, channels shocks internationally via a reduction in lending activity. Contrary to this research, this paper's modelling effort focuses on the incentive mechanism behind the provision of sovereign bailout guarantees. These are in turn the key factor explaining the transmission of credit risk from bank to public accounts. The next paragraph shows that a sovereign willing to reduce the probability of a banking default, chooses to recapitalise, at least partly, its banks consistently with a *self-protection* framework, whenever there is a positive cost associated with banks' default. A commitment to full recapitalisations takes places when the cost of banks' insolvency is sufficiently higher than the actual capital gaps. This framework extends the seminal work by Ehrlich and Becker

(1972) on self-protection models, to characterise the incentive behind the implicit provision of public bailout guarantees on banks.

3 Banks' capital gaps, external exposure, and sovereigns' default risk

Let us consider the simplest model of sovereign default. Assume that a government's income comprises a fixed value $\bar{\delta}$ and stochastic component resulting from a random shock ξ affecting its tax base y. We can consider the fixed component of government income $\bar{\delta}$ as its structural fiscal deficit resulting from an exogenous steady state. Market participants assessing sovereign default risk discount the possibility that the government will choose to inject an amount of liquidity q into its financial sector, should it be in distress. The government's budget constraint for a generic country i is

$$\tau_i y_i(\xi_i) - \bar{\delta}_i - q_i \geq 0 \tag{1}$$

A default occurs if the above condition is not satisfied. Defining a new random variable ω_i such that $\omega_i = \tau_i y_i(\xi_i)$, before both the income shock and banks' capital needs are known, the government's default probability is

$$\pi_i(\bar{\delta}_i - q_i) = prob(\omega < \bar{\delta}_i - q_i) = F_{(\bar{\delta}_i - q_i)} \tag{2}$$

where $F_{(\bar{\delta}_i - q_i)}$ is the risk-neutral probability of default for government i. Consider a one-period model and imagine that stochastic shocks realise at the end of the period. At time zero, the government issues a one-period bond having a payoff of 1 if the government is solvent and 0 if it defaults. The price of the government's bond at the beginning of the period is

$$P_i = (1 - F_{(\bar{\delta}_i - q_i)})e^{-Y_{rf}} \tag{3}$$

where Y_{rf} is the risk-free yield, such that $P_i^{rf} = e^{-Y_{rf}}$ is the price of the risk-free bond. Substituting this into equation 4 and solving for $F_{(\bar{\delta}_i - q_i)}$, we obtain an expression of the sovereign probability of default in terms of yield spreads:

$$F_{(\bar{\delta}_i - q_i)} = 1 - e^{-s_i} \tag{4}$$

where $s_i = Y_i - Y_{rf}$ is the spread between the sovereign and risk-free yield.

3.1 Banks' capital gaps

In considering the financial strength of banking intermediaries, I make reference to the concept of regulatory capital that, within this limited framework, I simply identify with banks' equity ratio. Defining $\bar{k}$ as the minimum regulatory capital, below which a recapitalization is necessary, banks suffer from capital gaps for positive values of:

$$\bar{k} - \left(1 - \frac{L_i}{A_i}\right) \tag{5}$$

Where the expression in brackets is the capital asset ratio for country i banks, A_i represents banks' assets and L_i liabilities. Let's assume that banks' assets are subject to a stochastic shock ζ, this implies that banks' capital shortfall is in turn stochastic and defined as follows:

$$\tilde{k}_i(\zeta) = (\bar{k} - 1)A_i(\zeta) + L_i \tag{6}$$

With $\tilde{k}_i \in [0, \bar{k}A]$. Let's assume further that the stochastic nature of A_i depends on the probability of default of each single asset in the balance sheet of the financial sector and that assets can be divided into two categories of foreign and domestic, each bearing specific credit risk. Let's call the set of foreign claims J, its complement, containing domestic assets is $\widetilde{J}$. The expected value for banks assets in country i at the beginning of the period is then:

$$E[A_i(\zeta_i)] = \sum_J a_{ij}(1 - \pi_j) + \sum_{\widetilde{J}} a_{i\tilde{j}}(1 - \pi_{\tilde{j}}) \tag{7}$$

Such that $A_i = \sum_J a_{ij} + \sum_{\widetilde{J}} a_{i\tilde{j}}$. In the above equation a_{ij} represents the total assets of country i banking sector in country j (I will call this simply the exposure to country j) and $a_{i\tilde{j}}$ is the overall exposure in other assets. π_j is the default probability for country j and $\pi_{\tilde{j}}$ is the risk specific to each other asset. Let's define for the ease of notation $e_i = \sum_J a_{ij}\pi_j$, representing the risk-weighted sum of country i banks' foreign exposure to countries in J, and $z_i = \sum_{\widetilde{J}} a_{i\tilde{j}}\pi_{\tilde{j}}$, the risk-weighted exposure in other assets. Then the expected capital shortfall at the beginning of the period can be written as:

$$E[\tilde{k}_i(\zeta)] = (1 - \bar{k})(e_i + z_i) - B_i \tag{8}$$

Where $B_i = C_i - \bar{k}A_i$ represents banks' capital buffer. If at the beginning of the period bank capital matches exactly capital requirements, then expected capital gaps reduce to $e_i + z_i$. Equation 8 states that banks' expected capital shortfall depends on their risky assets held domestically and abroad and on intermediaries capital buffers.

