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The Eurozone Crisis: How Banks and Sovereigns Came to be Joined at the Hip

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The Eurozone Crisis:

How Banks and Sovereigns Came to be Joined at the Hip

Ashoka Mody and Damiano Sandri[1]

September 15, 2011

Abstract

We use the rise and dispersion of sovereign spreads to tell the story of the emergence and escalation of financial tensions within the eurozone. This process evolved through three stages. Following the onset of the Subprime crisis in July 2007, spreads rose but mainly due to common global factors. The rescue of Bear Stearns in March 2008 marked the start of a distinctively European banking crisis. During this key phase, sovereign spreads tended to rise with the growing demand for support by weakening domestic financial sectors, especially in countries with lower growth prospects and higher debt burdens. As the constraint of continued fiscal commitments became clearer, and coinciding with the nationalization of Anglo Irish in January 2009, the separation between the sovereign and the financial sector disappeared.

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I. INTRODUCTION

In early July 2007, when the Subprime crisis was just placing the world on notice, the spread (risk premium) on the 10-year maturity Irish sovereign bond was still negative. In other words, the Irish sovereign paid a lower interest rate than did the German sovereign. Even in March 2008, when Bear Stearns was rescued—the point at which, in our view, the European banking-sovereign crisis took a decisive turn—the Irish spread was only 30 basis points.[2] Thereafter, spreads rose at a more rapid pace, with some ups and downs, but through the Lehman bankruptcy to the nationalization of Anglo Irish in January 2009. They had risen then to 300 basis points. That increase in a short period of 9 months seemed dramatic, but in retrospect appears quaint. As of this writing, in mid-September 2011, Irish spreads are about 650 basis points, having scaled over a 1000 basis points before retreating.

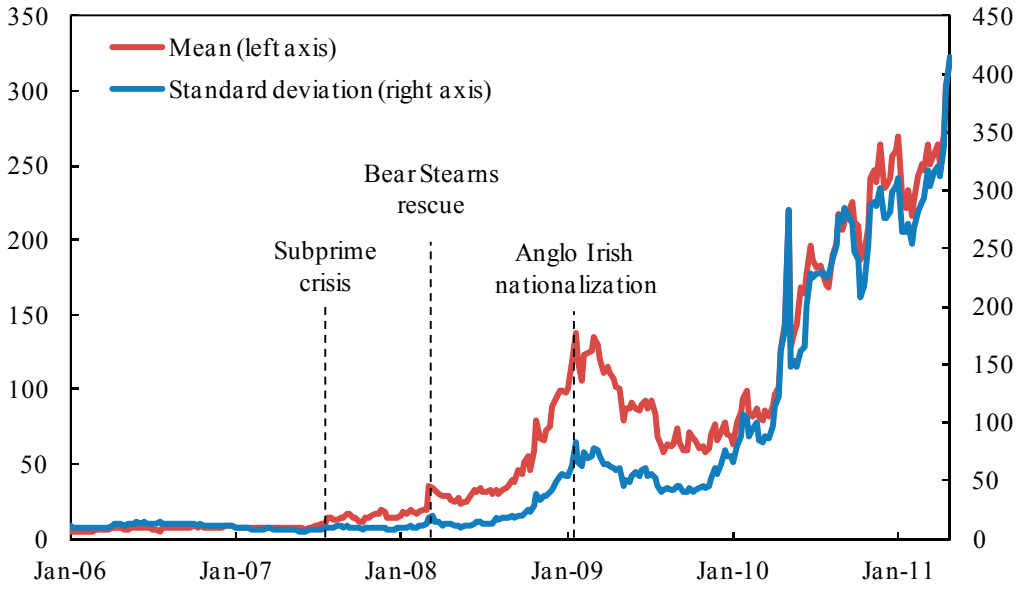
This basic sequence of striking developments played out, with varying intensities, across the eurozone. For several tranquil years—from the introduction of the euro in January 1999 to the start of the Subprime crisis in mid-July 2007—spreads on bonds of eurozone sovereigns had moved in a narrow range with only modest differentiation across countries (Figure 1).[3] The homogeneity was questionable then and became untenable as the crisis unfolded. In this paper, we tell the tale of that crisis as it unfolded in three phases:

- In the first phase, global financial stress was transmitted to Europe. Spreads of European sovereigns rose along with metrics of the health of global banks. This phase lasted from July 2007 through to the rescue of Bear Stearns in March 2008. At that point, spreads had risen modestly, but the differentiation across countries was still low.

[2] 100 basis points equal one percentage point.

[3] At the launch of the euro on January 1, 1999, eleven members of the European Union were admitted to the eurozone. These included Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Greece was admitted on January 1, 2001. Cyprus (January 2008), Malta (January 2008), Slovenia (January 2007), Slovakia (January 2009), and Estonia (January 2011) are now also part of the eurozone.

Figure 1: Increase and dispersion of eurozone sovereign spreads
(basis points)



- From Bear Stearns onwards, a distinctive European dimension of the banking crisis emerged. A sovereign's spread responded increasingly to the weakness of its own financial sector. It was as if the sovereign's implied debt burden was recalibrated as news became available about its financial sector's likely claims on the public purse. This phase lasted through to January 2009, when Anglo Irish was nationalized—an Irish episode but with a European marker. The role of global developments did not disappear, with the Lehman bankruptcy raising, for example, risk premia everywhere. However, the substantial increase in spreads was now accompanied by a significant differentiation across countries.

- After Anglo Irish, the crisis evolved into its full-blown phase characterized by highly intertwined financial and sovereign shocks. Not only did financial sector stress raise sovereign spreads as before, but now sovereign weakness also transmitted to the financial sector. Although spreads declined initially after the nationalization of Anglo Irish, the subsequent march upwards was spectacular, as was the country differentiation.

This narrative is informed by a model of financial crises and sovereign default, which, in turn, guides an econometric analysis. In its essence, the model posits that default occurs beyond a certain public debt-to-GDP threshold. This implies that spreads are increasing in the amount of debt that sovereigns have to finance tracing the rising default probability, which, under a lognormal distribution for GDP shocks, can be exponential. The evolution of the default probability is conditioned also by the health of the financial sector, which finances investment

and, hence, growth. A weak financial sector causes growth to slow and the public debt-to-GDP ratio to rise, all else equal. The government can contain this growth contraction by recapitalizing the banks, but at the cost of incurring significant fiscal outlays. This trade-off is rendered more acute where the underlying growth potential is low and the starting debt-to-GDP is high. Where, at some point, the government loses fiscal credibility, not only do shocks transmit from the financial sector to the government, but the revelation of new fiscal constraints undermines the prospects of the financial sector. The econometric analysis confirms two non-linearities highlighted by the model. First, sovereign spreads in countries with a slower growth potential are more adversely affected by financial sector shocks. Second, financial shocks also have a larger impact on countries with higher public debt ratios, and this was more so after the Anglo Irish nationalisation by when global growth assumptions and debt projections had taken a turn for the worse.

The econometric analysis studies the determinants of weekly *changes* in the sovereign bond spreads of 10 eurozone countries over the period January 2006 to May 2011. Estimates based on monthly changes are also presented to assess the timing of the effects and the robustness of the results. The countries included in the analysis are Austria, Belgium, Netherlands, Finland, France, Greece, Ireland, Italy, Portugal, and Spain. Germany is excluded since the yield on the benchmark "German Bund" is treated as the "risk-free" rate or the numeraire over which each country's spreads are computed.[4] Also excluded are Luxembourg (which has limited traded public debt) and those countries that have entered the euro area only

[4] The spreads are based on yields reported in the secondary market trades of government bonds. Spreads on credit default swaps (CDS) offer another perspective on the market's perception of default risk. Because CDS spreads are, in effect, an insurance premium on a notional outstanding amount, they exist also for Germany—and these have also risen (and, in this sense, the notion the German Bund is "risk free" is not necessarily precise). For the purpose of this paper, CDS spreads are not suitable since the series are shorter and the markets are thinner than for the conventional government bonds.

recently, such as Cyprus, Malta, Slovakia, Slovenia, and Estonia, given their shorter histories in the eurozone. For a high-frequency measure of financial sector prospects, we use the ratio of the financial sector equity index over the overall equity index. When this index goes down, the market is assessing that the financial sector is more vulnerable than the rest of the economy.[5]

