University of Leicester

Department of Economics

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Heather D. Gibson, Bank of Greece

Stephen G. Hall, University of Leicester

George S. Tavlas, Bank of Greece

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Heather D. Gibson
Bank of Greece

Stephen G. Hall
University of Leicester
Bank of Greece

George S. Tavlas*
Bank of Greece

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ABSTRACT

During the euro-area financial crisis, interactions between sovereign spreads and credit ratings appeared to have led to self-generating feedback loops. To examine the interaction between spreads and ratings, we estimate a simultaneous two-equation model in which spreads and ratings are endogenous. Using a panel of 5 euro-area countries, we construct time series comprising the ratings of its sovereigns determined by the three major rating agencies. We find that, controlling for the economic and political fundamentals, spreads and ratings strongly interacted with each other during the crisis, producing effects well-beyond those of the fundamentals, and with the interactions demonstrating high persistence.

Keywords: euro area financial crisis, sovereign spreads, rating agencies
JEL Classification: E63, G12

* Corresponding author: George Tavlas, Bank of Greece, 21 E Venizelos Ave, Athens, 10250, Greece, Tel. no. +30 210 320 2370; Fax. no. +30 210 320 2432; Email address: gtavlas@bankofgreece.gr

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1. Introduction

The euro-area financial crisis has given rise to a large empirical literature investigating the determinants of sovereign bond spreads and CDS spreads in the euro-area's crisis countries -- typically taken to include Greece, Ireland, Portugal and Spain, but sometimes also including Cyprus and/or Italy. Among the findings of the literature, the following two features stand-out. First, the various fundamental variables that have been used in an attempt to explain spreads are not able to account for either the very-low spreads (measured relative to German sovereigns) that prevailed in the years preceding the outbreak of the euro-area crisis in 2009 or the very-sharp rise in spreads that took place following the onset of the crisis. The general finding that spreads overshot in a downward direction before the crisis and in an upward direction after the crisis holds regardless of the mix of fundamental variables used to explain spreads and whether the fundamentals are supplemented with additional variables -- for example, measures of contagion (Grammatikos and Vermuelen, 2012), measures of credit risk (Annaert, De Ceuster, Van Roy and Vespro, 2013), and sovereign credit ratings (Gibson, Hall, and Tavlas, 2014; Aizenman, Binici and Hutchison 2013; Alfonso, Furceri, and Gomes, 2011). Moreover, this finding is robust to the particular sample and time period used, and the estimation procedure employed.[1] Second, the euro-area crisis has been marked by negative feedback loops between the sovereigns and the banks of the countries in question (Goodhart, 2014; Pisani-Ferry, 2013; Mink and De Haan, 2013). This circumstance reflects the relatively large sizes of the banks relative to national GDPs, and the large amounts of sovereigns held in the portfolios of the banks.[2] As a result, national banking crises placed large fiscal burdens on governments, calling into question their solvency.

[1] For example, Gibson, Hall and Tavlas (2012, 2014) apply both ordinary least squares and the Kalman filter to Greek data, Arce, Mayordomo, and Peña (2013) apply a two-stage estimation procedure to a pooled sample of 32 euro-area banks, and Maltritz (2012) applies Bayesian estimation on a pooled sample of 10 euro-area countries.

[2] Although the largest banks in the euro area and the United States are of roughly the same size in terms of euro-area GDP and U.S. GDP, respectively, the largest euro area banks represent a much larger share of any individual national economy compared with the situation of U.S. banks.

In this paper, we investigate whether a second feedback mechanism -- between credit ratings and spreads -- may have operated during the euro-area crisis, resulting in negative feedback loops between spreads and credit ratings, and contributing to the overshooting of spreads in the downward direction observed, before, and in the upward direction, after, the outbreak of the crisis. The intuition underlying this mechanism is as follows. Consider a world that includes two rating agencies, A and B. In assigning ratings to a particular sovereign, both agencies have access to essentially identical information sets comprised of the (present and projected) fundamentals, including spreads, competitiveness, real growth, inflation, fiscal and external positions, and, perhaps, non-economic variables such as measures of political stability. Suppose that, based on its assessment of the information set of a particular country, rating agency A moves to downgrade the sovereign debt of the country in question. The announcement of the downgrade will very likely trigger a rise in the sovereign's interest rate.[3] In addition, under the ECB's collateral framework, haircuts on sovereigns rise if ratings fall to a specified (triple-B) level and are non-eligible as collateral below single-B minus. For these reasons, the very action by rating agency A changes the information set of rating agency B, since that information set now includes both A's downgrade, the resulting higher interest rates, and possibly higher haircuts on collateral, lower projected growth (because of the rise in interest rates), and less-sustainable fiscal balances for the country in question. Consequently, rating agency B, which may have been content with the rating it had assigned to the sovereign in question prior to A's downgrade, may move to downgrade the sovereign's rating based on the changed information set. In this way, A's original action can precipitate a downgrade by B, triggering self-perpetuating feedback loops between ratings and spreads.

To examine the possible interaction between spreads and ratings, we estimate a simultaneous two-equation model in which both spreads and ratings are both endogenous, using a panel of 5 euro-area countries[4]. The data are monthly and the estimation period is 1998m1 to 2013m3. For each country considered, we have constructed time series comprising the ratings of its sovereigns determined by the three

[3] Typically, market prices of sovereigns are tied to ratings.
[4] In some preliminary estimations, we include 10 euro-area countries.

major rating agencies -- Fitch, Moody's, and Standard & Poor's (S&Ps). Our results strongly indicate that, controlling for economic fundamentals and political stability, both ratings and spreads exhibit high degrees of auto-correlation and strongly interact with each other. Additionally, simulations suggest that changes in economic fundamentals and political stability can explain only a small proportion of the variation in spreads and ratings. A considerable part of the variation stems from previous movements in spreads and ratings, along with interactions between the two variables. These interactions also tend to have long-lasting effects. We also find that ratings react slowly to news about the fundamentals, suggesting that the process of setting ratings may be marked by irrational behavior on the part of rating agencies.