3.2 Bank bailouts as self-protection

We can imagine that it is within the interest of governments to maintain a solid financial sector and that sovereigns, under some circumstances, such as the inability of intermediaries to access financial markets autonomously, bear the responsibility for bank recapitalisations.

Governments backup guarantee on credit institutions can be both implicit or explicit, in the form of formal deposit insurance. In both cases the public commitment toward banking institutions originates from recognising that an insolvent financial sector can cause significant losses to the economy. To this extent, we can formalise a sovereign pledge to recapitalise banks within the framework of a model of self-protection, where the sovereign chooses the optimal amount of capital injections with the objective of maximising its expected utility. Within the terminology used by Ehrlich and Becker (1972), self-insurance describes an effort that reduces the size of the loss, while self-protection is an effort that reduces the *probability* of the loss. If the probability of banks' default (the hazardous state) can be reduced with public capital injections, sovereigns will offer bailout guarantees if and to the extent this is consistent with the maximisation of their expected utility. Formally we can imagine that a sovereign maximises

$$EU = p(\tilde{k} - q)U(\bar{w} - q - L) + [1 - p(\tilde{k} - q)]U(\bar{w} - q) \tag{9}$$

subject to:

$$\tilde{k} - q \geq 0 \tag{10}$$

This last constraint only indicates that banks' bailout plans cannot be larger than existing capital gaps. In equation 9, $L \geq 0$ is the loss associated with the hazardous event, $\bar{w}$ is government's wealth and q represents public capital injections. $p(\tilde{k} - q)$ is the probability of default for the banking sector, function of banks' capital gaps after public recapitalisations, and $p'_{\tilde{k}} = \frac{\partial p}{\partial \tilde{k}} > 0$, $p'_q = \frac{\partial p}{\partial q} < 0$. This means that the probability of intermediaries' default is strictly increasing on banks' capital gaps $\tilde{k}$ and decreasing on public capital injections q. Finally, U is a strictly increasing utility function for government wealth. The optimality condition requires that

$$p'_q[U(\bar{w} - q - L) - U(\bar{w} - q)] = pU'(\bar{w} - q - L) + (1 - p)U'(\bar{w} - q) \tag{11}$$

The left-hand side of equation 11 represents the marginal gain of a reduction in the probability of default for banks, the term on the right is the marginal cost. The second order condition is

$$\begin{aligned} &p''_q[U(\bar{w} - q - L) - U(\bar{w} - q)] - 2p'_q[U'(\bar{w} - q - L) - U'(\bar{w} - q)] \\ &\quad + pU''(\bar{w} - q - L) + (1 - p)U''(\bar{w} - q) < 0 \end{aligned} \tag{12}$$

As observed by Ehrlich and Becker (1972) and shown analytically by Dionne and Eeckhoudt (1985), unlike the case of self-insurance, decreasing marginal utility of wealth is not sufficient for satisfying equation 12, and thus the incentive to self-protect does not depend on attitudes toward risk. As a direct consequence of the non-negativity constraint for banks' capital gaps, the amount of public capital injections will be a share of the capital shortage. Thus, $q = \phi\tilde{k}$, $\phi \in [0, 1]$. Let us define ϕ^* such that

$$\underset{\phi^* \in [0,1]}{argmax} \;\; p((1-\phi^*)\tilde{k})U(\bar{w}-\phi^*\tilde{k}-L) + [1-p((1-\phi^*)\tilde{k})]U(\bar{w}-\phi^*\tilde{k}) \tag{13}$$

and that equation 12 is verified. Then ϕ^* is the optimal amount of public capital injections satisfying:

$$q^* = \phi^*\tilde{k} \in [0, \tilde{k}] \tag{14}$$

Before the shock affecting banks' assets is realised, capital gaps are known only in terms of expectations. At this time, government default probability becomes

$$\pi_i = F_{(\bar{\delta}_i - \phi^* E[\tilde{k}])} \tag{15}$$

Or equivalently, in terms of sovereign spreads, after substituting equation 8

$$e^{-s_i} = 1 - F_{(\bar{\delta}_i - \phi^*((1-\bar{k})(e_i+z_i)-B_i))} \tag{16}$$

Equation 16 is important as it shows that sovereign bond spreads depend on expected losses on banks' balance sheets, both domestically and abroad. This result depends on the fact that governments' default risk is affected by prospective deficits related to the implementation of possible bank bailout plans. The magnitude of this relationship depends on ϕ^*. However, sovereigns' default risk will be affected by banks' capital gaps as long as $\phi^* \neq 0$. This corner solution verifies when the marginal gain of protection is zero vis--vis a positive marginal cost. Considering equation 11 and excluding the case in which $p' = 0$, wherein public recapitalisations do not affect banks' default probability, this condition is verified when $L = 0$. Only in this case, the left-hand side of equation 11 equals zero, while its right-hand side, which expresses the marginal cost of self-protection, is equal to $U'(\bar{w} - q) \neq 0$.

Given a strictly increasing utility function for wealth, the presence of a positive loss associated with banks' default is the only condition necessary to assume that the government will commit to fill a share $\phi^* \neq 0$ of banks' capital gaps. This is also the only condition necessary to postulate a direct role for banks' balance sheets in affecting sovereigns' default risk, or in other words, to assume for equation 16 to hold. It is nonetheless interesting to review some conditions that are necessary to ensure that the government will recapitalise a distressed banking sector $in\ full$. These mainly relate to the size of L with respect to q, when some assumptions about the government utility function and probability distribution for p are verified.