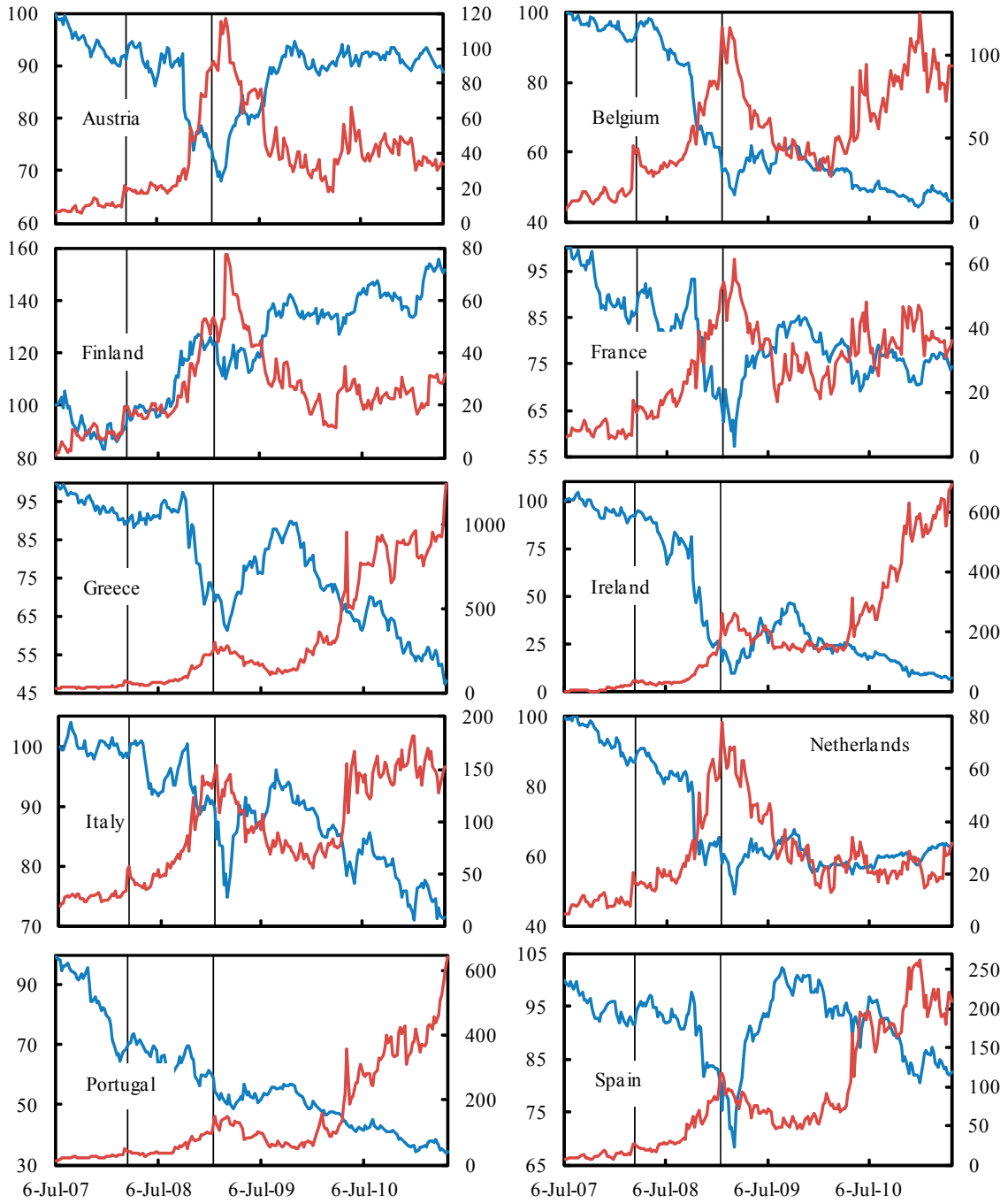
The key developments start around the rescue of Bear Stearns. Spreads at the time were still trivially low. Bear Stearns, as Reinhart (2011) has most forcefully argued, created a presumption that policymakers would provide sufficient financial support to banks to enable the bailout of the banks' creditors. If there was an intended policy message in the Lehman bankruptcy in September 2008, the message was rapidly reversed as the U.S. authorities quickly thereafter bailed out several other large financial institutions. The presumption that European authorities would also do the same is noticeable in Figure 1, where Lehman (despite its cataclysmic impact on global financial markets) is not a visible milestone in the run up of eurozone sovereign spreads from Bear Sterns to Anglo Irish. Each sovereign's spreads during this period evolved largely in response to the stress experienced by its domestic financial sector (Figure 2). We measure financial sector stress by the ratio of financial equity prices to aggregate equity prices (the financial sector pressure index). As this index fell, sovereign spreads rose.

The econometric analysis shows that post-Bear Stearns, a drop in the financial sector pressure index was followed over two or three weeks by a rise in sovereign spreads. This implies that as information about financial sector weakness emerged, the market filtered its implications for sovereign debt and output growth and reflected that assessment in sovereign spreads. The rapid rise in spreads reflected not only a new estimate of future public liabilities but also the

[5] It is also possible to use the CDS spreads of banks to measure the market's perception of their vulnerability. As with sovereign CDS spreads, the series are short and the markets thin.

increased uncertainty of what those liabilities may be—with the uncertainty priced into the sovereign risk premia.

Figure 2: Prospects of the financial sector and sovereign spreads



First vertical line: rescue of Bear Stearns. Second vertical line: nationalization of Anglo Irish

Growth prospects also played a key role during this period. Growth projections were massively revised down during the course of 2008. While some part of this downward revision was the result of the emerging Great Recession, it also involved realignment from unsustainable growth towards the countries' actual growth potential. The eurozone countries that had experienced a large appreciation of their effective real exchange rate had become competitively weak, and the pre-crisis buoyancy in some of them was not sustainable. The econometric results show, indeed, that countries with weaker competitiveness were prone to greater sovereign stress resulting from financial sector weakness. Thus, during this key phase, financial shocks translated into higher spreads especially for countries with lower growth prospects and higher debt burden.

The significance of the Anglo Irish nationalisation as the other turning point is, at first, less evident. This was a small bank in a small eurozone country. But, it came in the wake of Lehman bankruptcy in September 2008 with banks worldwide in an elevated state of vulnerability and a widespread sense of interconnections in bank balance sheets, as seen in the heightened comovement of banks' credit default spreads (Eichengreen, Mody, Nedeljkovic, and Sarno, 2009). Reporting the nationalisation of Anglo Irish on January 16, 2009, the British newspaper, the Independent, noted that the event had generated "talk of further state control of U.K. and U.S. banks." It went on to say:[6]

> "Bank shares fell heavily in the U.S. and Europe yesterday on fears that more big lenders would have to ask for state help. Speculation mounted that Bank of America and Citigroup could be fully nationalised. In the U.K., where the Government now owns part or all of five banks, concerns increased that Royal Bank of Scotland could be fully nationalised after a dire profit warning from Deutsche Bank. Germany's biggest lender admitted to a disastrous fourth quarter in the wake of the Lehman Brothers bankruptcy that spelt bad news for U.K. banks such as RBS and Barclays."

[6] http://www.independent.co.uk/news/business/news/anglo-irish-bank-nationalised-1380495.html

Such actions would imply higher public debt ratios everywhere, not least because of rapidly slowing growth. Suddenly, the ability of sovereigns to prop up the financial sector was in doubt. In this sense, Anglo Irish crystallized the public finance implications of global banking tensions. Thereafter, not only did the weakness of the financial sector raise sovereign spreads, but shocks to a sovereign's fiscal strength compromised the scope of financial sector support. Banks and the sovereign, at this point, were joined at the hip.

