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DID THE ABSENCE OF A CENTRAL BANK BACKSTOP IN THE SOVEREIGN BOND MARKETS EXACERBATE SPILLOVERS DURING THE EURO-AREA CRISIS?

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ABSTRACT

The euro-area sovereign debt crisis was characterized by feedback loops between (1) sovereign bond ratings and sovereign spreads in single jurisdictions and (2) sovereign spreads and ratings among jurisdictions. One explanation of this circumstance is that the ECB was unable to perform the role of lender of last resort in the sovereign bond markets during the crisis. We provide a spatial framework that allows us to distinguish among European countries whose central banks were permitted to function as lender of last resort in those markets and countries whose central banks were not permitted to do so. Our results are consistent with the view that the absence of a central bank backstop in the sovereign bond markets exacerbated feedback loops.

Keywords: euro-area crisis, simultaneous spatial model, European banks, spreads, sovereign ratings

JEL-Classification: E3, G01, G14, G21

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1. Introduction

The euro-area sovereign-debt crisis was broad, deep, and long. It began in late 2009 in Greece and did not come to an end until 2015, by which time it had inundated a periphery that included -- in addition to Greece -- Cyprus, Ireland, Italy, Portugal and Spain. Between 2010 and 2014, real GDP in those six countries contracted by an average of 11.7 per cent[1], bank credit fell by 37.1per cent[2], spreads against German interest rates reached record highs, before retreating, and peripheral sovereigns experienced successive declines in credit ratings (Figures 1 and 2). The crisis was characterized by feedback loops between (1) sovereign ratings and sovereign spreads in single jurisdictions and (2) sovereign ratings and sovereign spreads among jurisdictions.

Why was the euro-area crisis so severe? There are several reasons. One reason was the inadequacy of the single-currency area's banking and fiscal architecture. A second reason concerns the perception that the ECB's monetary-policy responses to the crisis were often viewed in the markets as inadequate and delayed (Hartmann and Smets, 2018). It was not until actions were taken to move in the direction of a banking union and to create a sovereign-debt-resolution mechanism, and the ECB moved its deposit facility rate into negative territory and undertook quantitative easing and other non-standard policies, that the crisis began to abate. Third, as emphasized by De Grauwe (2011; 2018, Chapter 7) and De Grauwe and Ji (2018), the interconnections between euro-area banking systems and sovereigns contributed to the depth and duration of the crisis. Those interconnections were especially pronounced because, in contrast to a full-fledged monetary union, such as that of the United States, the ECB does not have the mandate to act as a lender-of-last-resort to governments.

The notion that the absence of a central bank backstop in the sovereign bond market can create or exacerbate self-fulfilling crises runs as follows. The assets and liabilities of governments have similar characteristics to those of banks. The liabilities (*i.e.*, bonds) issued by sovereigns are liquid, but their assets (*e.g.*, infrastructure, claims on taxpayers) tend to be illiquid. Thus, in periods of crises, when bondholders

[1] This is the average decline in GDP for each country from peak to trough (Eurostat, AMECO).

[2] This number is the average from peak to trough credit for Ireland and peak to end-2019 for other countries since they have not yet reached a trough. Credit is defined as loans to domestic non-MFIs reported by MFIs (Source: ECB).

sell government bonds, in the absence of a central-bank backstop the governments may not be able to generate sufficient liquidity to pay off bondholders. Without a central-bank backstop, euro-area sovereigns cannot guarantee bondholders that the sovereigns will always have the necessary domestic-currency liquidity to repay their bonds at maturity. In contrast, nations that have their own central bank can guarantee that the cash to redeem sovereign bonds will be available because they can always force the central bank to create the necessary currency (De Grauwe, 2018, pp. 133-35).

During the euro-area crisis, the absence of a central-bank lender-of-last-resort for sovereign debt led to the following situation. Perceptions of increased credit risk and/or default risk on the debt of a particular government led to higher spreads on the sovereign in question. This circumstance set the stage for feedback loops between sovereign spreads and sovereign ratings in individual countries. The feedback relationship between sovereign spreads and sovereign ratings, however, did not stop there. A salient feature of the euro-area crisis was cross-country contagion; deteriorations in sovereign ratings and rises in spreads in one country, say Spain, spilled-over to spreads and ratings in other peripheral countries, creating a second source of feedback.

To provide context, consider the respective cases of Spain, a euro-area member, and the United Kingdom, a non-euro-area country. During the period 2010-12, the Spanish central bank, the ECB, did not provide the role of lender-of-last resort to Spanish sovereign debt. Consequently, there was no implicit guarantee to the holders of Spanish sovereign debt that they would be paid out when the debt matured. The case of the United Kingdom was different; holders of U.K. government bonds recognized that they would be paid (in pounds) because the Bank of England provided an implicit guarantee that it would act as a lender-of-last resort in the government bond market. Table 1 shows the macroeconomic fundamentals -- current-account imbalances, fiscal deficits, and government debt, each as a percentage of GDP -- of Spain and the UK for the period 2010-12. The table shows the similarity of fundamentals in the two countries. In 2012, Spain suffered a banking crisis which had the effect of creating a sovereign debt crisis. As a result, Spain was forced to arrange a loan of € 100 billion from the European Stability Mechanism (ESM) to bail out its banking system. The United Kingdom, which suffered a banking crisis in 2008 and

had similar fundamentals to those of Spain during the years 2009-2012, did not need to resort to external borrowing to bail out its sovereign and/or banks.

In this paper, we investigate the significance of both types of feedback loops -- that is, the feedback relationship between sovereign spreads and sovereign ratings in one jurisdiction, and feedback relationships among jurisdictions. Given that cross-country contagion among the peripheral countries within the euro-area helped characterize the euro-area crisis, our contribution is to provide an empirical framework that distinguishes spillover effects in a group of peripheral countries from a group of core euro-area countries. Moreover, since spillover effects among euro-area countries as a group may have exceeded spillover effects on non-euro-area countries -- as postulated under the view that the absence of a lender-of-last-resort for sovereigns in the euro area intensified contagion in that area -- we also provide an extended empirical framework that allows us to distinguish among feedback effects in the euro-area periphery, the euro-area core, and a group of European countries that are not members of the single-currency union.

The remainder of this paper is structured as follows. In section 2, we describe our modelling strategy. In section 3, we discuss the macroeconomic determinants of spreads and ratings and provide definitions of the data used. Section 4 presents some descriptive developments of the spreads and sovereign ratings in our sample while section 5 presents our results. Section 6 concludes.

2. A simultaneous spatial model

The single equation spatial autoregressive (SAR) model, introduced by Cliff and Ord (1973, 1981) has received increasing attention as economists become interested in contemporaneous spillovers between economic agents[3]. Important contributions to this area include Kelejian and Prucha (1998, 1999) and Lee (2004), who established the properties of two stage least squares (2SLS), three stage least squares (3SLS), quasi maximum likelihood (QML) and generalized methods of moments (GMM) estimation of the single equation SAR model. There have been applications of the SAR model using both cross section as well as panel data in the empirical literature,

[3] An excellent summary of the early literature may be found in Anselin (1988).

since it is a natural way to model the spillovers between economic agents who are interconnected across space.

Less attention has been paid to the issue of systems of simultaneous spatial autoregressive equations (SESAR). The groundwork in this area was laid by Kelejian and Prucha (2004), Baltagi and Pirotte (2011), Yang and Lee (2017) and Liu and Saraiva (2019). The combined work of those authors developed the properties and identification conditions for a range of estimators including 2SLS, 3SLS, QML and GMM[4].