Proposition 1 - full-protection for a risk neutral government: given a well behaved utility function for a risk neutral government $U : [0, \bar{w}] \to \mathbb{R}^+ \cup \{0\} \mid U' \geq 0$ and a continuous distribution function on a bounded interval $P_x : [0, \bar{k}A] \to (0,1) \mid P'(x) \geq 0, P''(x) > 0, \lim_{x\to 0} P'(x) = 0$ and $x = \tilde{k} - q$, then for $L \to +\infty$, equation 12 is always satisfied and equation 11 is verified for $q \to \tilde{k}$.

Proof: In case of a risk neutral government 11 reduces to:

$$-p'_q = \frac{1}{L} \tag{17}$$

For $L \rightarrow +\infty$ the right hand side of the equation converges to zero which implies $-p'_q \rightarrow 0 \Leftrightarrow q \rightarrow \tilde{k}$. Equation 11 is verified as $p''_q > 0$.

A corner solution implying $\phi^* = 1$ is also achieved in the case of a risk-adverse government, although a few more assumptions are needed.

Proposition 2 - full-protection for a risk adverse government: given a well behaved utility function $U : [0, \bar{w}] \rightarrow \mathbb{R}^+ \cup \{0\} \mid U' \geq 0, U'' < 0, \lim_{x \rightarrow \bar{w}} U'(x) = 0, \lim_{x \rightarrow 0} U'(x) = +\infty$ and a continuous distribution function on a bounded interval $P_x : [0, \bar{k}A] \rightarrow [0, 1) \mid P(0) = 0$ and $x = \tilde{k} - q$, then $\forall L, q, \bar{w} \in \mathbb{R}^+ \mid L + q \rightarrow \bar{w}$ and $L >> q$, equation 11 is verified for $q = \tilde{k}$.

Proof: consider equation 11, for $L + q \rightarrow \bar{w} \Longrightarrow U(\bar{w} - q - L) \rightarrow 0$, while $L >> q$ insure that $U(\bar{w} - q) \rightarrow b \in \mathbb{R}^+$, as P'_x the probability density function of P_x is bounded, the left hand side of the equation converges to a real number. However the right hand side of the equation for $L + q \rightarrow \bar{w} \Longrightarrow U'(\bar{w} - q - L) \rightarrow +\infty$ and $U'(\bar{w} - q) \rightarrow c \in \mathbb{R}^+$, is finite only if $p = 0$ which implies $q = \tilde{k}$.

Before proceeding with the analysis, it is important to discuss some of the assumptions used for obtaining the above results. The first concerns the distribution function relating capital gaps and banks' probability of default, which is supposed to be bounded between $[0, \bar{k}A]$. This means that, if well capitalised, banks suffer no risk of defaulting while intermediaries having non-positive equity bear a default risk equal to 1. The limit of this assumption is obviously its inability to take into account assets' liquidity. The assumption of a monotonic increasing and convex probability density function of banks' default states that the rate at which banks' default risk increases with capital gaps is non-decreasing, and therefore, higher capital gaps correspond a higher marginal increase in default risk. This is reasonable to the extent the marginal effect of capital shortage on banks' probability of default should be higher when capital is already low. Finally, the loss related to banking sector default L is assumed to be sufficiently larger than capital gaps q. This is the most compelling of all assumptions considered; in case of a systemic default of intermediaries, the cost suffered by the economy is higher than intermediaries' capital shortage.

This discussion suggests that while the optimal level of governments' commitment toward bank recapitalisations can vary, it is likely that most sovereigns will choose to fully protect themselves against banks' defaults by offering their intermediaries a full bailout guarantee.

4 Empirics

Most of the literature on the determinants of sovereign credit risk uses bond spreads instead of Credit Default Swaps (CDS) for measuring government default probability. This is because bond spreads are typically more liquid and available in longer time series. Considering a panel of euro area members, in this section, I estimate the effect of bank foreign claims on sovereign default probability. The baseline specification is a linear approximation to equation 16. Consider the following model:

$$s_{it} = \lambda_i s_{it-1} + (1 - \lambda_i)(\beta e_{it} + \gamma_i \Omega_{it} + \alpha_i) + v_{it} \tag{18}$$

where for a generic country i, s_{it} is the spread between its ten-year sovereign bill and the corresponding yield for the German Bund, Ω_{it} is a vector of controls, and v_{it} is an idiosyncratic zero mean error term. Controls in Ω_{it} are chosen in line with the existing literature on the determinants of sovereign credit risk, and they closely match the models considered by Codogno et al. (2003) and Favero et al. (2010). The key regressor in 18 is e_{it}, representing banks' risk-weighted exposure to foreign claims. This is constructed using data from the Bank of International Settlements (BIS), which collects information on bank international claims by country. I start by considering only foreign public sector claims, which comprise those of the general government sector, central banks, and multilateral development banks. Note that to the extent possible, as this analysis focuses on eurozone members, the analysed category essentially contains only general government claims. Unfortunately, as this series is available only since the fourth quarter of 2010 and only for major European economies[1], the number of available observations for the estimation is limited to about forty quarters. Foreign public claims are scaled for country i GDP and aggregated in an index where each position is weighted with the credit risk of the corresponding country measured by its sovereign yield spread. Thus, for each country i at time t, the variable is constructed as follows:

$$e_{it} = \sum_{j \neq i} a_{ijt} s_{jt} \tag{19}$$

Following the mainstream literature on the determinants of sovereign spreads, I control for two fiscal indicators: debt and annualised fiscal balance on GDP. I control for common shocks to markets' risk appetite considering Moody's Baa-Aaa US corporate bond spreads together with the Euro stock 50 index (VSTOXX) as an indicator of market anxiety specific to European capital markets. This index provides a measure of market expectations of near- to long-term volatility based on the EURO STOXX 50 options, the underling index being a blue-chip representation of sector leaders in the eurozone. I consider comovements in sovereign default risk generated by a latent factor by controlling for the principal component of euro area sovereign spreads. Following Manganelli and Wolswijk

[1] Germany, France, Italy, Spain, and Belgium.

(2009), I control for liquidity considering the spread between AAA rated sovereign bonds of two set of countries in the Eurozone, differing for the volume of outstanding sovereign debt. I compute this spread by subtracting sovereign bond yields of Germany from the ones of Finland and Luxembourg, aggregated with a simple mean. Finally, I control for intermediaries' capitalisation measured by the log of banks' equity ratio in each country i. The introduction of this regressor aims at capturing fluctuations in banks' capital buffers B_{it} as identified in equation 16. Banks' equity ratios are obtained from the European Central Bank's Monetary Financial Institutions (MFI) balance sheet statistics. The simple introduction of this variable in equation 18 can pose an identification issue; following the structural representation of model 16, bank assets are, by construction, correlated with z_{it}, which, as explained below, cannot be directly identified. I instrument this control with the log of bank liabilities and the remaining exogenous covariates. Except fiscal indicators, the Baa-Aaa corporate bond spreads, and liquidity spreads, all remaining variables are in logs. The time sample is from the fourth quarter of 2010 to the third quarter of 2013.

Before proceeding with the estimation, some considerations about the identification of e_{it} need to be made. Let us consider a linear representation of equation 15 together with equation 8. Further, let us make explicit the dependence of z_i on π_i, to the extent z_i also contains banks' claims on the domestic public sector.

$$\begin{aligned} \pi_{it} &= \bar{\delta}_i + \phi^* E[\tilde{k}_{it}] \\ E[\tilde{k}_{it}] &= (1-\bar{k})(e_{it} + z_{it}(\pi_{it})) - B_{it} \end{aligned} \tag{20}$$

The first equation states that sovereign default probability also depends on expected banks' capital gaps. The second equation makes it explicit that banks' capital shortfalls are the sum of expected losses on foreign public assets (e_i), expected losses on other domestic claims also containing public sector securities of country i, and capital buffers. This is a textbook example of a simultaneous equations model, and it underscores what the literature refers to as the *diabolic loop* between banks' and sovereigns' default risk. As banks' expected capital gaps are not observable, no instrument can be used for a direct estimation of $E[\tilde{k}_i]$. Also, the determination of z_{it} is quite problematic, to the extent that doing so would require knowledge of the credit risk associated with each individual bank claim not related to the foreign public sector. However, e_i could be directly inserted as a regressor in the first equation of system 20 with B_{it}, obtaining a model close to 18. This means that even if we fail to quantify z_{it} in the estimation of equation 18, thus resulting in an error term that incorporates the missing regressor (so that $v_{it} = f(z_{it})$), nonetheless, the identification of the coefficient associated with e_i is possible as long as $E(e_i, z_i) = 0$. I assume this condition holds in this paragraph and relax it in the next section. It is important, however, to stress that this assumption also implies the possibly restrictive condition of uncorrelated credit risk between foreign private and public claims. A final consideration concerns the interpretation of β in 18. The use of a panel estimation with common coefficients produces an estimate for β corresponding to the cross-country average of the structural parameter. Also, recovering ϕ^* from the estimated coefficient is not straightforward, as this would imply knowledge of the regulatory capital ratio $\bar{k}$. This parameter, however, is established by banking regulators in terms of risk-adjusted assets and not a simple equity ratio. Moreover, regulatory capital ratios have changed over time, becoming more stringent in the wake of the financial crisis.

It is well known that simple least squares estimations of dynamic panel models produce biased pooled coefficients when the time dimension is finite. This is especially the case when the autoregressive process is persistent. To deal with this common issue, I estimate model 18 using the difference generalized method of moments (GMM) proposed by Arellano and Bond (1991).

The regression results reported in Tables 1 and 2 are from the robust one-step estimators for model 18. Table 1 shows the regression output for the baseline model. The first equation mimics traditional models of sovereign spreads, includes fiscal variables, and controls for liquidity and market risk appetite. In the second model, I add foreign, risk-weighed public claims. The remaining models test the resistance of the coefficient associated with this regressor to the introduction of other controls for common factors affecting sovereign credit risk and for bank capital strength. The results are interesting. The index aggregating banks' external public claims is a significant predictor of governments credit risk in all equations. A one-percent increase in this variable increases government default probability by 14 to 15 basis percentage points. This empirical finding is consistent with the postulation by equation 16, and it provides evidence of a direct role of banks' foreign public claims in affecting government default risk. Moreover, the coefficient associated with banks' equity ratios is negative and significant, suggesting that banks' capitalisation *per se* reduces sovereign default probability. A one-percent increase in banks' equity ratio decreases government credit risk by about 7 basis points. This is again consistent with equation 16, suggesting that banks' expected capital gaps, decreasing on intermediaries capitalisation, are a significant source of fluctuations for sovereign yield spreads.

