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Credit ratings and the pricing of sovereign debt during the euro crisis

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Abstract This paper investigates the impact of credit rating changes on the sovereign spreads in the European Union and investigates the macro and financial factors that account for the time-varying effects of a given credit rating change. We find that changes of ratings are informative, economically important, and highly statistically significant in panel models, even after controlling for a host of domestic and global fundamental factors and investigating various functional forms, time and country groupings, and dynamic structures. Dynamic panel model estimates indicate that a credit rating upgrade decreases credit default swap (CDS) spreads by about 45 basis points, on average, for European Union (EU) countries. However, the association between credit rating changes and spreads shifted markedly between the pre-crisis and crisis periods. European countries had quite similar CDS responses to credit rating changes during the pre-crisis period, but large differences emerged during the crisis period between the now highly sensitive GIIPS group (Greece, Italy, Ireland, Portugal, Spain) and other European country groupings (EU and euro area excluding GIIPS, and the non-EU area). We also find a complicated non-linear pattern dependent on the level of the credit rating. The results are robust to the inclusion of credit 'outlook' or 'watch' signals by credit rating agencies. In addition, contagion from rating downgrades in GIIPS to other euro countries is not evident once own-country credit rating changes are taken into account.

Key words: CDS spreads, credit ratings, sovereign debt, eurozone

JEL classification: F30, G01, G24, H63

I. Introduction and overview

Concerns about the information content of credit ratings and their association with sovereign spreads and default risk were mostly muted during the Great Moderation period. The global crisis of 2008–9, and especially the on-going euro crisis, again put to the fore these issues at the time of an unprecedented rise in volatility. A number

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of issues arise in this context, foremost among them are whether credit rating agency (CRA) rating changes systemically provide markets with new information on the likelihood of sovereign default and how risk pricing responds. Do CRAs have superior information on current or likely future fundamentals and/or provide value by coordinating disparate market views on creditworthiness such that rating changes have an economic importance? Has the markets' perception of the information value of credit ratings been diminished since the advent of the global financial crisis (GFC) and their failure to adequately judge the default risk of mortgage-backed securities and other derivative products at that time?

The impact of credit rating changes on sovereign bonds and on the pricing of credit default swaps (CDS) seems particularly important in the European context for several reasons. First, the first sovereign default in EU history occurred when Greece defaulted on government bonds in 2012. Prior to the default, many public officials and others had expressed frustration that the CRAs and market participants pricing CDS were betting on a Greek default—in their view putting in motion a process driving down bond prices, causing the cost of public funding to rise, and creating a self-fulfilling prophesy leading to default. Second, the GIIPS group (Greece, Italy, Ireland, Portugal, Spain), a subset of the EU and all countries which participate in the eurozone, has been particularly affected by credit downgrades, with one or more CRAs rating Greece, Portugal, and Ireland at 'junk' status since spring 2010. Many officials publicly stated that these downgrades accelerated a burgeoning eurozone sovereign debt crisis and, partly in response to this criticism, several new regulations and rules on CRAs have been put in place.[1] A recent European Commission (EC) memo explaining new rules states:

> CRAs have a major impact on today's financial markets, with rating actions being closely followed and impacting on investors, borrowers, issuers and governments: e.g. sovereign ratings play a crucial role for the rated country, since a downgrading has the immediate effect of making a country's borrowing more expensive. (EC, 2013)

Third, there are concerns that the EU, and the eurozone in particular, is being divided into two distinct groups, in one of which sovereign risk is priced fairly and by international norms, but with another group (GIIPS), which is subject to 'excessive' pricing and sensitivity to economic development, in turn putting at risk the solvency of public finances.[2]

To address these issues, we investigate how changes in credit ratings and economic factors have influenced CDS spreads in Europe in the context of the recent crisis. Specifically, we use monthly data, January 2005 to August 2012, for 26 EU countries, to evaluate the transmission of credit rating changes on sovereign CDS spreads, while controlling for country-specific and global economic factors, in the context of a dynamic panel model with fixed effects. We examine possible time-varying responses to credit ratings, especially price sensitivity before and after the GFC, and look at whether

[1] These are commonly referred to as CRA I and CRA II regulations. New rules were also adopted in early 2013: http://ec.europa.eu/internal_market/securities/agencies/index_en.htm

[2] This is sometimes referred to in the European context as self-fulfilling 'bad' expectations equilibrium (e.g. DeGrauwe and Yi, 2013).

pricing responses and pricing dynamics differ between GIIPs and others in the EU. In addition, we explore whether the response of CDS to rating changes depends upon the initial level of credit rating, and hence whether non-linearity and particular threshold points (e.g. investment grade credit rating point) are apparent in the pricing of risk. Finally, we investigate cross-border transmission of credit rating changes from GIIPS to others in the EU, and the degree to which these associations are time dependent and non-linear.

The focus on Europe allows us to investigate the concern that market pricing of sovereign risk during the crisis may not be justified by economic fundamentals, and whether the association between credit ratings and the pricing of sovereign debt is influenced by participation in the eurozone. In addition, contrasting the crisis period (and heightened volatility of shocks) with the preceding period of relative market tranquillity provides sharper identification of these linkages.

We find that changes in credit ratings are informative, significant economically, and robust, even after controlling for conventional economic fundamentals. Specifically, an upgrade decreases CDS spreads by about 45 basis points, while a 1 per cent rise in the domestic stock price index lowers CDS spreads by 1.5–2 basis points. World commodity and oil price increases also consistently decrease CDS spreads, probably because world economic conditions are generally strong when these prices are rising. By contrast, a rise in global market uncertainty, proxied by the VIX index, increases domestic CDS spreads. These effects are sizeable: a one standard deviation rise in credit ratings lowers CDS spreads by 0.15 of a standard deviation, similar to the effect of a one standard deviation rise in equity prices. Standardized changes in commodity prices, oil prices, or the VIX have smaller effects on CDS spreads. The main result is robust and persistent: credit rating changes have important statistical and economic effects on CDS spreads, even when controlling for a host of domestic and economic variables. However, these responses are not stable over time or consistent across groups. CDS sensitivity to credit rating changes was modest during the pre-crisis period and similar across the GIIPS and other EU countries, but rose markedly during the crisis period, especially in the GIIPS group. Moreover, CDS pricing dynamics changed from moderate to very low persistence between the crisis and non-crisis periods.

As the credit rating scale does not correspond in any rigid way to economic fundamentals, there is no prior reason to expect it to be linked in a linear manner to actual sovereign spreads. Indeed, we find that the association between credit rating changes and spreads follows a complicated non-linear pattern dependent on the level of the credit rating. Applying a non-linear 'spline' regression, we find high sensitivity (a large change in spreads for a given change in ratings) at the very low end of credit ratings and then a U shape—ratings at the moderately low end (B–) and very high end (above A) of credit levels are fairly insensitive, while middle ratings are quite sensitive to credit rating changes (with the highest sensitivity at the BB+ level—the cut-off between speculative and low investment grade bonds). Although the response is largest in magnitude at the lowest credit rating, this effect appears to emerge mainly during the crisis period, when the risk of sovereign default rises and markets price risk more aggressively. Our results are robust to the inclusion of 'outlook' and 'watch' changes by the CRAs, which may precede actual credit rating changes. In addition, contagion from changing the ranking of the GIIPS on other euro countries, initially evident, disappears when own-country credit rating changes are taken into account.

We start with a brief overview of the background literature (section II) and the data (section III), continue with the empirical analysis (section IV, with five sub-sections), and close with concluding remarks.

II. Literature review

The debate about the role and functioning of the CRAs pre-dates the GFC of 2008–9 and its aftermath. While the Great Moderation period dampened the intensity of the debate about the efficacy of the CRAs, the global crisis of 2008–9, and the euro crisis since 2010, again put to the fore concerns about the information content and the market impact of credit ratings. A fundamentally benevolent interpretation of the rating agencies is as aggregators of costly information, ameliorating the market failure induced by costly information, a market failure highlighted by Grossman and Stiglitz (1980)'s seminal paper. This view, however, is challenged by the need to design the proper incentive structure for the rating agencies, required in order to deliver efficient outcomes. The design of such an incentive system is a non-trivial challenge, and the welfare effects of the rating agencies remains a contestable issue (see Kashyap and Kovrijnykh, 2013).[3] Indeed, questions dealing with the economic rationale for the design and the functioning of the rating industry are probably as old as the rating industry itself.

Cantor and Packer (1994) pointed out that although credit ratings provide accurate rank-orderings of default risk, the meaning of specific letter grades varies over time and across agencies. Noting that current regulations do not explicitly adjust for agency differences, the authors argue that a reassessment of the use of ratings and the adequacy of public oversight is overdue. In their follow-up paper, Cantor and Packer (1997) noted that regulations incorporate private-sector credit ratings to determine investment prohibitions and capital requirements for institutional portfolio investments. These regulations implicitly assume that different agencies have equivalent rating scales, despite the fact that some agencies assign systematically higher ratings than others. They tested whether observed rating differences reflect different rating scales or simply result from sample selection bias, and found only limited evidence of selection bias.