It is worth juxtaposing our analysis with the celebrated findings of Reinhart and Rogoff (2009, 2011). First, they report that banking crashes are followed by fiscal crises. Because they deal with annual data, their estimate of the gap between the two is somewhat coarse. We can time the gap more precisely. If the start of the European banking crises coincides with the rescue of Bear Stearns in March 2008, as we suggest, and the ability of the sovereign to shield the financial sector was neutralized in January 2009, then the fiscal crisis followed the banking crisis by nine months. Second, Reinhart and Rogoff find that sovereign debt ratios (and the likelihood of a sovereign default) typically rise substantially after a banking crisis. Importantly, they point out that the rise in sovereign debt is not primarily due to the liability incurred for rescuing the financial system. Rather, slower growth after a financial crisis leads to a rapid rise in the public debt ratios. Our model and econometric results go a step further: a country that is predisposed to grow slowly will experience a more virulent interaction between financial sector shocks and public debt. This low growth potential—often camouflaged by the pre-crisis boom—is made manifest by the crisis rather than being mainly an outcome. Finally, they do not find a feedback loop from rising public debt to banking crises, from which they infer that it is primarily the surge in private debt that causes banking crises. While private debt may instigate the initial incidence of a banking crisis, our results show that the perpetuation of these twin crises is due to their mutual reinforcement.

Looking ahead, therefore, the banking sector vulnerabilities uncovered by the crisis, weaker growth prospects, and higher debt ratios (and higher spreads) could persist because they have the potential to reinforce each other. In this sense, the paper documents a transition from a benign equilibrium to a new, more stressed equilibrium. Indications of stress were present in the pre-crisis years, albeit in muted form. But markets chose to largely ignore them. That is no longer the case, creating new challenges for policymakers.

The rest of the paper is organized as follows. We begin in Section II by presenting the model that will guide the empirical analysis. Section III describes the data and the econometric approach. In Section IV, we consider the period before the nationalization of Anglo Irish and establish the case that the domestic financial sector matters in explaining changes in sovereign bond spreads; this link holds even when various global influences are accounted for. Section V documents the coevolution of bank and public sector fragilities after Anglo Irish. In Section VI, we examine the differences between country groups with large and more moderate losses in competitiveness, highlighting the non-linearities due to financial shocks, high debt ratios and weak growth potential. In conclusion, Section VII cautions that the downward reassessment of short-term global growth prospects, an unstable financial sector, and rising public debt can continue absent decisive intervention in the financial sector.

II. A Model of Financial Crisis and Sovereign Default

We investigate the relation between financial shocks and sovereign spreads by considering a parsimonious two-period model featuring the government, risk-neutral investors, and the financial sector. In period 1, the government issues a stock of bonds, B_1, pledging a rate of return r. The government's ability to honor that commitment in period 2 depends on the ratio of outstanding liabilities to GDP, Y_2, given by

$$b_2 = \frac{B_1(1+r)}{Y_2}$$

As a simple stylization, we assume that the government defaults if b_2 exceeds an exogenous threshold $\bar{b}$. This reduced form specification of default captures the insights from more structural models à la Eaton and Gersovitz (1981), where a risk-averse sovereign endogenously uses default to smooth consumption. This class of models highlights that the incentive to default is indeed higher during recessions and when facing a large debt burden, i.e. when the debt-to-GDP ratio b_2 is high. In these circumstances, avoiding debt repayments is a valuable expedient to sustain consumption despite falling GDP.

We assume that GDP is determined by:

$$Y_2 = A_1(1+g)K_1\varepsilon_2$$

where K_1 is capital investment at time 1, A_1 is the level of productivity, which grows between time 1 and 2 at the economy's potential growth rate g, and ε_2 is a mean-one log-normally distributed shock with standard deviation σ.[7] The government's probability of default is:

$$D = Prob\left[\frac{B_1(1+r)}{A_1(1+g)K_1\varepsilon_2} > \bar{b}\right] = Prob\left[\varepsilon_2 < \frac{B_1(1+r)}{\bar{b}A_1(1+g)K_1}\right]$$

To compensate for the risk of government default, risk-neutral investors demand a premium over the exogenous risk-free interest rate i. Thus, the expected return on government bonds has to equal the risk-free rate

$$(1-D)(1+r) + D\mu(1+r) = (1+i)$$

[7] A log-normal distribution is naturally truncated at zero and thus prevents the possibility of having a negative GDP. Assuming a normal distribution makes no substantive difference to these results.

where μ is the recovery rate in case of default. By combining this arbitrage condition with the definition of the default probability, we can solve numerically for the equilibrium rate, r, on government bonds.

The role of the financial sector in this context is to determine capital investment K_1. Banks leverage their own equity endowment E_1 with external funds to finance investment, so that

$$K_1 = \lambda E_1$$

where λ is the leverage factor. This formulation captures the idea that a reduction in the capitalization of the banking sector impairs investment and reduces GDP.

The benchmark calibration of the model is summarized in Table 1 and is based on fairly conventional values. The qualitative results presented in this section are anyway robust to alternative parameter choices. Note that the equity endowment of the financial sector is set to 500 so that expected GDP, $A_1(1+g)\lambda E_1$, is equal to 100. The productivity growth rate is set to 0, but we will present results also under alternative growth rates.

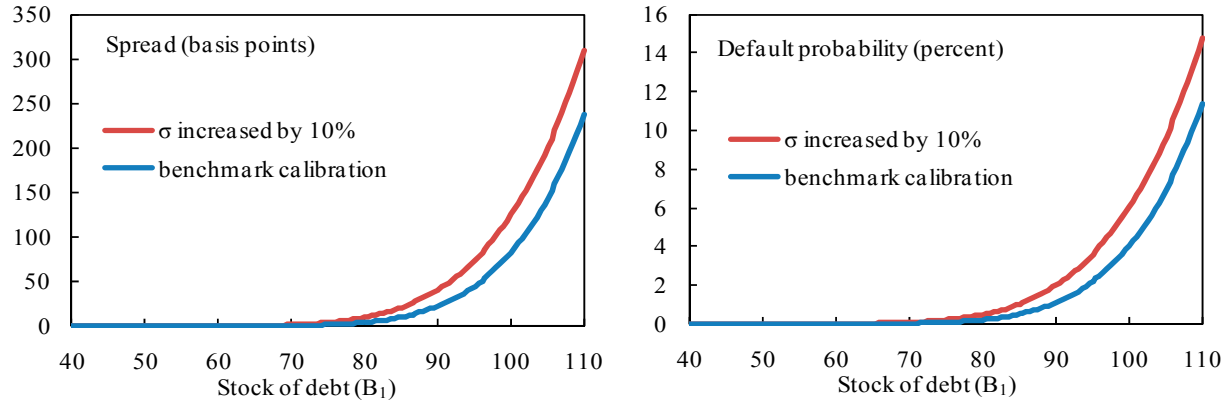
Table 1: Benchmark calibration

Parameter	Description	Value
σ	Standard deviation of GDP shock	20%
$\bar{b}$	Default threshold	150%
μ	Default recovery rate	80%
i	Risk-free rate	2%
A	Capital productivity	10%
g	Productivity growth	0%
λ	Financial sector's leverage	10
E_1	Financial sector's equity	100

We begin the analysis by considering the determination of sovereign yields. The realization of a sufficiently negative GDP shock, ε_2, pushes the debt-to-GDP ratio above the threshold, leading to default. As debt levels rise, the likelihood of being pushed above the

threshold increases and so does the spread on government bonds. Figure 3 shows how this spread, $r - i$, varies with the stock of government debt. Note that since expected GDP has been normalized to 100, the values on the horizontal axis can also be interpreted as the stock of debt as a percentage of expected GDP. We observe that spreads are exponentially increasing in the debt stock, mirroring the increase in the default risk. The exponential increase in default risk reflects the exponential increase in the log normal cumulative distributive function of the GDP shock, ε_2.[8] If, moreover, the volatility of ε_2 also increased with the debt stock, then the rise in spread would be even quicker. Of course, a rise in risk aversion would also raise spreads on sovereign bonds (as on other risky assets). We do not formally model risk aversion in part because the more parsimonious framework we do adopt suggests that an observed rise in risk premia may reflect a shift in the perceived trajectory of debt and the variance of economic outcomes; as such, it does not appear necessary to invoke a change in risk aversion—which implies a more far reaching assumption of a shift in the utility functions—to interpret the developments.