From a policy standpoint, it is interesting to know if a stronger fiscal position or higher bank capitalisation could result in an effective backstop for international sovereign credit risk spill over via banks' claims. Table 2 tries to answer this question by introducing interactions between some key variables. Equation 2 considers how the effect of banks' foreign public claims on government default risk changes for different levels of bank capitalisation. The interaction term is negative and significant, supporting the prior argument that more capitalised banks reduce international credit risk transmission via bank balance sheets. Equations 3 and 4 instead consider a possible backstop role for fiscal variables. Stronger fiscal balances are found to effectively reduce the role of foreign public claims in country default risk, while public indebtedness does not appear to significantly affect the target relationship.

4.1 Robustness

In this paragraph, I consider two robustness exercises dealing with possible limitations of the previous analysis. These essentially concern the assumption that $E(e_{it}, z_{it}) = 0$, which is necessary to ensure consistency in equation 18. I gradually relax this assumption in this section.

In the previous paragraph, and according to the theoretical framework developed in this paper, e_{it} is constructed as the risk-weighted sum of banks' public claims held by other eurozone members. z_{it}, instead, contains all residual risk-weighted assets. Assuming $E(e_{it}, z_{it}) = 0$ means that the following conditions hold true:

$$E(\pi_{jt}, \pi_{\tilde{j}t}) = 0, E(\pi_{jt}, a_{i\tilde{j}t}) = 0, E(a_{ijt}, \pi_{\tilde{j}t}) = 0, E(a_{ijt}, a_{i\tilde{j}t}) = 0$$

The first condition implies that no correlation exists between the credit risk of foreign public and all other assets in banks' balance sheets. The second and third conditions assume no cross-correlation between one of the two types of claims and the default risk associated with the other. The last assumes that there is no correlation between assets volumes in the two classes.

4.1.1 Correlation in credit risk between private and public foreign claims

Let us start by relaxing the first of the four conditions considered in the previous paragraph. $E(\pi_{jt}, \pi_{\tilde{j}t}) = 0$ could be violated because the default probability of foreign public assets in a generic country j could be correlated with one of the non-public claims in the same country. In fact, under some circumstances at least, the default risk of public and private assets co-move. Should this be the case, however, we can imagine pricing all foreign assets with the default probability of the sovereign where the claims are held. Let us call e^1_{it} the risk-weighted sum of all bank foreign claims, where the risk associated with each asset is the risk of the corresponding foreign country. This new variable represents a proxy for banks' risk-weighted exposure to all types of international claims, where the quality of the approximation increases with the correlation between public and private assets credit risk. The use of e^1_{it} in equation 18 ensures that $E(\pi_{jt}, \pi_{\tilde{j}t}) = 0$ only if foreign and domestic sovereign default risk are not correlated *beyond* the co-movement due to common factors captured by controls considered in 18. These are the financial markets' risk appetite and the first latent source of correlation among euro area spreads measured by the principal component.

The construction of this new regressor also permits a significant extension of the time and country samples available for estimation. This is to the extent BIS's series on intermediaries' foreign claims, regardless of the sector, are available since 1999 for all major euro area members. This wider class of international claims contains both bank cross-border claims and local claims of foreign affiliates in euros. I substitute e^1_{it} in 18 and re-estimate the equation. The estimation output for a fixed effect model is presented in Table 3. The results confirm previous findings. Banks' foreign claims are positive determinants of sovereign credit risk while bank capitalisation reduces public default probability. Moreover, estimated coefficients do not vary significantly when the new regressor is considered. Finally, interactions terms confirm findings about the role of fiscal balance and banks' capitalisation as backstops to the international transmission of credit risk. Contrary to what was found previously, fiscal variables now have the expected sign and are statistically significant. This could be due to the longer time series available in this second analysis.

4.1.2 Instrumental variables

The second robustness exercise is more substantial. It considers the possibility that none of the conditions necessary for $E(e_i, z_i) = 0$ to hold are verified. Let us consider the possibility that innovations to a country's sovereign credit risk are not orthogonal to shocks in the default probability of other countries. Also, consider the possibility that fluctuations in banks' domestic and foreign claims can be correlated such that $E(a_{ijt}, a_{\widetilde{ijt}}) \neq 0$, but let us assume that the cross volume-risk elasticities of foreign and domestic claims are zero beyond the co-movements generated by virtue of $E(a_{ijt}, a_{\widetilde{ijt}}) \neq 0$ and $E(\pi_{it}, \pi_{jt}) \neq 0$. This means that foreign and domestic asset holdings and their credit risk co-move only due to correlated shocks affecting volumes or portfolio rebalancing mechanisms.