Partnoy (1999) also outlines a legalistic critical view of the role of CRAs in providing information about bonds. The 'reputational capital' view of CRAs is that the agencies have survived and prospered since the early 1900s based on their ability to accumulate and retain good reputations by providing valuable information about the bonds they rate. Partnoy argues, however, that this view fails to explain, and is inconsistent with, estimation of credit spreads, the number of credit-ratings-driven transactions, and the explosion in the use of credit derivatives. In place of the reputational capital view, he offers a 'regulatory licence' view of rating agencies as generating value,

[3] They analyse the optimal compensation schemes for the rating agencies that differ depending on whether a social planner, the firm, or investors order the ratings. They find that rating errors are larger when the firm orders them than when investors do. However, investors ask for ratings inefficiently often. They also show that competition among CRAs causes them to reduce their fees and put in less effort, thus leading to less accurate ratings.

not by providing valuable information, but by enabling issuers and investors to satisfy certain regulatory requirements.

The heightened volatility and turbulence associated with the crises during the late 2000s provided new and rich information, propagating insightful research. Alsakka and ap Gwilym (2010*a*) analysed lead–lag relationships in sovereign ratings across five agencies, and found evidence of interdependence in rating actions. Upgrade (downgrade) probabilities are much higher, and downgrade (upgrade) probabilities are much lower for a sovereign issuer with a recent upgrade (downgrade) by another agency. They find complex intertemporal patterns, where lagged ranking changes by a rating agency tend to impact the future ranking changes of other agencies. Standard & Poor's (S&P) tends to demonstrate the least dependence on other agencies, and Moody's tends to be the first mover in upgrades. Rating actions by Japanese agencies tend to lag those of the larger agencies, although there is some evidence that they lead Moody's downgrades. In a paper that focuses on emerging markets, Alsakka and ap Gwilym (2010*b*) find that split-rated sovereigns are prone to be upgraded (downgraded) by the agency from which a lower (higher) rating exists. In particular, they find that the harsher is the split of ratings between two agencies, the greater the effect on probabilities of future rating changes. The rating dynamics of Capital Intelligence, Japan Credit Rating Agency, and Japan Rating & Investment Information are affected by their rating disagreements with the larger agencies. Only Moody's upgrade decisions are influenced by rating differentials with the smaller agencies.

Some studies applied the event case-study methodology. Ismailescu and Kazemi (2010) studied the effect of sovereign credit rating change announcements on the CDS spreads of the event countries, and their spillover effects on other emerging economies' CDS premiums. They find that positive credit rating events have a greater impact on CDS markets in the 2-day period surrounding the event, and are more likely to spill over to other emerging countries. CDS markets anticipate negative events, and previous changes in CDS premiums can be used to estimate the probability of a negative credit event. A generic downside of event analyses is that such studies are not informative regarding the longer-term adjustments induced by rating changes. This concern motivates us to focus on a monthly frequency in the empirical part of this paper.

Bergman *et al.* (2013) consider daily CDS data for GIIPS countries and estimate the effects of EU-wide and national monetary, fiscal, and financial stability policy announcements. They find that these announcements have economically important and statistically significant effects on CDS spreads. Lucas *et al.* (2013) also consider the effects of several EU policy announcements on CDS spreads. They find significant time-variation in distress dependence and spill-over effects for sovereign default risk. The foreign exchange market reaction to credit ratings has been investigated by Alsakka and ap Gwilym (2013). They found that rating agencies' signals do affect the own-country exchange rate and propagate spillover effects to other countries' exchange rates in the region. Furthermore, the impact of outlook and watch signals is stronger than the impact of actual rating changes. Market reactions and spillovers were far stronger during the financial crisis period, 2006–10, than pre-crisis, 2000–6. They also find differential effects of the various agencies. Negative news from all three major agencies has an impact, whereas only Moody's positive news produces a reaction. Negative news from Fitch tends to have the strongest effect. We revisit these issues in our analysis, controlling for the possible impact of outlook or watch signals on future ranking changes.

In terms of the broader literature on sovereign risk and CDS spreads, the crisis of 2008–9 also heralded renewed interest in the area and, perhaps, hitherto underpriced vulnerabilities. Arghyroua and Kontonikasb (2012) focus on the euro sovereign debt crisis. They find a shift in market pricing behaviour. Prior to the global credit crunch (January 1999–July 2007) they find that markets priced neither macro fundamentals nor the—very low at the time—international risk factor. Markets, however, apparently changed the pricing mode to one driven by macro fundamentals and international risk during the crisis period. They also find evidence consistent with contagion, particularly among euro periphery countries. Unlike the early stages of the euro crisis, where contagion was mainly originating from Greece, the latter stages of the euro crisis involved multiple sources of contagion.

Longstaff *et al.* (2011) find that most of sovereign credit risk appears related to global rather than country-specific factors. In particular, they find that CDS spreads are more closely related to US stock and high-yield markets than to local economic measures. Palladini and Portes (2011) investigate sovereign CDS and bond pricing dynamics in the eurozone and find that the CDS market moves ahead of the bond market in terms of price discovery.

Aizenman *et al.* (2013), looking at the euro debt crisis in the context of the pricing of sovereign debt of 50 countries, find a complex and time-varying environment, with a key role for fiscal space in pricing sovereign risk, controlling for other relevant macro variables. A structural break occurred during the turbulent 2008–10 crisis episode—during the crisis, pricing of risk was largely decoupled from fiscal space measures, and the TED spread (a proxy for market volatility) emerged as a key pricing factor in the crisis. The risk of default in the euro periphery countries group appeared to be somewhat 'underpriced' relative to international norms in the period prior to the GFC and to substantially 'overpriced' countries during and after the crisis, especially in 2010, with actual CDS values much higher than the model predicts, given fundamentals.[4]

These results are also in line with Beirne and Fratzscher (2013), who showed that a deterioration in countries' fundamentals and a sharp rise in the sensitivity of financial markets to fundamentals were the main explanations for the rise in sovereign yield spreads and CDS spreads during the crisis, not only for euro area countries but globally. Yet, empirical models with economic fundamentals generally do a poor job in explaining sovereign risk in the pre-crisis period for European economies, suggesting that the market pricing of sovereign risk may not have been fully reflecting fundamentals prior to the crisis.

Against the background of this literature, we turn to evaluate the credit ratings and the pricing of sovereign debt during the euro crisis.

[4] A potential explanation for the switch from under- to over-pricing of default risk is that markets were forward looking, not pricing entirely on current fundamentals but on expected further deterioration in future fundamentals, especially in the realm of fiscal space. Alternatively, the results are consistent with multiple equilibrium with an abrupt switch from a 'good' (optimistic) expectations equilibrium in the euro area, to a 'bad' (pessimistic) expectations equilibrium in these same countries—with high expected default rates and high interest rates where fiscal positions are not sustainable. While concerns about multiple equilibria in the eurozone pre-dated the euro crisis, the developments in the late 2000s sharpened the apprehensions about the fiscal lapses of the eurozone, and focused attention on the incompleteness of the euro project (see Morris and Shin (2000) for the importance of agents' uncertainty about economic fundamentals and the uncertainty about others' beliefs in explaining susceptibility to multiple equilibria).

III. Data and descriptive statistics

We use monthly data in our analysis, ranging from January 2005 to August 2012 for the longest sample. Daily data on CDS prices taken from Markit[5] are averaged into monthly values. The data are 5-year on-the-run CDS spreads in US dollars on sovereign bonds. The quoting convention for CDS is the annual premium payment as a percentage of the notional amount of the reference obligation. The sovereign CDS spreads are reported in basis points, with a basis point equal to $1,000 to insure $10m of debt.[6] The description, transformation, and source for each of the variables used in the empirical analysis is given in the Data Appendix.

Table 1 provides summary statistics on the CDS spreads for the European countries in our sample, showing country means, medians, standard deviations, minimum and maximum values, and the number of observations. The countries in our sample include all of the 27 European Union countries except Luxembourg, for which CDS data is not available. Table 1 shows the wide divergence in CDS spreads across EU countries, with the low end of the spectrum (in terms of mean, median, and standard deviations) represented by Finland and Germany, and the high end of the spectrum represented by Greece and, to a much lesser extent, Cyprus and Portugal.[7] Greece is the only country in the sample to have had a 'credit event' (partial or full default)—on 9 March 2012—that triggered CDS payments.[8]

Figure 1 shows the evolution of CDS spreads for four groups of countries: EU members, eurozone members, EU members that do not participate in the eurozone, and the GIIPS. Average values for each group are shown in the figure. The GIIPS countries are dominating the sharp run-up in CDS spreads starting in 2010 for the EU and euro area. The average over the full 2005–12 sample for GIIPS was 310 basis points, with only 154 basis points for the euro area (83 for the euro area excluding GIIPS), and 134 basis points for the other EU (non-euro area). It is noteworthy that the non-euro countries saw only modest increases over the sample period.

The credit ratings are taken from S&P and Fitch, which apply an ordinal-alphabetic scale reflecting an opinion about credit risk, i.e. the agency's judgement about the ability and willingness of a debtor to meet its obligations in full and on time. For example, S&P provides 25 rating categories, ranging from 'AAA', described as 'extremely strong capacity to meet financial commitments,' to 'D', described as 'payment default on financial

[5] Markit receives CDS data from market-makers, contributed from their official books and records. According to the company, Markit 'cleans' these data, testing them 'for stale, flat curves, outliers and inconsistent data'. If a contribution fails any one of these tests, it discards it. Markit states that it ensures superior data quality for an accurate mark-to-market and market surveillance.