Figure 3: Spread and default probability are increasing in the debt stock



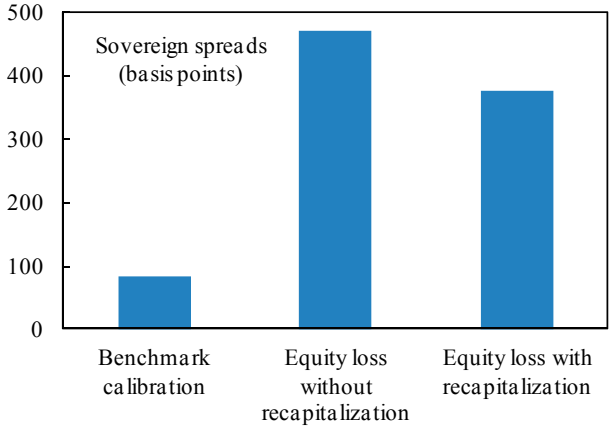
[8] This is the case as long as the ratio of government liabilities to expected GDP, b_2, is sufficiently below the default threshold $\bar{b}$. At very high levels of debt approaching the default threshold, the default probability is already close to 1 and so it increases only slowly with further additions of debt.

In this set up, how do shocks to the financial sector affect sovereign spreads? A loss in the financial sector's capital reduces its ability to intermediate funds and support investment. This reduces expected GDP, which increases default risk and sovereign spreads. Consider, for example, the case of a government that has to issue 100 bonds. As shown in Figure 4, the benchmark calibration implies a sovereign spread of around 80 basis points. If the financial sector experiences a 15 percent equity loss, expected GDP also falls by 15 percent and the spread jumps up to more than 450 basis points.[9] Thus, a hole revealed in the banks' books translates into higher sovereign spreads. Note that this consequence follows even without the government undertaking any recapitalization obligation.

In fact, government support to banks can actually reduce the public debt ratio. By injecting capital into the banks, the government can limit the impact from the banks' equity loss on GDP, mitigating the rise in the debt ratio and in spreads. Sovereign spreads still rise because additional public debt is incurred but less so than in the absence of government intervention (Figure 4). Looking back at Figure 1, note the modest decline in spreads following the rescue of Bear Stearns, and the more extended decrease following the nationalization of Anglo Irish. In both cases, the availability of a government safety net provided short-term reassurance to markets that banks, and, hence, economic growth, would be protected. Of course, the recapitalization is not a substitute for winding down an unviable financial institution. In retrospect, the government support for Anglo Irish proved more than the state could handle as the hole in rogue bank's balance sheet was relentlessly revealed to be deeper. That said, bank recapitalization, when undertaken judiciously, can be an important policy tool for breaking the vicious circle of sovereign and banks' vulnerability.

[9] In our econometric analysis, the shock to banks' equity is measured by changes in the financial sector equity index normalized by the overall equity index.

Figure 4: Impact of equity losses in the financial sector on sovereign spreads

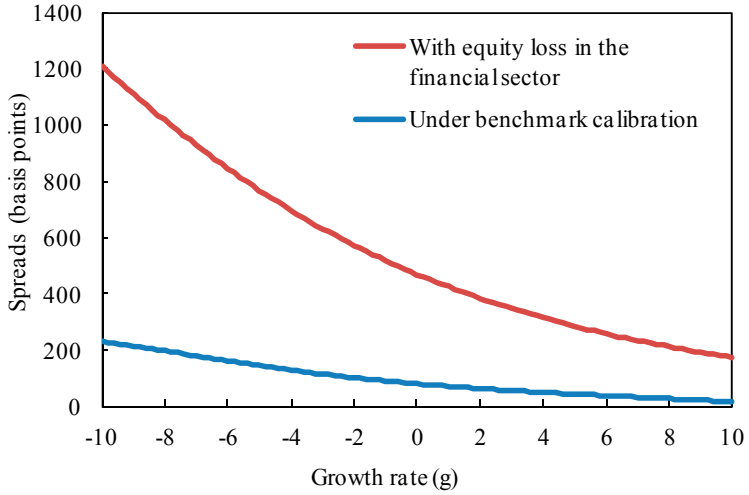


However, recapitalization need not always be benign. The government faces a trade-off between preventing the fall in GDP due to impaired financial intermediation and avoiding the fiscal costs of recapitalization. In the context of the model, this trade-off is primarily determined by the leverage in the financial sector. A highly levered financial sector can operate with a small net worth and thus can in principle be recapitalized by the government to meet regulatory requirements with limited additional funding. However, high leverage may be untenable in a period of financial turmoil, as investors require intermediaries to hold capital buffers that are larger than required by prevailing regulatory norms. Therefore the bailout funds needed to support an adequate level of lending may increase considerably. At some point, the government's ability to provide recapitalization funds will no longer be credible.

The model can also illustrate how the impact of financial shocks on sovereign spreads depends on countries' characteristics. We conduct this analysis for the case of non-recapitalization, but the qualitative results are unchanged if the government were to inject capital in the financial sector. Consider first the economy's productivity or potential growth rate g. The blue line in Figure 5 shows how spreads vary with the growth rate for a given level of debt ($B_1 = 100$) under the benchmark calibration. A lower growth rate increases the spread since it reduces expected GDP. The red line plots the spread in case of a 15 percent reduction in financial

sector capital. Now, the increase in spread is much more pronounced for economies facing low growth prospects. Essentially this result derives from the exponential increase of the default risk with respect to the debt to expected GDP ratio. While a negative financial shock in a healthy growing country only mildly increases the default probability, it has a much larger impact on a slower growing or contracting economy. We test this key insight in the econometric analysis. Note also that the association between financial crises and slow subsequent growth is often interpreted as suggesting long-lasting negative effects on growth from financial crises. Our analysis reveals, however, that weak growth prospects can breed the crises.

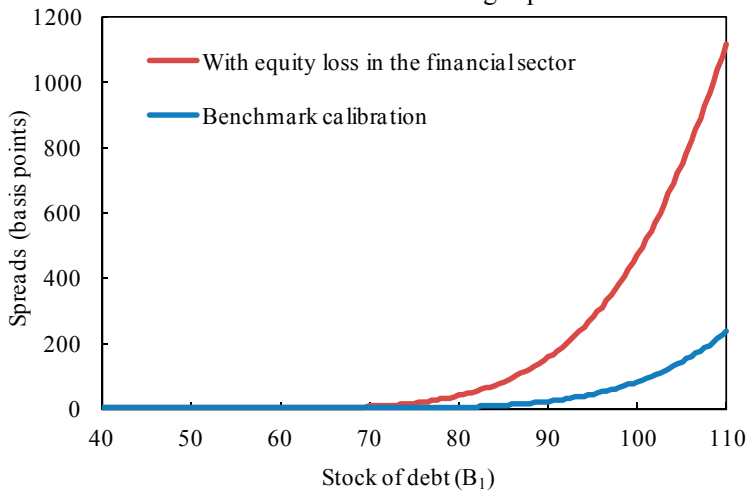
Figure 5: The impact of financialshocks on sovereign spreads is stronger in slow growing countries



The country's fiscal position is another important factor that differentiates the response in spreads to financial shocks. Figure 6 shows the variation of spreads as a function of the country's stock of debt. The blue and red lines plot respectively the spreads in the benchmark and equity loss scenario. The same capital loss in the financial sector triggers a much larger increase in sovereign spreads for countries with a large stock of debt. More interestingly, there are negative synergies between low growth and high debt. Figure 7 plots the increase in spreads at different levels of public debt following a 15 percent equity loss in the financial sector but under different potential growth rates. The blue line traces the increase in spreads assuming zero growth, while

the red line considers the case of positive growth. The magnifying effect of high public debt on spreads is especially strong if the growth potential is low. In other words, the model suggests that during the recent financial crisis high debt levels should have more strongly increased sovereign spreads in slow growth countries. This hypothesis will also be tested in the econometric analysis.

