PURE OR WAKE-UP-CALL CONTAGION?
ANOTHER LOOK AT THE EMU SOVEREIGN DEBT CRISIS

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We test whether the sharp increase in sovereign spreads of euro-area countries with respect to Germany after the explosion of the Greek crisis was due to deteriorating macroeconomic and fiscal fundamentals or to some form of financial contagion. Our analysis includes indicators of domestic and external imbalances which were mostly disregarded by previous studies, and distinguishes between investors' increased attention to the variables which ultimately determine the creditworthiness of a sovereign borrower (wake-up-call contagion) and behaviour not linked to fundamentals (pure contagion). We find evidence of wake-up-call contagion but not of pure contagion.

1 Introduction

At the beginning of 2009, ten years after the launch of the euro, many commentators viewed the single currency as a major success. In the run-up to the euro's introduction, interest rates had rapidly converged towards the low levels of the most creditworthy member states: in the period 1992-98, the average spread of long-term government bond yields with respect to the German one had declined from about 200 to 24 basis points. From 1999 onwards spreads continued to narrow, and at the end of 2007 they were negligible (16 basis points on average). Due to the financial turmoil triggered by the Lehman Brothers bankruptcy, some tensions started to surface in September 2008, but at the end of that year the average yield spread in the euro area was still about 100 basis points. Strains on government securities markets became worrisome only towards the end of 2009 (Figure 1). The focus of concern was Greece. After a series of upward deficit revisions, the last of which equal to nearly 3 percentage points of GDP in October 2009, the Greek government estimated the deficit at 12.7 per cent of GDP in 2009, up from 7.7 per cent in 2008. The tensions spilled over from Greece to the government securities of other euro-area countries, notably Ireland, Portugal and, to a lesser extent, Spain and Italy. Three years after these events, some countries still are basically shut out of the bond market[1] and sovereign debt strains in the euro area remain worrisome and widespread, despite important progresses in fiscal adjustment by national governments.

The debate concerning the causes of the European sovereign debt crisis inflames both politics and academia. While some argue that fiscal deterioration and fundamental macroeconomic weaknesses are at the root of the crisis, others claim that spreads are well above the levels justified by fundamentals, and invoke forms of "market irrationality" and/or "contagion". The aim of the present paper is to assess the relative merits of these competing opinions through a formal econometric analysis.

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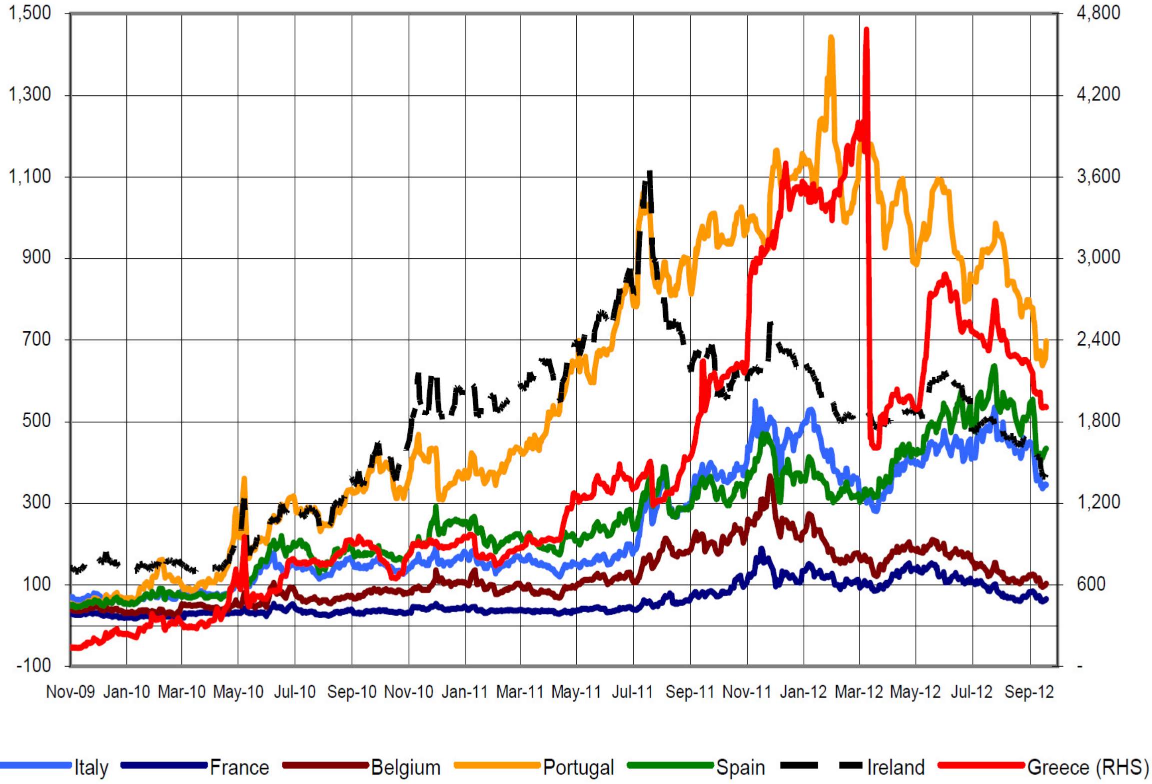
[1] Greece applied for financial support in May 2010, followed by Ireland (November 2010) and Portugal (April 2011).

Figure 1

Yield Spreads Between 10-year Government Bonds and the German Bund

(basis points)



Needless to say, the answer to this question has significant policy implications. Evidence of sizable and systematic mispricing of sovereign credit risk would imply that it is ill-advised to rely on markets to induce fiscal and macroeconomic discipline. Furthermore, it would strengthen the case for interventions by European Union institutions such as the European Financial Stability Facility (EFSF), the European Stability Mechanism (ESM) and the European Central Bank (ECB) in the sovereign bond markets. In fact, the Eurogroup summit of 29 June 2012 decided to use the EFSF/ESM instruments in order to stabilize the markets of member states honouring all their European commitments on schedule. Soon afterwards, the ECB decided to undertake Outright Monetary Transactions (OMT) in the secondary markets for sovereign bonds in the euro area "to address severe distortions which originate from, in particular, unfounded fears of the reversibility of the euro" (press conference following the meeting of the Governing Council on 6 September 2012).

While several other papers have studied the relationship between spreads and fiscal fundamentals in European Monetary Union (EMU), ours contributes to the discussion in three ways. First, it considers a broader set of fundamentals. One lesson of the EMU crisis is that even countries with low levels of public debt and deficits can suffer a sudden deterioration of their fiscal position, for example as an effect of financial sector bailouts (which may transform private liabilities into public debt). This risk was considered obvious for emerging markets at least since the Asian crisis of the late nineties, but it was not taken into account by the EMU rules and – as we show here – by investors. Our second contribution to the literature is to distinguish between different forms of contagion and to measure their relative importance in explaining the post-crisis behaviour of European sovereign spreads.[2] Our third contribution is methodological: for the first time we apply to sovereign spreads panel methodologies designed to detect and tackle non-stationarity and cointegration.

To give a preview of our results, we find that the explosion of the Greek crisis had a systematic impact on the other euro area countries' sovereign spreads. However, this impact differed across borrowers. In particular, investors penalized governments with weaker fiscal and macroeconomic fundamentals more heavily.

The rest of the paper proceeds as follows. In Section 2 we review the literature and clarify our definition of contagion. In Section 3 we present our dataset and in Section 4 we discuss our empirical strategies and show our results. In Section 5 we discuss several robustness checks. In Section 6 we provide numerical estimates of the long-run values of the spreads, derived from our empirical analysis. Finally, in Section 6 we draw some tentative conclusions and policy implications.

2 Literature review

Several papers assess the determinants of sovereign spreads in EMU. Starting from Codogno *et al.* (2003), the literature has expanded significantly in the last few years (see, among others, Favero *et al.*, 2010; Beber *et al.*, 2010, Schuknecht *et al.*, 2009 and 2011; Attinasi *et al.*, 2009; Sgherri and Zoli, 2009; Hallerberg and Wolff, 2008). Typically, these studies explore the role of (a) country-specific factors, namely fiscal fundamentals and market liquidity, and (b) common factors, such as the market appetite for risk. In particular, they bring to the data an empirical model such as:

$$s_{it} = \alpha_0 + \alpha_1 s_{it-1} + \beta_0 Z_{it} + \beta_1 F_t + \varepsilon_{it} \ , \ |\alpha_1| < 1 \tag{1}$$

where *Zit* is a vector of country-specific variables and *Ft* is a vector of variables that are common across countries. The above-mentioned papers differ from one another in terms of data frequency (from daily to yearly), the regressors included and estimation method (in particular, some adopt a pooled cross-section/time-series approach, others provide country-specific estimates). Of course, studies using high-frequency data, such as Favero *et al.* (2010) and Beber *et al.* (2010), do not consider the role of fiscal and macro fundamentals, which are available only at lower frequencies.