[6] For example, a spread of 197 basis points for a 10-year tenor means that it costs US$197,000 to insure against US$10m in sovereign debt for 10 years; 1.97 per cent of the notional amount needs to be paid each year, so 0.0197 x 10m = US$197,000 per year.

[7] Interestingly, Finland has a lower average CDS spread and standard deviation than Germany. This may reflect the relatively stronger fiscal position of Finland, its successful resolution of a major banking crisis in the early 1990s, and the perception that Germany may be politically pressured to provide particularly large amounts to fund EU-wide banking and fiscal bailouts.

[8] The International Swaps and Derivatives Association (ISDA), which determines whether a credit event has occurred, said the use of 'collective action clauses (CACs) to amend the terms of Greek law governed bonds issued by The Hellenic Republic such that the right of all holders of the Affected Bonds to receive payments has been reduced' (reported in Reuters, 9 March 2012).

Table 1: Descriptive statistics for sovereign credit default swap spreads

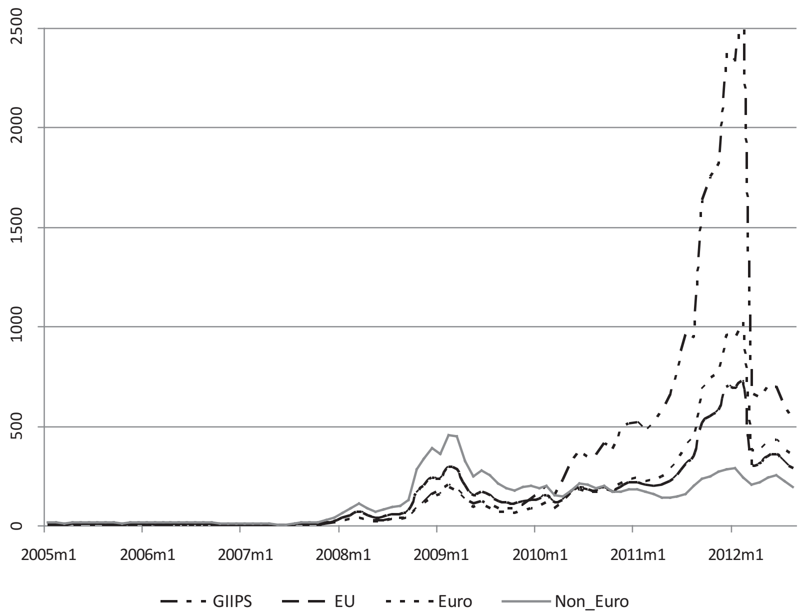
	Mean	Median	SD	Minimum	Maximum	N
Euro area						
Austria	57.82	53.23	62.50	1.61	205.09	92
Belgium	76.32	34.03	91.48	2.05	326.52	92
Cyprus	242.76	65.08	418.86	5.70	1,577.84	91
Estonia	122.37	94.87	149.45	3.93	686.72	92
Finland	24.40	19.59	24.92	1.15	83.63	92
France	50.17	23.22	62.26	1.52	211.76	92
Germany	28.82	21.26	30.45	1.38	102.02	92
Greece	812.25	52.76	2,019.63	5.05	10,633.20	86
Ireland	220.77	102.63	276.82	1.88	986.28	92
Italy	125.60	69.53	152.25	5.76	536.11	92
Malta	111.38	71.95	127.27	4.86	417.17	91
Netherlands	37.93	32.63	38.10	1.15	121.42	83
Portugal	262.29	53.72	396.86	4.11	1,323.36	92
Slovak R.	76.29	61.38	81.35	5.67	295.33	92
Slovenia	86.67	55.55	119.74	3.57	475.97	92
Spain	129.00	65.38	158.19	2.43	582.52	92
Other EU, non-euro						
Bulgaria	186.09	198.40	151.35	13.73	610.25	92
Czech R.	66.30	70.66	62.66	4.96	302.21	92
Denmark	36.79	30.61	42.27	1.27	131.85	92
Hungary	214.17	187.52	189.60	12.19	642.22	92
Latvia	247.60	224.02	251.82	5.63	1038.80	92
Lithuania	187.92	201.09	183.16	5.90	766.59	92
Poland	104.16	99.48	91.17	7.98	362.81	92
Romania	215.62	221.41	174.26	17.22	712.40	92
Sweden	29.04	24.25	31.06	1.31	129.36	92
UK	48.25	57.99	38.03	1.25	143.73	77

Notes: The table reports summary statistics of monthly average for 5-year sovereign CDS contracts for the January 2005 to August 2012 period. CDS spreads are measured in basis points.

commitments'. In its description of the credit ratings, S&P notes that likelihood of default is the single most important factor in its assessment of creditworthiness, but that reasons for ratings adjustments vary, and may be broadly related to overall shifts in the economy or business environment, or more narrowly focused on circumstances affecting a specific industry, entity, or individual debt issue, e.g. the creditworthiness of a state or municipality may be impacted by population shifts or lower incomes of taxpayers, which reduce tax receipts and ability to repay debt (S&P, 2013). In terms of sovereign ratings, S&P states that five factors form the foundation of its sovereign credit analysis: institutional effectiveness and political risks; economic structure and growth prospects; external liquidity and international investment position; fiscal performance and flexibility, as well as debt burden; and monetary flexibility (S&P, 2012).

The alphabetic rating scales of the rating agencies together with our numerical rating transformation are given in Table 2. The high end of the rating scale of both Fitch and S&P is AAA, and is given the numerical index of 25. Seven countries in the sample—Denmark, Finland, Germany, Luxembourg, Netherlands, Sweden, and the UK—had the highest rating (AAA) from both CRAs for the entire sample period. The low end of the ratings spectrum is D for Fitch at a numerical rating of 1. DD for Fitch and D

Figure 1: CDS spreads: EU, euro, non-euro (EU), and GIIPS



Notes: CDS spreads for Greece is not available after February 2012; therefore decline in average CDS is mainly due to Greek not being included in average.

for S&P (their lowest rating) are numerically rated at 2. In our sample, however, the lowest-rated country is Greece, which ranges from A+ (numerical rating 21) for both CRAs in January 2004 to CCC (numerical rating 8) in August 2012. The average rating for Greece over the sample period given by Fitch was 17.29, and by S&P it was 16.67.

The rating levels as well as changes in ratings and dates are given in Table 3. The ratings used in the empirical analysis are the average ratings between each of the two numerical scales for S&P and Fitch. Usually these ratings coincide, but not always. For example, Ireland was rated BBB+ by Fitch and A by S&P in December 2010, but both agencies rated Ireland BBB+ in August 2012. Greece and Bulgaria had the lowest average ratings over the sample period. Greece had the largest number of downgrades during the sample period (eight), followed by Portugal (five). Bulgaria has only one downgrade as its rating was among the lowest for the entire sample period. A number of countries had four downgrades over the sample period. Several countries also had upgrades, in some cases on two occasions (Estonia, Slovak Republic, Czech Republic, and Romania).

For illustrative purposes, Figure 2 shows the evolution of CDS spreads in Greece together with vertical lines showing the dates of credit rating downgrades. The Greek CDS data runs until the credit event announcement in March 2012. The announcement of CDS credit downgrades appears to significantly increase Greek CDS spreads. The very high level of CDS in February 2012 in Greece clearly indicated the high expectation of an imminent credit event that would result in CDS payments.

Figure 3 shows a scatter diagram of CDS spreads and credit ratings for the four groups of EU countries—total EU, eurozone, GIIPS, and EU excluding eurozone. The average CDS

Table 2: Linear scaling of credit ratings

Fitch ratings	S&P ratings	Numerical scale
AAA	AAA	25
AA+	AA+	24
AA	AA	23
AA–	AA–	22
A+	A+	21
A	A	20
A–	A–	19
BBB+	BBB+	18
BBB	BBB	17
BBB–	BBB–	16
BB+	BB+	15
BB	BB	14
BB–	BB–	13
B+	B+	12
B	B	11
B–	B–	10
CCC+	CCC+	9
CCC	CCC	8
CCC–	CCC–	7
CC	CC	6
C	–	5
RD	R	4
DDD	SD	3
DD	D	2
D		1

Source: Fitch and S&P websites, and authors' calculations.

spread and credit rating value for each country-month observation for the group is plotted in the figure. A clear negative relationship between the credit rating level and CDS spreads is evident. CDS spreads are much lower for highly rated sovereign bonds, indicating that market pricing is expecting less likelihood of default. The relationship is particular evident for the GIIPS and, to a lesser extent, for the euro area. This inverse relation is less strong for the non-euro area EU countries. A credit rating of 16 in the GIIPS group appears consistent with two CDS pricing equilibrium, 500 basis points and 2,000 basis points. This is consistent with a 'two equilibrium' interpretation of broader empirical results discussed below. (The euro group follows a similar pattern, reflecting the pattern of the GIIPS members.)