The general SESAR model for t periods and m cross section observations may be stated as:

$$Y_{tm}\Gamma_m = W_t Y_{tm}\Lambda_m + X_t\Phi_\mu + u_{tm} \quad (1)$$

where Y_{tm} is a $t*m$ matrix consisting of m endogenous variables over t periods. Γ_m is an m*m matrix which reflects the simultaneous effects in the off diagonal elements and where the diagonal elements are normalized to unity. W_t is a $t*t$ matrix which summarizes the spatial interactions and is assumed to be known. Λ_m is an $m*m$ matrix of parameters for the spatial effects. X_t is a $t*k$ matrix of k exogenous variables. Φ_m is a $k*m$ matrix of parameters on the exogenous variables. Finally, u_{tm} is a matrix of $t*m$ errors which are assumed IID with zero mean and covariance matrix Σ_{im} for $i=1\ldots t$.

A number of techniques have been proposed to estimate the SESAR model outlined above. Kelejian and Prucha (2004) outline both a two stage least squares (2SLS) estimation approach and a three stage least squares approach (3SLS) for cross section models. Baltagi and Deng (2015) extend this model to a panel data setting with random effects and derive the appropriate 3SLS estimator while Baltagi and Bresson (2011) use a maximum likelihood approach (QML). Yang and Lee (2017) establish the conditions for identification of these models and the consistency and asymptotic normality of the QML estimator. Finally, Liu and Saraiva (2019) propose a GMM estimator. They establish the identification and conditions for consistency and asymptotic normality which are validated by Monte Carlo methods.

[4] The SESAR model has found a small number of applications in areas such as migration and employment, government expenditures and network games.

It is common in this literature[5] to use both linear and quadratic moment conditions. Thus, if we define the vector of residuals of the kth equation as:

$$u_k = y_k - Y_k\gamma_k - W_kY_k\lambda_k - X_k\beta_k \quad (2)$$

The linear moment conditions are:

$$E(Q'u_k) = 0 \quad (3)$$

where Q is an $n*K_q$ matrix of instrumental variables. The quadratic moment conditions are then given by:

$$E(u_k' Yu_l) = 0 \quad (4)$$

where Y is an $n*n$ matrix of constants with zeros on the diagonal.

In this paper we propose a novel way of specifying the model in a standard simultaneous setting. Specifically we set up the system for each equation explicitly and apply a standard 3SLS estimator.[6]

3. Macroeconomic and political variables: their impact on spreads and ratings[7]

Our sample consists of 14 EU countries -- 11 euro-area countries (Austria, Belgium, Finland, Germany, France, the Netherlands; Spain, Greece, Ireland, Italy and Portugal) and 3 non-euro-area countries (the UK, Sweden and Denmark).

Spreads are defined as the difference between the yield on 10-year government bonds in each country relative to Germany.[8] Ratings are taken from Standard and Poor's, Fitch and Moody's and are transformed into a numerical scale with 'triple A' having the value 1 and 'selected default' having the value 22 (so a rise in both spreads and ratings implies a deterioration). Changes in ratings are based on which of the three main credit rating agencies moved first. Both spreads and ratings are available at a monthly frequency and are shown in Figures 1 and 2.

[5] See for example Lee (2007) and Lin and Lee (2010).
[6] See the explicit specification in Appendix 1; it was implemented using EVIEWS.
[7] Appendix 2 provides details of data sources.
[8] Source: ECB Statistical Data Warehouse (SDW).

Spreads and ratings are dependent on both economic and political fundamentals. Previous work (Gibson, Hall and Tavlas, 2017) has shown that the following variables should be considered:

The ratio of government debt to GDP. An increase in the debt-to-GDP ratio would be expected to cause spreads to rise and ratings to deteriorate. Thus the sign of the coefficient is expected to be positive.

Fiscal news. We construct real-time fiscal data and generate a series of forecast revisions using European Commission forecasts. We posit that it is fiscal news rather than actual fiscal outcomes that influence markets, not least because fiscal outcomes are known only with some delay. The revisions of Commission forecasts are cumulated to produce the fiscal news variable. An increase in the variable represents better news (that is, a decline in the forecast deficit or a rise in the forecast surplus) and, hence, should lead spreads and ratings to improve (generating a negative coefficient on the fiscal news variable).

Real GDP growth. Higher growth helps to keep imbalances under control and, in particular, improve debt sustainability. Thus, we anticipate that higher real GDP growth will be associated with lower spreads and higher ratings (a negative coefficient).

The current account balance as a percentage of GDP. Along with fiscal imbalances current account imbalances are often a sign of weakening macroeconomic conditions. An increase in the current account balance (either a fall in the deficit or a rise in the surplus) is expected to affect spreads and ratings negatively.

Competiveness measured by relative prices. Harmonised consumer prices are measured relative to Germany. A deterioration in relative prices (i.e. an increase in the prices of country x relative to Germany) would be expected to cause spreads to rise and ratings to worsen. Thus the coefficient would be expected to be positive.

Political uncertainty. We create an index of political uncertainty which reflects the climate for foreign investors and political stability. An increase in this variable implies an improvement in political stability and this would be expected to reduce spreads and raise ratings suggesting a negative coefficient.

All variables are interpolated into a monthly frequency.[9]

4. Spreads and ratings developments across country groups.

Spreads in the euro area started to increase gradually following the onset of the global financial crisis in 2008. Some euro-area countries, particularly the southern countries, experienced continuous and rapid downgrades from the credit rating agencies. The increase in spreads accelerated when Greece sought official financial assistance in April 2010 and again when Portugal sought official support in April 2011. By that time economic conditions in several euro-area countries were deteriorating rapidly, in light of concerns that the respective national authorities did not have the resources to resolve their problems.

In May 2010, the ECB launched the Securities Markets Programme (SMP), the aim of which was to restore an appropriate functioning of the monetary policy transmission mechanism by ensuring depth and liquidity in the sovereign bond markets of euro-area distressed countries. During 2010-12, the ECB purchased about € 220 billion of sovereigns issued by five countries: Greece, Ireland, Portugal, Spain and Italy (Eser and Schwaab, 2013, p. 1). The econometric evidence on the effectiveness of the SMP was reviewed by Hartmann and Smets, who found that the SMP interventions "did not stop the rise in sovereign spreads [in distressed countries]" (2018, p. 29)[10]. As we discuss below, our results suggest that the SMP may have provided a backstop for banking systems of countries in the euro-area North; under the SMP, the ECB purchased sovereign bonds of distressed countries off the balance sheets of banks primarily situated in countries in the euro-area North.

Market concerns temporarily subsided when the ECB launched two very long-term refinancing operations (VLTROs) in December 2011 and February 2012, respectively; the total uptake of these two operations amounted to more than one-trillion euros. Nevertheless, spreads in most euro-area countries again started to increase acutely and ratings further deteriorated when the Spanish banking system started showing intense signs of stress. Indeed, in July 2012 Spain joined the group of euro-area countries -- Greece, Ireland, and Portugal -- that had sought official

[9] This is done using a standard quadratic interpolation technique in EVIEWS.
[10] See also Gibson *et al.* (2016).

financial support, leading to further market tensions. As a result, spreads moved toward their previous highs. Further escalation was averted by the announcement of Outright Monetary Transactions (OMT) by the ECB in August 2012.[11] After the announcement of the OMT, spreads in all euro-area countries posted a marked decline. Ratings also began to improve.[12]

Despite the fact that several countries experienced common co-movements in spreads in the euro area, there were significant differences among countries. Crisis countries showed a marked, almost simultaneous, increase in both spreads and ratings with significant co-movements (see Figures 3A and 3B and Appendix 3).[13] Moreover, the shocks hitting the crisis countries were large. Even excluding Greece, whose spreads reached more than 30 percentage points, spreads in Portugal increased to more than 10 percentage points, while spreads in Spain and Italy reached 5 percentage points.