Bernoth *et al.* (2012) consider a slightly different dependent variable (primary instead of secondary market spreads); their sample period ends in 2009, so it does not include the post-Greek-crisis period. Although their analysis focuses on the structural break due to the introduction of EMU in 1999, it also discusses the possible effects of the Lehman bankruptcy in September 2008. Using an approach similar to ours, Bernoth *et al.* (2012) find that the Lehman bankrupcy increased the sensitivity of spreads to country-specific fundamentals and global factors.

Few papers consider instead the issue of contagion among sovereign securities within EMU. Some papers simply augment equation (1) with a further Z_{it} variable, which captures developments in all the other EMU countries different from *i*. In particular, Cáceres *et al.* (2010) employ a measure of "distress dependence", which is built by extracting from the vector of CDS premia the unconditional marginal probability of default for each country. They then infer from those marginal distributions the joint probability of default, and build and add-up the default probability of country *i* conditional on the default of the other countries. Similarly, Hondroyiannis *et al.* (2012) add a

[2] Of course, the two contributions are related: to understand whether spreads are excessive with respect to fundamentals, it is necessary to take a stance concerning the relevant fundamentals.

"contagion variable", defined as a weighted combination of other countries' spreads. Neither Cáceres *et al.* (2010) nor Hondroyiannis *et al.* (2010) consider the more recent years.

Our contribution borrows from a different strand of the literature, which discusses contagion concentrating on developing countries. In this literature, more precise and circumscribed definitions of contagion are used.[3] We follow, in particular, Eichengreen *et al.* (1996), Masson (1998) and Goldstein *et al.* (2000), who distinguish between three kinds of circumstances:[4]

- Wake-up-call contagion, a situation in which a crisis initially confined to one country provides new information that prompts investors to reassess the default risk of other countries (this concept is used, for example, by Goldstein, 1998, Masson, 1999, Goldstein *et al.*, 2000). In this case, domestic fundamentals justified a flight from sovereign debt even before the crisis event, but investors did not price/perceive the risk correctly. The wake-up-call hypothesis was first put forward by Goldstein (1998) to explain contagion from Thailand (a relatively small and closed economy) to other Asian countries in the Asian crisis of the late nineties. He argues that the other countries were affected by the same structural and institutional weaknesses as Thailand (crony capitalism, weak banking system, etc.), but investors ignored those weaknesses until the Thai "wake-up call". Such behaviour is also consistent with forms of "rational inattention" (Tutino, 2011, and Wielderholt, 2010). According to rational inattention theory, given the existence of costs in acquiring and processing information, rational agents could optimally choose to ignore some information, for example concerning fundamentals.
- Shift contagion, which occurs when the normal cross-market channel intensifies after a crisis in one country. It can be seen as analogous to wake-up-call contagion except that it is due to increased sensitivity to common factors such as global risk aversion – the F_t term in equation (1) – instead of country-specific factors. We borrow the term and the concept from the work of Forbes and Rigobon (2002).
- Pure contagion. This residual category covers any instance of contagion that is completely unrelated not only to changes in fundamentals (as in the case of wake-up-call and shift contagion) but also to the level of fundamentals, be they country-specific (as in the case of the wake-up-call contagion) or global (as in the case of shift-contagion). Pure contagion may arise from self-fulfilling (and therefore individually rational) loss of confidence (Calvo, 1988), from irrational herding behaviour (Chari and Kehoe, 2003), or from margin calls and other wealth effects for investors, triggered by capital losses in the country which originated the crisis (Kodres and Pritsker, 2002; Kyle and Xiong, 2001; Calvo and Mendoza, 2000; Schinasi and Smith, 2000).

In distinguishing between the three types of contagion, our contribution is similar to the paper by Bekaert *et al.* (2011). They use an international asset pricing framework with global and local factors to predict equity returns, defining unexplained increases in factor loadings as indicative of contagion, and find evidence of systematic contagion whose severity is inversely related to the quality of countries' economic fundamentals and policies. They conclude that the wake-up-call hypothesis holds for equity markets, with markets and investors paying substantially more attention to country-specific characteristics during the crisis.

We also see the approach pioneered by Gande and Parsley (2005) as very relevant and complementary to ours. They consider a sample of emerging countries and allow rating news concerning any one of them to influence the sovereign spreads in the others. In the present paper,

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[3] This literature is surveyed in Pericoli and Sbracia (2003), and Dungey *et al.* (2005).

[4] While our contagion definitions are quite widespread in the literature, other papers use the word "contagion" differently (as discussed in the recent survey by Forbes, 2012).

we likewise consider a unidirectional version of their methodology, substituting our crisis dummy with a variable summarizing Greek rating developments.[5]

Finally, let us remark that in our regressions, while taking into account the possibility that the situation of banks may have an impact on sovereign spreads, we focus on contagion across sovereign bond markets, leaving aside the issue of contagion from sovereign to other financial markets or to the banking sector (on this, see, among others, Acharya *et al.*, 2011; Alter and Schuler, 2011; Angeloni and Wolff, 2012).

3 Data and descriptive statistics

Our dataset covers nine euro-area countries (Austria, Belgium, Finland, France, Ireland, Italy, Portugal, Spain and the Netherlands) using monthly data from January 2000 to December 2011. As is customary in the literature, we exclude Greece (the "ground-zero" country) from the analysis.[6] Our dependent variable is the 10-year government bond yield spread with respect to the corre sponding German bund.[7]

In our baseline specification we consider as common factor the F_t variable in equation (1) the VIX, the most common indicator of the propensity of investors to bear credit risk.[8] Data on government bond yields and on the other financial market variables are taken from Thomson Financial Reuters. These data are released daily, and we compute monthly averages of them.

Like our dependent variable, country-specific fundamentals – the Z_{it} vector in equation (1) – are in differences with respect to the corresponding German variables. They include GDP growth and the ratios with respect to GDP of general government debt, private sector debt, defined as household plus non-financial corporation debt, and the current account surplus.

We also control for liquidity, measured by the difference between the country's bid-ask spread on government bonds and the German one.[9] We do not control instead for differences in debt characteristics such as inflation-indexation and currency denomination. Indeed, unlike in emerging countries, in our sample public debt is mostly in nominal terms and denominated in euros.[10]

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5 Two recent papers on the EMU sovereign debt crisis use multi-equation econometric techniques and can be seen as multi-equation extensions of Gande and Parsley (2005). Arezki *et al.* (2011) estimate a VAR model allowing for the mutual inter-dependence of sovereign debt markets and the stock market. De Santis (2012) allows for a long-run co-integrating relationship between spreads and other variables. Chudik and Fratzscher (2013) use the VAR methodology to study yields (not spreads) and consider stocks and foreign currencies in addition to sovereign bonds.

6 We have verified that our main results do not change if Greece is included in the regressions. We excluded Luxembourg because, for most of the sample period, it essentially had no public debt. We had to exclude the remaining five countries because, as recent entrants to the euro, the pre-crisis period was clearly too short for us to estimate reliably our model (Estonia and Slovakia joined the union in 2011 and 2009 respectively, Cyprus and Malta in 2008, Slovenia in 2007). Moreover, private debt data are missing for the late-accession countries.

7 An often-used alternative measure for the default risk is the credit default swap (CDS) premia. However, for our purposes it suffers from several shortcomings. First, a well-developed CDS market exists only for few countries in our sample, and even for those countries data are available only for the more recent years. Second, CDS premia are driven not only by credit risk considerations but also by counterparty risk. Third, during the crisis in some countries CDS markets were subject to policy interventions, such as short-selling bans, which are likely to have had an impact on CDS premia.

8 The VIX, the Chicago Board Options Exchange Market Volatility Index, is a measure of the implied volatility of the S&P 500 stock index; it is considered a good indicator of the level of risk aversion in global capital markets.

9 This measure of liquidity is common in the literature (see, among others, Codogno, Favero and Missale, 2003, and Favero, Pagano and von Thadden, 2010). Our variable is computed as the difference between the minimum bid yield and the maximum ask yield observed at daily frequencies for benchmark bonds; this computational method implies limited variability over time of this difference. Favero, Pagano and von Thadden (2010) use instead the best five bid and ask prices.

10 As is well known this is not true of emerging economies (see, e.g., the contributions in Eichengreen and Hausmann, 2004). Concerning debt duration, in our sample we observe moderate cross-country differences, but they are basically time-invariant and therefore mostly captured by the country fixed effects.

The inclusion of private debt and the current account balance, while non-standard in the literature on advanced economies (an exception is Gourinchas and Obstfeld, 2012), is frequent in studies concerning emerging countries and has strong economic rationale inasmuch as these are indicators of the domestic and external leverage of an economy. While a current account deficit does not mean per se a higher sovereign vulnerability, it is often associated with competitiveness imbalance and problematic macroeconomic developments. Furthermore, external capital inflows (the mirror image of the current account deficit) may trigger a boom in the non-tradable sector (particularly the housing market), increasing the risk of a subsequent bust.[11] A similar line of reasoning can be applied to private sector debt: if households and firms turn out to be unable to repay their debt, this might jeopardize public finances, either because the government may bail them out directly or as often happens – because it bails out the domestic banks that lent to households and firms in the first place. In any case, in the presence of substantial private liabilities, public debt might increase significantly and overnight. Notice that both variables are to be monitored at the European level under the new Macroeconomic Imbalances Procedure (European Commission, 2012).[12]

Fiscal and macroeconomic variables are taken from the Eurostat quarterly database. These data are generally released with a delay of one quarter. Our monthly series are obtained keeping the value of the variable constant in each month of the quarter. In our specification we thus assume that spreads react simultaneously to liquidity and volatility factors and with a 3-month lag to fiscal and macroeconomic variables. This also limits endogeneity problems and thus concerns about possible reverse causation between the current spread and the independent variables.