IV. Empirical results

(i) Baseline specification

This section presents our basic empirical results, where we test the effect of changes in credit rating changes on changes in CDS spreads, controlling for a host of country-specific and global economic factors. We estimate dynamic panel regressions for 26 EU countries over the period January 2005–August 2012 using monthly data. We estimate an equation of the form:

Table 3: Average sovereign ratings, downgrades and upgrades

	Average ratings		Number of downgrades		Number of upgrades	
	Fitch	S&P	Fitch	S&P	Fitch	S&P
Austria	25.00	24.91	–	1	–	–
Belgium	23.74	23.89	1	1	1	–
Cyprus	20.75	19.68	4	6	1	1
Estonia	19.76	20.17	2	1	2	2
Finland	25.00	25.00	–	–	–	–
France	25.00	24.91	–	1	–	–
Germany	25.00	25.00	–	–	–	–
Greece	17.29	16.67	8	8	1	1
Ireland	22.88	22.98	4	6	–	–
Italy	21.93	20.92	3	3	–	–
Luxembourg	25.00	25.00	–	–	–	–
Malta	20.67	19.91	–	1	1	–
Netherlands	25.00	25.00	–	–	–	–
Portugal	21.39	20.18	5	5	–	–
Slovak R.	20.45	20.29	–	1	2	2
Slovenia	22.49	22.61	3	3	1	1
Spain	24.18	23.80	4	5	–	–
Bulgaria	16.42	17.16	1	1	1	2
Czech R.	20.51	19.92	–	–	2	2
Denmark	25.00	25.00	–	–	–	–
Hungary	17.30	17.13	4	4	–	–
Latvia	17.08	16.70	4	5	1	2
Lithuania	18.33	18.30	3	3	1	1
Poland	18.74	18.72	–	–	1	1
Romania	15.95	15.40	1	1	2	1
Sweden	25.00	25.00	–	–	–	–
UK	25.00	25.00	–	–	–	–

Source: Fitch and S&P websites, and authors' calculations.

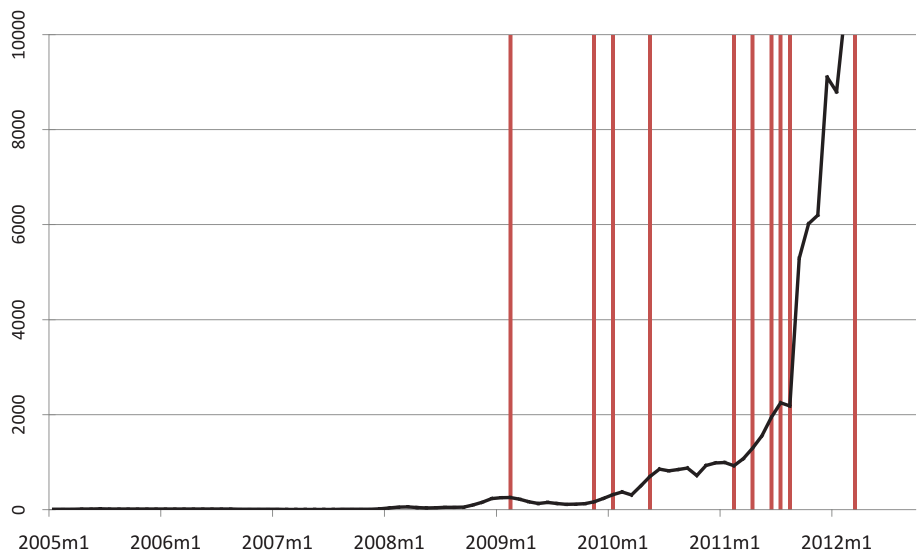
$$\Delta CDS_{it} = \beta_0 + \beta_1 \Delta CDS_{it-1} + \beta_2 \Delta Credit\ Rating_{it} + \beta_3 \left(Z_{it}\right) + \varepsilon_{it}, \qquad (1)$$

where ΔCDS_{it} is the change in the credit default swap spread (in basis points); $\Delta Credit\ Rating_{it}$ is the change in the credit rating scale variable; Z_{it} is a vector of country specific and global control variables (including country fixed effects, μ_i).

Given that the error term and lagged dependent variable is correlated by construction, thus introducing biased estimators, we estimate the dynamic model and use the Arellano and Bond (1991) generalized method of moment (GMM) approach. The estimators are obtained from moment equations constructed from further lagged levels of dependent variable and the first-differenced errors. Given the endogeneity problem introduced by the lagged dependent variable, further lags of ΔCDS are used as instruments (the number of lags is determined by $T_i - p - 2$).

The Arellano and Bond (1991) procedure allows the introduction of other endogenous variables. We treat contemporaneous credit rating changes $(\Delta\ Credit\ Rating_{it})$ endogenously in our dynamic panel setting, and use its first lag as an instrument.

Figure 2: Greek CDS spreads and credit rating downgrades



Notes: CDS spreads for Greece is not available after February 2012. Vertical lines indicate S&P and Fitch dates of downgrades.

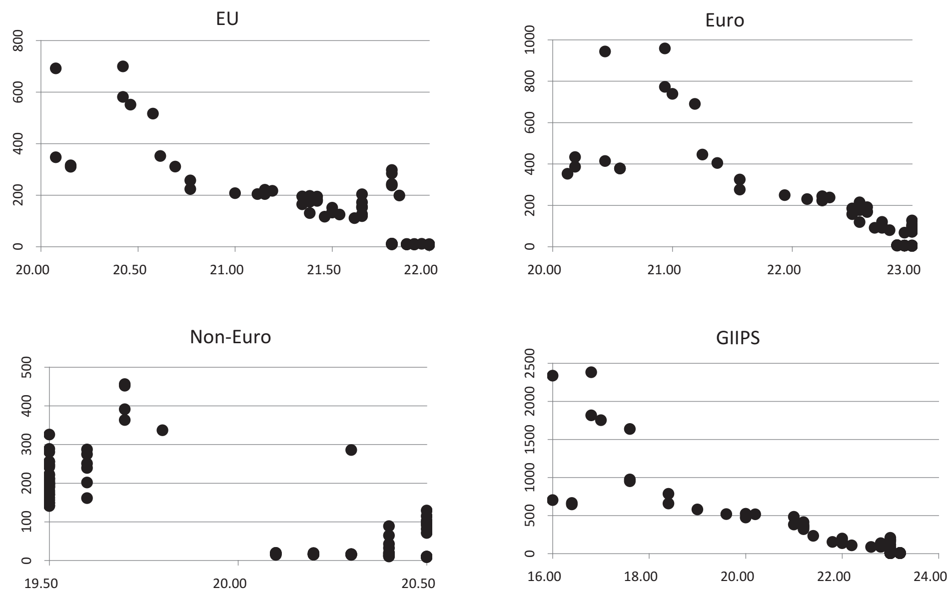
Although the flexibility of GMM estimation in a dynamic panel model is favourable, this estimator is designed for datasets with a large number of cross-section units (large N) and few time periods (small T). The opposite case (large T, small N) implies a large number of instruments, and may generate an over-identification problem. Given that our GMM dynamic panel model results are largely comparable with those of a static panel model, and the persistency in CDS changes is small, we can also use the GMM estimators that incorporate the dynamic adjustment in CDS spreads.[9] We report robust standard errors to control for heteroskedasticity and autocorrelation.

We have pre-tested with a number of possible country-specific and global control variables, including foreign exchange reserves, inflation, industrial production, and unemployment. We only report the control variables that are consistently statistically significant. The main result linking change in credit ratings to change in CDS spreads is robust to every specification of the equation, irrespective of the included control variables.

We report the estimates from the baseline formulation of the model in Table 4. A one unit rise in the average credit rating (*ΔCreditRating*) decreases CDS spreads within a very narrow range for all of the seven estimated equations, ranging from –42 to –46 basis points. The coefficient estimates are robust to inclusion of various controls, and

[9] The static model estimates are not reported for the sake of brevity, but are available upon request. The dynamic panel Arellano–Bond estimates give results that are almost identical to the static least squares estimations.

Figure 3: CDS spreads and credit ratings



Notes: Vertical axis has CDS spreads; horizontal axis has sovereign ratings as scaled in Table 2.

all are significant at the 5 per cent level of confidence.[10] The control variables are also statistically significant at the 1 per cent level of confidence with the expected signs. A 1 per cent rise in the domestic stock price index lowers CDS spreads by –1.5 to –2 basis points. World commodity and oil price increases also consistently decrease CDS spreads, probably because world economic conditions are generally strong when these prices are rising. By contrast, a rise in the VIX index, reflecting global market uncertainty, generally increases domestic CDS spreads. There is highly significant but low persistence, with the lagged dependent variable coefficient estimates ranging from –0.03 to –0.05. The total observations range from 2,338 to 2,344 across model specifications.

To get a sense of the relative economic significance of these variables we show the results of standardized variables in Table 5. Table 5 shows the previous results (Table 4) using standardized coefficients (where the data is normalized as unit standard deviations around the mean). The significance levels of the coefficients are not affected by this variable normalization. This procedure indicates that a one standard deviation rise in credit ratings lowers CDS spreads by –0.15 to –0.16 of a standard deviation, not dissimilar to the effect of a one standard deviation rise in equity prices (–0.11 to –0.15). Standardized changes in commodity prices and oil prices have smaller effects on CDS spreads, ranging from –0.07 to –0.12, while the VIX coefficients range from 0.03 to 0.10. Clearly, credit rating changes have economically important effects on CDS spreads, as well as being statistically significant, even when controlling for domestic and global economic variables.