By contrast, the increase in spreads in the northern euro-area countries was much less pronounced. The highest spread was observed for Belgium, at slightly below 3 hundred basis points (see Figures 4A and 4B). Co-movements in spreads for northern countries were relatively low; for example, the co-movements in spreads for Austria and the Netherlands were significantly lower than co-movements among any of the countries in the South (see Appendix 3). Moreover, co-movements in spreads and ratings for the North were less evident than for countries in the South. Ratings among northern countries were also largely unaffected, except at the height of the crisis in 2012;[14] but even then, downgrades were confined to one notch at most.

For the non-euro-area countries, movements in spreads seemed to be highly idiosyncratic (see Figure 5). The hovering of Swedish and Danish spreads at around zero basis points was reflected in their ratings, which remained stable over the entire period of observation; meanwhile, the increase observed in UK spreads was also reflected in the development of UK ratings.

[11] The technical details of the OMT were announced on September 2, 2012.
[12] Note that we define an increase in ratings to represent a deterioration in ratings.
[13] Some of the countries in our sample are excluded from the figures in order for them to be legible.
[14] Ratings in northern euro-area countries experience some deterioration prior to ECB President Draghi's July 2012 statement that the ECB would do "whatever it takes to preserve the euro."

The dynamics between spreads and ratings observed in the figures motivate the empirical investigation that we carry-out in what follows. In implementing our investigation, it will be important to control for economic and political fundamentals. Thus we now proceed to investigate the relationship between sovereign spreads and sovereign ratings. This investigation will allow us to quantify the feedback effects between spreads and ratings, along with elements of contagion among groups of countries.

5. Simultaneous spatial results

The basic model is a two equation spatially autoregressive simultaneous system for sovereign ratings and spreads. We have a balanced panel for all 14 countries and monthly data from January 2000 to April 2019. In order to assess if spillovers depend on whether countries have a lender of last resort, we split the panel into one group consisting of the euro-area countries and one group consisting of the non-euro-area countries by the use of two row-normalized weighting matrices. Specifically, W_1 interrelates all the euro-area countries with equal weight and W_2 interrelates all the non-euro-area countries, again with equal weights. The specific form of the model is the following simultaneous system:

$$Rate = c_1 + c_2 * sp + c_3 * d(lgdp) + c_4 * \frac{Debt}{GDP} + c_5 * News + c_6 * P/P^* + c_7 * W_1 * Rate + c_8 * W_2 * Rate$$

$$SP = c_{11} + c_{12} * Rate + c_{13} * d(lgdp) + c_{14} * \frac{Debt}{GDP} + c_{15} * Pol + c_{16} * \frac{CA}{GDP} + c_{17} * W_1 * SP + c_{18} * W_2 * SP$$

where W_1*SP and W_1*Rate* are the spatial effects of *SP (spreads)* and *Rate (sovereign ratings),* respectively, for the euro-area countries, while W_2*SP and W_2*Rate* are the spillovers between the non-euro-area countries. That is, they measure the effects of other countries' spreads and ratings on a country's spreads and ratings for each group.

Nesting down the model to include only significant variables and/or variables with the correct sign we end up with:

$$Rate = c_1 + c_2 * sp + c_4 * \frac{Debt}{GDP} + c_6 * W_1 * Rate + c_7 * W_2 * Rate$$

$$SP = c_{11} + c_{12} * Rate + c_{13} * d(lgdp) + c_{14} * Pol + c_{15} * W_1 * SP + c_{16} * W_2 * SP$$

Given that the cross section element of our data is relatively small, we approach the estimation of this model in a novel, different way from the usual. We set up the system explicitly as a 28 equation simultaneous system and estimate it with standard system estimators.[15] There are a number of advantages to this setup, such as the possibility of estimating fixed effects and an increased flexibility in the model specification which allows for the inclusion of dynamics. Finally it is also possible to consider standard diagnostics on individual equations. This setup uses a slightly different instrument set than what is common in SESAR models.[16] The results of estimating this model are presented in Table 2.

With regard to economic fundamentals we can see that for ratings both spreads and the debt-to-GDP ratio are highly significant in explaining their differences. The direct effects imply that one percentage point increase in spreads is accompanied by a deterioration in ratings of 0.31, while an increase in the debt-to-GDP ratio of 1 percentage point (say from 80% to 81%) leads to a deterioration in ratings by 0.044. For spreads the direct effects depend on ratings, real GDP growth and political stability. In particular, a 1 percentage point increase in real GDP growth decreases spreads by 0.1 percentage point, while an increase of 1 notch in ratings increases spreads by 0.3 percentage point. Finally, political stability is also important with an improvement in stability of 1 unit decreasing spreads by 0.14 percentage point.

In both equations of the simultaneous system, spillovers are highly significant, with the spillovers between the euro-area countries being far larger than for the non-euro-area countries. Specifically, the results imply that if ratings go up (*i.e.*, deteriorate) by one notch in any euro-area country, ratings in other euro-area countries go up (deteriorate) by 0.5 notch; similarly, if spreads rise by 100 basis points in a representative euro-area country, spreads in other euro-area countries increase by 43 basis points. Corresponding estimates for non-euro-area countries are 0.13 for ratings and 0.11 for spreads. These results suggest that the euro-area government bond

[15] The estimations of the simultaneous systems are done in Eviews.
[16] In particular, we do not use the quadratic moment conditions which are not appropriate for a weighting matrix where all the weights are unity. Appendix 1 gives the full model specification for the simultaneous system of 14 countries with fixed effects in each equation in the system.

markets are more closely inter-connected than those of the non-euro-area countries. At this point, we conjecture that these results possibly reflect the fact that each of the non-euro-area countries has had its own lender of last resort.

However, since the system is highly simultaneous, both across space as well as across equations, it is not straightforward to interpret individual coefficients as the effect on the dependent variables of changing one of the exogenous variables. Thus, in order to obtain a better understanding of how the whole system adjusts to a shock the most straight forward approach is to simulate it. The results of the simulations are presented in Table 3. This is akin to performing an impulse response in a standard VAR to assess the effects in that system. As with a VAR impulse response, we will use an average shock over our historical period to scale the size of the shock. In our case, we have chosen to use one standard deviation of the change in ratings and spreads (see note in Table 3). Since the system is linear the effect of the scaling of the shock only affects the results in a proportionate way. We have, therefore, chosen to scale the actual standard deviation by multiplying it by 10 so as to avoid a large number of zeros in our results.

We first apply a shock in the form of the scaled standard deviation in ratings for each group of countries. An initial shock of 2.1 notches in ratings for the euro-area country in which the shock originates produces a final impact of 2.96 notches on that country's ratings. Moreover, the spatial simultaneity also increases (*i.e.*, leads to a deterioration in) ratings in other euro-area countries by 0.91 notches. Additionally, due to the shock in ratings, spreads in the country in which the shock originates rise by 1.2 percentage points, while spreads in other euro-area countries increase by about 0.61 percentage points. For the non-euro-area countries, an initial shock of 0.62 notches in ratings produces a final impact of 0.7 notches for the country in which the shock originates, while the spatial simultaneity implies that ratings in the other non-euro-area countries increase by only 0.06 notches. At the same time, spreads in the non-euro-area country in which the shock originates increase by 0.24 percentage point, while spreads in the other non-euro-area countries rise by about 0.035 of a percentage point.

Similarly a shock to spreads for a euro-area country (2.4 percentage points) produces a larger final impact on spreads for the country in which the shock originates (3.1 percentage points) and a significant increase in the country's deterioration in the

country's ratings of 1.3 notches. The spillovers of the shock to other euro-area countries are also economically significant. Specifically, spreads in other euro-area countries increase by 0.75 percentage point while ratings increase by 0.68 notches. A similar pattern is observed for the non-euro-area countries with respect to an initial spreads shock; however, the final effects on spreads and ratings, as well as the spillovers to other non-euro-area countries, are significantly smaller both in absolute terms (as the size of the observed shocks differ) and also in relative terms (for an equal shock) compared to the euro-area sample.