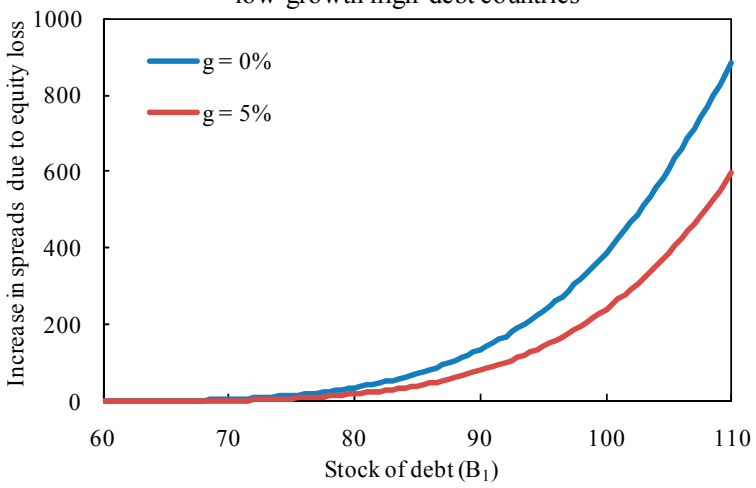
Figure 6: High public debt magnifies the impact of financial shocks on sovereign spreads



In this analysis, we have not explored the feedback from higher sovereign spreads to the banking sector that we believe became particularly important in the post-Anglo phase of the crisis.[10] But channels for that are evident. Most simply, banks may hold government securities, and the mark-down on these assets when spreads rise would reduce capital. Higher sovereign spreads may, moreover, increase borrowing rates for banks and hence for businesses and households. In the model, investment is not related to interest rate paid on borrowed funds, but this realistically will be the case. Investment and growth would, therefore, decline. Other, more complex, possibilities exist. These feedback effects create further non-linearities in the evolution of spreads and financial sector pressures.

[10] Recent papers modeling the impact of sovereign risk on the banking system are Bolton and Jeanne (2011) and Gennaioli et al. (2010).

Figure7: The increase in spreads is particularly large in low-growth high-debt countries



III. THE DATA AND ECONOMETRIC APPROACH

The sovereign spread for country "i" at time "t", S_{it}, is measured as the difference between the secondary-market yield on the country's 10-year bond and the yield on the German 10-year benchmark government bond (the German "Bund"). Since the yield on the Bund is regarded as a "risk-free" rate, the spread is the premium paid for the risk of default. Figure 2 plots the sovereign spread for each country against a measure of the prospects of the financial sector. This measure, F_{it}, is the ratio of the equity index of the country's financial sector divided by the overall equity index. Thus, a fall in F_{it} indicates that the financial sector is expected to underperform the rest of the economy. With some exceptions, a striking inverse relationship exists between S_{it} and F_{it}. In other words, as markets revised down their view of a country's domestic financial sector, sovereign spreads rose—and vice versa. This relationship has held in the short-term movements and over the long haul. For example, normalized to 100 in the first week of July 2007, the Irish F_{it}, was in mid-May 2011 below 10, while spreads rose over that time by nearly 800 basis points.

To explain sovereign risk premia and their association to the conditions in the financial sector, we analyze their correlation structure at weekly frequencies. Consider the following relationship which is first specified in *levels* to motivate the discussion:

$$S_{it} = \alpha + \sum_{s=o}^{p} \beta_{i,t-s} S_{i,t-s} + \sum_{s=o}^{m} \lambda_{i,t-s} F_{i,t-s} + \sum_{s=o}^{n} \phi_{i,t-s} Z_{i,t-s} + \varepsilon_{it}$$

Possible persistence in the spreads is captured by their lagged values. Consistent with our model, a weaker financial sector (a lower F_{it}) is hypothesized to raise spreads as public debt dynamics worsen due either to lower growth prospects or because large bailout costs are anticipated. The Z_t regressors include other factors likely to affect risk perceptions. For example, flight to quality is proxied by the yields on U.S. government bonds. Flight to quality is a nebulous concept but could be understood as risk aversion or, as discussed in the context of our model, a reevaluation of global risk, including the path of GDP and public debt. Slower, more uncertain growth and even rising public debt projections have been associated with lower U.S. treasury yields, including after the S&P downgrade of U.S. debt. We use credit default swaps (CDS) on U.S. banks to capture global financial conditions.

A number of econometric issues are associated with estimating this relationship. First, as is clear from Figure 2, both S_{it} and F_{it} trend. As such, the equation is estimated in first differences: in other words, the estimation explains the *change* in spreads. Second, although weekly observations for the full time period allow for country-by-country estimations, there is an important evolution over time in the relationship between spreads and financial stress. Investigating this evolution even with weekly data is not possible on a country-by-country basis since the sample size becomes too small. To maintain comparability of results across phases, it, therefore, helps to stay throughout within a common panel framework. Third, within that panel framework, because the time series dimension of the data is relatively long even for the smaller

samples, the endogeneity concern on account of the lagged dependent variable does not arise. Hence, dynamic panel data techniques are not required. Instead, the panel estimation technique used allows for heteroskedasticity, i.e., for the variance of the error terms to vary by country. It allows for first-order autocorrelation in errors and for contemporaneous correlation of error terms across countries and, hence, for unobserved global shocks felt by all countries.[11]

Fourth, the U.S. government bond yields and CDS spreads of banks do not capture all the global impulses. As Figure 8 shows, the fall of Lehman in September of 2008 involved a global downward revision of growth prospects and had an inevitable effect on sovereign risk premia in Europe. To allow for such shift, we include a dummy variable D_t for the period between Lehman and Anglo Irish. The inclusion of this dummy variable implies that the estimation explains a country's deviation in the change in spreads from the period average change for all countries in the sample. Finally, in all but the set of regressions where we examine the effect of public debt ratios (which do not change much over time), country dummies δ_i are included to allow for the influence of unobserved country factors. With those considerations to guide the analysis, the specification to be estimated is:

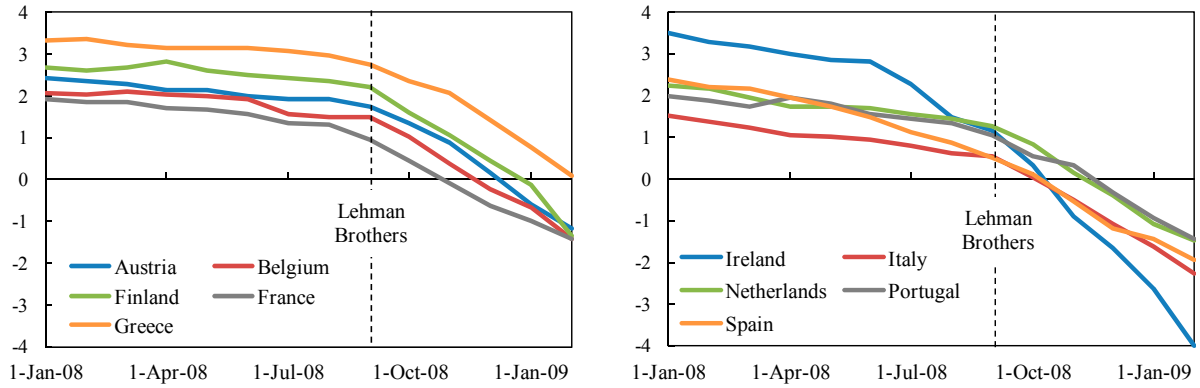
$$\Delta S_{it} = \sum_{s=o}^{p} \beta_{i,t-s} \Delta S_{i,t-s} + \sum_{s=o}^{m} \lambda_{i,t-s} \Delta F_{i,t-s} + \sum_{s=o}^{n} \phi_{i,t-s} \Delta Z_{i,t-s} + \varepsilon_{it} + \delta_i + D_t$$

The goal is to identify the factors that led to the rise and dispersion of sovereign spreads. Through these regressions, we can identify the principal correlates of the short-term variations in sovereign spreads. There remains the thorny question of whether these correlates are

[11] As Beck and Katz (1995) suggest, we allow for a common autocorrelation coefficient for all countries. They caution that this is best since it guards against the risk of mismeasurement of the autocorrelation coefficient for individual countries, and we follow that recommendation. In practice, the results do not change qualitatively if the autocorrelation coefficients are country specific.

"determinants" of spreads in a causal sense. We discuss below the extent to which the lag structure revealed by our high-frequency data can be used to draw inferences about causality.