[10] This range of coefficient estimates, –42 to –46, is very close to the –43 to –47 range of estimates in the static panel estimates. The results are robust throughout the various specifications to differences in estimation procedure.

Table 4: CDS spreads and credit ratings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ CDS (t–1)	0.05**	0.05**	0.04**	0.04**	0.04**	0.03***	0.04***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Δ Credit Rating	–45.87**	–43.07**	–45.12**	–43.55**	–43.80**	–43.85**	–42.54**
	(19.87)	(18.94)	(19.74)	(19.77)	(19.65)	(19.63)	(18.97)
Δ Stock Prices		–1.96***					–1.47***
		(0.57)					(0.53)
Δ Commodity			–1.66***		–1.31***		–0.94***
			(0.32)		(0.22)		(0.22)
VIX				1.09***	0.70***	0.79***	0.37**
				(0.28)	(0.22)	(0.29)	(0.16)
Δ Oil Price						–0.93***	
						(0.16)	
Constant	5.50*	4.75	6.91**	–18.16***	–8.50***	–10.70***	–2.32
	(3.27)	(2.99)	(3.49)	(3.04)	(1.53)	(3.33)	(2.04)
Observations	2,344	2,338	2,344	2,344	2,344	2,344	2,338
No. of countries	26	26	26	26	26	26	26
Wald chi-squared	186	860	306	289	315	289	1,131

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating as an endogenous variable. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors reported.

Table 5: CDS spreads and credit ratings: standardized coefficients

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ CDS (t–1)	0.04*	0.04**	0.04**	0.03*	0.03**	0.03**	0.04**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
Δ Credit Rating	–0.16**	–0.15**	–0.15**	–0.15**	–0.15**	–0.15**	–0.15**
	(0.07)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)
Δ Stock Prices		–0.15***					–0.11***
		(0.04)					(0.04)
Δ Commodity			–0.12***		–0.10***		–0.07***
			(0.02)		(0.02)		(0.02)
VIX				0.10***	0.06***	0.07***	0.03**
				(0.03)	(0.02)	(0.03)	(0.01)
Δ Oil Price						–0.08***	
						(0.01)	
Observations	2,302	2,298	2,302	2,302	2,302	2,302	2,298
No. of countries	26	26	26	26	26	26	26
Wald chi-squared	160.1	699.8	264.1	239.7	261.5	235.6	901.3

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating as an endogenous variable. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors reported.

(ii) Differential responses over time and across country-groupings

An important issue in the European sovereign debt crisis context is whether CDS pricing has changed over time, or is different across EU countries. To address this issue we consider differential responses over time, i.e. between the tranquil (2005–7) period and the global crisis (2008–12) period, and across country groups. The basic model specification for the EU is given in the first panel of Table 6(*a*) with the heading 'EU, including GIIPS'. This panel shows estimates of the model for the full sample of EU countries, estimated for the pre-crisis and crisis periods. While the model estimates for the global crisis period are virtually identical to the full sample period (–42 point estimate), the estimates are very different for the pre-crisis sample. In particular, a one notch credit rating rise is estimated to have increased CDS spreads by only 1.8 basis points during 2005–7, but by 42.2 basis points during 2008–12. All estimates are statistically significant at the 5 per cent level or higher.

The other panels in Tables 6(*a*) and 6(*b*) report our investigation of systematic differences in the response of CDS spreads to credit rating changes in particular country groupings, as well as across pre-crisis and crisis periods. The second and third panels of Table 6(*a*) consider the euro area group (16 countries) and the non-euro EU group (10 countries), respectively. The coefficient estimates on $\Delta CreditRating$ for the euro group and non-euro group indicate low responsiveness of similar orders of magnitude during the pre-crisis period, at –0.62 and –1.93, respectively. (All estimates are statistically significant.) Divergences emerge during the crisis period, however, with responsiveness rising in both groups but to a much larger extent in the euro area. In particular, the sensitivity of spreads to credit ratings for the euro area (–45.2) is estimated to be four times larger than the non-euro area (–11.4) in the crisis period. This difference explains the divergence in responsiveness between the two groups also evident in the coefficients estimated for the full sample period.

Table 6(*b*) reports a similar exercise, but with the GIIPS group excluded from the EU and euro area sample of countries in the first and second panels, and model estimates for the GIIPS group separately reported in the third panel. The sensitivity to credit rating changes rises markedly between the pre-crisis and crisis period for every country grouping. The EU and euro (excluding GIIPS) coefficient estimates for credit ratings are very similar in the crisis period, at –20.2 and –22.7, respectively. This responsiveness is less than half of that of the GIIPS group (–55). The lowest sensitivity, however, is that of the non-euro group (third panel of Table 6(*a*))—the 10 countries *not* participating in the euro area, but members of the EU (Bulgaria, Czech Republic, Denmark, Hungary, Latvia, Lithuania, Poland, Romania, Sweden, and the UK). This indicates that the non-euro EU group responded quite differently than the euro area countries to changes in credit ratings.

Two other features of Tables 6(*a*) and (*b*) are noteworthy. First, the estimated degree of persistence in CDS spreads drops markedly from the pre-crisis to crisis periods. The estimated coefficient on the lagged dependent variable for the EU group (Table 6(*a*), first panel) for the pre-crisis sample is 0.43 and virtually zero for the crisis sample. Sharp declines in persistence between the pre-crisis and crisis periods are evident in all of the country-group estimates. (The smallest decline, from 0.35 to 0.14, is in the non-euro group.) This suggests much more randomness and less predictability of CDS spreads during the crisis. Second, CDS responses to changes in the control variables also shift between the two periods. Generally, domestic stock and global commodity price fluctuations play a much larger in CDS pricing during the crisis period across the various country groupings. Fluctuations in VIX, by contrast, seem to play a consistent role in CDS pricing across the pre-crisis and crisis samples (positive and significant, with similar estimated magnitudes).

Table 6(*a*): Regional groups and sub-samples—EU and euro area Including GIIPS

	EU (including GIIPS)			EURO (including GIIPS)			Non-euro		
	Pre-crisis: 2005–7	**Global crisis: 2008–12**	**Full sample: 2005–12**	**Pre-crisis: 2005–7**	**Global crisis: 2008–12**	**Full sample: 2005–12**	**Pre-crisis: 2005–7**	**Global crisis: 2008–12**	**Full sample: 2005–12**
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Δ CDS (t–1)	0.43***	0.01	0.04***	0.73***	0.01	0.04***	0.35**	0.14***	0.17***
	(0.16)	(0.02)	(0.02)	(0.22)	(0.01)	(0.01)	(0.17)	(0.03)	(0.02)
Δ Credit Rating	–1.77**	–42.16***	–42.54**	–0.62***	–45.15**	–48.83**	–1.93*	–11.41*	–7.33*
	(0.70)	(15.52)	(18.97)	(0.23)	(17.61)	(21.95)	(1.11)	(6.42)	(4.05)
Δ Stock Prices	–0.02	–1.56***	–1.47***	–0.01	–1.80**	–1.72**	–0.02	–1.32	–1.19*
	(0.01)	(0.59)	(0.53)	(0.01)	(0.74)	(0.76)	(0.02)	(0.86)	(0.66)
Δ Commodity	–0.04***	–1.30***	–0.94***	–0.01	–1.11***	–0.79***	–0.09***	–1.46**	–1.16***
	(0.01)	(0.38)	(0.22)	(0.01)	(0.39)	(0.20)	(0.03)	(0.62)	(0.43)
VIX	0.30***	0.28**	0.37**	0.15***	0.14	0.36	0.52***	0.54*	0.34
	(0.07)	(0.13)	(0.16)	(0.02)	(0.11)	(0.23)	(0.15)	(0.32)	(0.23)
Constant	–3.84***	–0.75	–2.32	–1.92***	6.39	–0.27	–6.74***	–13.46*	–5.12
	(0.90)	(7.28)	(2.04)	(0.30)	(9.14)	(1.55)	(1.99)	(7.67)	(4.70)
Observations	888	1,450	2,338	556	890	1,446	332	560	892
No. of countries	26	26	26	16	16	16	10	10	10
Wald chi-squared	77.49	306.8	1131	79.43	209.1	2,176	56.45	1,077	1,031

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating as an endogenous variable. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors reported.