The following conclusions emerge. First, the simultaneous spillovers between ratings and spreads imply that the final impacts on both ratings are significantly larger than the original shocks. This holds for both groups of countries (euro-area and non-euro-area). Second, the spatial spillovers of shocks to both ratings and spreads are economically significant. Third, the final impact of a shock on the euro area is significantly larger than for the non-euro area, both in absolute and in relative terms.

Next, we investigate the effects of splitting the euro zone itself into two parts -- the southern euro-area countries which were most affected by the financial crises (Greece, Italy, Spain, Portugal and Ireland) and the remaining northern countries by introducing a third weighting matrix. Thus, we have three groups of countries: (1) euro-area southern countries; (2) euro-area northern countries; and (3) non-euro-area countries.

Specifically, our model takes the following form:

$$Rate = c_1 + c_2 * sp + c_3 * d(lgdp) + c_4 * \frac{Debt}{GDP} + c_5 * News + c_6 * W_1 * Rate + c_7 * W_2 * Rate + c_8 * W_3 * Rate$$

$$SP = c_{11} + c_{12} * Rate + c_{13} * d(lgdp) + c_{14} * Pol + c_{15} * W_1 * SP + c_{16} * W_2 * SP + c_{17} * W_3 * SP$$

where W_1 is modified to involve only the northern euro-area countries, W_2 involves the non-euro-area countries and W_3 involves the southern euro-area counties. The results of our simultaneous system are reported in Table 4.

As expected, the results regarding our economic fundamentals on ratings and spreads remain the same as in Table 2. However, here the sum of the spatial parameters for the South is larger than the equivalent parameter for the North. They

are also considerably larger than the non-euro-area spillovers. This may imply that there are stronger spatial spillovers in the southern euro area than the other two regions. Moreover, in the ratings equation we now have a negative spillover in the north. As in our previous example, in order to obtain a better understanding of how the entire system adjusts to a shock we simulate our system using in-sample shocks for a country in each region of interest. This will give us an insight into the magnitude of the final impact of a shock as well as the impact on other countries within the same region.

The results of this three region simulation are reported in Table 5. (The magnitudes of the shocks are reported in the footnote to Table 5.) This table presents an interesting contrast between the response in the North and the South. A shock to ratings for the North produces a final impact on a Northern country's own ratings which is smaller than the original shock. At the same time the impact on its own spreads is economically very small (20 basis points). The spillover effects to other Northern countries are in effect economically negligible. By contrast the effects of a shock to ratings for the South are economically large. While this depends on the size of the initial shock, the spillovers to other countries in the same region are non-negligible in economic terms. In fact, while the spillovers in a relative sense (*i.e.* for the same shock) are smaller in the South – implying that the markets were able, up to a point, to distinguish between countries in the same 'region' - the final impact on a country's ratings and the spillovers to other countries are economically important. Finally, as regards the non-euro-area countries a shock to ratings, while similar in size with the Northern countries, is magnified and produces a final impact which is slightly larger. The spillover effects are, as for the Northern euro-area countries, negligible.

As regards the simulation of a shock to spreads the results show that for the North they are economically small. In fact, an initial shock of 0.6 percentage points to a country's own spreads gives a final impact of 0.32 percentage points, i.e. almost half the size of the original shock. The spillovers (at 0.14 percentage points) to other Northern countries' spreads are economically small. For the South the shock produces a final impact which is economically large. Moreover, the spillovers to other Southern countries are also economically important and larger than in the North. The effect of the spreads shock is to raise spreads by 6.0 percentage points and ratings by 2.4

notches with substantial spillovers to other countries of 1.56 percentage points on spreads and 1.23 notches on ratings. The ratings shock for the south raises ratings by 5.27 notches with spreads rising by 2.15 percentage points and spillover effects to other southern countries of 1.53 notches on ratings and 1.08 percentage points on spreads. For the non-euro-area countries a shock of 0.6 percentage points leads to a final impact of 0.7 percentage points. Additionally, the spillovers to spreads in other non-euro-area countries are virtually non-existent. On balance our results show consistently that the economic effects of the spillovers are significantly larger for the South and fairly small for the North and the non-euro-area countries.

On balance, our results seem to corroborate a 'flight to quality' argument for the euro-area countries. First, the results for the northern euro-area countries are similar in economic magnitude to those of the non-euro-area countries. Second, contrary to the non-euro-area countries, an initial shock is not magnified for the North. Rather, the final impact is smaller and in the case of spreads the final impact is reduced by half.[17] By contrast, shocks to the 'South' were economically large and magnified through spillovers in the region. Thus, while it seems that for the North an implicit central bank backstop in the sovereign bond market existed, it was absent in the South.

What explains these results? We believe that the ECB's Securities Markets Programme (SMP), to which we referred earlier, may have played a role. As mentioned, under the SMP, the ECB purchased about €220 billion of sovereign bonds issued by distressed countries -- Greece, Ireland, Spain, Portugal and Italy. The purchases were made in the secondary markets. The modalities of the purchases were such that most of the purchases were made from the balance sheets of banks in the euro-area North. For example, during 2010 and 2011, the Eurosystem purchased about €46 billion of Greek sovereigns under the SMP. Of that amount, only between €2 and €3 billion was purchased from Greek banks.[18] The remainder was mainly purchased from banks in the North. Effectively, the SMP helped sever the feedback

[17] From an estimation point of view, the slightly negative spillovers for the ratings equation, in conjunction with the very high spillovers for the spreads equations, leads to a decline in the initial shock.
[18] Tavlas (2019, p. 59).

loop between sovereigns and banks in the North, while not addressing the feedback effects between banks and sovereigns in the distressed countries.[19]

6. Conclusions

We have examined the role of spillovers among three groups of European countries during the euro-area sovereign debt crisis. We found that, on balance, euro-area spillovers were larger and more economically significant than spillovers among non-euro-area countries. However, within the euro area, both the shocks and the spillovers can be almost fully attributed to the euro-area South. By contrast results for the North are more in line with the non-euro-area countries. Moreover our results tend to indicate that a 'flight' to safety was prevalent in the euro area as initial shocks were magnified in the South but were reduced in the North.

The results imply that, controlling for economic fundamentals, the countries comprising the euro-area South, as a group, were treated differently than both the countries comprising the euro-area North and European countries outside the euro area. An interpretation of these findings in terms of the lender-of-last-resort hypothesis put forward by De Grauwe (2011) and De Grauwe and Ji (2018) is the following. The financial markets perceived that, at least in the early stages of the euro-area crisis, the ECB was legally constrained from exercising the role of lender-of-last resort in the government bond markets. Consequently, markets separated euro-area sovereign bond markets into two groups: (1) those bond markets that were judged to be relatively immune from a liquidity crisis (in the absence of a lender-of-last resort function by the central bank), and (2) the sovereign bond markets which were judged to be susceptible to such a crisis. As is typically the situation in cases of liquidity vulnerabilities, the latter sovereign bond markets were susceptible to spillover effects. These spillover effects were of two types: (i) feedback relationships between sovereign spreads and sovereign ratings in individual countries and (ii) spillover effects of spreads and ratings among groups of countries.

By 2014/15, the euro-area financial architecture had been upgraded and it became clear that the ECB had undertaken -- at least in part -- a lender-of-last resort

[19] In May 2010, former Bundesbank President Karl Otto Pöhl described the purpose of the SMP as follows: "It was about protecting German banks, but especially French banks, from debt write-offs" (quoted from Orphanides, 2015, p. 553).

function in the sovereign bond markets. It was expected that this would lead to a reduction in the spillover effects, something that has been strengthened by the recent policies adopted by the ECB in the face of COVID-19.