I construct an instrument for banks' foreign claims consistent with the above conditions by considering the overall *unweighted* volume of banks' foreign claims. With respect to how e_{it} was constructed before, avoiding the use of foreign sovereign spreads eliminates the possibility that the weights used for the construction of e_{it} could co-move with shocks in π_{it}, thus biasing β_i in 18. Sill changes in the volume of banks' domestic and foreign claims can be correlated due to common trends in the evolution of banks assets or portfolio rebalancing effects. To account for this possibility, I subtract from banks' foreign claims the fitted values resulting from their regression on all bank domestic assets. This latter variable is obtained by subtracting from all bank assets in a generic courtly i, as reported in the European Central Banks (ECB) MIF database, the BIS series on banks' foreign claims. The resulting variable corresponds in practice to the residuals of a regression between foreign and domestic claims, and thus, by construction it is orthogonal to changes in home held assets. I use this new variable to construct the key identifying condition for the estimation of e_{it} and its interactions in a GMM framework. Other orthogonal conditions are obtained using coincident and one-time lagged observations of remaining exogenous regressors.

The estimation results are reported in Table 4. Banks' foreign exposure now has a stronger effect than before on sovereign default risk. A one-percent increase in banks' risky foreign claims increases domestic sovereign spreads by 43 basis percentage points. The results on the backstop effect of fiscal balance and banks' capitalisation are confirmed by the relevant interaction terms.

5 Conclusions

This paper documented the role of banks' foreign claims in transmitting sovereign credit risk across countries. Sovereign default increases as a consequence of prospected deficits relating to banks' bailout plans, which are a consequence of expected losses on intermediaries' foreign claims. Theoretically, the paper modeled sovereigns' decisions to offer backup guarantees to credit institutions within the framework of a self-protection model, where governments decide to commit to bailout plans to decrease the risk of insolvency for the overall banking sector. In this framework, while the optimal share of bank recapitalisation depends on public preferences and the economic cost of banks' default, the government is expected to commit, at least partially, to support its banks as long as their failure represents a cost for the national economy. This pledge, however, results in tightening the solvency of governments to banks' balance sheets. The characterisation of sovereigns' commitments to their banks along the lines of a voluntary self-protection scheme contributes to our understanding of the linkages between the default risk on private and public accounts and advances the identification of tools and policies to isolate sovereign solvability from external shocks.

Empirically, this paper provided evidence that intermediaries' foreign claims affect country default risk. An additional important result concerns the role of banks' capitalisation in reducing government credit risk per se and when interacted with banks' foreign exposure. Also, a country's fiscal position, measured via the fiscal balance, can provide additional protection against international credit risk transmission. These results are important additions to the existing literature on the determinant of sovereign spreads and represent a step forward in our understanding of the role of banks in channelling shocks internationally.

From a policy standpoint, if intermediaries' international claims represent a threat to sovereign solvability, banks capital strength is an important backstop factor before international contagion, and so it is a solid fiscal position. The normative implications are straightforward: strong financial integration should be accompanied by adequate bank capitalisation and increased fiscal strength.

References

Acharya, V.V., Drechsler, I., Schnabl, P., 2011. A pyrrhic victory?-bank bailouts and sovereign credit risk. Technical Report. National Bureau of Economic Research.

Afonso, A., Strauch, R., 2007. Fiscal policy events and interest rate swap spreads: Evidence from the eu. Journal of International Financial Markets, Institutions and Money 17, 261–276.

Alter, A., Schüler, Y.S., 2012. Credit spread interdependencies of european states and banks during the financial crisis. Journal of Banking & Finance 36, 3444–3468.

Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. The review of economic studies 58, 277–297.

Arora, V., Cerisola, M., 2001. How does us monetary policy influence sovereign spreads in emerging markets? IMF Staff papers , 474–498.

Attinasi, M.G., Checherita, C., Nickel, C., 2009. What explains the surge in euro area sovereign spreads during the financial crisis of 2007-09? .

Burnside, C., Eichenbaum, M., Rebelo, S., 1998. Prospective deficits and the Asian currency crisis. Technical Report. National Bureau of Economic Research.

Calvo, G.A., Mendoza, E.G., 1997. Rational herd behavior and the globalization of securities markets. Institute for Empirical Macroeconomics, Federal Reserve Bank of Minneapolis.

Chan-Lau, J.A., Mitra, S., Ong, L.L., 2007. Contagion risk in the international banking system and implications for London as a global financial center. International Monetary Fund.

Cifuentes, R., Ferrucci, G., Shin, H.S., 2005. Liquidity risk and contagion. Journal of the European Economic Association 3, 556–566.

Codogno, L., Favero, C., Missale, A., 2003. Yield spreads on emu government bonds. Economic Policy 18, 503–532.

Demirgüç-Kunt, A., Huizinga, H., 2013. Are banks too big to fail or too big to save? international evidence from equity prices and cds spreads. Journal of Banking & Finance 37, 875–894.

Dieckmann, S., Plank, T., 2012. Default risk of advanced economies: An empirical analysis of credit default swaps during the financial crisis. Review of Finance 16, 903–934.

Dionne, G., Eeckhoudt, L., 1985. Self-insurance, self-protection and increased risk aversion. Economics Letters 17, 39–42.

Edwards, S., 1986. The pricing of bonds and bank loans in international markets: An empirical analysis of developing countries' foreign borrowing. European Economic Review 30, 565–589.

Ehrlich, I., Becker, G.S., 1972. Market insurance, self-insurance, and self-protection. The Journal of Political Economy , 623–648.

Eichengreen, B., Hale, G., Mody, A., 2001. Flight to quality: investor risk tolerance and the spread of emerging market crises, in: International financial contagion. Springer, pp. 129–155.