Table 6(*b*): Regional groups and sub-samples: EU and euro area excluding GIIPS

	EU (excluding GIIPS)			EURO (excluding GIIPS)			GIIPS		
	Pre-crisis: 2005–7	**Global crisis: 2008–12**	**Full sample: 2005–12**	**Pre-crisis: 2005–7**	**Global crisis: 2008–12**	**Full sample: 2005–12**	**Pre-crisis: 2005–7**	**Global crisis: 2008–12**	**Full sample: 2005–12**
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Δ CDS (t–1)	0.43***	0.19***	0.21***	0.79***	0.27***	0.28***	0.51***	0.01*	0.03***
	(0.16)	(0.02)	(0.02)	(0.26)	(0.02)	(0.02)	(0.07)	(0.00)	(0.00)
Δ Credit Rating	–1.84**	–20.27**	–15.54**	–0.45	–22.70**	–19.79*	–0.79**	–55.02**	–60.95**
	(0.76)	(8.42)	(6.98)	(0.32)	(11.54)	(10.39)	(0.37)	(21.59)	(26.46)
Δ Stock Prices	–0.02	–1.11**	–0.98***	–0.01	–0.80***	–0.71***	0.00	–4.19***	–4.41***
	(0.01)	(0.46)	(0.34)	(0.01)	(0.27)	(0.20)	(0.01)	(1.26)	(1.50)
Δ Commodity	–0.05***	–0.97***	–0.78***	–0.01	–0.59***	–0.48***	–0.00	–2.18*	–1.34**
	(0.02)	(0.32)	(0.21)	(0.01)	(0.20)	(0.14)	(0.01)	(1.15)	(0.53)
VIX	0.32***	0.28**	0.18*	0.13***	0.12***	0.08**	0.20***	–0.25	0.50
	(0.08)	(0.12)	(0.10)	(0.03)	(0.04)	(0.04)	(0.03)	(0.26)	(0.67)
Constant	–4.10***	–6.36**	–1.79	–1.72***	–1.49	0.22	–2.58***	30.38	4.04
	(1.09)	(2.92)	(2.10)	(0.40)	(1.22)	(0.61)	(0.39)	(24.46)	(3.37)
Observations	708	1,176	1,884	376	616	992	180	274	454
No. of countries	21	21	21	11	11	11	5	5	5
Wald chi-squared	66.06	2513	2319	36.33	9,616	10,827	3,457	128.4	9.16E+11

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating as an endogenous variable. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors reported.

These results indicate that two different pricing mechanisms were at work in the pre-crisis and crisis periods—highly sensitive responses during the crisis period and fairly muted responses during the 'tranquil' pre-crisis period. This supports work by Aizenman *et al.* (2013) and De Grauwe and Ji (2013) and others, and may support a 'good' (pre-crisis) and 'bad' (crisis) equilibrium interpretation of events.

(iii) Non-linearity

One issue raised in the context of the European sovereign debt crisis is whether the response of market risk perceptions, as reflected in CDS spreads, to credit rating changes might be conditional upon the level of the credit rating. That is, do CDS spreads in countries with lower credit ratings respond more to credit rating downgrades than do spreads in countries with higher credit ratings? We test for these non-linear effects in Table 7. In these specifications we include an interaction term that multiplies the change in the credit rating by the credit rating level ($\Delta CreditRating * RatingLevel$). Combining the two coefficients and the level of credit ratings therefore allows us to test and measure whether the CDS response changes systematically with the level of the credit rating at the time of the downgrade (or upgrade). The specific functional form is given by:

$$\Delta CDS_{it} = \beta_0 + \beta_1 \Delta CDS_{i,t-1} + \beta_2 \Delta CreditRating_{it} + \beta_3 (\Delta CreditRating * RatingLevel)_{it} + \beta_4 (Z_{it}) + \varepsilon_{it} \quad (2)$$

Table 7: CDS spreads and credit ratings with interaction effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ CDS (t–1)	0.05**	0.05***	0.04***	0.04**	0.04***	0.03***	0.04***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ Credit Rating	–286.88***	–281.70***	–285.41***	–287.58***	–286.23***	–285.21***	–282.51***
	(36.65)	(36.37)	(38.34)	(38.88)	(39.55)	(40.80)	(38.40)
ΔCredit Rating*Crdt Level	14.29***	14.14***	14.25***	14.48***	14.38***	14.32***	14.23***
	(2.40)	(2.42)	(2.51)	(2.56)	(2.60)	(2.67)	(2.55)
Δ Stock Prices		–1.92***					–1.39***
		(0.54)					(0.46)
Δ Commodity			–1.65***		–1.26***		–0.91***
			(0.34)		(0.21)		(0.22)
VIX				1.15***	0.77***	0.88**	0.46*
				(0.35)	(0.30)	(0.38)	(0.23)
Δ Oil Price						–0.84***	
						(0.18)	
Constant	5.48*	4.73	6.88*	–19.44***	–10.17***	–12.70**	–4.25*
	(3.32)	(3.04)	(3.56)	(4.49)	(3.12)	(5.15)	(2.36)
Observations	2,344	2,338	2,344	2,344	2,344	2,344	2,338
No. of countries	26	26	26	26	26	26	26
Wald chi-squared	1,200	3,064	1,067	1,080	912.5	808.2	2,201

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating and interaction terms as an endogenous variable. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors reported.

The results reported in Table 7 are again statistically significant with the expected signs of the coefficients, and are robust and stable. In particular, the negative term (–282 to –288) on $\Delta CreditRating_{it}$ indicates the fall in CDS spreads for a country with an initial credit rate of zero. The coefficient on $\Delta CreditRating * RatingLevel$, ranging from 14.1 to 14.4, is interpreted as the marginal effect on the response for a given level of initial credit. The higher the initial credit rating level, the less is the response of credit rating upgrades (downgrades). For example, our estimates (using model 7) suggest that a rise in the credit rating of a country (e.g. Greece) from CCC (8) to CCC+ (9) would result in a reduction in the CDS spread by –170 points (= –282.51+14.23*8), while a rise in credit rating for a country (e.g. Romania) with an initial rating of BBB– (16) to BBB (17) would decrease CDS spreads by –55 points. Clearly, the CDS response of credit rating changes to initially lower-rated credits are much stronger than higher-rated credits. In addition, the significance levels, signs, and magnitudes of all of the control variables in the regressions of Table 7 are virtually identical to Table 4, indicating a set of stable and robust results.

One issue that arises with the specification of our interaction term for the regressions in Table 7 is that the linear specification gives unrealistic estimates once the level of credit ratings reach 20 and beyond (using regression model seven of Table 7). At this point, very small estimated negative effects (the expected effect *a priori*) turn to positive estimated effects of a rating rise. To address this issue, we considered several non-linear functional response forms,[11] the most promising of which is the piecewise linear regression model using the ‘spline’ functional form.[12] The spline function allows several discrete step changes in the response of CDS ratings to credit rating changes. In particular, the effect on CDS spreads from a one unit rise in credit ratings may generally be declining, the higher is the level of the credit rating, but there may also be several distinct threshold points (knots) where the marginal changes shift.

Spline estimation requires selection of the number of knots as well as the threshold points (placement of knots). As an initial starting point to begin the estimation we chose two knots since the country ratings are located mainly in three regions, namely As, Bs, and Cs.[13] In order to find optimal location of these knots, we follow a two-stage procedure. First, we regress rating changes on level of rating by arbitrarily choosing initial knots of rating cutoffs 19 (A– and above) and 10 (B– and above), which gives the following equation:

$$\Delta CDS_{it} = \beta_0 + \beta_1 Rating_{it} + \beta_2 d_1 \left(Rating_{it} - 10\right) + \beta_3 d_2 \left(Rating_{it} - 19\right) + \varepsilon_{it}. \qquad (3)$$

Second, using the initial parameters and knot values, we implement a non-linear optimization for spline placement.[14] The non-linear estimation of the model is an iterative, grid search process, where the residual sum of squares at each combination of

[11] We also considered *ΔCreditRating* squared to capture non-linear effects and different effects for each level of credit rating. These results are omitted for brevity but are available from the authors upon request.

[12] See Greene (2003, pp. 158–60) for an excellent discussion of this technique.

[13] We also extended the work to three knots. The third knot threshold was not statistically significant.

[14] We use nl command in Stata to implement non-linear estimation. The nl estimation fits the non-linear function by least squares using the alternative iterative methods, including the gradient method, the Newton and Marquardt method, etc. For further details on non-linear estimation implemented, see Davidson and McKinnon (2004, ch. 6).

parameter values are evaluated to determine the set of parameter values producing the lowest residual sum of squares.

$$\Delta\, CDS_{it} = \{\alpha_0\} + \{\alpha_1\} Rating_{it} + \{\alpha_2\}\, max\left(Rating_{it} - \{k_1 = x_1\}, 0\right) + \{\alpha_3\}\, max\left(Rating_{it} - \{k_2 = x_1\}, 0\right) + \epsilon_{it}, \tag{4}$$

where the initial values for each alpha correspond to the betas from equation (3). For knot placement, we again start with initial values of 10 and 19 for x_1 and x_2. We have also tried different initial values for knot placement in both equations (3) and (4). The estimation results from the second model give $k_1 = 8.65$ (between CCC and CCC+) and $k_2 = 14.5$ (between BB and BB+). Finally, using these two knot placements, we estimate the fixed effect model involving the interaction of rating changes and rating level that we call spline estimation in equation (5).

The spline function estimated and presented in the tables is given by:

$$\begin{aligned}\Delta\, CDS_{it} = {} & \beta_0 + \beta_1 \Delta\, CDS_{i,t-1} + \beta_2 \Delta\, CreditRating_{it} \\ & + \beta_3 (\Delta\, CreditRating^{*} RatingLevel)_{it} \\ & + \beta_4 d_1 \Delta\, CreditRating_{it}\,(Rating_{it} - 8.65) \\ & + \beta_5 d_2 \Delta\, CreditRating_{it}\,(Rating_{it} - 14.5) + \beta_6 (Z_{it}) + \varepsilon_{it},\end{aligned} \tag{5}$$

where $d_1 = 1$ if rating ≥ 8.65, zero otherwise; and $d_2 = 1$ if rating ≥ 14.5, zero otherwise.