The remainder of this paper is structured as follows. Section 2 provides some context to our conjecture that spreads and ratings interact, using the case of Greece, which experienced by-far more sovereign downgrades than any other euro-area country; to illustrate, whereas Greece experienced 27 downgrades during the period examined, Portugal had 16, Spain, 15 and Italy, 11. Section 3 provides an overview of related studies. Section 4 describes our data and presents results of the effect of ratings on spreads using a single-equation approach. Section 5 extends the analysis to a simultaneous-equation setting. In that section we also present the simulation results of the effects of changes in the fundamentals on spreads and ratings. Section 6 concludes.

2. Interactions between ratings and spreads

Sovereign ratings are important because they (1) directly influence the interest rate charged to the sovereign in the international capital markets, (2) affect size of the haircut applied to collateral (under the Eurosystem's collateral framework), and (3) impact on the ratings assigned to other borrowers, including banks, particularly of the same nationality. In this paper we examine the effects of the sovereign ratings of the three main rating agencies: Moody's, S&P, and Fitch.

Table 1 lists the ratings' categories for long-term debt for each of the agencies. Fitch and S&P use identical symbols in assigning credit risk. The symbols used by Moody's differ from those of the other two agencies, but each Moody's symbol has a counterpart in the ratings of Fitch and S&P. Typically, the ratings of sovereigns assigned

by the three agencies have been in close correspondence; when the ratings have not been in correspondence they have tended to differ by one notch.

The trigger for the euro-area crisis occurred in early-October 2009 following national elections in Greece on October 4, 2009. Several days later a newly-elected (socialist) government surprised the markets with the announcement that the fiscal deficit for 2009 was on a track that would bring it to more than double the outgoing (conservative) government's projection of a deficit of 6 per cent of GDP.[5] Prior to the elections, each of the rating agencies had maintained the ratings on 10-year Greek sovereigns unchanged since at least 2004, as follows: Fitch, A; Moody's A1; S&P, A. In reaction to the news about Greece's fiscal position, the rating agencies moved quickly. The following account focuses on Greece, but the ratings-downgrade scenario was replicated (though to a lesser extent) in other euro-area crisis countries.

On October 10, 2009, S&P downgraded the 10-year Greek sovereign from A to A-minus (Figure 1). On October 22, 2009, Fitch followed with an identical move. With the financial situation deteriorating, spreads began to rise sharply (Figure 1). On December 8, 2009, Fitch moved again, cutting the sovereign rating from A-minus to triple-B-plus. On December 15, 2009, S&P followed with an identical move. Six days later, on December 22, 2009, Moody's cut its rating from A1 to A2. Sovereign downgrades were followed in rapid succession by downgrades of Greek banks. The processes of negative feedback loops between sovereign downgrades and spreads, and between sovereign downgrades and bank downgrades, were underway. Over the next 27 months (*i.e.,* until March 2012), 18 additional downgrades of the sovereign took place; by the beginning of March 2012, Greek sovereigns were rated in the "selective default" category. During that 27-month period, the four major Greek banks (accounting for 85 per cent of the banking sector at the onset of the crisis) underwent a total of 76 separate downgrades[6]. At the end of the period, the banks were not able to use Greek sovereigns as collateral

[5] The final figure would be a deficit of 15.6 per cent of GDP.
[6] The 4 major banks and the respective number of downgrades were as follows: NBG 18, Piraeus 18, Alpha Bank 20, Eurobank 21.

at the ECB.[7] The spread on the 10-year sovereign rose from 230 basis points at end-December 2009 to a peak of 3,800 basis points in February 2012.

3. Related literature

An initial attempt to examine links between ratings and spreads was made by Cantor and Packer (1996), who investigated the determinants of spreads for a sample of 40 sovereigns. These authors found that ratings are related to economic fundamentals, including the level of per-capita GDP, the growth of real GDP, external debt, and other macroeconomic variables; they also found, however, that ratings influence spreads over and above the information contained in macroeconomic fundamentals. Subsequent work confirmed that finding. Gonzales-Rosanda and Levy Yeyati (2008), in a study of emerging markets between 1994 and 2005, found that changes in credit ratings appear to have a role in explaining movements in spreads beyond the effects of macroeconomic fundamentals. In a study dealing with the euro area sovereign debt crisis over the period 2009 to 2011, Gartner and Griesbach (2012) modeled ratings as a function of macroeconomic determinants and lagged spreads. They also modeled spreads as a function of ratings, and found considerable evidence of nonlinearities; changes in ratings around the triple-B level caused spreads to move much more than a change in ratings when a country was at or above the single-A category.

The above mentioned papers do not address the issue of the potential endogeneity of spreads. Subsequent work has addressed endogeneity. Aizenmann, Binici and Hutchinson (2013) examined whether credit ratings are a significant determinant of spreads on credit default swaps (CDSs) in 26 EU countries over the period January 2005 to August 2012, even controlling for fundamentals. They used a panel GMM estimator to deal with the potential endogeneity of ratings. Their results suggest a separate role for ratings in explaining spreads on CDSs beyond macroeconomic fundamentals. De Santis (2012) used a SVECM model to examine the relationship between spreads and ratings in euro area countries and found evidence of both ratings responding to spreads, as well as ratings affecting spreads. Impulse response functions showed that spreads are more

[7] The banks had to satisfy their liquidity needs by obtaining Emergency Liquidity Assistance (ELA) from the Bank of Greece. The cost of borrowing ELA is higher than that under the Eurosystem's monetary-policy operations.

strongly influenced by ratings (a 1-notch downgrade leads to a 50 basis points rise in spreads after one quarter), than ratings are by spreads.

An alternative method of dealing with endogeneity is to purge ratings of fundamentals and then incorporate the residuals from the ratings equation into an equation explaining spreads. This method was first used by Eichengreen and Mody (2000). It has recently been applied to explain movements in spreads during the Greek sovereign debt crisis by Gibson, Hall and Tavlas (2014). They found a strong effect from ratings (purged of macroeconomic variables). The inclusion of an index of political stability implies that the residual effect of ratings exists even controlling for political factors which ratings agencies take into account when setting their ratings and could explain the significance of ratings even when controlling for economic fundamentals.