Figure 8: Downward revision of Consenus Forecast for 2009 real GDP growth



IV. From Eurozone Tranquility to Crisis

The basic structure of the regressions is as follows: lags of the dependent variable are used to assess the degree of persistence in the change in spreads; changes in the domestic financial sector pressure index (and its lags) ascertains the relationship of key interest, that between financial sector stress and sovereign spreads; and global variables, including the post-Lehman dummy variable, control for generalized influences on spreads. The regressions examine the lags in the relationships not just for their intrinsic interest but also for what they may tell us about the sequencing of developments and hence (potentially) about causality.

In the tranquil phase up until the start of the Subprime crisis, the changes in sovereign spreads were essentially random. The variables used in this analysis certainly do not explain those changes, and the R-squared of the regression is also small (column 1, Table 2). This conclusion is consistent with earlier studies, which have examined other possibilities (see summaries of the previous literature in Codogno et al., 2003, and Pagano and von Thadden, 2004). In their 2004 paper, Pagano and von Thadden conclude that explaining the time variation

in spreads had been "challenging," and that remained the case through to the start of the Subprime crisis. The differences in spreads levels across countries did reflect the variation in debt levels or credit ratings, but the differentiation was negligible by current standards. These considerations do not necessarily imply that eurozone sovereign bonds were mispriced. But clearly sovereign spreads had converged to a much a greater degree than economic prospects had.

Starting with the onset of the Subprime crisis in mid-July of 2007 and going through to the rescue of Bear Stearns in mid-March 2008, the variation in sovereign spreads was no longer white noise (column 2, Table 2). In this phase, the change in spreads was related to "global factors," mainly reflecting global financial risk.[12] Empirically, such risk is found to be best proxied by the change in the spreads on credit default swaps (CDS) of U.S. banks, which are highly correlated with CDS spreads of banks elsewhere, as noted in Eichengreen et al., 2009. Thus, the Subprime crisis shook the eurozone out of its tranquility, as sovereigns paid a premium for global financial risk. In terms of our model, the observed rise in sovereign spreads can be interpreted as the premium for the expected in increase in public debt ratios and higher variance of global GDP, both of which raised the probability of default with minimal country differentiation.

Though Bear Stearns was a U.S. bank, its rescue marks the start of a distinct eurozone financial crisis. Three trends are noticeable in the econometric analysis. First, the influence of the identifiable global factors declined. Thus, columns 3-4 of Table 2 show that the correlation between the change in CDS spreads of U.S. banks and the change in eurozone sovereign spreads became insignificant at conventional levels. Second, external factors did play a role in the post-

[12] The importance of global factors for the movements of sovereign spreads during the early phase of the crisis is also documented in Sgherri and Zoli (2009), and Caceres et al. (2010).

Bear Stearns phase: but mainly through the general upward pressure on risk premia after the Lehman bankruptcy, proxied by the dummy for that period.

Table 2: Phases of the crisis prior to the nationalization of Anglo Irish

	(1)	(2)	(3)	(4)
	Pre Subprime	Subprime to Bear Stearns	From Bear Stearns to Anglo Irish	
VARIABLES	Δ.S	Δ.S	Δ.S	Δ.S
LΔ.S	-0.07	-0.04	-0.12	-0.19**
	(0.06)	(0.15)	(0.10)	(0.09)
L2Δ.S	0.04	0.09	-0.28***	-0.32***
	(0.06)	(0.14)	(0.10)	(0.09)
Δ.F	0	0.13	-0.02	0.02
	(0.02)	(0.09)	(0.08)	(0.08)
LΔ.F	-0.01	0.17*	-0.15*	-0.11
	(0.02)	(0.09)	(0.08)	(0.08)
L2Δ.F	0.02	0.13	-0.32***	-0.27***
	(0.02)	(0.09)	(0.08)	(0.08)
L3Δ.F	0.01	-0.05	-0.26***	-0.20***
	(0.02)	(0.09)	(0.08)	(0.08)
D.US_yields	-0.62	-2.51	-7.56**	-4.81
	(0.73)	(3.29)	(3.78)	(3.71)
D.CDS_US_banks	0.06	0.09***	-0.02*	-0.01
	(0.04)	(0.02)	(0.01)	(0.01)
LD.CDS_US_banks	0.03	0.07***	-0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.01)
L2D.CDS_US_banks	0.05	-0.01	0	0.01
	(0.05)	(0.02)	(0.01)	(0.01)
Lehman to Anglo Irish				3.80***
				(1.43)
Constant	0.1	-0.31	0.94	-0.09
	(0.06)	(0.42)	(0.78)	(0.86)
Observations	760	340	440	440
R-squared	0.03	0.44	0.19	0.25
p-value for sum of lagged ΔF=0	0.52	0.15	0.00	0.00

Panel-corrected standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Δ is the difference operator; L, L2, and L3 are the first, second, and third lags respectively.

Third, the big change in the post-Bear Stearns phase was the important role of domestic factors, represented by the market's assessment of financial sector prospects. Note, however, that the coefficient on the contemporary effect is insignificant. Rather, the lagged effects (from the previous three weeks) are statistically significant. In other words, following an observed

weakness in financial sector prospects, sovereign spreads rose with a delay of a few weeks.[13] Adding the post-Lehman dummy, does, as expected, reduce the strength of the relationship between financial sector stress and the rise in sovereign spreads. However, the time pattern of that relationship is unchanged and the statistical relationship remains clear and strong. Thus, sovereign spreads began responding to perceived equity loss in their domestic banks. This period is also characterized by increased differentiation in spreads across countries. This can be explained by differences in the size of domestic financial shocks, as well as by the interactions between financial shocks and countries' characteristics as analyzed in section VI.

Bear Stearns, therefore, marked an important turning point in the crisis as seen through the lens of eurozone sovereign spreads. The debate on whether or not Bear Stearns should have been bailed out has hinged on the risk of moral hazard— critics have warned that bank managers will become even more irresponsible while proponents of the rescue have been focused on the stability of the financial system. Even as that debate plays out, the data show that there was an immediate impact. The implicit assumption that systemically-important banks would typically be bailed out was converted into an explicit and close tie between banks and the dynamics of public finance.[14] Interestingly, the Bear Stearns rescue initially generated optimism that the financial sector had become safer and, as Figure 1 shows, sovereign spreads fell.[15] However, that optimism

[13] These results are confirmed also for individual country. The financial indexes and sovereign spreads are not significantly correlated in any country before Bear Stearns, while between Bear Stearns and Anglo Irish lagged changes in the financial indexes predict spreads in all but two countries (these are Finland, where, as discussed below, we would expect the relationship to be weak, and Portugal, where the financial sector was not seen to be a concern during that period). We have also verified that the results are robust to outliers by running median regressions and trimming the tails of the data distribution.

[14] Consistently with this claim, Ejsing and Lemke (2011) document a reduction in the CDS of eurozone banks during this period mirrored by the increase in credit spreads on the sovereigns.

[15] This is consistent with Figure 4 of the model showing that the recapitalization of highly levered financial institutions can actually reduce sovereign spreads by supporting lending and GDP.

lasted briefly. Two months later, by mid-May, 2008, the financial sector was being perceived as increasingly weaker and sovereign spreads were, once again, on the rise.

V. POST-ANGLO IRISH: A NEW DYNAMIC

Following the nationalisation of Anglo Irish in January 2009, sovereign spreads started to decline after a virtually uninterrupted increase in the previous 18 months (Figure 1). While this fall was thereafter reversed for a prolonged and, in some countries, a dramatic rise, the econometric analysis reveals, more importantly, a qualitative evolution of the crisis after the Anglo nationalization. Financial stress no longer preceded the rise in sovereign spreads; rather the two moved contemporaneously.

There are three differences of interest between the Bear Stearns to Anglo and the post-Anglo periods (Table 3).[16] First, from Bear Stearns to Anglo, the coefficients on the first and second lags of the dependent variable are negative and highly significant: the rise in spreads tended to overshoot and then pulled back somewhat over the next few weeks. In the post-Anglo phase this is much less the case. One interpretation is that there was much greater learning going on in the first phase. The market was absorbing information on financial sector losses and relating that to their eventual implication for public debt. This was all new to the market and it is not surprising that there was a tendency to overshoot early in the crisis.