In Table 1 we report some descriptive statistics of the variables used in our benchmark specification, distinguishing between two sub-periods (before and during the crisis). In the upper part of each panel we summarize the evolution of our dependent variable, *i.e.*, the average yield spread, and the financial factors that in our specification are assumed to influence it. In the bottom part we summarize the development of fiscal and macroeconomic fundamentals. Statistics refer to all countries except Germany and Greece.

The spread between the government bond yields of these nine euro-area countries and the German one increased on average from 19 basis points in the period before the crisis to 175 basis points from October 2009 onwards. The increase was significantly larger in the sub-group of peripheral countries (Portugal, Ireland, Italy and Spain), from 25 to 330 basis points. Liquidity, measured by the bid-ask spread, worsened on average in the second part of our sample period (on average the spread increased from 1 to 6 basis points). The evolution of the VIX shows that global risk aversion increased during the euro-area sovereign crisis; however, as acute financial markets tensions had already emerged following the Lehman Brothers bankruptcy, the difference across sub-periods is not appreciable.

Turning to fundamentals, both fiscal and macroeconomic conditions deteriorated significantly during the sovereign debt crisis. Among domestic imbalances, the average general government debt increased by 17 percentage points of GDP (almost 30 in the peripheral countries); the increase in private debt was even larger (42 percentage points in the entire sample and 57 in the peripheral countries). GDP growth slowed on average from 1.8 to 1.1 per cent, reflecting a negligible acceleration in the "virtuous" countries and a marked slow-down in the others (from 2 to

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[11] This, in turn, would induce sizable output gaps and revenue shortfalls, increasing public debt and jeopardizing its sustainability. This is how Spaventa and Giavazzi (2011) interpret the EMU crisis.

[12] Concerning external imbalances, the European scoreboard also includes the net investment position (the stock counterpart of the current account balance), the change in export market shares, the change in unit labour costs, and the change in the real effective exchange rate. Concerning domestic imbalances, the scoreboard includes the private-sector credit flow (the flow counterpart of domestic debt), the change in the house price index, and the unemployment rate.

Table 1

Descriptive Statistics

	Mean	**St. dev**	**Min.**	**Max**	**Mean**	**St. dev**	**Min.**	**Max**
	January 2000-October 2009				**November 2009-December 2011**			
Overall sample								
Sovereign spread *(bp)*	19.3	27.9	22.1	242.4	174.9	220.0	12.3	1109.3
Bid-Ask spread *(bp)*	1.0	0.8	0.2	6.0	5.5	14.8	0.3	85.4
Risk aversion (VIX)	25.9	10.9	12.6	63.3	28.0	7.1	20.1	45.6
Public debt/GDPx100	64.0	24.5	24.5	117.0	81.3	22.0	43.5	121.0
Private debt/GDPx100	162.0	42.8	75.2	303.1	204.4	49.3	125.3	303.4
GDP growth *(percent)*	1.8	3.0	9.8	12.4	1.1	2.0	6.5	5.8
Current account surplus/GDPx100	0.5	5.5	13.3	11.9	0.7	5.0	13.3	11.7
Ireland, Italy, Spain and Portugal								
Sovereign spread *(bp)*	25.7	35.6	22.1	242.4	328.1	253.5	52.7	1109.3
Bid-Ask spread *(bp)*	1.3	0.9	0.3	3.7	11.0	20.9	0.6	85.4
Risk aversion (VIX)	25.9	10.9	12.6	63.3	28.0	7.1	20.1	45.6
Public debt/GDPx100	63.2	28.8	24.5	117.0	92.1	22.2	3.9	121.0
Private debt/GDPx100	164.8	52.6	75.2	303.1	222.2	61.1	125.3	303.4
GDP growth *(percent)*	2.0	3.3	8.3	12.4	0.1	1.5	5.5	2.2
Current account surplus/GDPx100	4.8	4.1	13.3	1.9	3.9	4.0	13.3	4.2
Austria, Belgium, Finland, France and the Netherlands								
Sovereign spread *(bp)*	14.2	18.3	15.8	108.2	52.4	45.8	12.3	292.0
Bid-Ask spread *(bp)*	0.9	0.6	0.2	6.0	1.2	0.9	0.3	4.1
Risk aversion (VIX)	25.9	10.9	12.6	63.3	28	7.1	20.1	45.6
Public debt/GDPx100	64.7	20.4	29.9	115.6	72.7	17.7	43.5	100.0
Private debt/GDPx100	159.8	34.2	16.2	98.7	190.1	30.8	156.8	242.3
GDP growth *(percent)*	1.7	2.6	9.8	6.4	1.9	1.9	6.5	5.8
Current account surplus/GDPx100	2.9	3.6	8.6	11.9	1.9	4.2	6.0	11.7

almost 0). External positions also worsened: on average the current account deficit increased from 0.5 to 0.7 per cent of GDP; with respect to Germany the deterioration was greater (about 2.5 percentage points of GDP), reflecting strongly diverging competitiveness paths between Germany, on one side, and the other countries, on the other.

4 Empirical analysis

We use two alternative empirical models. The first (Section 4.1) is akin to equation (1), as it assumes that the spread is a stationary variable, even if it has an auto-regressive component. As stationarity is assumed by all the previous literature, we provide estimates of this model mainly for the sake of comparability. However, as we will argue below, there are good empirical reasons to question the stationarity hypothesis and also to conjecture the existence of a long-run cointegrating relationship between the spread and the other covariates (Section 4.2). Therefore, we will subsequently focus on the estimation of that long-run relationship (Section 4.3).

4.1 Stationary case

The empirical model – We enrich the specification in (1) in order to take into account the three different kinds of contagion effects outlined in Section 2. We estimate the following model:

$$s_{it} = \alpha_{i0}+\alpha_1 s_{it-1}+\beta_0 Z_{it}+\beta_1 F_t+\gamma_0 D_t+\gamma_1 D_t s_{it-1}+\gamma_2 D_t Z_{it}+\gamma_3 D_t F_t+\varepsilon_{it},\ \ |\alpha_1|, |\alpha_1+\gamma_1| < 1 \quad (2)$$

where the error term is assumed zero-mean, stationary and independent across countries (but we allow for heteroskedasticity and auto-correlation), and D_t is a dummy variable taking value one after the outbreak of the Greek crisis, which in our model coincides with the revision of the official public finance figures by the new government in October 2009.

Therefore, γ_0 captures "pure contagion", the vector of coefficients γ_2 captures the wake-up-call effect (a more pronounced post-crisis sensitivity to country-specific fundamentals), and γ_3 captures shift-contagion (an increased sensitivity to common factors).

Notice that in our specification we allow for country-specific fixed effects, to control for time-invariant unobserved characteristics. Indeed, the previous literature has pointed to some very slow-moving features that influence a sovereign's creditworthiness, such as the political system (Akitoby and Stratmann, 2008) or debt intolerance (Quian *et al.* 2011). We also allow for a change in the auto-correlation coefficient in the post-crisis period (γ_1).

Baseline results – The Least Square Dummy Variables (LSDV) estimates of equation (2) shows that in the pre-crisis period the only statistically significant coefficients are those of GDP growth and of the VIX: both a slowdown in GDP and a decrease in global risk appetite widen the spread (Table 2, column 1).

Instead, during the crisis the relationship becomes significant for all the fundamental variables except private debt and the bid-ask spread. This suggests that a wake-up-call effect exists for EMU countries. In particular, current account imbalances and public debt are not relevant in the pre-crisis period, whereas in the crisis period they become positively related to the sovereign spreads. By contrast, neither "pure contagion" nor "shift-contagion" effects are present (both γ_0 and γ_3 are insignificant). Finally, the estimated auto-correlation parameter is relatively high (with no change in the coefficient after the Greek crisis), which points to possible non stationarity.