4. Spreads and credit rating interactions: evidence from the euro area

As a first step, we examine the determinants of spreads in 5 most affected euro-are countries: Greece (GR), Ireland (IR), Italy (IT), Portugal (PG) and Spain (ES). The data are monthly and the panel is unbalanced; most of the data are, however, available over the estimation period, 1998m1 to 2013m3. In those cases for which the original data are quarterly, the data have been interpolated to a monthly frequency. We use the following explanatory variables in our basic spreads' specification. (Where appropriate, variables are measured relative to the corresponding variables for Germany; consequently, Germany does not explicitly appear as part of the panel.)

Real GDP growth. A relatively high rate of economic growth suggests that a country's existing debt burden will become easier to service over time.

Relative prices. To help capture relative changes in competitiveness, we use each country's Harmonized Index of Consumer Prices (HICP, all items index) relative to that of Germany.

External balance. A large current account deficit (relative to GDP) indicates that the public and private sectors together rely heavily on funds from abroad. Current account

deficits that persist result in growth in foreign indebtedness, which may become unsustainable over time.

Government debt. A higher debt burden should correspond to a higher risk of default. We include the general government consolidated gross debt-to-GDP ratio (expressed as a percentage), interpolated from a quarterly to a monthly frequency.

Fiscal balance. A large federal deficit absorbs private domestic savings and suggests that a government lacks the ability to tax its citizenry to cover current expenses or to service its debt. We use the general government balance as a percentage of GDP, again interpolated to monthly frequency.

Fiscal news. In order to capture the news (or surprise) element that has figured strongly in the euro-area experience, we also construct real-time fiscal data. In particular, using the European Commission Spring and Autumn forecasts, we create a series of forecast revisions. For example, the revision in the Spring 2001 forecasts is the 2001 deficit/GDP ratio in the Spring compared to the forecast for 2001 made in the Autumn of 2000. This procedure allows us to generate a series of revisions, which, when cumulated over time, provides a cumulative fiscal news variable.

Political stability. We use the IFO World Economic Survey Index of Political Stability. A rise in the index implies greater stability.[8]

To capture the effects of ratings on spreads, we include ordinal ratings across all countries to allow for nonlinearities in the relationship between ratings and spreads. For example, the dummy variable triple-A for a particular country takes a value of 1 for the period for which the country in question has a triple-A rating, and a value of zero otherwise (see Table 1). We date rating changes by identifying in each case the agency that made the first move from one rating to another, on the assumption that the first mover would cause the subsequent reaction. In other words, if rating agency A downgraded a country from A- to BBB+ in April, say, and subsequently rating agency B

[8] Apart from the fiscal-news variable, the above variables are standard variables used in the empirical literature dealing with the determinants of spreads. The fiscal-news variable was first used by Gibson, Hall, and Tavlas (2012). It has subsequently been incorporated in more-recent studies.

downgraded the same country from A to A- in June, then the second downgrade would not register.

The results are presented in Table 2 where we include all likely fundamental determinants regardless of their sign or significance. The results indicate that movements in spreads appear to be dominated by ratings. Given the fundamentals, spreads for countries rated in the broadly-defined A and B categories (from double-B-minus to triple-A), appear to be low; for categories double-C and Selective Default, spreads are high, given the fundamentals. The results suggest the presence of nonlinearities (confirming Gartner and Griesbach, 2012). The markets do not appear to distinguish very much among the countries rated in the broad A category (that is A-minus to triple-A). A distinction appears to set-in once the rating reaches the triple-B-minus category; the coefficient on ratings falls from -8.6 under triple-B-plus to -5.9 under triple-B-minus. Ratings at the double-C notch (applicable to only Greece in our sample) face a heavy penalty over and above that arising from the impact of the fundamentals. The penalty is even higher than if a country is categorized as being in selective default. This circumstance reflects the fact that the short periods during which Greece spent in selective default were associated with policies (private sector involvement and the debt buy-back) that were designed to raise the country's credit rating going forward. Among the macroeconomic variables, relative prices, debt and fiscal news are significant and correctly signed. Political stability also plays a role in determining spreads. Ratings have a very significant and large impact on spreads over and above fundamentals – both economic and political.

The above results could reflect the possibility that fundamentals affect ratings, as well as spreads. Consequently, the coefficients on ratings may be capturing the effects of the fundamentals on spreads (through the impact of the fundamentals on ratings). To deal with this potential simultaneity issue, we estimate a regression for ratings.

In their statements on rating criteria, the rating agencies list various economic and political criteria that underlie their sovereign credit ratings. However the agencies provide little guidance as to the relative weights assigned to the various factors, and they do not make their methodological approaches explicit. In this paper, we use the

same set of variables used to explain spreads to explain ratings. We then use the residuals from that equation in a regression for spreads. In this way, we purge ratings of the economic and political fundamentals. To this end, we transform the ordinal ratings data into a cardinal series (shown in Table 1; a rise in the series represents a downgrade). Table 3 provides the results for the ratings regression. The main determinants of ratings are competitiveness (relative prices), the fiscal position (as reflected in the debt-to-GDP ratio), fiscal news, economic growth, and the index of political stability; these variables have the correct signs and are significant. Although, ratings also appear to be significantly determined by the current account and general government balances, the signs are contrary to expectations.

We then re-estimate the equation for spreads, using the residuals from the ratings equations. These results are presented in Table 4. Once again, fundamentals, including the external sector, general government debt, growth and political stability all affect spreads in the expected way. The current account balance, general government balance and fiscal news have signs contrary to theory, although, in the case of the current account and fiscal news, they are not significant. In addition, however, ratings, now purged of the impact of fundamentals, play a very significant role in determining spreads. The positive coefficient can be interpreted as follows. When ratings are worse than predicted by fundamentals (in which case the residual is positive), spreads are higher than the fundamentals alone would suggest.