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Appendix 1: Estimation of the 14 country spatial model with three weighting matrices

Our nested down simultaneous system of equations has the following general form when we split our countries into three groups:

$$Rate = c_1 + c_2 * sp + c_4 * \frac{Debt}{GDP} + c_6 * W_1 * Rate + c_7 * W_2 * Rate$$

$$SP = c_{11} + c_{12} * Rate + c_{13} * d(lgdp) + c_{14} * Pol + c_{15} * W_1 * SP + c_{16} * W_2 * SP$$

Where c1 and c11 are country fixed effects, c2, c4, c12, c13 and c14 are common estimates for all countries. Our weighting matrices are row-normalized. We have 6 Northern countries, 5 Southern countries and 3 non euro-area countries.

This implies that each Northern country has 5 'neighbours'. Each neighbour has an equal weight and when we row-normalize the weighting matrix for the north this implies a weight of 0.2 for each 'neighbour'. So, an explicit estimation of the simultaneous system for e.g. Belgium would be:

$$Rate_{BE} = c_{1,BE} + c_2 * SP_{BE} + c_4 * \left(\frac{Debt}{GDP}\right)_{BE} + c_6 * (0.2 * Rate_{AT} + 0 * Rate_{BE} + 0.2 * Rate_{FI} + 0.2 * Rate_{FR} + 0.2 * Rate_{DE} + 0.2 * Rate_{NL}) + c_7 * 0 * Rate + c_8 * 0 * Rate$$

$$SP_{BE} = c_{11,BE} + c_{12} * Rate_{BE} + c_{13} * d(lgdp)_{BE} + c_{14} * Pol_{BE} + c_{15} * (0.2 * SP_{AT} + 0 * SP_{BE} + 0.2 * SP_{FI} + 0.2 * SP_{FR} + 0.2 * SP_{DE} + 0.2 * SP_{NL}) + c_{16} * \mathbf{0} * SP + c_{17} * \mathbf{0} * SP$$

As Belgium belongs to the 'northern' countries it implies that W_2 and W_3 are just zeros for Belgium (and for all northern countries).

Similarly a Southern country, has 4 'neighbours'. This implies a row-normalized weight of 0.25 for each neighbour. Thus, an explicit estimation of the simultaneous system for e.g. Spain would be:

$$Rate_{ES} = c_{1,ES} + c_2 * SP_{ES} + c_4 * \left(\frac{Debt}{GDP}\right)_{ES} + c_6 * \mathbf{0} * Rate + c_7 * \mathbf{0} * Rate + c_8 * (0.25 * Rate_{GR} + 0.25 * Rate_{IR} + 0.25 * Rate_{IT} + 0.25 * Rate_{PT} + 0 * Rate_{ES})$$

$$SP_{ES} = c_{11,ES} + c_{12} * Rate_{ES} + c_{13} * d(lgdp)_{ES} + c_{14} * Pol_{ES} + c_{15} * 0 * SP + c_{16} * 0 * SP + c_{17} * (0.25 * SP_{GR} + 0.25 * SP_{IR} + 0.25 * SP_{IT} + 0.25 * SP_{PT})$$

Finally, each non euro-area country has 2 'neighbours', implying a row-normalized weight of 0.5 for each neighbour and an explicit estimation for e.g. Sweden would be:

$$Rate_{SE} = c_{1,SE} + c_2 * SP_{SE} + c_4 * \left(\frac{Debt}{GDP}\right)_{SE} + c_6 * \mathbf{0} * Rate + c_7 * (0.5 * Rate_{DK} + 0 * Rate_{SE} + 0.5 * Rate_{UK}) + c_8 * \mathbf{0} * Rate$$

$$SP_{SE} = c_{11,SE} + c_{12} * Rate_{SE} + c_{13} * d(lgdp)_{SE} + c_{14} * Pol_{SE} + c_{15} * 0 * SP + c_{16} * (0.5 * SP_{DK} + 0 * SP_{SE} + 0.5 * SP_{UK}) + c_{17} * 0 * SP$$

We can thus write up the equations explicitly for each country in a program like EVIEWS and estimate it using standard 3SLS techniques for simultaneous systems.

Appendix 2: Data used for estimation

- Spreads: monthly data from Statistical Data Warehouse, ECB.
- Ratings: monthly data from Fitch, Standard and Poor's and Moody's.
- The ratio of government debt to GDP: quarterly data is Thomson Reuters Datastream.
- Fiscal news: European Commission forecasts published in European Economy.
- Real GDP growth: quarterly data from Thomson Reuters Datastream.
- Current account balance as a percentage of GDP: Either monthly or quarterly from Thomson Reuters Datastream. (We expect a negative relationship.)
- Harmonised Consumer Price Index, monthly data from Thomson Reuters Datstream.
- Political uncertainty: IFO World Economic Survey. Two variables have been used in order to create the variable political uncertainty. 1) The present climate for foreign investors, political stability (which was discontinued), which was updated with information from the new variable, 2) Political instability, using an appropriate mapping for the reported values of each variable.

Appendix 3: Cross correlations of spreads and ratings across groups

The North

		Spreads				Ratings			
		AT	BE	FR	NL	AT	BE	FR	NL
Spreads	AT	1	0.46	0.44	0.46	0.13	0.05	0.08	0.01
	BE	0.46	1	0.91	0.78	0.19	-0.19	0.05	-0.02
	FR	0.44	0.91	1	0.76	0.52	-0.11	0.37	0.11
	NL	0.46	0.78	0.76	1	0.20	-0.23	0.07	0.06
Ratings	AT	0.13	0.19	0.52	0.20	1	0.21	0.95	0.41
	BE	0.05	-0.19	-0.11	-0.23	0.21	1	0.20	0.09
	FR	0.08	0.05	0.37	0.07	0.95	0.20	1	0.47
	NL	0.01	-0.02	0.11	0.06	0.41	0.09	0.47	1

The South

		Spreads				Ratings			
		ES	PT	GR	IT	ES	PT	GR	IT
Spreads	ES	1	0.92	0.89	0.91	0.64	0.77	0.76	0.48
	PT	0.92	1	0.95	0.86	0.51	0.71	0.74	0.38
	GR	0.89	0.95	1	0.85	0.54	0.72	0.77	0.45
	IT	0.91	0.86	0.85	1	0.70	0.80	0.81	0.62
Ratings	ES	0.64	0.51	0.54	0.70	1	0.93	0.88	0.91
	PT	0.77	0.71	0.72	0.80	0.93	1	0.96	0.89
	GR	0.76	0.74	0.77	0.81	0.88	0.96	1	0.85
	IT	0.48	0.38	0.45	0.62	0.91	0.89	0.85	1

Non-euro area

		Spreads			Ratings		
		UK	SE	DK	UK	SE	DK
Spreads	UK	1	0.12	-0.26	0.55	-0.43	0.00
	SE	0.12	1	0.13	0.28	0.03	0.00
	DK	-0.26	0.13	1	-0.25	0.40	0.00
Ratings	UK	0.55	0.28	-0.25	1	-0.24	0.00
	SE	-0.43	0.03	0.40	-0.24	1	0.00
	DK	0.00	0.00	0.00	0.00	0.00	1

***Table 1: Spain and the United Kingdom: some Macroeconomic Data* (% of GDP), *2010-12*.**

	Spain			United Kingdom		
	2010	2011	2012	2010	2011	2012
Current Account	-3.7	-2.7	+0.1	-3.2	-1.8	-3.4
Fiscal Deficit	-9.5	-9.7	-10.7	-9.3	-7.5	-8.2
Government Debt	60.1	69.5	85.7	62.9	69.3	72.9

Sources: World Bank Data Bank (current account), CEIC (fiscal balance), trading economics (government debt).

Table 2: A simultaneous spatial model with fixed effects.