We report the spline function form in Table 8 and graph the estimated responses for each credit level for the full period in Figures 4(*a*) and 4(*b*).

Figure 4(*a*) indicates that the response to a credit rate change is very large at the lowest credit ratings in our sample, with an estimated CDS response of –150 basis points when a credit rating of CCC– (scale 7) is upgraded to CCC (scale 8). However, the CDS response becomes much less sensitive (less negative) at somewhat higher ratings, implausibly positive in the 9–11 basis point range, and then gradually increasing. The shift from large negative to slightly positive is probably due to the large role played by Greece at the low end of the spectrum, making the results fragile in this range. The relevant range of credit ratings, excluding the low end of the range only occupied by Greece during our sample period, is shown in Figure 4(*b*). This figure shows insensitivity of response at a B+ rating (scale of 12), reaching a maximum negative point of around –40 basis points at a BB+ credit rating (scale of 15) and gradually becoming less sensitive for higher credit ratings. A credit rating rise from AA– (22), for example, results in almost no change in CDS spread. The local maximum (–40) estimated at the BB+ rating may be attributable to the fact that this level represents the cut-off point between high speculative grade (BB+) and low investment grade (BBB–) bond ratings. Regulatory restrictions on portfolios, or portfolio habitat preference, may make this threshold especially important for risk assessment and pricing of bonds.

(iv) Outlook and watch changes

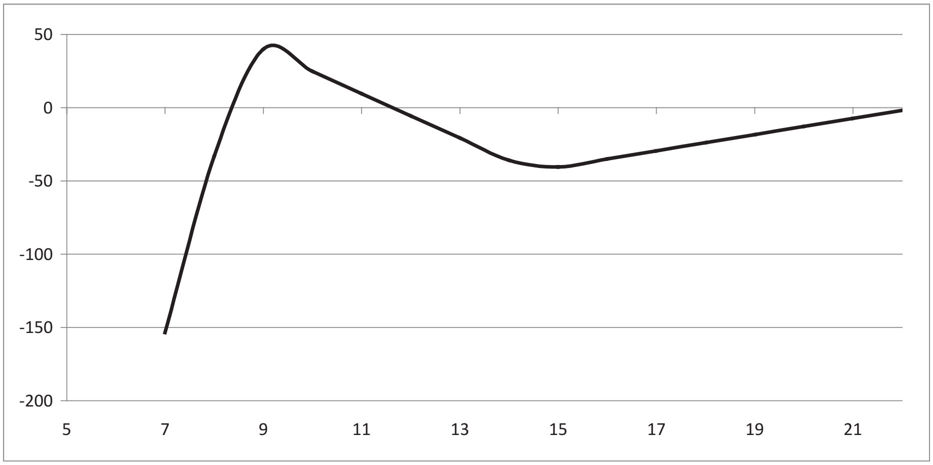
Our general objective in this research paper is to evaluate the information value provided by CRAs in the market pricing of sovereign default risk. As in any asset market, only 'surprise' or unanticipated credit rating changes, which are also valued by the market,

Table 8: CDS spreads and credit ratings: spline function

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ CDS (t–1)	0.08***	0.07***	0.07***	0.06***	0.06***	0.06***	0.07***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ Credit Rating	–1,020.07***	–1,010.89***	–1,027.76***	–1,013.95***	–1,022.32***	–1,015.74***	–1,015.92***
	(5.78)	(6.71)	(4.66)	(5.39)	(4.97)	(5.07)	(5.23)
ΔRating*scale	124.00***	123.08***	125.14***	122.87***	124.20***	123.15***	123.62***
	(0.95)	(0.96)	(0.84)	(0.95)	(0.90)	(0.91)	(0.83)
d_1*ΔRating*	–141.12***	–139.76***	–142.15***	–138.72***	–140.42***	–138.75***	–139.89***
(scale–8.65)	(2.49)	(2.30)	(2.91)	(2.90)	(3.09)	(3.06)	(2.72)
d_2*ΔRating*	23.04***	22.28***	22.43***	21.54***	21.61***	20.73***	21.59***
(scale–14.49)	(3.35)	(3.31)	(3.78)	(3.75)	(3.97)	(4.04)	(3.76)
Δ Stock Prices		–1.90***					–1.36***
		(0.52)					(0.44)
Δ Commodity			–1.73***		–1.38***		–1.04***
			(0.41)		(0.30)		(0.27)
VIX				1.12***	0.71***	0.83**	0.40**
				(0.32)	(0.23)	(0.33)	(0.19)
Δ Oil Price						–0.92***	
						(0.15)	
Constant	5.35*	4.62	6.83*	–18.96***	–8.82***	–11.60***	–3.05
	(3.22)	(2.95)	(3.52)	(3.98)	(1.86)	(4.10)	(1.89)
Observations	2,344	2,338	2,344	2,344	2,344	2,344	2,338
No. of countries	26	26	26	26	26	26	26
Wald chi-squared	4.27E+07	1.50E+13	3.77E+07	1.16E+13	1.25E+07	4.65E+13	2.45E+07

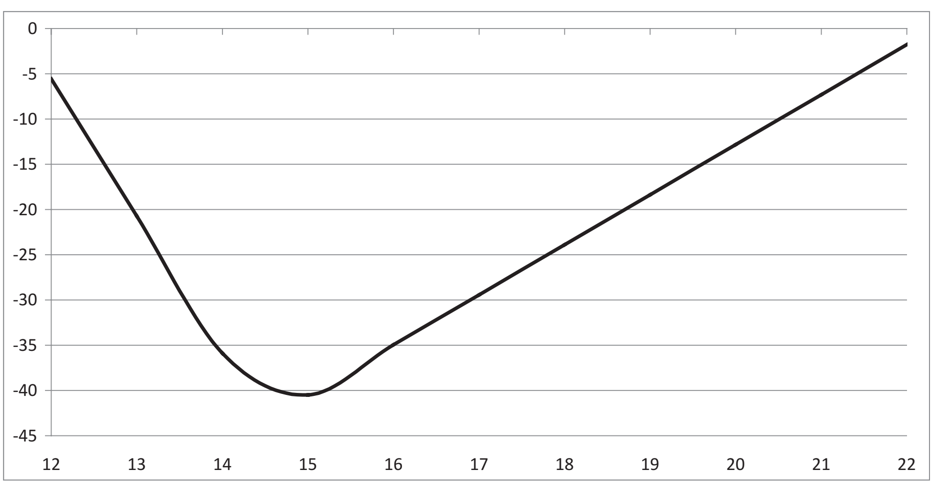
Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating and interaction terms as an endogenous variable. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors reported.

Figure 4(*a*): Change in CDS spread associated with credit rating change conditional on level of credit rating



Notes: Full Sample (Pre-Crisis, Crisis) graph calculated from Table 7 (Table 8), Column 7 (Columns 5, 6), spline function estimation. For credit rating level 19–25(A– to AAA), d1=d2=1; for rating level 10–18 (B– to BBB+), d1=1 and d2=0; for rating level 1–9 (CCC+ and below), d1=d2=0.

Figure 4(*b*): Change in CDS spread associated with credit rating change conditional on level of credit rating, excluding the low end of the range (only occupied by Greece during our sample period)



Notes: Full sample (pre-crisis, crisis) graph calculated from Table 7 (Table 8), Column 7 (Columns 5, 6), spline function estimation. For credit rating level 19–25(A– to AAA), d1=d2=1; for rating level 10–18 (B– to BBB+), d1=1 and d2=0; for rating level 1–9 (CCC+ and below), d1=d2=0.

should impact CDS spreads. In addition to credit ratings, however, CRAs also provide signals about the possibility of future credit rating changes. These signals, for S&P CRAs (the other CRAs have similar designations), take the form of either 'outlook' or 'watch' designations. The outlook and watch designations may be positive, negative, stable, or developing (explained as uncertain as to whether the change may be positive or negative) in terms of the likelihood of a future ratings changes. The outlook horizon is defined by S&P as 6–24 months ahead, and the watch horizon is within 3 months.

Our estimates of the effect of credit rating changes on CDS spreads may be biased downwards to the extent that an actual credit rating change incorporates an expected component (signalled previously by an outlook or watch change) and an unexpected component. In principle, only the unexpected component would presumably affect CDS spreads. Since actual credit rating changes include both components, the net effect would be the average of expected and unexpected, and tend to bias downwards the estimated effect.

We include changes in outlook or watch signals from S&P and Fitch in our basic regressions in order to control for this potential source of bias. These results are reported in Table 9. Various specifications of the basic model are reported and the results are robust to the different forms. In particular, a negative change in a signal (from stable to negative, or from positive to stable) raises CDS spreads by 15–25 basis points, while a positive change in the signal (from steady to positive or negative to steady) has no measurable impact. Most important for the purposes of our study, however, is that the effect of credit rating changes on CDS spreads does not change when changes in the signals are included in the regression (the point estimates remain in the –41 to –43 range and are significant at the 5 per cent level of confidence).

(v) Contagion

An issue that frequently arises in the context of the European sovereign debt crisis is to what extent might there be contagion from the GIIPS group to other countries in the EU.