4.1. Robustness check

In the above analysis, we presented results which include all potentially relevant fundamentals for the determinants of spreads and ratings, irrespective of the direction of their influence or their significance. The advantage of this approach is that it sets the bar quite high in that we purge ratings of as many fundamentals as possible. However, it is useful to check that the significance of purged ratings in the spreads equation does not arise from the inclusion of variables which are highly significant but have the wrong sign.

To this end, we present a robustness check of the results in Tables 3 and 4 in Tables 5 and 6. In Table 5, we present a parsimonious ratings equation where we have dropped the incorrectly signed variables – the current account and general government balances. We then use the residuals from this equation in the spreads equation in Table 6, where again we have removed the incorrectly signed variables. The results appear robust. The residuals purged of fundamentals are still highly significant.

5. Spreads-credit ratings interactions: system estimates

In the light of the above findings which corroborate those in the literature and suggest that ratings do appear to play a role in the determination of spreads over and above that of fundamentals, we now provide system estimates for spreads sovereign ratings and commercial bankratings simultaneously. We treat all three variables as endogenous. Such system estimates will also allow us to explore further the relationship between sovereign ratings commercial bank ratings and spreads and the potential existence of a vicious circle for some euro area peripheral countries.

We use a panel GMM estimator which is robust to autocorrelation and heteroskedasticity (HAC). We are interested in a two equation simultaneous system for a group of n countries, estimated over T periods. Our baseline model can be expressed as:

$$S_{it} = \alpha_0 + \alpha_1 SR_{it} + \alpha_2 BR_{it} + \sum_{k=1}^{K} \alpha_{2+k} X_{itk} + \varepsilon_{it}$$

$$SR_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 BR_{it} + \sum_{k=1}^{K} \beta_{2+k} X_{itk} + \varpi_{it}$$

$$BR_{it} = \chi_0 + \chi_1 S_{it} + \chi_2 SR_{it} + \sum_{k=1}^{K} \chi_{2+k} X_{itk} + \upsilon_{it}$$

where i=1…N, t=1…T and K is the number of exogenous regressors. S_{it} is the interest rate spread between country i and Germany, SR_{it} is the soveriegn rating for country I, BR_{it} is the rating for commercial banks in country i. and ε_{it} , ω_{it} and υ are error terms. We assume there are suitable exclusion restrictions on α β and χ to either exactly or over identify the system.

GMM estimation requires the specification of a set of theoretical moment conditions that the parameters of interest φ should satisfy, thus,

$$E(m(y,\varphi)) = 0$$

Where y is a vector of variables relevant for the specific moment conditions being specified , m is the moment function (e.g. mean, covariance etc) and the method of moments estimator is defined by replacing these with their sample analog.

$$\sum_t m(y_t,\varphi)/T = 0$$

In the case of the specific GMM estimator we are using here the moments conditions are specified in terms of orthogonality conditions between the residuals of each equation and a set of instruments (Z_t). that is ε_{it} ϖ_{it} and υ_{it} are assumed to be orthogonal to the vector of instrumental variables Z.

If the number of parameters of interest is exactly equal to the number of moment conditions then we can exactly satisfy these moment conditions and we obtain the method of moment's estimator. However, when the number of moment conditions is greater than the number of parameters of interest then we cannot meet all the moment conditions at the same time and instead we minimize the following function, which gives rise to the Generalised Method of Moments (GMM):

$$\sum_t m(y_t,\varphi)A(y_t,\varphi)m(y_t,\varphi)$$

where A is a weighting matrix. While any positive definite symmetric matrix will give rise to a consistent estimator, the optimal A is given by the inverse of the covariance matrix of the moment conditions. When the number of endogenous variables exactly equals the number of instruments the model is exactly identified, when there are less instruments than endogenous variables the model is underidentified and cannot be estimated. When there are more instruments than endogenous variables the model is over identified, in the case of our estimates below the model is overidentified.

The results are presented in Table 7. We focus on the 5 southern European countries most affected by the crises Greece, Italy, Portugal Ireland and Spain.

The spreads equation again highlights the significance of external disequilibrium (as expressed in both the current account surplus and relative prices), fiscal imbalances (in particular fiscal news), growth and political stability. Spreads are strongly autoregressive and ratings play the expected positive role – the worse the ratings, the higher spreads. In the ratings equation, fundamentals such as fiscal news and the level of general government debt (as a percentage of GDP) along with growth are significant and have the expected signs. Ratings are also highly persistent. Additionally, ratings are positively affected by spreads; that is, the higher spreads, the worse the rating.

It is also worth noting that the proportion of the variance in spreads and ratings that is now explained using this system approach is considerably higher than that achieved under the single equation estimation.

These results provide strong evidence of the potential presence of vicious circles of rising spreads causing ratings to worsen, leading to rising spreads and so on. Exogenous shocks to fundamentals are propagated both through the autoregressive nature of spreads and ratings and through the interactions between them. In order to explore these interactions further, it is interesting to undertake simulations.

Figures 2a and 2b show the impact of a permanent 1-notch downgrade on both ratings and spreads. Because of the lagged effect of ratings and the impact on spreads which then interacts with ratings, the long-term effect of the 1-notch downgrade is for ratings to deteriorate further by another 0.7 of a notch. It is also interesting to note the long lags that are generated by the autoregressive nature of spreads and ratings and the interactions between them. For spreads, the initial impact of the 1-notch downgrade is a rise in spreads of 14 basis points; this cumulates to 200 basis points after 5 years.

To further explore the relationships in the system, Table 8 examines the impact on both ratings and spreads, in the short and long run, of changes in the exogenous fundamentals. The short-run effect on ratings and spreads is equivalent to the impact effect; the long-run effect is the effect once the interactions have been factored in (that is, after about 5 years).

The purpose of the exercise is to examine "likely" changes in the economic fundamentals[9]. A 10pp higher debt-to-GDP ratio initially causes a 0.14 of a notch downgrade, an effect which rises to a 1.5-notch downgrade after 5 years. The shock has no immediate impact on spreads, but the interaction effects imply a rise in spreads of 170 basis points in the longer run. The impact of a deterioration in relative prices or a worsening of the current account (as a percentage of GDP) have similarly small impact effects and long-run effects on spreads that are comparable to those of the rise in the debt-to-GDP ratio (rises of 140 bps and 160 bps, respectively). The impacts of these shocks to competitiveness on ratings are smaller than the debt-to-GDP increase.