Table 2

Regression Results

	(1)	(2)	(3)	(4)	(5)
spread*(t–J)*	0.927 ***	0.930 ***			
	(0.035)	*(0.037)*			
general government debt	–0.018	–0.088	1.211 ***	1.120 ***	0.337 ***
	(0.116)	*(0.147)*	*(0.295)*	*(0.258)*	*(0.0671)*
private debt	0.050	0.043	0.926 ***	0.939 ***	0.167 ***
	(0.040)	*(0.031)*	*(0.077)*	*(0.080)*	*(0.039)*
GDP growth	–0.542 **	–1.062 ***	–0.077	–1.276	–2.341 ***
	(0.27)	*(0.408)*	*(0.639)*	*(0.783)*	*(0.825)*
current account surplus	0.147	0.416	2.610 ***	2.619 ***	–0.351
	(0.135)	*(0.308)*	*(0.369)*	*(0.392)*	*(0.246)*
liquidity (bid-ask)	0.422	1.480 *	7.751 ***	7.659 ***	10.998 ***
	(0.561)	*(0.835)*	*(1.342)*	*(1.454)*	*(1.824)*
VIX	0.152 ***	0.191 ***	0.676 ***	0.603 ***	0.960 ***
	(0.027)	*(0.046)*	*(0.077)*	*(0.107)*	*(0.131)*
Dummy crisis	–15.128	–43.819	–84.738 ***	–85.365 ***	–95.619 ***
	(10.377)	*(35.894)*	*(25.716)*	*(23.346)*	*(15.467)*
spread*(t–J)* x crisis	0.083	0.061			
	(0.052)	*(0.073)*			
public debt x crisis	0.151 *	0.543 *	1.381 ***	1.300 ***	1.388 ***
	(0.091)	*(0.294)*	*(0.275)*	*(0.247)*	*(0.168)*
private debt x crisis	0.044	0.139	0.337 **	0.293 **	0.649 ***
	(0.047)	*(0.115)*	*(0.138)*	*(0.121)*	*(0.080)*
GDP growth x crisis	–3.193	–7.274	–26.123 ***	–21.603 ***	–29.393 ***
	(2.090)	*(5.019)*	*(3.614)*	*(3.231)*	*(1.965)*
current account surplus x crisis	–0.871	–1.909	–4.597 ***	–4.249 ***	–5.282 ***
	(0.524) *	*(1.333)*	*(1.219)*	*(1.124)*	*(0.673)*
liquidity x crisis	–0.594	–1.657	0.065	0.064	–2.470
	(0.769)	*(1.018)*	*(1.507)*	*(1.463)*	*(1.840)*
VIX xcrisis	0.198	0.192	2.174 **	2.204 ***	2.007 ***
	(0.345)	*(0.893)*	*(0.882)*	*(0.825)*	*(0.462)*
R^2	0.98	0.98	0.87	0.89	0.85
Observations	1,269	564	1,269	1,242	1,269

Notes: Columns 1,2,3: LSDV; Column 4: DOLS (1 lead and 1 lag added for each variable; country dummies incl.); Column 5: FGLS. All estimations except column 5: Huber-white robust standard errors in parentheses. All estimations except column 2: full sample (Column 2: sample limited to the periphery countries: PT, IT, IR, ES). *: significant at the 10 per cent level; ** at the 5 per cent; *** at 1 per cent.

Considering only the peripheral countries – The results could be different if one only considers peripheral euro area countries. First, it is more likely that investors' attention to these countries was already high before the crisis, given that their fiscal reputation was already undeniably worse. This reduces the probability of observing wake-up-call contagion. Second, the probability of observing pure contagion should increase as investors possibly consider these countries more similar to Greece.

However, even when we restrict the sample to Portugal, Spain, Ireland and Italy, we find no pure contagion. The results are quite similar to the baseline estimation (Table 2, column 2). While Portugal, Spain, Ireland and Italy are conventionally considered the "periphery" of the euro area, the results are qualitatively unchanged when we include Belgium or both Belgium and France together in the periphery.

Bias-corrected estimates – Since Nickell (1981), it is well known that the LSDV estimator is biased when used in dynamic panels. While the fact that this bias decreases with the length of the panel should be reassuring, given our very long sample period, we also experimented with the Kiviet (1995) estimation technique, which appears to be particularly appropriate for macroeconomic (*i.e.*, big T/small N) panels (Judson and Owen, 1999). It turns out that the bias-corrected estimates are basically identical to our baseline.[13]

4.2 *Testing for unit roots and cointegration*

A legitimate issue with the econometric analysis presented in Section 4.1, given the observed high persistence of the spreads, is that they could actually be non-stationary. Indeed, performing common panel unit root tests such as those proposed by Levin Lin and Chu and by Pesaran, Im and Shin (see Banerjee, 1999; Baltagi, 2008; and Choi, 2006), we could not reject the null of integration for the sovereign spreads (Table 3, top panel). This result is robust even if we compute the relevant test statistics using different lag structures and different time spans. In particular, unit roots appear to be present not only if we look at the full sample, or at the post-crisis period, but also when we restrict the analysis to the pre-crisis period.[14]

We also tested for the existence of a cointegrating relationship between the spread and its determinants. In particular, we adopted the residual-based approach by Kao and Pedroni (see Banerjee, 1999; and Baltagi, 2008). While the results are consistent with the existence of a cointegrating vector, they are not very clear-cut (Table 3, bottom panel).

4.3 *Non-stationary case*

In this section we model the long-run relationship between spreads and fundamentals as:

$$s_{it} = \alpha_{i0} + \beta_0 Z_{it} + \beta_1 F_t + \gamma_0 D_t + \gamma_1 D_t Z_{it} + \gamma_2 D_t F_t + \varepsilon_{it}, \tag{3}$$

therefore allowing for a structural change in the relationship in the post-crisis period, and for the different kinds of contagion effects highlighted in the previous sections. As before, the error term is assumed independent across countries but possibly heteroskedastic and auto-correlated.

[13] Results are not shown.

[14] This suggests some caution in interpreting the results of previous papers, which did not consider the issue.

Table 3

Unit Root and Cointegration Tests

Panel Unit Root Tests	
*Levin, Lin and Chou t**	15.940
H0: unit roots for all *i*'s (H1: no unit root)	(1,000)
Im, Pesaran and Shin W-stat	11.970
H0: unit roots for all *i*'s (H1: some unit roots)	(1,000)
Panel Cointegration Tests	
ADF statistic (Pedroni 1)	–1.642
H0: no cointegration (H1 assumes common autocorr. coefficient)	(0,0503)
ADF statistic (Pedroni 2)	–1.170
H0: no cointegration (H1 allows country-specific autocorr. coefficients)	(0,121)

Notes: *p*-values in parentheses; number of lags =1.

To estimate equation (3), we resort to different methods, in order to check the robustness of the results to different statistical assumptions.

First, we run a simple LSDV regression. Indeed, if spreads are $I(1)$ and there is no cointegrating relationship between spreads and fundamentals, *i.e.*, ε_{it} in equation (3) is $I(1)$, the LSDV estimator delivers consistent estimates of the long-run average relationship between them, contrary to the pure time-series case (Phillips and Moon, 1999, Phillips and Moon, 2000, and Baltagi, 2008).

The results are qualitatively similar to those obtained with the stationary model, but much more pronounced and clear-cut (Table 2, column 3). Before the crisis, all the fundamentals are significant with economically meaningful signs, except GDP growth (which is not significant) and the current account surplus (which has the wrong sign). After the start of the crisis, the effect on the spread is magnified and with the expected sign for all the fundamentals. In particular, the effect of GDP growth and of the current account surplus becomes significant and negative, as it should be if markets correctly assess sovereign creditworthiness. Also, shift contagion (*i.e.*, an increased post-crisis role of the VIX) emerges.

If spreads are $I(1)$ but there exists a cointegrating relationship between spreads and fundamentals, *i.e.*, ε_{it} in equation (3) is $I(0)$, it can be shown that OLS estimates are inconsistent. We therefore estimate equation (3) using the panel dynamic least square (DOLS) estimator proposed by Kao and Chiang (2000), which extends to panel data the approach of Saikkonen (1991) and Stock and Watson (1993). That is, estimates of the coefficients of interest are found by running the following OLS regression:

$$s_{it} = \alpha_{i0} + \beta_0 Z_{it} + \beta F_t + \gamma_0 D_t + \gamma_2 D_t Z_{it} + \gamma_3 D_t F_t + \sum_{j=-2}^{2} \delta_{0j} \Delta Z_{it+j} + \sum_{j=-2}^{2} \delta_{1j} \Delta F_{t+j} + \varepsilon_{it}, \quad (4)$$

where the inclusion of ΔZ_{it+j} and ΔF_{t+j} among the regressors helps to get a consistent estimate of the βs and the γs. The results are remarkably similar to those of the previous exercise (Table 2, column 4).

As a final exercise, we consider a model with random, instead of fixed, individual effects. As shown by Baltagi *et al.* (2008, 2011), to this end the best available option is to estimate equation (3) with feasible generalized least squares (notice that this holds irrespective of whether ε_{it} is $I(0)$ or $I(1)$). The results are qualitatively similar to those obtained with the fixed-effects specification (Table 2, column 5).

5 Robustness checks

5.1 Using different proxies

As a first robustness exercise, we consider two alternative measures of liquidity. One, used by Attinasi *et al.* (2009), among others, is the country's share of the euro-area long- and medium-term sovereign bond issuance. The other is the monthly average of the traded volumes of the country's government securities with maturity between nine and eleven years relative to Germany's, used for example by Codogno *et al.* (2003). In both cases, we found liquidity to be statistically insignificant, both alone and interacted with the crisis dummy.

As a second check, we experiment with a different proxy for global risk aversion and, following Codogno *et al.* (2003) and Bernoth *et al.* (2012), we substitute the VIX with the yield spread between low-rated (BBA) US corporate bonds and the US Treasuries of corresponding maturity, without any notable effect on the results.

5.2 Controlling for banking sector stress

As is commonly acknowledged, in several EMU countries worries about public debt sustainability were magnified by concerns about the state of the banking sector. While the role of banks in the EMU crisis is not the focus of this paper, it is important to control for this channel.