Table 9: CDS spreads, credit ratings, outlook/watch

	(1)	(2)	(3)	(4)	(5)	(6)
Δ CDS (t–1)	0.05**	0.05**	0.05**	0.04***	0.04***	0.04***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Δ Credit Rating				–42.93**	–40.81**	–41.24**
				(19.11)	(18.32)	(18.51)
Δ Positive	–2.46		–2.06	–10.93		–10.36
Outlook/Watch	(4.23)		(3.97)	(8.01)		(7.92)
Δ Negative		25.09**	25.08**		15.32***	15.17***
Outlook/Watch		(11.28)	(11.29)		(5.41)	(5.33)
Δ Stock Prices	–1.53***	–1.54***	–1.54***	–1.46***	–1.47***	–1.47***
	(0.57)	(0.57)	(0.57)	(0.53)	(0.53)	(0.53)
Δ Commodity	–0.91***	–0.91***	–0.91***	–0.94***	–0.94***	–0.94***
	(0.22)	(0.22)	(0.22)	(0.21)	(0.21)	(0.21)
VIX	0.46**	0.42**	0.42**	0.37**	0.35**	0.35**
	(0.19)	(0.17)	(0.17)	(0.16)	(0.15)	(0.15)
Constant	–2.68	–3.16	–3.14	–2.08	–2.60	–2.36
	(2.44)	(2.31)	(2.33)	(2.10)	(2.03)	(2.09)
Observations	2,338	2,338	2,338	2,338	2,338	2,338
No. of countries	26	26	26	26	26	26
Wald chi-squared	637.1	579.4	641.5	1363	991.9	1245

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating as an endogenous variable. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors reported.

Several recent papers have addressed the issue of contagion using CDS spreads or sovereign yields (e.g. Beirne and Fratzscher, 2013).[15] We are concerned in this section, by contrast, with the transmission of changes in credit ratings in the GIIPS area with changes in CDS spreads in other areas outside of GIIPS. We measure GIIPS rating changes in two ways. The first method ('aggregate GIIPS rating index') measures the sum of the GIIPS rating changes in a given month, e.g. if three of the GIIPS countries are downgraded one notch, one GIIPS country is downgraded by two notches, and one country is not downgraded in a given month, then the indicator would register a five-notch change. The second method ('maximum GIIPS rating index') measures the maximum of the changes in GIIPS, e.g. if during a given month, one country was downgraded by two notches, and the others by one notch, then the indicator would register a two-notch change.

The results are shown in Table 10. The results on the euro area (excluding GIIPS) are given in columns (1)–(2) for the aggregate method and (5)–(6) for the maximum method. The results for transmission from GIIPS credit rating changes to the non-euro EU group are given in columns (3)–(4) for the aggregate method, and in columns (7)–(8) for the maximum method.

Both measurement methods give consistent results. There is initially evidence of contagion from GIIPS to other countries in the euro area, but this effect disappears when own-country credit rating changes are taken into account. Evidence of contagion from GIIPS rating changes to CDS spreads in the non-euro group is even weaker—no significant transmission is found regardless of the specification of the model or measurement of GIIPS index rating. This evidence indicates that concerns about contagion from the GIIPS to other countries in the EU may be exaggerated.

V. Conclusion

Risk assessments on sovereign bonds by CRAs are a systematically important determinant of CDS spreads in the EU. CRAs play an important role in the pricing of sovereign risk—rating changes are informative and significant economically, and the marginal information value is robust to controlling for conventional economic fundamentals.

However, our paper reveals a complex and time-varying association between credit ratings and the pricing of sovereign debt during the euro crisis. The association between credit rating changes and CDS spreads shifts between the pre-crisis and crisis periods. European countries had quite similar CDS responses to credit rating changes during the pre-crisis period, but large differences emerged during the crisis period between the now highly sensitive GIIPS group and other European country groupings (EU and euro area excluding GIIPS, and the non-EU area). The response is largest in magnitude at the lowest credit rating but these effects appear to emerge mainly during

[15] A number of studies have considered various aspects of contagion. For example, Mink and De Haan (2013) consider how 'news' of Greece during the crisis in 2010 was transmitted to 48 banks in Greece and elsewhere in Europe. Beetsma *et al.* (2013) explore co-movements among interest spreads *vis-à-vis* Germany on European public debt and spillovers in response to macroeconomic and financial news. They investigate both how news affected domestic interest spreads and how it was propagated to other countries during the recent crisis period, thereby distinguishing between the GIIPS countries and other European countries.

Table 10: Contagion—effects of GIIPS rating changes on euro and non-euro countries

	Aggregate GIIPS Rating Index				Maximum GIIPS Rating Index			
	Effect on euro EU		Effect on Non-euro EU		Effect on euro EU		Effect on Non-euro EU	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ CDS (t–1)	0.30***	0.28***	0.18***	0.17***	0.30***	0.28***	0.18***	0.17***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
Δ GIIPS Credit	–0.61***	–0.03	0.11	0.11	–0.84**	–0.42	–0.23	–0.23
Rating	(0.23)	(0.35)	(0.51)	(0.49)	(0.33)	(0.26)	(0.43)	(0.42)
Δ Credit Rating		–19.74*		–7.33*		–19.53*		–7.32*
		(10.81)		(4.04)		(10.44)		(4.06)
Δ Stock Prices	–0.77***	–0.71***	–1.20*	–1.19*	–0.77***	–0.72***	–1.20*	–1.19*
	(0.16)	(0.21)	(0.66)	(0.66)	(0.16)	(0.20)	(0.66)	(0.66)
Δ Commodity	–0.49***	–0.48***	–1.16***	–1.15***	–0.49***	–0.50***	–1.17***	–1.16***
	(0.15)	(0.14)	(0.41)	(0.41)	(0.15)	(0.14)	(0.42)	(0.42)
VIX	0.06	0.08*	0.37	0.34	0.06*	0.08*	0.36	0.33
	(0.03)	(0.04)	(0.24)	(0.24)	(0.03)	(0.04)	(0.23)	(0.23)
Constant	0.55	0.21	–5.65	–5.10	0.50	0.14	–5.70	–5.15
	(1.00)	(0.60)	(4.61)	(4.66)	(0.99)	(0.60)	(4.61)	(4.66)
Observations	992	992	892	892	992	992	892	892
No. of countries	11	11	10	10	11	11	10	10
Wald chi-squared	5,517	10,933	673.1	1,130	6,952	13,225	668.2	1,054

Notes: GMM Arellano–Bond dynamic panel estimates with ΔCreditRating as an endogenous variable. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors reported.

the crisis period when the risk of sovereign default rises and markets price risk more aggressively.

The association between credit rating changes and CDS spreads appears to follow a complicated non-linear pattern dependent on the level of the credit rating. Applying a non-linear 'spline' regression, we find high sensitivity (large change in spreads for a given change in ratings) at the very low end of credit ratings and then a U shape—ratings at the moderately low end and very high end of credit levels are fairly insensitive, while middle ratings are quite sensitive to credit rating changes. The threshold where sovereign bond ratings climb from speculative to low investment grade status appears particularly sensitive, perhaps because of regulatory or preferred portfolio habitat considerations.

On the other hand, we do not find contagion from GIIPS credit downgrades to CDS spreads in other euro area countries once own-country credit rating changes are taken into account. This result suggests that fears of contagion may be exaggerated. Market pricing of sovereign default risk is determined by a host of domestic and global macroeconomic factors, including the country's own CRA ratings, and these linkages may vary over time and have non-linear elements. But contagion from GIIPS CRA ratings to market pricing of risk in other EU member countries does not appear to be a critical factor.

The heightened sensitivity of markets to news and credit rating changes during the sovereign debt crisis episode in Europe, particularly among the GIIPS, and evidence of especially large responses when credit ratings are already at low levels, suggests a shift in the underlying market pricing of sovereign default risk. These results are consistent with multiple equilibria in market pricing of sovereign default risk and raise questions about the consistency between market perceptions of risk and assessments made by CRAs. However, this may not be a 'pure' multiple equilibria explanation, with the economy alternating randomly between 'good' and 'bad' states, but rather may contain an element of 'rational inattention' by investors. In the first years of Economic and Monetary Union (EMU), investors may not have focused on fundamental asymmetries and weakness in the system that, combined with major economic shocks such as the GFC, could lead to sharply increased risk of sovereign default. Once markets focus on these risks, it may be difficult to return to financial market tranquillity without fundamental changes in EU institutions and fiscal conditions among EMU member states.

Data Appendix

Table A1: Data descriptions and sources

Variable	Description	Source
CDS spread	Market prices for five-year sovereign CDS contracts (in a basis points), daily data is averaged into monthly values. Used as monthly basis point change in regressions.	Markit, Bloomberg
Sovereign ratings	Fitch and S&P long-term foreign currency ratings, scaled from 1 (D) to 25 (AAA). Monthly (in unit) change	Fitch and S&P websites
Stock prices	Local Stock Market Index—MSCI or host country. Used as monthly percentage change in regressions.	Bloomberg, Thomson Reuters Datastream
Commodity	S&P Goldman Sacks Commodity Price Index (SPGSCI), US dollar. Used as monthly percentage change in regressions.	Bloomberg
Oil price	Crude oil price ($/bbl), monthly average Used as monthly percentage change in regressions.	World Bank Commodity Price Data (Pink Sheet)
VIX	Chicago Board Options Exchange Market Volatility Index (implied volatility of S&P 500 index options), monthly average (of daily adjusted close)	Yahoo-Finance

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