Bad fiscal news of a magnitude observed in the data and a deterioration in growth equivalent to an annual decline of 1pp have much smaller impacts on spreads and ratings. In the case of growth, this suggests that most of the negative impact of a deterioration in growth comes through its effect on the debt-to-GDP ratio and the current account to GDP ratio. The figures in Table 8 examine the effect of a change in growth, holding these two ratios constant.

The effects of the exogenous shocks at first sight appear rather small relative to the large movement in spreads and ratings that have been observed since 2008 (see Figure 1). However, it has to be borne in mind that countries experienced simultaneous shocks. Thus in order to explore further how much of rise in spreads our model can explain, we undertake a second set of simulations. For each country, we examine the deterioration in the independent variables that occurred. For competitiveness, we measure the deterioration in relative prices and the current account-to-GDP ratio over the period 2000 to 2008 (when deficits in most countries peaked). In the case of Italy, relative prices continued to deteriorate until 2011 and hence we use that year as our end-date. We employ a similar methodology for the political stability index and fiscal news.

This approach allows us to incorporate possible learning effects in the markets which we have examined in an earlier paper (see Gibson, Hall and Tavlas,2013). In other

[9] These simulations somewhat underestimate the size of the shocks that were observed in the data over the period 2008-2012. We address this period through presenting results of simultaneous shocks as observed in the data later.

words, we do not expect rating agencies or markets to react immediately and fully to changes in economic fundamentals; rather we allow for lags. Such lags could result either from inertia or from the impact of nonlinearities, reflecting the idea that the deterioration in fundamentals has to cumulate significantly before rating agencies and markets will react.

Finally, in the case of the debt-to-GDP ratio and growth, we focus on the more recent past. We use the cumulative deterioration in the debt-to-GDP ratio and growth from 2008 until the beginning of a programme; in the case of Italy until the sharp rise in spreads in the summer of 2011.

The results of the exercise, along with the precise assumptions used for each country, are presented in Table 9. The impact of simultaneous and fairly large shifts in the exogenous determinants of both ratings and spreads causes the latter two variables to move substantially. A number of observations are in order. First, in the case of Italy, the impact of the changes on ratings and/or spreads is more muted than for the other 3 countries. This result, perhaps, reflects the fact that Italy did not adopt an economic adjustment programme. Second, Greece is by far the worst affected with the exogenous shocks leading ultimately to an 11-notch downgrade and a rise in spreads to over 1900 basis points. Third, the effect of the interaction between spreads and ratings is what acts to drive spreads and ratings to the levels observed. In the absence of interaction, all four countries would not even have experienced a ratings downgrade (the combined effect of the exogenous shocks leads to less than a 1-notch downgrade). Multi-notch downgrades are present once the feedback loops have been added. Similarly, the impact effects for spreads are fairly modest. The impact on spreads only begins to bear some relation to reality once the feedback loops have been incorporated.

Interestingly if we compare actual peaks of spreads with those simulated in the model, it can be noted that in the cases of Spain and Italy, the model suggests spreads should have been higher. The highest spreads recorded (on a monthly basis) for Spain was about 550 basis points; the simulation suggests that spreads should have risen to around 1400 basis points. Similarly for Italy, the simulation suggests spreads of 640 basis points yet they peaked at around 500 basis points. By contrast, spreads rose by more

than the simulation suggests in Portugal, reaching 1230 basis points compared to the 1000 simulated in the model. For Greece, the unexplained part remains the highest by some way. The simulations can account for a rise in spreads to almost 2000 basis points, yet spreads actually rose to around 3360 basis points. This suggests that there was something special about Greece's treatment, a result that we have highlighted in earlier work (Gibson, Hall and Tavlas, 2013; 2014).

6. Conclusions

This paper has examined the interactions between sovereign spreads and credit ratings, while controlling for economic fundamentals and political stability which also influence spreads. The aim was to examine whether there was any support for the widely-held view that the current euro area crisis has been characterised by interactions between sovereign spreads and credit ratings which led to self-generating feedback loops.

We initially showed that for a group of 10 euro-area countries, ratings appear to play a role in determining spreads over and above the fundamentals. However, ratings and spreads are determined by similar fundamentals. It thus seemed appropriate to estimate a system of equations where both ratings and spreads are treated as endogenous. The estimation of a system also allowed us to incorporate potential dynamics between ratings and spreads which are key to the narrative of self-generating feedback loops.

To this end, we estimated a simultaneous two-equation model. Using a panel of 5 euro-area countries, including those more likely to be affected by the feedback loops, we found that, controlling for the economic and political fundamentals, spreads and ratings strongly interacted with each other during the crisis. The effects produced go well-beyond those of the fundamentals and the dynamics demonstrate high levels of persistence.

Simulations suggest that this system of equations can explain movements in spreads better than focusing purely on fundamentals. They also suggest that spreads in

Spain and Italy rose by less than would have been predicted by the model, whereas those in Portugal, and even more so Greece, rose by more. This provides support for the view that Greece's treatment, relative to other euro-area countries during the crisis, was special.