System obs: 6496		
One-step weighting matrix		
	Coeff.	t-stat
Rate equation		
SP	0.314	89.7
Debt/GDP	0.044	114.7
W_1**Rate*	0.503	166.6
W_2**Rate*	0.129	8.57
SP equation		
Rate	0.329	79.2
d(lgdp)	-10.43	9.1
Pol	-0.143	42.4
W_1**SP*	0.432	82.40
W_2**SP*	0.113	3.25
Note: Fixed Effects not reported		

Table 3. A simulated shock of one Standard deviation shock (multiplied by 10) to ratings and spreads in one country in each zone

	Euro-area		Non-Euro area	
	Ratings Shock			
	Own country	Other country	Own country	Other country
Ratings	2.96	0.91	0.70	0.06
Spreads	1.2	0.61	0.24	0.035
	Spread shock			
Ratings	1.3	0.68	0.21	0.03
Spreads	3.1	0.746	0.95	0.07

Note: The shocks applied are 10 times the average absolute change in ratings and spreads in each region over our estimation sample. These are: 1) for the euro area: ratings 0.216 and spreads 0.24, 2) for the non- euro area: ratings 0.062 and spreads 0.084

Table 4: Three Weighting Matrices for Non-euro area, northern and southern euro-area countries.

System obs: 6496

One-step weighting matrix

	Coeff.	t-stat
Rate equation		
SP	0.309	80.8
Debt/GDP	0.044	118.1
W_1**Rate*	-0.12	10.86
W_2**Rate*	0.131	7.97
W_3**Rate*	0.49	164.4
SP equation		
Rate	0.320	67.2
d(lgdp)	-9.60	8.3
Pol	-0.130	37.4
W_1**SP*	0.95	31.9
W_2**SP*	0.13	3.75
W_3**SP*	0.433	76.0

Note: Fixed Effects not reported.

Table 5: A simulated shock of one standard deviation (multiplied by 10) to ratings and spreads in one country in each zone

	North Euro area		South Euro area		Non-Euro area	
	Ratings Shock					
	Own country	Other country	Own country	Other country	Own country	Other country
Ratings	0.58	0.02	5.27	1.53	0.70	0.06
Spreads	0.2	0.09	2.15	1.08	0.23	0.037
	Spreads Shock					
Ratings	0.08	0.04	2.47	1.23	0.3	0.05
Spreads	0.32	0.14	6.06	1.56	0.95	0.08

Note: The shocks applied are 10 times one standard deviation in the change in ratings and spreads in each region. These are: 1) for the north euro area: ratings 0.07 and spreads 0.06; 2) for the south euro area: ratings 0.39 and spreads 0.46; and 3) for the non-euro area: ratings 0.06 and spreads 0.084.

Figure 1: Spreads on 10-year bonds relative to the 10-year Bund

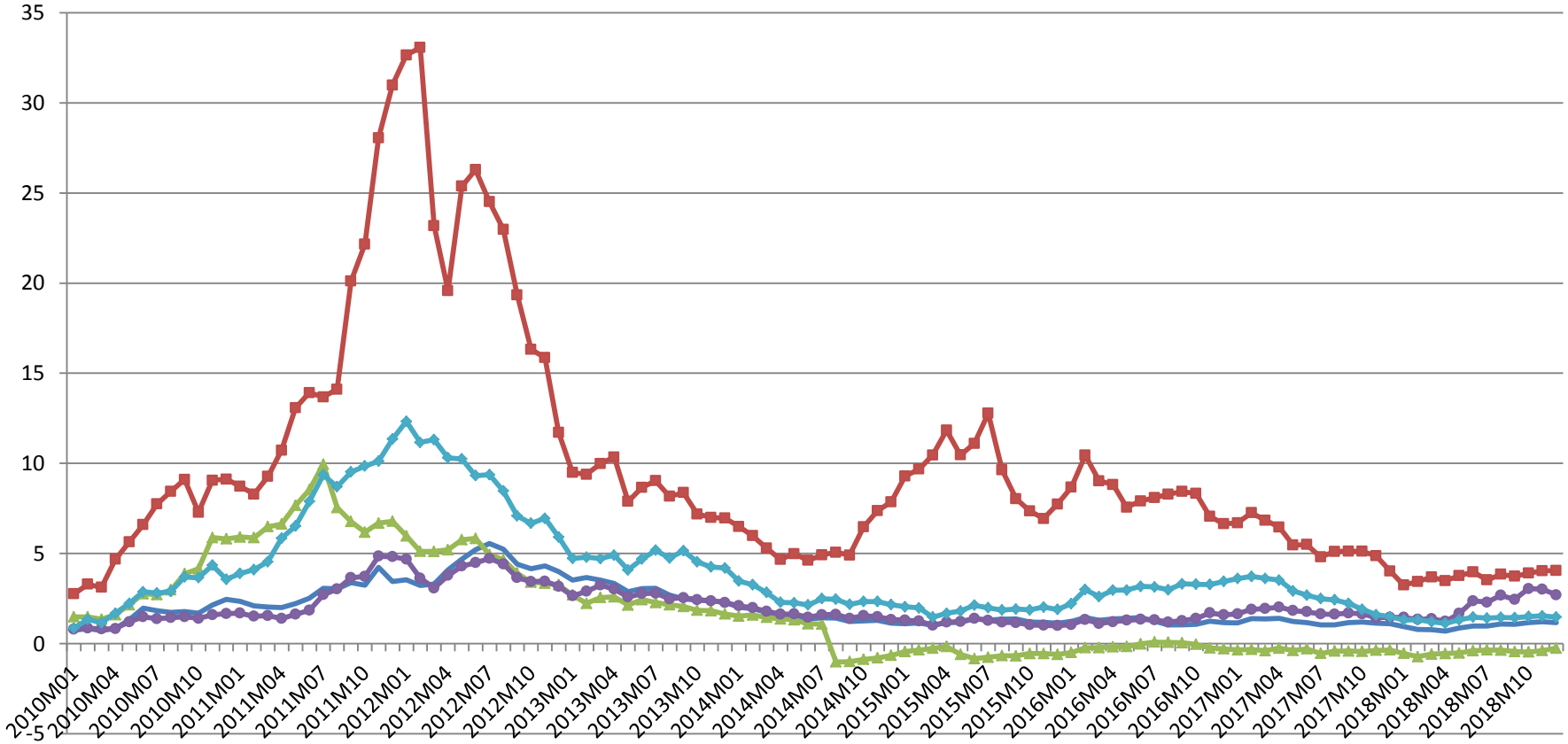
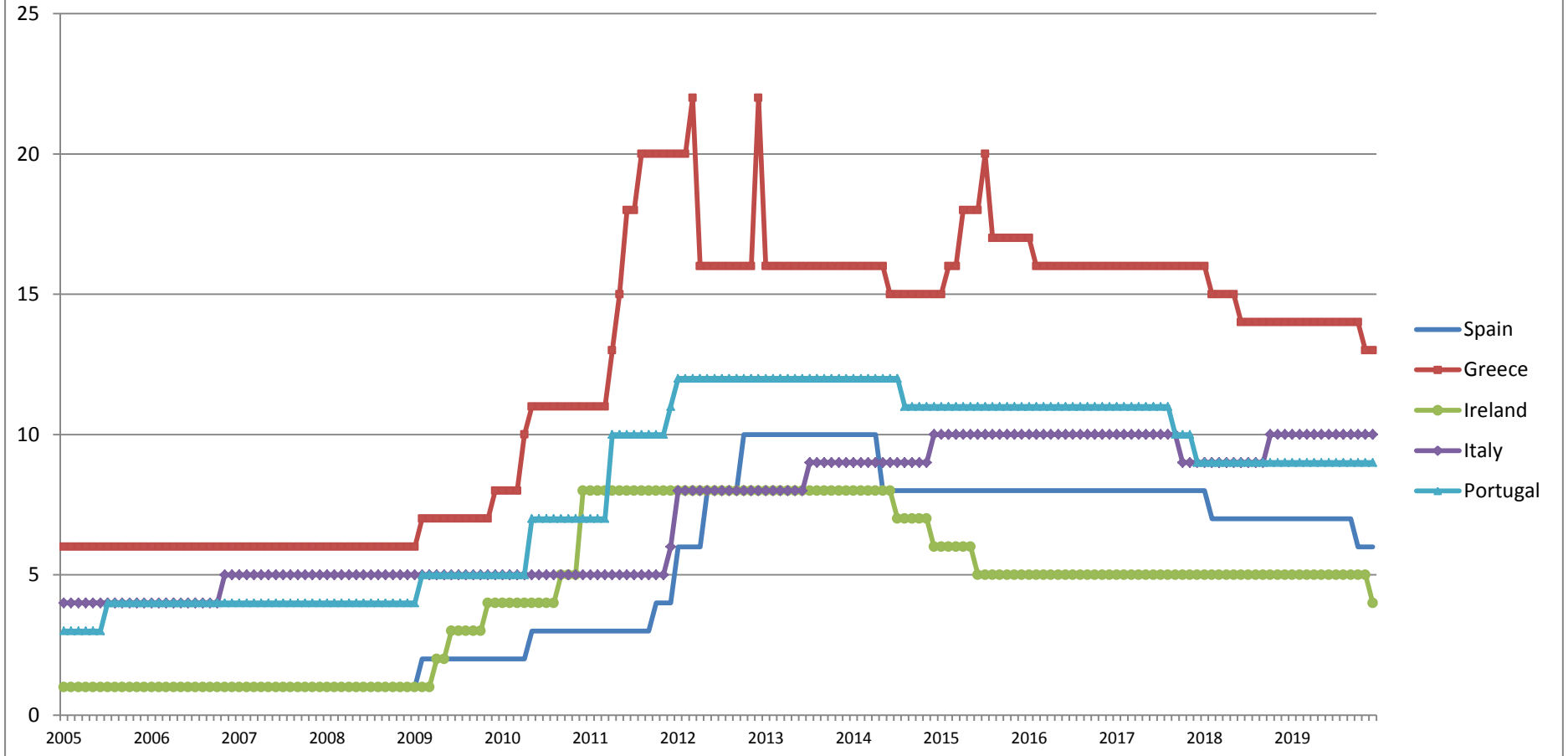