Second, and more importantly, the correlation structure between sovereign spreads and the financial sector index changed markedly after the rescue of Anglo Irish. A weakening of the financial sector was now contemporaneously associated with higher spreads, while the lagged

[16] To facilitate the comparison between the pre and post Anglo Irish periods, we repeat in column 1 of Table 3 the results of column 4 in Table 2.

coefficients of the financial index turned statistically insignificant.[17] How do we interpret these findings? While recognizing that lagged correlations cannot prove causality, we believe the econometric results suggest a plausible and interesting progression of the crisis.

Table 3: The post Anglo Irish phase

	(1)	(2)		(3)	(4)
	From Bear Stearns to Anglo Irish	Post Anglo Irish		From Bear Stearns to Anglo Irish	Post Anglo Irish
VARIABLES	Δ.S	Δ.S	VARIABLES	Δ.F	Δ.F
LΔ.S	-0.19**	-0.11	LΔ.F	-0.13	0.03
	(0.09)	(0.08)		(0.09)	(0.05)
L2Δ.S	-0.32***	0.02	L2Δ.F	-0.03	0.04
	(0.09)	(0.08)		(0.10)	(0.05)
Δ.F	0.02	-1.69***	Δ.S	0.01	-0.02***
	(0.08)	(0.37)		(0.04)	(0.00)
LΔ.F	-0.11	-0.2	LΔ.S	0.03	0.00
	(0.08)	(0.36)		(0.04)	(0.00)
L2Δ.F	-0.27***	0.2	L2Δ.S	-0.02	0.00
	(0.08)	(0.36)		(0.04)	(0.00)
L3Δ.F	-0.20***	0.19	L3Δ.S	0.01	0.00
	(0.08)	(0.36)		(0.04)	(0.00)
D.US_yields	-4.81	-27.69***	D.US_yields	0.7	0.52
	(3.71)	(9.64)		(1.91)	(0.94)
D.CDS_US_banks	-0.01	0.11*	D.CDS_US_banks	0.00	-0.04***
	(0.01)	(0.06)		(0.01)	(0.01)
LD.CDS_US_banks	0.01	0.04	LD.CDS_US_banks	0.01*	0.00
	(0.01)	(0.06)		(0.01)	(0.01)
L2D.CDS_US_banks	0.01	-0.02	L2D.CDS_US_banks	0.00	0.00
	(0.01)	(0.06)		(0.01)	(0.01)
Lehman to Anglo Irish	3.80***		Lehman to Anglo	-1.13	
	(1.43)			(0.79)	
Constant	-0.09	0.49	Constant	-1.31	0.4
	(0.86)	(0.79)		(1.33)	(0.41)
Observations	440	1,200	Observations	440	1,200
R-squared	0.25	0.10	R-squared	0.11	0.17
p-value for sum of lagged ΔF=0	0.00	0.76	p-value for sum of lagged ΔS=0	0.84	0.15

Panel-corrected standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Δ is the difference operator; L, L2, and L3 are the first, second, and third lags respectively.

[17] The change in the correlation structure can be detected also at the level of individual countries. While no country displays a negative contemporaneous correlation between the financial indexes and sovereign spreads prior to Anglo Irish, all of them do afterwards.

Prior to the nationalization of Anglo Irish, the absence of a contemporaneous correlation and the presence of lagged effects suggest that the crisis was primarily driven by financial sector shocks, which were gradually transmitted to the sovereign. These lags are consistent with the theme noted above: markets were still learning about the nature and the size of the crisis, and, in particular, its implication for public debt and growth. The objection to such an inference is that reverse causality may nevertheless have operated. For instance, anticipating weakness in public finances, the market could have perceived a diminished government ability to support banks and hence marked down their equity prices. But such a possibility appears unrealistic: if markets were indeed persuaded that government finances were under greater strain, it is not clear why financial stocks would be marked down before sovereign spreads rose. At the very least, there would be a contemporaneous relationship.

In the spirit of Granger causality tests, we explore this idea further by reversing the regression, with the financial sector equity index as the dependent variable and the lags of the sovereign spreads as explanatory variables. This analysis confirms that sovereign spreads did not predict a change in the financial sector prospects in the Bear Stearns-Anglo phase (column 3, Table 3).[18] Together, then, the evidence suggests that in this phase the news of financial sector developments filtered into a reassessment of the government's fiscal commitments and, hence, into sovereign bond spreads.

After Anglo Irish, the correlation between spreads and the financial index becomes contemporaneous, suggesting a new stage of the crisis. After having driven the increase in spreads from Bear Stearns to Anglo Irish, in this phase, the financial sector was also hurt when greater stress on the sovereign was revealed. The contemporaneous correlation between the

[18] This is the case also for individual countries, with the exception of a weak significance of the second lag in Ireland and the third lag in Spain compensated however by the opposite-sign first lag.

financial sector and the sovereign is also clearly evident when the regression is reversed (column 4, Table 3). It is possible, of course, that growth and other shocks impacted both the financial sector and the sovereign and these were reflected in the contemporaneous correlation. But this possibility also existed before Anglo. Rather, after supporting banks in the previous months, the by now weakened public finances had themselves an adverse impact on the financial sector. The government's ability to support banks had been compromised, and banks' holdings of public bonds became a more serious strain on them. Also higher sovereign spreads meant higher borrowing costs for domestic banks, leading to higher rates charged for investment and, hence, lower investment rates and growth. At the same time, new revelations of banks' weakness raised sovereign spreads. Thus stresses in one domain were quickly transmitted to the other. This feedback loop goes some way towards explaining the rapid rise in spreads in some countries and hence the emergence of a very high degree of country differentiation.

Finally, post-Anglo, we also find a more substantial role for a generalized reevaluation of eurozone risk. Thus, higher risk perceptions of the eurozone, reflected in higher sovereign spreads, were associated with lower U.S. Treasury yields. While countries within the eurozone were being differentiated, the eurozone was itself being perceived as a greater risk.

To provide further perspective on the timing of developments—but also as a test of the robustness of the findings—Table 4 reports on the *monthly* rather than weekly changes in spreads. While the results do not pick up some of the high frequency movements, they reassuringly capture the main narrative. Before the Subprime crisis, the movement in spreads had no evident explanation. From the start of the Subprime crisis to Bear Stearns, global risk was factored into the risk premia paid by eurozone sovereigns. In these monthly regressions, we find that the influence of U.S. banks' CDS spreads is statistically weaker than in the weekly regressions; that influence is absorbed by the U.S. government yield. It is as if the impact from

the CDS spreads reversed relatively quickly, and is, therefore, not evident over the longer, monthly horizon. Instead, global risk is reflected in the flight to safe U.S. treasury bonds picks up the global financial risk. Importantly, in the next phase, the domestic financial sector vulnerabilities, which had no role before Bear Stearns, led the changes in sovereign bond spreads and, thereby, acted to differentiate the evolution of spreads. The Lehman effect is also there as a generalized aversion to risks. Finally, after Anglo Irish, the relationship between financial sector and sovereign vulnerability becomes contemporaneous.

Table 4: Phases as seen through monthly changes in spreads

	(1)	(2)	(3)	(4)
	Pre Subprime	Subprime to Bear Stearns	From Bear to Anglo Irish	Post Anglo Irish
VARIABLES	Δ.S	Δ.S	Δ.S	Δ.S
LΔ.S	-0.04	-0.19	0.18	0.03
	(0.14)	(0.22)	(0.18)	(0.15)
L2Δ.S	0.11	-0.17	0.29	-0.01
	(0.14)	(0.22)	(0.23)	(0.14)
Δ.F	-0.04	0.01	-0.2	-1.48***
	(0.04)	(0.13)	(0.16)	(0.47)
LΔ.F	0.07*	-0.1	-0.35**	0.27
	(0.04)	(0.09)	(0.16)	(0.49)
D.US_yields	-0.53	-10.40**	-3.77	-17.43
	(1.21)	(4.80)	(5.81)	(11.62)
D.CDS_US_banks	0	-0.01	0.01	0.13
	(0.07)	(0.04)	(0.02)	(0.10)
LD.CDS_US_banks	-0.06	-0.03	0.02	-0.03
	(0.08)	(0.03)	(0.02)	(0.09)
Lehman to Anglo Irish			9.18**	
			(4.01)	
Constant	0.26	-0.8	-2.5	1.7
	(0.30)	(1.41)	(2.35)	(2.46)
Observations	150	80	110	270
R-squared	0.06	0.46	0.61	0.20

Panel-corrected standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Δ is the difference operator; L, and L2 are the first, and second lags respectively.