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Table 1: S&P, Moody's and Fitch ratings

Interpretation	Moody's	Fitch/Standard and Poor's	Numerical representation in the paper
INVESTMENT - GRADE RATINGS			
Highest credit quality – Lowest expectation of default – exceptionally strong capacity for payment	Aaa	AAA	1
Very high credit quality – Very low default risk – Very strong capacity to meet financial commitments	Aa1	AA+	2
	Aa2	AA	3
	Aa3	AA-	4
High credit quality – Low default risk -Strong payment capacity	A1	A+	5
	A2	A	6
	A3	A-	7
Good credit quality – Expectations of default risk are currently low - Adequate payment capacity but subject to business or economic conditions	Baa1	BBB+	8
	Baa2	BBB	9
	Baa3	BBB-	10
SPECULATIVE - GRADE RATINGS			
Speculative - Elevated vulnerability to default risk - Likely to fulfill obligations, ongoing uncertainty	Ba1	BB+	11
	Ba2	BB	12
	Ba3	BB-	13
Material default risk present, but a limited margin of safety remains – High-risk obligations	B1	B+	14
	B2	B	15
	B3	B-	16
Substantial Credit Risk – Default is a real possibility	Caa1	CCC+	17
	Caa2	CCC	18
	Caa3	CCC-	19
Very high levels of credit risk – Default appears probable	Ca	CC	20
Exceptionally high levels of credit risk – default is imminent or inevitable, or the issuer is at a standstill	C	C	21
Issuer has experienced an uncured payment default on any material financial obligation but is has not entered into bankruptcy filings, administration, liquidation or any other formal winding-up procedure		SD/RD	22
Default - Issuer has entered into bankruptcy filings, administration, liquidation or any other formal winding-up procedure		D	23

Table 2: The determinants of spreads on euro-area sovereign bond yields relative to German bond yields (10-year)

Sample: 1998(8) to 2013(3)
Fixed effects estimation
Observations: 1607

Constant	10.009	0.703	14.229	0.000
Current account to GDP	-0.002	0.004	-0.457	0.648
Relative prices	8.292	1.224	6.774	0.000
General government balance to GDP	0.005	0.020	0.247	0.805
Debt to GDP	0.032	0.005	6.867	0.000
Fiscal news	-0.002	0.001	-2.726	0.006
Growth	1.057	7.198	0.147	0.883
Political stability	-0.145	0.032	-4.561	0.000
Ratings				
AAA	-10.927	0.481	-22.713	0.000
AA+	-10.854	0.448	-24.214	0.000
AA	-10.796	0.418	-25.838	0.000
AA-	-11.008	0.399	-27.576	0.000
A+	-10.711	0.386	-27.723	0.000
A	-11.082	0.376	-29.469	0.000
A-	-9.642	0.383	-25.163	0.000
BBB+	-8.634	0.389	-22.177	0.000
BBB-	-5.851	0.433	-13.526	0.000
BB+	-5.956	0.468	-12.706	0.000
BB	-5.556	0.485	-11.444	0.000
BB-	-4.385	1.211	-3.620	0.000
B	-2.178	1.212	-1.798	0.073
CCC	-1.342	0.894	-1.501	0.134
CC	11.460	0.558	20.533	0.000
SD	3.024	0.888	3.404	0.001

R-squared	0.843	Mean dependent var	1.0101
Adjusted R-squared	0.840	S.D. dependent var	2.904
S.E. of regression	1.162	Akaike info criterion	3.159
Sum squared resid	2125.512	Schwarz criterion	3.269
Log likelihood	-2504.928	Hannan-Quinn criter.	3.200
F-statistic	264.308	Durbin-Watson stat	0.695
Prob(F-statistic)	0.000		

Table 3: The determinants of credit ratings in selected euro-area countries

Sample: 1998(8) to 2013(3)
Fixed effects estimation
Observations: 1625

Constant	-3.795	0.285	-13.301	0.000
Current account to GDP	0.014	0.004	3.988	0.000
Relative prices	9.574	0.968	9.896	0.000
General government balance to GDP	0.153	0.016	9.743	0.000
Debt to GDP	0.100	0.003	37.649	0.000
Fiscal news	-0.001	0.000	-1.994	0.046
Growth	-22.558	5.925	-3.807	0.000
Political stability	-0.086	0.025	-3.442	0.001

R-squared	0.883	Mean dependent var	2.927
Adjusted R-squared	0.882	S.D. dependent var	2.886
S.E. of regression	0.993	Akaike info criterion	2.835
Sum squared resid	1586.145	Schwarz criterion	2.891
Log likelihood	-2286.111	Hannan-Quinn criter.	2.856
F-statistic	756.488	Durbin-Watson stat	0.169
Prob(F-statistic)	0.000		

Table 4: The impact of ratings on sovereign bond spreads

Sample: 1998(8) to 2013(3)
Fixed effects estimation
Observations: 1597

Constant	-3.564	0.357	-9.976	0.000
Current account to GDP	0.006	0.005	1.420	0.156
Relative prices	19.662	1.234	15.935	0.000
General government balance to GDP	0.174	0.020	8.851	0.000
Debt to GDP	0.103	0.003	30.854	0.000
Fiscal news	0.000	0.000	0.873	0.383
Growth	-23.117	7.635	-3.028	0.002
Political stability	-0.431	0.031	-13.785	0.000
Residuals (ratings equation, Table 3)	1.463	0.031	45.738	0.000

R-squared	0.823	Mean dependent var	1.015
Adjusted R-squared	0.821	S.D. dependent var	2.913
S.E. of regression	1.233	Akaike info criterion	3.267
Sum squared resid	2401.978	Schwarz criterion	3.329
Log likelihood	-2591.965	Hannan-Quinn criter.	3.291
F-statistic	430.743	Durbin-Watson stat	0.475
Prob(F-statistic)	0.000		

Table 5: The determinants of credit ratings in selected euro-area countries

Sample: 1998(8) to 2013(3)
Fixed effects estimation
Observations: 1663

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-4.024	0.287	-14.014	0.000
Relative prices	8.054	0.980	8.2151	0.000
Debt to GDP	0.097	0.003	37.248	0.000
Fiscal news	-0.000	0.000	-0.9965	0.319
Growth	-17.588	6.132	-2.8682	0.004
Political stability	-0.046	0.026	-1.7907	0.074

R-squared	0.873	Mean dependent var	2.929
Adjusted R-squared	0.872	S.D. dependent var	2.880
S.E. of regression	1.032	Akaike info criterion	2.910
Sum squared resid	1723.684	Schwarz criterion	2.960
Log likelihood	-2361.254	Hannan-Quinn criter.	2.929
F-statistic	791.855	Durbin-Watson stat	0.119
Prob(F-statistic)	0.000		