To do this, we first add to our baseline regressions a measure of domestic banks' credit risk, proxied by the CDS banking index, to account for the negative feedback effects from the banking to the government sector.[15] Both in the stationary and in the non-stationary models, the absence of pure contagion and the presence of wake-up-call contagion are robust to the inclusion of the new variable. The latter is significant and has the expected sign, except for the stationary specification. That is, an increase in the country's CDS banking index increases the country's sovereign spread as well. However, the effect does not appear to have increased in the post-crisis period.

Alternatively, we introduced in our regressions, as a factor common to all countries (therefore included in the *Ft* vector together with the VIX), the spread between the three-month euro interbank offered rate (Euribor) and the corresponding OIS swap rate (which captures the market's expectations of the overnight funds rate). This difference is considered a gauge of fears of bank insolvency (see, *e.g.*, Thornton, 2009). Contrary to country-specific CDS premia, this regressor becomes much stronger after the crisis, suggesting that the crisis gave rise to widespread concern about the health of the European banking system as a whole. In any case, even in these richer specifications we still find wake-up-call contagion, while we do not find pure contagion.

[15] We define the CDS banking index as the simple average of all the CDS premia on banks resident in a given country which are available in the Thomson Financial Reuters database. Due to lack of banks' CDS data, we drop Finland from the sample.

5.3 The definition of the contagious event

A possible pitfall of our analysis is that it relies on a sharp hypothesis concerning the start of the EMU sovereign crisis, although we do find that changing the moment of the structural break from October 2009 to May 2010 (when the euro area countries launched the first Greek bailout programme) or to November 2010 (when for the first time EU authorities officially envisaged the possibility of private sector involvement in sovereign debt crises resolution) does not drastically change the estimation results. Moreover, a dichotomous crisis dummy cannot capture changes in the intensity of the crisis.

We address both problems by using, instead of our crisis dummy, a variable summarizing the Greek credit rating; we borrow this approach from Gande and Parsley (2005) and De Santis (2012). In particular, we transform the sovereign credit rating information (expressed in letters) of the three major credit rating agencies (Fitch, Moody's and Standard & Poor's) into a numerical variable using a linear scale. The variable takes 22 values from 1 (triple-A) to 22 (selective default). We also take credit-watch changes into consideration: a negative credit watch increases the value of the variable by 0.5 while a positive credit watch corresponds to a decrease of 0.5. We use the average of the numerical indicators computed for the three main rating agencies.

The results are analogous to our baseline regressions (Table 4, columns 1-4). In particular, the only fundamental variable which is statistically significant when taken in isolation is GDP growth. When interacted with the Greek rating variable, instead, government debt and the current account surplus also become significant, as in the baseline regression. In particular, the analysis shows that a worsening of the situation in Greece magnifies the positive effect of a current account surplus and the negative effect of public debt on the spreads of the other EMU countries. Finally, as in our baseline model, the Greek fiscal situation index, taken alone, has no effect on other countries' spreads.

5.4 EU policy-makers at work

In the months following the crisis, EU authorities announced and implemented several crisis-management interventions. While the efforts to improve the euro-area crisis management framework have continued after the end of our sample period (see e.g. the ECB's OMT, announced in August 2012), during our sample period three major policy episodes can be singled out.

- After several weeks of discussion, the turning-point in the EU authorities' approach to the Greek crisis came in the spring of 2010. On 2 May the euro-area countries agreed on a three-year financial support plan that provided bilateral loans to Greece. On 10 May, the EU Council established the EFSF, a vehicle empowered to issue securities guaranteed by euro-area countries and to provide loans to countries experiencing severe financial disturbance (loans are provided under conditions similar to those applied by the IMF). On the same day, the ECB launched the SMP, a programme of purchases of public and private debt securities issued in the euro area to support segments of the market especially hard hit by the crisis.
- On 28 November 2010, the euro-area finance ministers agreed to institute the ESM, a permanent crisis management tool, which is due to replace the EFSF, providing financial support to countries that request assistance subject to strict conditions. Assistance is also subject to a rigorous debt sustainability analysis. Member states considered insolvent would have to negotiate a restructuring plan with private creditors. On the same day, the finance ministers also decided to grant support to Ireland through the EFSF.
- On 21 July 2011, the Council agreed on a new Greek assistance programme, which included a sizable bail-in for private investors (with estimated losses amounting to €50 billion).

Table 4

Regression Results

(continuous crisis variable)

	(1)	(2)	(3)	(4)
spread(*t*–1)	0.947 ***			
	(0.040)			
general government debt	0.179	2.088 ***	0.625 ***	2.000 ***
	(0.112)	*(0.278)*	*(0.057)*	*(0.256)*
private debt	0.087 **	1.117 ***	0.388 ***	1.102 ***
	(0.043)	*(0.073)*	*(0.032)*	*(0.070)*
GDP growth	–1.172 **	–3.301 ***	–6.520 ***	–3.483 ***
	(0.516)	*(0.825)*	*(0.705)*	*(0.870)*
current account surplus	0.068	1.599 ***	–1.360 ***	1.494 ***
	(0.166)	*(0.354)*	*(0.217)*	*(0.361)*
liquidity (bid-ask)	1.413	6.517 ***	10.154 ***	7.141 ***
	(1.144)	*(1.816)*	*(1.015)*	*(1.604)*
VIX	0.101	0.604 ***	0.890 ***	0.597 ***
	(0.068)	*(0.124)*	*(0.121)*	*(0.141)*
Greek rating	–0.238	–4.747 *	–4.120 **	–5.920 **
	(1.626)	*(2.857)*	*(1.728)*	*(2.611)*
public debt x Greek rating	0.028 *	0.165 ***	0.176 ***	0.171 ***
	(0.016)	*(0.032)*	*(0.019)*	*(0.030)*
private debt x Greek rating	0.009	0.073 ***	0.105 ***	0.074 ***
	(0.011)	*(0.230)*	*(0.011)*	*(0.022)*
GDP growth x Greek rating	–0.743	–2.863 ***	–2.958 ***	–2.144 ***
	(0.484)	*(0.721)*	*(0.308)*	*(0.652)*
current account x Greek rating	–0.126 *	–0.898 ***	–0.920 ***	–0.881 ***
	(0.076)	*(0.128)*	*(0.084)*	*(0.132)*
liquidy x Greek rating	–0.132	–0.196	–0.403 ***	–0.236 *
	(0.097)	*(0.154)*	*(0.081)*	*(0.138)*
VIX*Greek rating	–0.010	0.055	–0.010	0.088
	(0.044)	*(0.079)*	*(0.043)*	*(0.074)*
R^2	0.98	0.91	0.87	0.93
Observations	1,269	1,269	1,269	1,242

Notes: Columns 1,2: LSDV; Column 3: DOLS (1 lead and 1 lag added for each variable; country dummies incl.); Column 4: FGLS. All estimations except column 4: Huber-white robust standard errors in parentheses. *: significant at the 10 per cent level; ** at the 5 per cent; *** at 1 per cent.

These policy actions may have influenced sovereign debt markets. To investigate this issue, we augment our empirical models with three event dummies, set equal to one in May 2010 (creation of the EFSF and launch of the SMP), December 2010 (creation of the ESM) and July 2011 (Greek private sector involvement), respectively. Introducing the event dummies does not change the economic and statistical significance of the other coefficients (Table 5, columns 1-4). However, non-conventional actions of EU policy-makers had an impact. In particular, as expected, the actions taken in May 2010 eased the tensions on the sovereign debt markets, and the involvement of the private sector in the Greek debt restructuring increased spreads. The results concerning the announcement of the ESM are somewhat less obvious, as that policy dummy is either insignificant (Table 5, columns 1 and 2) or significant with a positive sign (Table 5, columns 3 and 4). This indicates that the replacement of the temporary EFSF with the permanent ESM did not calm the markets, possibly owing to the news that Ireland as well as Greece had lost market access and had to be bailed-out, or to the official announcement that private sector involvement would be a permanent feature of the EU crisis resolution mechanism in the future.

5.5 *A richer set of common factors*

Ideally, one would like to control completely for unobserved time-varying common factors with a full set of time dummies. In practice, however, this would drastically reduce the degrees of freedom of our estimation. Moreover, the crisis dummy, which is the focus of our analysis, would be collinear with these dummies.[16] However, we can go some way in accounting for common time trends by enriching our vector of controls. In particular, we add to our F_t vector two further variables: (1) the monetary policy rate set by the ECB (*i.e.*, the interest rate on main refinancing operations); (2) an index of economic policy uncertainty for Europe computed recently by Baker *et al.* (2013). This second addition is quite interesting for its own sake. According to this index, economic policy uncertainty increased on average by 48 per cent in the crisis period. We show that this richer specification leaves our results unaffected (Table 6, columns 1-4). The two common factors appear significant in some but not all of the models that we estimate. They display the expected signs: both a tightening of monetary policy and an increase in policy uncertainty tend to increase sovereign spreads.