Figure 2: Sovereign ratings



Source: sovereign ratings were sourced from Standard and Poor's, Fitch and Moody's - an increase repesents a downgrade

Figure 3A: Spreads and Ratings in the euro area: the South

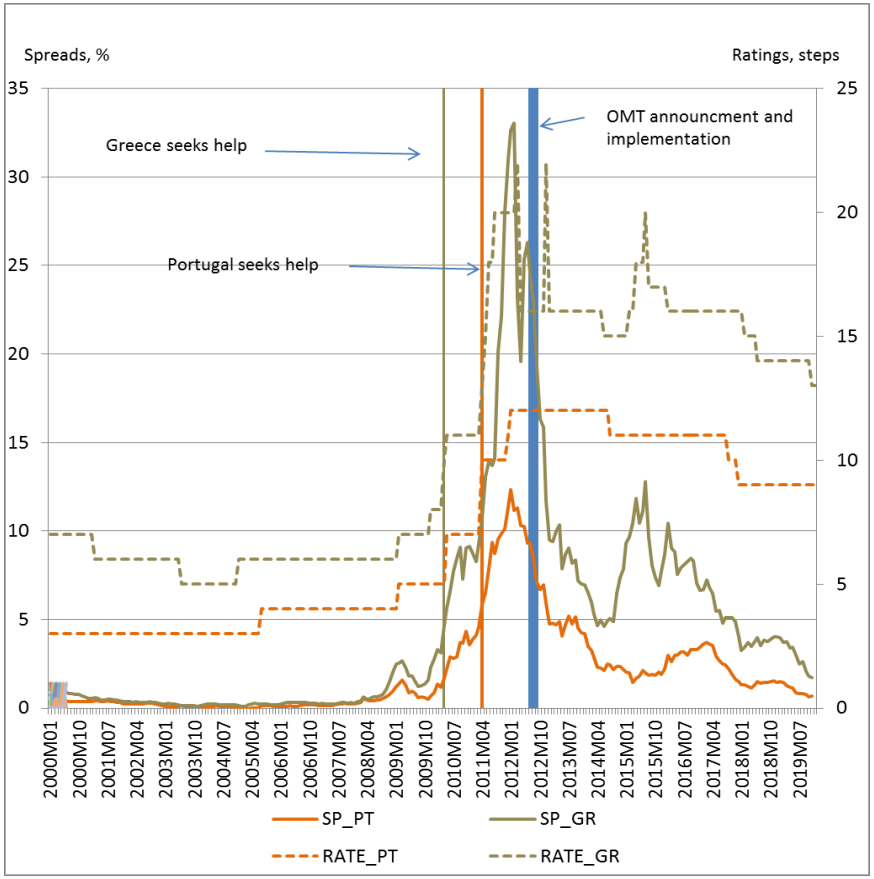


Figure 3B: Spreads and Ratings in the euro area: the South

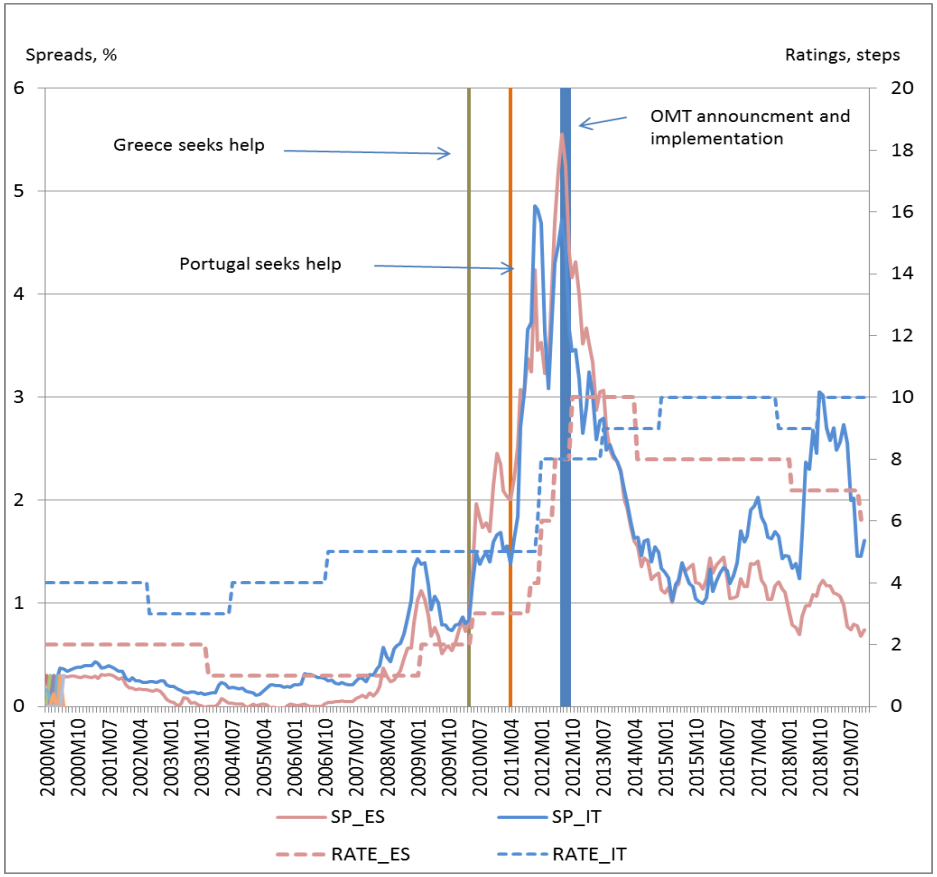