Table 6: The impact of ratings on on sovereign bond spreads

Sample: 1998(8) to 2013(3)
Fixed effects estimation
Observations: 1605

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-3.547	0.301	-11.766	0.000
Current account to GDP	-0.010	0.004	-2.322	0.020
Relative prices	18.420	1.170	15.738	0.000
Debt to GDP	0.096	0.002	42.411	0.000
Growth	-19.982	7.369	-2.711	0.007
Political stability	-0.385	0.030	-12.802	0.000
Residuals (ratings equation, Table 5)	1.490	0.030	49.683	0.000

R-squared	0.833	Mean dependent var	1.012
Adjusted R-squared	0.831	S.D. dependent var	2.906
S.E. of regression	1.195	Akaike info criterion	3.203
Sum squared resid	2267.734	Schwarz criterion	3.257
Log likelihood	-2554.786	Hannan-Quinn criter.	3.223
F-statistic	526.749	Durbin-Watson stat	0.423
Prob(F-statistic)	0.000		

Table 7: System estimation

GMM estimation
Observations: 1630 **Sample: 1998(11)-2013(3)**

		Coefficient	Std. Error	t-Statistic	Prob.
Constant – GR	SPREADS EQUATION	-0.620	0.023	-27.536	0.000
Current account to GDP		-0.004	0.000	-21.406	0.000
Relative prices		0.941	0.053	17.894	0.000
Cumulative fiscal news		-0.002	0.000	-18.407	0.000
Growth		-3.060	0.685	-4.468	0.000
Political stability		-0.019	0.001	-15.245	0.000
Spreads (t-1)		0.882	0.003	316.335	0.000
Ratings		0.141	0.004	33.324	0.000
Constant – GR	RATINGS EQUATION	-0.533	0.016	-32.538	0.000
Debt to GDP		0.015	0.000	39.178	0.000
Cumulative fiscal news		-0.001	0.000	-11.080	0.000
Growth		-10.674	0.617	-17.310	0.000
Ratings(t-1)		0.833	0.004	198.746	0.000
Spreads		0.062	0.001	41.653	0.000
Constant – PT – spread eq.		-0.418	0.016	-26.042	0.000
Constant – PT – ratings eq.		-0.309	0.009	-34.392	0.000
Constant – SP – spread eq.		-0.099	0.010	-9.828	0.000
Constant – SP – ratings eq.		-0.466	0.013	-36.786	0.000
Constant – IT – spread eq.		-0.446	0.016	-27.966	0.000
Constant – IT – ratings eq.		-0.900	0.024	-37.360	0.000
Constant – BG – spread eq.		-0.169	0.009	-18.506	0.000
Constant – BG – ratings eq.		-0.998	0.027	-37.168	0.000
Determinant residual covariance			5.44E-12		
J-statistic			0.202838		

Greek equation for spreads

R-squared	0.967	Mean dependent var	3.930
Adjusted R-squared	0.966	S.D. dependent var	7.544
S.E. of regression	1.393	Sum squared resid	285.446
Durbin-Watson stat	1.268		

Greek equation for ratings

R-squared	0.965	Mean dependent var	8.077
Adjusted R-squared	0.964	S.D. dependent var	4.250
S.E. of regression	0.807	Sum squared resid	97.002
Durbin-Watson stat	1.633		

Portuguese equation for spreads

R-squared	0.982	Mean dependent var	1.778
Adjusted R-squared	0.981	S.D. dependent var	3.085
S.E. of regression	0.422	Sum squared resid	26.730
Durbin-Watson stat	1.061		

Portuguese equation for ratings			
R-squared	0.990	Mean dependent var	5.000
Adjusted R-squared	0.990	S.D. dependent var	2.897
S.E. of regression	0.295	Sum squared resid	13.26
Durbin-Watson stat	2.013		

Spanish equation for spreads			
R-squared	0.976	Mean dependent var	0.873
Adjusted R-squared	0.975	S.D. dependent var	1.362
S.E. of regression	0.217	Sum squared resid	7.079
Durbin-Watson stat	1.326		

Spanish equation for ratings			
R-squared	0.978	Mean dependent var	2.038
Adjusted R-squared	0.977	S.D. dependent var	1.199
S.E. of regression	0.181	Sum squared resid	4.988
Durbin-Watson stat	1.711		

Italian equation for spreads			
R-squared	0.957	Mean dependent var	0.880
Adjusted R-squared	0.955	S.D. dependent var	1.181
S.E. of regression	0.251	Sum squared resid	10.295
Durbin-Watson stat	0.907		

Italian equation for ratings			
R-squared	0.968	Mean dependent var	4.579
Adjusted R-squared	0.967	S.D. dependent var	1.264
S.E. of regression	0.230	Sum squared resid	8.748
Durbin-Watson stat	1.152		

Belgian equation for spreads			
R-squared	0.914	Mean dependent var	0.452
Adjusted R-squared	0.911	S.D. dependent var	0.533
S.E. of regression	0.159	Sum squared resid	4.179
Durbin-Watson stat	1.107		

Belgium ratings equation			
R-squared	0.938	Mean dependent var	2.838
Adjusted R-squared	0.937	S.D. dependent var	0.783
S.E. of regression	0.197	Sum squared resid	6.501
Durbin-Watson stat	1.853		

Instruments:

Current account to GDP, relative prices, general government balance to GDP ratio, debt to GDP, fiscal news, growth, political stability, lagged spreads, lagged ratings, lagged debt to GDP, lagged GDP growth