6 Computing the long-run level of sovereign spreads

Equation (3) can be rewritten applying the Oaxaca-Blinder decomposition to the crisis-induced change in spreads, as in Eichengreen and Mody (2000). That is, the difference between the pre-crisis and the crisis spread can be decomposed into two parts: one due to a change in the regressors, the other due to a change in the coefficients. The change in the constant term is what we identify as the "pure" contagion effect. Conditional on the occurrence of the crisis, one gets:

$$\begin{aligned} E(s_{it}^{LR}|D_{it} &= 0) = \alpha_{0i} + \beta_0 E(Z_{it}|D_{it}=0) + \beta_1 E(F_t|D_{it}=0)\ , \\ E(s_{it}^{LR}|D_{it} &= 1) = \alpha_{0i} + \gamma_0 + (\beta_0+\gamma_1)\, E(Z_{it}|D_{it}=1) + (\beta_1+\gamma_2)\, E(F_t|D_{it}=1), \end{aligned}$$

where the *LR* superscripts serve as a reminder that we are considering here the long-run equilibrium values of the spread. Therefore, the post-crisis long-run value of the spread is equal to:

16 Incidentally, this is why Bernoth *et al.* (2012) cannot allow for pure contagion.

Table 5

Regression Results

(policy dummies)

	(1)	(2)	(3)	(4)
spread(t–1)	0.926 ***			
	(0.034)			
general government debt	0.007	1.299 ***	0.337 ***	1.222 ***
	(0.113)	*(0.288)*	*(0.065)*	*(0.249)*
private debt	0.047	0.900 ***	0.167 ***	0.894 ***
	(0.038)	*(0.073)*	*(0.037)*	*(0.075)*
GDP growth	–0.550 **	–0.107	–2.340 ***	–1.120
	(0.269)	*(0.637)*	*(0.795)*	*(0.743)*
current account surplus	0.102	2.338 ***	–0.351	2.263 ***
	(0.131)	*(0.346)*	*(0.237)*	*(0.352)*
liquidity (bid–ask)	0.430	7.758 ***	11.000 ***	7.636 ***
	(0.557)	*(1.312)*	*(1.758)*	*(1.424)*
VIX	0.151 ***	0.677 ***	0.960 ***	0.589 ***
	(0.027)	*(0.076)*	*(0.126)*	*(0.102)*
Dummy crisis	–20.962 **	–142.003 ***	–154.590 ***	–138.957 ***
	(10.37)	*(25.854)*	*(16.135)*	*(24.425)*
spread(*t*–1) x crisis	0.079			
	(0.052)			
Public debt x crisis	0.164 *	1.380 ***	1.387 ***	1.291 ***
	(0.092)	*(0.261)*	*(0.163)*	*(0.233)*
Private debt x crisis	0.053	0.376 ***	0.686 ***	0.330 ***
	(0.046)	*(0.131)*	*(0.078)*	*(0.114)*
GDP growth x crisis	–3.692 *	–27.587 ***	–30.780 ***	–22.798 ***
	(2.043)	*(3.607)*	*(1.904)*	*(3.207)*
Current account surplus x crisis	–0.986 *	–5.307 ***	–6.055 ***	–4.964 ***
	(0.536)	*(1.180)*	*(0.655)*	*(1.088)*
Liquidity x crisis	–0.689	–0.504	–3.001 ***	–0.448
	(0.743)	*(1.458)*	*(1.775)*	*(1.414)*
VIX x crisis	0.293	3.908 ***	3.770 ***	3.801 ***
	(0.349)	*(0.882)*	*(0.485)*	*(0.856)*
May 2010	8.488	–107.158 ***	–107.390 ***	–90.014 ***
	(7.750)	*(16.328)*	*(15.991)*	*(15.443)*
December 2010	–11.762	40.575	49.323 ***	66.071 **
	(11.366)	*(27.965)*	*(15.251)*	*(28.857)*
July 2011	54.110 ***	102.693 ***	106.139 ***	107.377 ***
	(16.942)	*(30.333)*	*(15.216)*	*(27.415)*
R^2	0.98	0.88	0.86	0.91
Observations	1,269	1,269	1,269	1,242

Notes: Columns 1,2: LSDV; Column 3: DOLS (1 lead and 1 lag added for each variable; country dummies incl.); Column 4: FGLS. All estimations except column 4: Huber-White robust standard errors in parentheses. *: significant at the 10 per cent level; ** at the 5 per cent; *** at 1 per cent.

Table 6

Regression Results

(more common factors)

	(1)	(2)	(3)	(4)
spread(*t*–1)	0.920 ***			
	(0.035)			
general government debt	0.012	1.381 ***	0.312 ***	1.333 ***
	(0.121)	*(0.303)*	*(0.065)*	*(0.258)*
private debt	0.059	0.873 ***	0.144 ***	0.901 ***
	(0.039)	*(0.072)*	*(0.038)*	*(0.074)*
GDP growth	–0.418	–0.725	–2.515 ***	–1.684 **
	(0.294)	*(0.684)*	*(0.819)*	*(0.776)*
current account surplus	0.118	2.501 ***	–0.299	2.411 ***
	(0.132)	*(0.357)*	*(0.241)*	*(0.347)*
liquidity (bid–ask)	0.167	6.702 ***	9.508 ***	6.657 ***
	(0.537)	*(1.304)*	*(1.820)*	*(1.399)*
VIX	0.076 ***	0.250 ***	0.252	–0.007
	(0.029)	*(0.093)*	*(0.225)*	*(0.139)*
policy uncertainty	0.037 ***	0.204 ***	0.349 ***	0.045
	(0.013)	*(0.038)*	*(0.090)*	*(0.062)*
monetary policy rate	0.910 ***	–1.048	–0.001	0.832
	(0.249)	*(0.738)*	*(1.503)*	*(0.775)*
dummy crisis	–84.379 ***	–244.561 ***	–231.860 ***	–262.364 ***
	(21.928)	*(55.081)*	*(28.368)*	*(50.019)*
spread(*t*–1) x crisis	0.082			
	(0.050)			
public debt x crisis	0.167 *	1.499 ***	1.511 ***	1.411 ***
	(0.091)	*(0.255)*	*(0.164)*	*(0.220)*
private debt x crisis	0.069	0.416 ***	0.751 ***	0.381 ***
	(0.047)	*(0.133)*	*(0.079)*	*(0.111)*
GDP growth x crisis	–3.053	–24.423 ***	–28.462 ***	–20.492 ***
	(1.947)	*(3.449)*	*(1.920)*	*(3.027)*
current account surplus x crisis	–1.067 **	–5.001 ***	–5.701 ***	–4.776 ***
	(0.544)	*(1.201)*	*(0.6576)*	*(1.108)*
liquidity x crisis	–0.455	0.314	–1.604	0.157
	(0.729)	*(1.484)*	*(1.837)*	*(1.424)*
VIX x crisis	–2.355 **	–1.025	–0.703	–0.855
	(1.005)	*(1.699)*	*(0.955)*	*(1.678)*
policy unceirtanty x crisis	0.669 **	0.168	0.049	0.170
	(0.282)	*(0.559)*	*(0.266)*	*(0.552)*
monetary policy rate x crisis	38.309 **	190.433	165.896 ***	212.190 ***
	(16.755)	*(39.688)*	*(21.661)*	*(29.616)*
R^2	0.98	0.88	0.85	0.92
Observations	1,269	1,269	1,269	1,242

Notes: Columns 1,2: LSDV; Column 3: DOLS (1 lead and 1 lag added for each variable; country dummies incl.); Column 4: FGLS. All estimations except column 4: Huber-White robust standard errors in parentheses. *: significant at the 10 per cent level; ** at the 5 per cent; *** at 1 per cent.

Table 7

Long-run Values of the Spread

(basis points)

	Fitted Values		
Coefficients	*pre-crisis*	*pre-crisis*	*post-crisis*
Fundamentals	*pre-crisis*	*post-crisis*	*post-crisis*
Italy	24	47	247
Austria	23	43	131
Belgium	21	45	210
Finland	0	16	81
France	7	32	175
Ireland	35	335	558
Portugal	46	257	507
Spain	28	97	269
Netherlands	10	35	134

Notes: Spreads computed with coeff. from Table 2, col. 4 (DOLS).

$$\begin{aligned} E(s_{it}^{LR}|D_{it} &= 1) = E(s_{it}^{LR}|D_{it}=0) + \\ & \beta_0\left[E(Z_{it}|D_{it}=1) - E(Z_{it}|D_{it}=0)\right] + \beta_1\left[E(F_t|D_{it}=1) - E(F_t|D_{it}=0)\right] + \\ & + \underbrace{\gamma_0}_{pure} + \underbrace{\gamma_2 E(Z_{it}|D_{it}=1)}_{wake-up-call} + \underbrace{\gamma_3 E(F_t|D_{it}=1)}_{shift} . \end{aligned} \tag{5}$$

Terms in the second row capture the post-crisis change in fundamentals, while terms in the third row capture the different kinds of contagion: γ_0 is what we call pure contagion and is unrelated to country characteristics; $\gamma_2 E(Z_{it}|D_{it} = 1)$ captures wake-up-call contagion, is country-specific and depends on fundamentals; $\gamma_3 E(F_t|D_{it} = 1)$ is the shift-contagion component.