Ejsing, J., Lemke, W., 2011. The janus-headed salvation: Sovereign and bank credit risk premia during 2008–2009. Economics Letters 110, 28–31.

Faini, R., 2006. Fiscal policy and interest rates in europe. Economic Policy 21, 443–489.

Fama, E.F., French, K.R., 1993. Common risk factors in the returns on stocks and bonds. Journal of financial economics 33, 3–56.

Favero, C., Pagano, M., Von Thadden, E.L., 2010. How does liquidity affect government bond yields? .

Favero, C.A., Giavazzi, F., 2000. Looking for contagion: Evidence from the ERM. Technical Report. National bureau of economic research.

Gai, P., Kapadia, S., 2010. Contagion in financial networks. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Science , rspa20090410.

Goldstein, I., Pauzner, A., 2004. Contagion of self-fulfilling financial crises due to diversification of investment portfolios. Journal of Economic Theory 119, 151–183.

Gómez-Puig, M., 2006. Size matters for liquidity: Evidence from emu sovereign yield spreads. Economics Letters 90, 156–162.

Guerrieri, L., Iacoviello, M., Minetti, R., 2012. Banks, sovereign debt and the international transmission of business cycles. Technical Report. National Bureau of Economic Research.

Kaminsky, G.L., Reinhart, C.M., 1999. The twin crises: the causes of banking and balance-of-payments problems. American economic review , 473–500.

Laubach, T., 2009. New evidence on the interest rate effects of budget deficits and debt. Journal of the European Economic Association 7, 858–885.

Manganelli, S., Wolswijk, G., 2009. What drives spreads in the euro area government bond market? Economic Policy 24, 191–240.

Mody, A., Sandri, D., 2012. The eurozone crisis: how banks and sovereigns came to be joined at the hip. Economic Policy 27, 199–230.

Poterba, J.M., Rueben, K., 1999. State fiscal institutions and the us municipal bond market, in: Fiscal institutions and fiscal performance. University of Chicago Press, pp. 181–208.

Schinasi, G.J., Smith, R.T., 2001. Portfolio diversification, leverage, and financial contagion. Springer.

Zoli, E., Sgherri, S., 2009. Euro Area Sovereign Risk During the Crisis (EPub). 9-222, International Monetary Fund.

Table 1: Sovereign bond spreads and bank external claims on public sector

	(1) Spread	(2) Spread	(3) Spread	(4) Spread
L.Spread	0.552**	0.203**	0.241**	0.167**
	(0.0320)	(0.0998)	(0.0906)	(0.0720)
Debt to GDP	0.0105**	0.00159	0.000498	0.00906**
	(0.00299)	(0.00142)	(0.00142)	(0.00328)
Fiscal Balance	0.00438	0.00365	0.00451	0.0000798
	(0.00965)	(0.00439)	(0.00378)	(0.00235)
Baa-Aaa Spread	0.0379	0.319**	0.195	0.260
	(0.109)	(0.142)	(0.154)	(0.175)
Liquidity	1.982**	1.769**	1.483**	1.584**
	(0.307)	(0.399)	(0.501)	(0.442)
B. Foreign Public Claims		0.144**	0.140**	0.138**
		(0.0331)	(0.0327)	(0.0278)
P.C. Bond Spreads			0.00217	0.00242
			(0.00236)	(0.00331)
Vstoxx 50			0.180	0.106
			(0.124)	(0.131)
Equity Ratio				-0.611**
				(0.207)
Observations	45	41	37	37
Countries	4	4	4	4

The table presets the relationship between sovereign default probability, measured with bond yields spreads with respect to the German Bund, and banking sector foreign public claims. B. Foreign Public Claims is an index aggregating all bank claims on foreign public sector as a share of GDP. Aggregation weights are the yield spreads of the corresponding country, used as a proxy for default risk. Countries considered are France, Italy, Belgium and Spain from 2010q4 to 2013q3. Liquidity is measured as the bond yield spread between the average sovereign yield of Finland and Luxembourg, and the one of Germany. The equity ratio is instrumented with coincident observations and one lag of banks' liabilities, used as principal instrument. Additional orthogonality conditions are obtained using coincident exogenous regressors. All variables with the exception of fiscal ratios, banks' equity ratio and the liquidity spread are in logs. Arellano-Bond dynamic panel estimator (difference GMM). Robust standard errors in parenthesis.

* $p < 0.10$, ** $p < 0.05$

Table 2: Sovereign bond spreads and bank external claims on public sector: Interactions

	(1) Spread	(2) Spread	(3) Spread	(4) Spread
L.Spread	0.167**	0.161**	0.201**	0.165**
	(0.0720)	(0.0731)	(0.0656)	(0.0732)
Debt to GDP	0.00906**	0.0103**	0.00845**	0.00915**
	(0.00328)	(0.00397)	(0.00346)	(0.00326)
Fiscal Balance	0.0000798	0.000174	-0.00833**	0.0000535
	(0.00235)	(0.00228)	(0.00384)	(0.00227)
Baa-Aaa Spread	0.260	0.257	0.217	0.264
	(0.175)	(0.178)	(0.133)	(0.188)
Liquidity	1.584**	1.576**	1.583**	1.586**
	(0.442)	(0.456)	(0.398)	(0.439)
Vstoxx 50	0.106	0.108	0.125	0.105
	(0.131)	(0.132)	(0.126)	(0.129)
P.C. Bond Spreads	0.00242	0.00242	0.00117	0.00241
	(0.00331)	(0.00340)	(0.00282)	(0.00336)
B. Foreign Public Claims	0.138**	0.222**	0.110**	0.130**
	(0.0278)	(0.0430)	(0.0251)	(0.0485)
Equity Ratio	-0.611**	-0.711**	-0.793**	-0.589**
	(0.207)	(0.261)	(0.166)	(0.262)
Equity.R. X B.F. Public Claims		-0.0409*		
		(0.0221)		
Fiscal.B. X B.F. Public Claims			-0.00709**	
			(0.00279)	
P.Debt X B.F. Public Claims				0.0000907
				(0.000391)
Observations	37	37	37	37
Countries	4	4	4	4