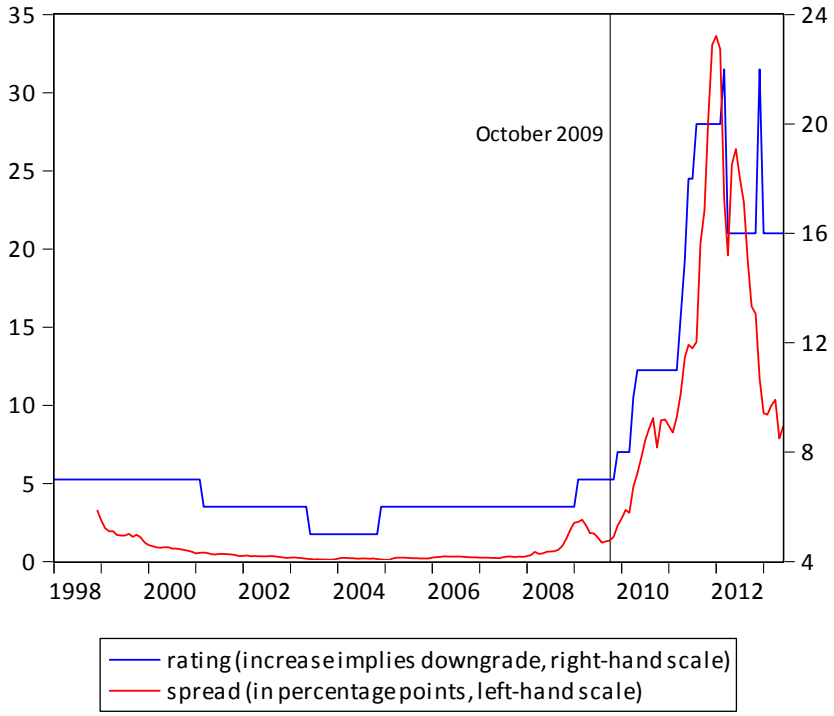
Table 8: The impact of changes in economic fundamentals: some simulation results

	Impact on ratings (notches)*		Impact on spreads (basis points)	
Exogenous shock	Impact effect	Long-run effect	Impact effect	Long-run effect
10pp increase in debt-to-GDP ratio	0.14	1.5	0	170
Deterioration in the square of cumulative fiscal news of 10 points	0.006	0.17	0.02	37
2.5pp deterioration in the current account to GDP ratio	0	0.06	1	160
10% increase in prices relative to Germany	0	0.5	9	140
1pp lower growth (per annum)	0.008	0.1	0.2	14
* a positive number implies a deterioration				

Table 9: Simulation results a simultaneous deterioration in the exogenous determinants of spreads and ratings

	Impact on ratings (notches)*		Impact on spreads (basis points)	
	Impact effect	Long-run effect	Impact effect	Long-run effect
Greece	0.75	11.2	79	1910
Portugal	0.62	7.1	29	1001
Spain	0.68	8.9	53	1415
Italy	0.3	3.8	0.28	640
Assumptions:				
(i) Greece				
Current account to GDP	10pp deterioration			
Relative prices	17% deterioration			
Debt to GDP	37pp deterioration			
Cumulative fiscal news	11.3pp deterioration			
Political stability	6 point deterioration			
Growth	actual growth 2009-2010			
(ii) Italy				
Current account to GDP	6pp deterioration			
Relative prices	7% deterioration			
Debt to GDP	15pp deterioration			
Cumulative fiscal news	4.5pp deterioration			
Political stability	3 point deterioration			
Growth	actual growth 2008-2010			
(ii) Portugal				
Current account to GDP	2pp deterioration			
Relative prices	8% deterioration			
Debt to GDP	37pp deterioration			
Cumulative fiscal news	5.7pp deterioration			
Political stability	no change			
Growth	actual growth 2009-2010			
(i) Spain				
Current account to GDP	6.5pp deterioration			
Relative prices	19.5% deterioration			
Debt to GDP	39pp deterioration			
Cumulative fiscal news	7.5pp deterioration			
Political stability	2.5 point deterioration			
Growth	actual growth 2009-2012			
Note: Re the growth path, we also used the deviation of actual from average during 2000-2007. The results are not quantitatively altered; they are simply slightly higher.				

Figure 1: Spreads and ratings in Greece



Note: Ratings have been transformed into a numerical series running from 1, equivalent to AAA, through to 22, which is selected default.

Figure 2a: The response of ratings to a 1-notch permanent downgrade

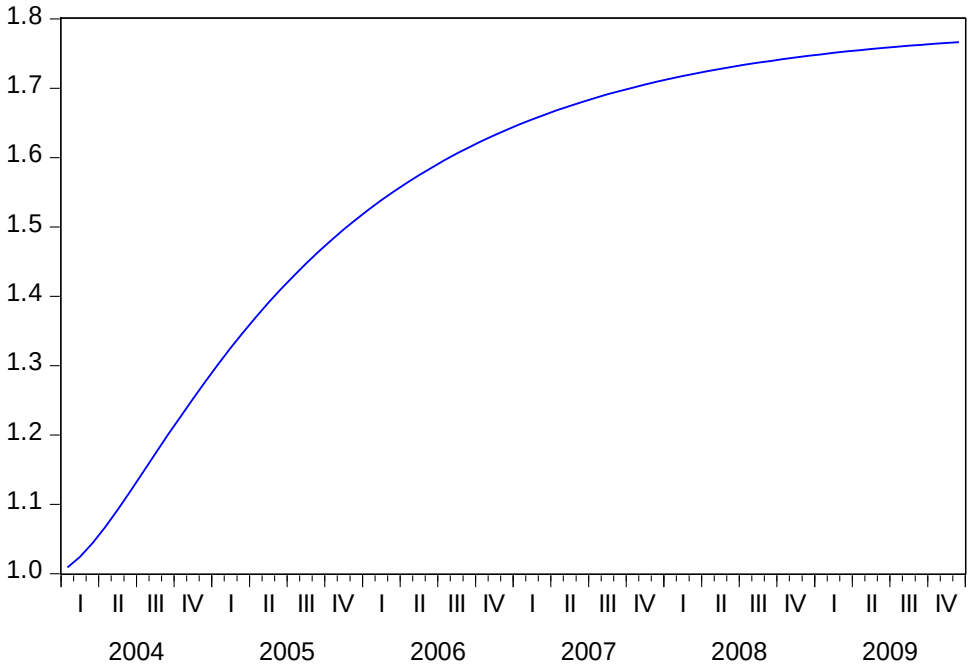


Figure 2b: The response of spreads to a 1-notch permanent downgrade