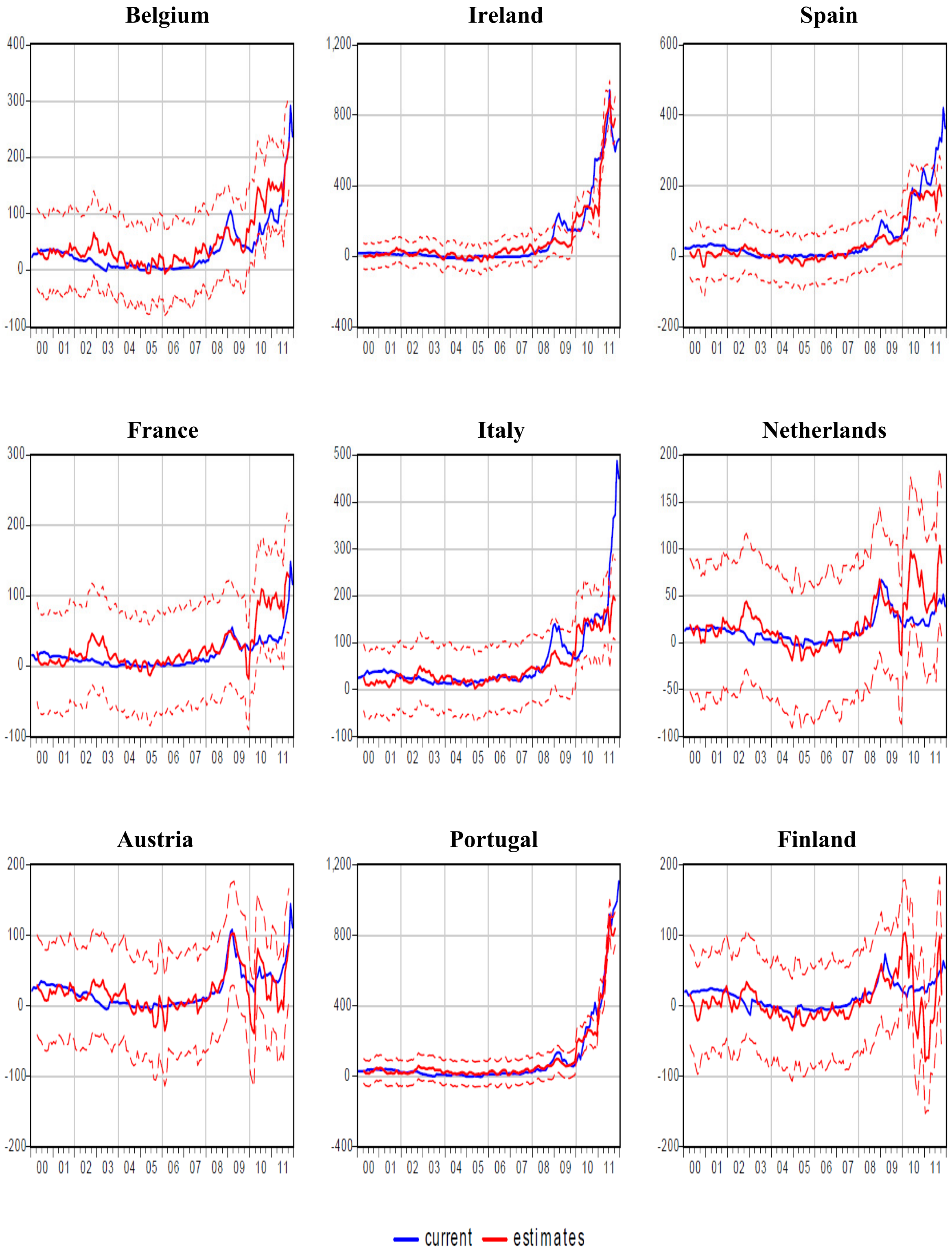
We use the estimates presented in Section 4.3 to compute the various pieces of equation (5). We first consider, for each country, the estimated value of $E[s_{it}^{LR}|D_t = 0]$ (Table 7, column 1). We then add to this value the terms in the second line of equation (5) (Table 7, column 2). To compute those values it is necessary to assess the pre- and post-crisis values of the fundamentals and of the VIX. In the table, we put them equal to their respective sample counterparts. Finally, we add the contagion terms, and we get to $E[s_{it}^{LR}|D_t = 1]$ (Table 7, column 3).

According to our calculations, for most countries the spreads observed at the end of the sample period (December 2011) are very close to their estimated long-run levels. However, for two countries, namely Spain and Italy, they are considerably above their equilibrium values (Figure 2).

Figure 2

Cointegrated Model: Predicted Values

(dashed lines: 95 per cent conf. bands)



7 Conclusions and policy implications

The analyses presented in this paper suggest that investors largely ignored macroeconomic indicators when pricing sovereign bonds before October 2009. At that date they started to discriminate among sovereigns based on the quality of their fundamentals. In particular, countries with worse fiscal conditions and external positions recorded higher spread levels. In the terminology adopted in this paper, the sharp increase in spreads observed for some countries after the start of the Greek crisis was the result of a wake-up-call rather than of a pure form of contagion: the Greek crisis increased investors' sensitivity to the fundamentals of the other euro-area countries.

Concerning the policy implications of our results, the fact that for some countries the current spread levels are above their long-run values argues for policy measures to speed up the convergence of spreads towards their long-run levels. It must be stressed that the absence of pure contagion, per se, does not settle the normative issue concerning the investors' ability to price sovereign bonds correctly.[17] We cannot say, for example, whether the increased post-crisis sensitivity to fundamentals is "appropriate": it could also be "too limited" or "excessive". Answering this question would be important in implementing the OMT. More broadly, it would help settle the debate about the relative merits of market-based as against rules-based fiscal and macroeconomic discipline, which is as old as the very idea of EMU. Indeed, already in 1989 the Delors report worried that market forces "might be either too slow and weak or too sudden and disruptive". Further research on this issue, both theoretical and empirical, is warranted.

Another related question is the possible reoccurence of a regime in which investors do not pay attention to fundamentals. To avoid disruptive cycles of excessive complacency and sudden wake-up calls, it seems advisable to push for market-friendly policies that highlight the fundamental imbalances of EMU countries even in good times. This is the rationale behind the decision to periodically publish scoreboards prepared by the European Commission and the results of the Macroeconomic Imbalance Procedure. Needless to say, the variables included and the methodology adopted in such exercises should be based on sound economic principles.[18]

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[17] Symmetrically, the existence of contagion does not imply malfunctioning of the markets. This is particularly true in the case of wake-up-call and shift contagion. For example, rational inattention stories would imply that markets are constrained-efficient, once the limits in information processing are taken into account. It appears more difficult, but not impossible, to reconcile "pure" contagion with market efficiency and/or with full rationality (Kyle and Chiong, 2001, Kodres and Pritsker, 2002).

[18] Another avenue for further research would be to investigate whether the risk of the break-up of the euro area influences sovereign debt spreads. Di Cesare *et al.* (2012) point out that this risk began to be perceived by investors in 2012, therefore after the end of our sample.

REFERENCES

Acharya, V.V., I. Drechsler and P. Schnabl (2011), "A Phyrric Victory? Bank Bailouts and Sovereign Credit Risk", NBER, Working Paper, No. 17136.

Akitoby, B. and T. Stratmann (2008), "Fiscal Policy and Financial Markets", *Economic Journal*, Vol. 118, pp. 1971-85.

Alter, A. and Y.S. Schuler (2011), "Credit Spread Interdependencies of European States and Banks During the Financial Crisis", University of Konstanz, Department of Economics, Working Paper, No. 24.

Angeloni, C. and B. Wolff (2012), "Are Banks Affected by Their Holdings of Government Debt?", Bruegel Working Paper, No. 07/2012.

Arezeki, R., B. Candelona and N. Sy (2011), "Sovereign Rating News and Financial Markets Spillover: Evidence Form the European Debt Crisis", IMF, Working Paper, No. 11/68.

Attinasi, M.G., C. Checherita and C. Nickel (2009), "What Explains the Surge in Euro Area Sovereign Spreads During the Financial Crisis of 2007-09?", ECB, Working Paper, No. 1131.

Baltagi, B.H. (2008), *Econometric Analysis of Panel Data*, fourth edition, John Wiley and Sons, Chichester (UK).

Baltagi, B.H., C. Kao and L. Liu (2008), "Asymptotic Properties of Estimators for the Linear Panel Regression Model with Random Individual Effects and Serially Correlated Errors: The Case of Stationary and Non-stationary Regressors and Residuals", *Econometrics Journal*, Vol. 11, pp. 554-72.

Baltagi, B.H., C. Kao and S. Na (2011), "Test of Hypotheses in Panel Data Model when the Regressor and the Disturbances Are Possibly Non-stationary", *Advances in Statistical Analysis*, Vol. 95, No. 4, pp. 329-50.

Banerjee, A. (1999), "Panel Data Unit Roots and Cointegration: An Overview", *Oxford Bulletin of Economics and Statistics*, Vol. 61, pp. 607-29.

Beber, A., M.W. Brandt and K.A. Kavajecz (2009), "Flight-to-quality or Flight-to-liquidity? Evidence from the Euro-area Bond Market", *Review of Financial Studies*, Vol. 22, No. 3, pp. 925-57.