Figure 4A: Spreads and Ratings in the euro area: the North

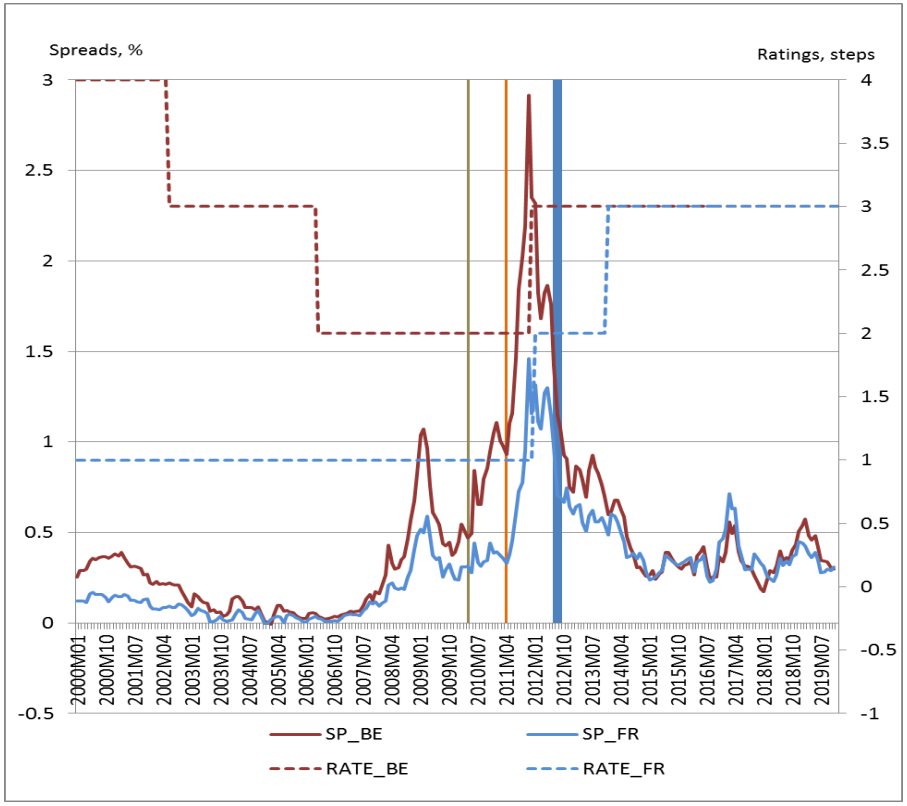


Figure 4B: Spreads and Ratings in the euro area: the North

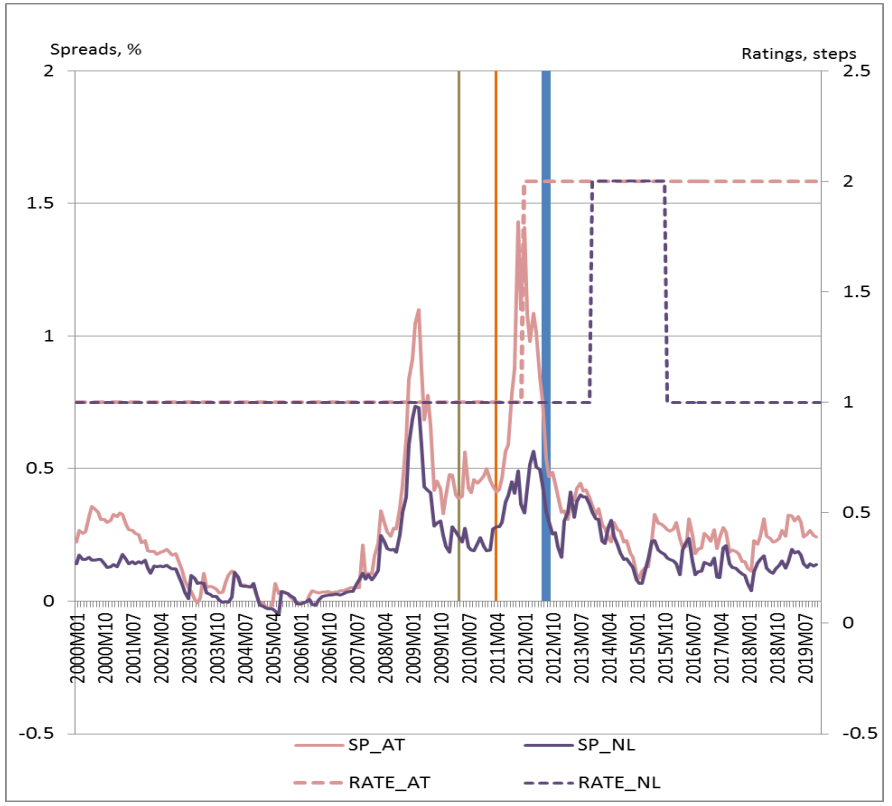
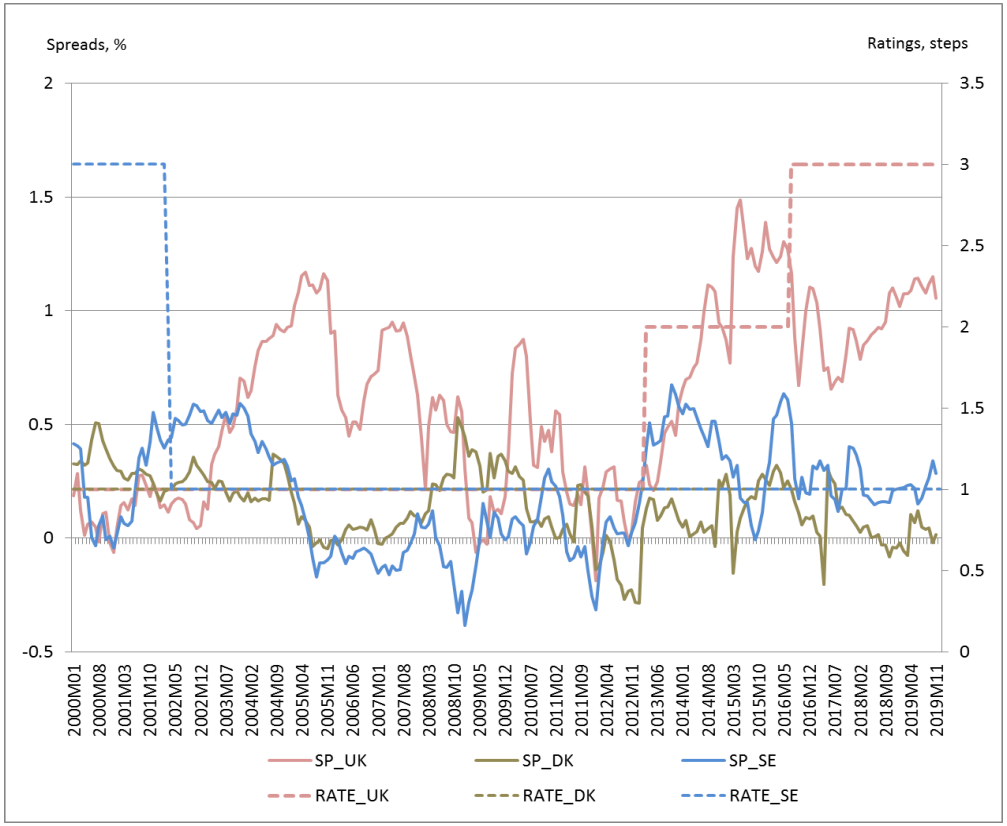


Figure 5: Spreads and Ratings in the non-euro area countries



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