The equity ratio and its interaction are instrumented with coincident and one lag of of bank liabilities. Additional orthogonality conditions are obtained using coincident exogenous regressors. All variables with the exception of fiscal ratios, bank equity ratio and the liquidity spread are in logs. Arellano-Bond dynamic panel estimator (difference GMM). Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$

Table 3: Sovereign bond spreads and bank external claims, public and private sector: interactions

	(1) Spread	(2) Spread	(3) Spread	(4) Spread
L.Spread	0.553**	0.538**	0.550**	0.565**
	(0.0374)	(0.0503)	(0.0389)	(0.0368)
Debt to GDP	0.0135**	0.0231**	0.0135**	0.0120**
	(0.00187)	(0.00452)	(0.00198)	(0.00169)
Fiscal Balance	-0.0141**	0.00528	-0.0149**	-0.0151**
	(0.00429)	(0.00861)	(0.00465)	(0.00435)
Liquidity	0.420**	0.148	0.465**	0.404**
	(0.0882)	(0.131)	(0.0866)	(0.0864)
Baa-Aaa Spread	-0.192**	-0.249**	-0.153*	-0.152*
	(0.0912)	(0.115)	(0.0896)	(0.0875)
Vstoxx 50	0.323**	0.280**	0.294**	0.294**
	(0.0961)	(0.113)	(0.0958)	(0.0940)
B. Foreign Claims	0.195**	2.008**	0.177**	0.139**
	(0.0233)	(0.655)	(0.0235)	(0.0509)
Equity Ratio	-0.785**	-1.242**	-0.503**	-0.598**
	(0.256)	(0.395)	(0.242)	(0.233)
Equity.R. X B. Foreign Claims		-0.914**		
		(0.329)		
Fiscal.B. X B. Foreign Claims			0.00451	
			(0.00283)	
Debt X B. Foreign Claims				0.000716
				(0.000607)
Country FE	Yes	Yes	Yes	Yes
Observations	449	449	449	449
Adjusted R^2	0.918	0.912	0.918	0.918

Fixed effect models. For each country, B. Foreign Claims is an index aggregating all bank claims on euro-area countries (private and public) on GDP. The equity ratio and its interaction are instrumented with coincident and one lag of of bank liabilities. Additional orthogonality conditions are obtained using coincident exogenous regressors. Country sample: EU-12, time sample 1999Q2-2013Q3. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$

Table 4: Sovereign bond spreads and bank foreign claims: instrumental variables

	(1) Spread	(2) Spread	(3) Spread	(4) Spread
L.Spread	0.481**	0.429**	0.495**	0.482**
	(0.0424)	(0.0491)	(0.0444)	(0.0429)
Debt to GDP	0.0103**	0.0157**	0.00730**	0.0104**
	(0.00187)	(0.00288)	(0.00240)	(0.00189)
Fiscal Balance	-0.00536	0.00384	-0.00105	-0.00487
	(0.00517)	(0.00657)	(0.00548)	(0.00605)
Liquidity	-0.156	-0.319**	-0.197	-0.162
	(0.132)	(0.148)	(0.140)	(0.131)
Baa-Aaa Spread	-0.00242	0.0439	-0.000777	0.00752
	(0.0885)	(0.0924)	(0.0941)	(0.0894)
Vstoxx 50	0.286**	0.268**	0.242**	0.278**
	(0.0888)	(0.0919)	(0.0938)	(0.0886)
B. Foreign Claims^{iv}	0.428**	1.341**	0.462**	0.442**
	(0.0516)	(0.367)	(0.0563)	(0.132)
Equity Ratio	-0.459**	-0.535**	-0.495**	-0.462**
	(0.200)	(0.229)	(0.215)	(0.225)
Equity.R. X B. Foreign Claims		-0.445**		
		(0.178)		
Fiscal.B. X B. Foreign Claims			-0.0174**	
			(0.00733)	
Debt X B. Foreign Claims				-0.000160
				(0.00163)
Country FE	Yes	Yes	Yes	Yes
Observations	459	459	459	459
Adjusted R^2	0.898	0.892	0.890	0.898

Fixed effect models. Instrumental variables: B. Foreign Claims^{iv} is the risk weighted sum of bank foreign public claims instrumented by the unweighted sum of foreign claims corrected for its correlation with domestic assets. The instruments is corrected for the correlation with domestic claims. The equity ratio and its interaction are instrumented with coincident and one lag of of bank liabilities. Additional orthogonality conditions are obtained using coincident exogenous regressors. Country sample: EU-12, time sample 1999Q2-2013Q3. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$