Bekaert, G., M. Ehrmann, M. Fratzscher and A.J. Mehl (2011), "Global Crises and Equity Market Contagion", NBER, Working Paper, No. 17121.

Baker, S.R., N. Bloom and S.J. Davis (2013), "Measuring Economic Policy Uncertainty", mimeo.

Bernoth, K., J. von Hagen and L. Schuknecht (2012), "Sovereign Risk Premiums in the European Government Bond Market", *Journal of International Money and Finance*, Vol. 31, pp. 975-95.

Cáceres, C., V. Guzzo and M. Segoviano (2010), "Sovereign Spreads: Global Risk Aversion, Contagion or Fundamentals?", IMF, Working Paper, No. 120/10.

Calvo, G.A. (1988), "Servicing the Public Debt: The Role of Expectations", *American Economic Review*, Vol. 78, pp. 647-61.

Calvo, G.A. and E.G. Mendoza (2000), "Rational Contagion and the Globalization of Securities Markets", *Journal of International Economics*, Vol. 51, No. 1, pp. 79-113.

Chari, V.V. and P.J. Kehoe (2003), "Hot Money", *Journal of Political Economy*, Vol. 111, No. 6, pp. 1262-92.

Choi, I. (2006), "Non-stationary Panels", in *Palgrave Handbooks of Econometrics*, Vol. 1, Palgrave Macmillan, London.

Chudik, A. and M. Fratzscher (2013), "Liquidity, Risk and the Global Transmission of the 2007-08 Financial Crisis and the 2010-2011 Sovereign Debt Crisis", *European Economic Review*, forthcoming.

Codogno, L., C.A. Favero and A. Missale (2003), "Yield Spreads on EMU Government Bonds", *Economic Policy*, pp. 503-32, October.

De Santis, R.A. (2012), "The Euro Area Sovereign Debt Crisis: Safe Haven, Credit Rating Agencies and the Spread of the Fever From Greece, Ireland and Portugal", ECB, Working Paper, No. 1419.

Dungey, M., R. Fry, B. González-Hermosillo and V.L. Martin (2005), "Empirical Modelling of Contagion: A Review of Methodologies", *Quantitative Finance*, Vol. 5, No. 1, pp. 9-24.

Di Cesare, A., G. Grande, M. Manna and M. Taboga (2012), "Recent Estimates of Sovereign Risk Premia for Euro-area Countries", Bank of Italy, Occasional Paper, No. 128.

Eichengreen, B., A. Rose and C. Wyplosz (1996), "Contagious Currency Crises: First Tests", *Scandinavian Journal of Economics*, Vol. 98, No. 4, pp. 463-84.

Eichengreen, B. and A. Mody (2000), "What Explains Changing Spreads on Emerging Market debt?", in S. Edwards (ed.), *Capital Flows and the Emerging Economies: Theory, Evidence and Controversies*, University of Chicago Press, Chicago (IL).

Eichengreen, B. and A.K. Rose (1999), "Contagious Currency Crises: Channels of Conveyance", in T. Ito and A.O. Krueger (eds.), *Exchange Rates in Rapidly Developing Countries: Theory, Practice, and Policy Issues*, University of Chicago Press, Chicago (IL).

Eichengreen, B. and R. Hausmann (2004), *Other People's Money: Debt Denomination and Financial Instability in Emerging Market Economics*, University of Chicago Press, Chicago (IL).

European Commission (2009), *EMU@1O: Successes and Challenges After 10 years of EMU*, Brussels.

—————(2012), "Scoreboard for the Surveillance of Macroeconomic Imbalances", European Economy, Occasional Paper, No. 92.

Favero, C.A., M. Pagano and E.L. von Thadden (2010), "How Does Liquidity Affect Government Bond Yields?", *Journal of Financial and Quantitative Analysis*, Vol. 45, No. 1, pp. 107-34.

Forbes, K.J. and R. Rigobon (2002), "No Contagion, Only Interdependence: Measuring Stock Market Comovements", *Journal of Finance*, Vol. 57, No. 5, pp. 2223-61.

Forbes, K.J. (2012), "The Big C: Identifying Contagion", NBER, Working Paper, No. 18465.

Gande, A. and D.C. Parsley (2005), "News Spillovers in the Sovereign Debt Market", *Journal of Financial Economics*, Vol. 75, No. 3, pp. 691-734.

Giavazzi F. and L. Spaventa (2011), "Why the Current Account May Matter in a Monetary Union: Lessons from the Financial Crisis in the Euro Area", in M. Beblavy, D. Cobham and L. Ódor (eds.), *The Euro Area and the Financial Crisis*, Cambridge University Press, Cambridge (UK).

Goldstein, M. (1998), *The Asian Financial Crises: Causes, Cures, and Systemic Implications*, Institute for International Economics, Washington (D.C.).

Goldstein, M., G.L. Kaminsky and C.M. Reinhart (2000), *Assessing Financial Vulnerability: An Early Warning System for Emerging Markets*, Peterson Institute of International Economics Press, Washington (D.C.).

Gourinchas, P.O. and M. Obstfeld (2012), "Stories of the Twentieth Century for the Twenty-First", *American Economic Journal: Macroeconomics*, Vol. 4, No. 1, pp. 226-65.

Hallerberg, M. and G. Wolff (2008), "Fiscal Institutions, Fiscal Policy and Sovereign Risk Premia", *Public Choice*, Vol. 136, pp. 379-96.

Hondroyiannis, G., H.H. Kelejian and G.S. Tavlas (2012), "Government Bond Spread and Contagion Among Euro Area Countries", Bank of Greece, mimeo.

Judson, R.A. and A.L. Owen (1999), "Estimating Dynamic Panel Data Models: A Guide for Macroeconomists", *Economics Letters*, Vol. 65, pp. 9-15.

Kao, C. and M.H. Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data", *Advances in Econometrics*, Vol. 15, pp. 179-222.

Kiviet, J.F. (1995), "On Bias, Inconsistency and Efficiency of Various Estimators in Dynamic Panel Data Models", *Journal of Econometrics*, Vol. 68, pp. 53-78.

Kyle, A.S. and W. Xiong (2001), "Contagion as a Wealth Effect", *Journal of Finance*, Vol. 56, No. 4, pp. 1401-40.

Kodres, L.E. and M. Pritsker (2002), "A Rational Expectations Model of Financial Contagion", *Journal of Finance*, Vol. 57, No. 2, pp. 769-99.

Masson, P.R. (1998), "Contagion-monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria", IMF, Working Paper, No. 98/142.

—————(1999), "Multiple Equilibria, Contagion, and the Emerging Market Crises", IMF, Working Paper, No. 99/164.

Nickell, S.J. (1981), "Bias in Dynamic Models with Fixed Effects", *Econometrica*, Vol. 49, pp. 1417-26.

Pericoli, M. and M. Sbracia (2003), "A Primer on Financial Contagion", *Journal of Economic Surveys*, Vol. 17, No. 4, pp. 571-608.

Phillips, P.C.B. and H.R. Moon (1999), "Linear Regression Limit Theory for Non-stationary Panel Data", *Econometrica*, Vol. 67, pp. 1057-111.

————— "Nonstationary Panel Data Analysis: An Overview of Some Recent Developments", *Econometric Reviews*, Vol. 19, No. 3, pp. 263-86.

Qian, R., C.M. Reinhart and K.S. Rogoff (2011), "On Graduation from Default, Inflation and Banking Crises: Elusive or Illusion?", in D. Acemoglu and M. Woodford (eds.), *NBER Macroeconomics Annual 2010*, MIT Press, Cambridge (MA).

Saikkonen, P. (1991), "Asymptotically Efficient Estimation of Cointegrating Regressions", *Econometric Theory*, Vol. 7, pp. 1-71.

Schinasi, G.J. and R.T. Smith (2000), "Portfolio Diversification Leverage and Financial Contagion", *IMF Staff Papers*, Vol. 47, No. 2, pp. 159-76.

Schuknecht, L., J. Von Hagen and G. Wolswijk (2009), "Government Risk Premiums in the Bond Market: EMU and Canada", *European Journal of Political Economy*, Vol. 25, pp. 371-84.

Schuknecht, L., J. Von Hagen and G. Wolswijk (2011), "Government Bond Risk Premiums in the EU Revisited: The Impact of the Financial Crisis", *European Journal of Political Economy*, Vol. 27, pp. 36-43.

Sgherri, S. and E. Zoli (2009), "Euro Area Sovereign Risk During the Crisis", IMF, Working Paper, No. 09/222.

Stock, J.H. and M.W. Watson (1993), "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems", *Econometrica*, Vol. 61, pp. 783-820.

Thornton, D.L. (2009), "What the Libor-OIS Spread Says", Federal Reserve Bank of St. Louis, *Economic Synopses*, No. 24.

Tutino, A. (2011), "Rational Inattention Guides Overloaded Brains, Helps Economists Understand Market Behaviour", *Federal Reserve Bank of Dallas Economic Letter*, Vol. 6, No. 3.

Wiederholt, M. (2010), "Rational Inattention", in *The New Palgrave Dictionary of Economics*, Palgrave Macmillan.