VI. COUNTRY DIFFERENCES

Are the countries across the eurozone affected uniformly by the factors identified above? Or, are there interesting and helpful distinctions across groups of countries? Our theoretical

analysis in section II suggests that the impact of financial shocks on sovereign spreads should be differentiated by the growth prospect and fiscal position of each country. In particular, countries with lower growth potential should be more sensitive to financial sector vulnerabilities; moreover, conditioned on growth potential, a higher public debt-to-GDP ratio should have a bigger impact on spreads. In this section we empirically test the relevance of these model implications.

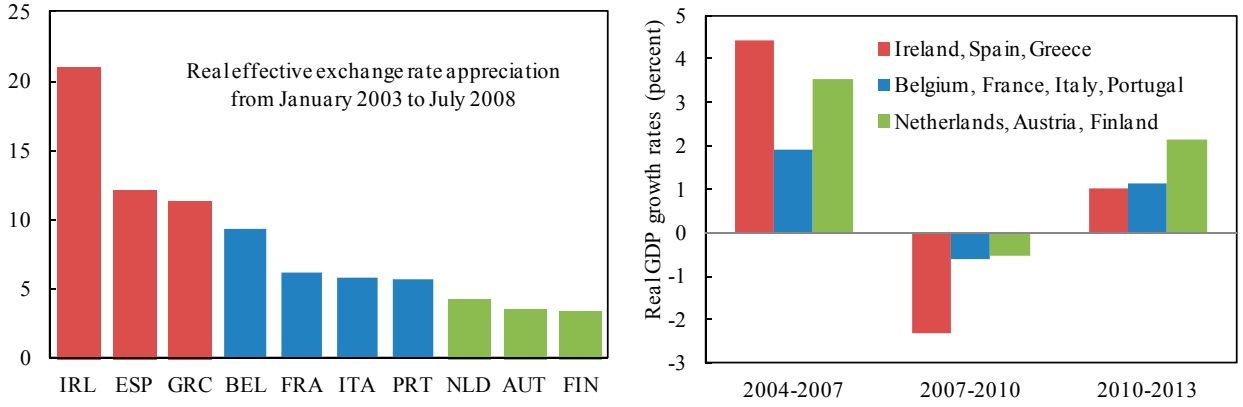
A. Following Bear Stearns: Spotlight on Countries' Loss of Competitiveness

In order to assess the growth potential of eurozone countries on the onset of the financial crisis, we focus on a measure of their competitiveness. Figure 9 is the starting point: its left panel shows the appreciation of the real effective exchange rate from January 2003, near the bottom of the previous cycle to July 2008, near the peak. Ireland had the largest appreciation, followed by Spain and Greece. At the other end, the Netherlands, Austria, and Finland experienced the most modest appreciations. The appreciation of the exchange rate over the previous cycle has an important bearing on how the economy will behave during the next cycle and hence on the short-term and medium-term growth outlook.[19] This conjecture is supported in the right panel of Figure 9. After very high growth prior to the crisis fueled by credit expansion, the countries with the largest appreciation experienced the most severe GDP contraction and have the lowest growth prospects. Our model suggests that it is exactly in these countries where the impact of financial shocks on sovereign spreads should have been the strongest. At the other end, Austria, Netherlands, and Finland had the least appreciation, the smallest decline in GDP growth during the crisis, and the highest medium-term projected growth. The middle group of countries was

[19] Instead of this admittedly crude measure, an alternative would be to assess the deviation from "equilibrium exchange rates." However, there are also well-known difficulties in such an assessment.

already growing slowly before the crisis, their decline in GDP growth during the crisis falls in the middle of these eurozone countries, as do their medium-term growth prospects. Thus, we use these country groupings to test if growth prospects did make a material difference to the interaction between financial stress and sovereign spreads.

Figure 9: From high appreciation to low growth prospects



Notice, first, that following the onset of the Subprime crisis but before the Bear Stearns rescue, the patterns are quite similar across countries (columns 1–3, Table 5). As we reported for the full sample of countries, global factors are influential for each of the groups and the domestic financial sector plays a limited role. Moreover, the coefficients on the global factors are close in size. This supports the claim made above that the eurozone sovereign bond markets had come within the ambit of the international financial tensions early on in the crisis, but there was no sense of a eurozone crisis or a tendency towards a differentiation of spreads before Bear Stearns.

Table 5: Country differentiation by loss of competitiveness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Subprime to Bear Stearns			Bear Stearns to Anglo Irish			Post Anglo Irish		
	IRL, ESP, GRC	BEL, FRA, ITA, PRT	NLD, AUT, FIN	IRL, ESP, GRC	BEL, FRA, ITA, PRT	NLD, AUT, FIN	IRL, ESP, GRC	BEL, FRA, ITA, PRT	NLD, AUT, FIN
VARIABLES	Δ.S	Δ.S	Δ.S	Δ.S	Δ.S	Δ.S	Δ.S	Δ.S	Δ.S
LΔ.S	-0.01	-0.1	-0.19	-0.07	-0.32***	-0.15	-0.13	-0.18**	-0.04
	(0.14)	(0.17)	(0.17)	(0.10)	(0.10)	(0.10)	(0.08)	(0.08)	(0.06)
L2Δ.S	0.13	0.16	-0.08	-0.33***	-0.37***	-0.34***	0.02	0	-0.13**
	(0.14)	(0.16)	(0.16)	(0.11)	(0.11)	(0.10)	(0.08)	(0.08)	(0.06)
Δ.F	0.02	0.17	0.14	-0.05	0.18	0.07	-3.50***	-1.03***	-0.53***
	(0.16)	(0.14)	(0.09)	(0.12)	(0.16)	(0.07)	(0.93)	(0.39)	(0.10)
LΔ.F	0.34**	0.22	0.04	-0.25**	0.02	0.06	-0.37	-0.44	-0.03
	(0.16)	(0.14)	(0.09)	(0.12)	(0.16)	(0.07)	(0.94)	(0.38)	(0.10)
L2Δ.F	0.08	0.15	0.14	-0.28**	-0.43***	-0.17**	0.3	0.51	-0.02
	(0.15)	(0.14)	(0.09)	(0.12)	(0.16)	(0.07)	(0.89)	(0.33)	(0.10)
L3Δ.F	-0.26	0.18	-0.06	-0.27**	-0.04	-0.16**	0.86	-0.22	0
	(0.16)	(0.14)	(0.10)	(0.12)	(0.16)	(0.07)	(0.89)	(0.32)	(0.10)
D.US_yields	-3.10	-3.29	-1.50	-8.07	-5.88	-3.44	-43.50**	-25.76***	-9.19***
	(3.48)	(3.63)	(2.81)	(4.93)	(4.06)	(2.68)	(21.21)	(7.42)	(2.21)
D.CDS_US_banks	0.09***	0.11***	0.06***	-0.02	-0.01	-0.01	0.14	0.10*	0.08***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.14)	(0.05)	(0.01)
LD.CDS_US_banks	0.06***	0.11***	0.06***	0	0	0	0.05	0.03	0.03**
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.14)	(0.05)	(0.01)
Lehman to Anglo-Irish				4.74**	3.20**	2.55**			
				(1.90)	(1.46)	(1.03)			
Constant	-0.56	-0.43	-0.15	2.56	1.85	0.9	9.06	5.28**	-0.12
	(0.39)	(0.57)	(0.38)	(1.64)	(1.33)	(0.72)	(5.68)	(2.66)	(0.46)
Observations	102	136	102	132	176	132	360	480	360
R-squared	0.43	0.52	0.47	0.29	0.27	0.31	0.12	0.15	0.36
p-value for sum of lagged ΔF=0	0.57	0.04	0.52	0.00	0.10	0.04	0.63	0.81	0.71

Panel-corrected standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Δ is the difference operator; L, L2, and L3 are the first, second, and third lags respectively.

Once Bear Stearns was rescued, markets placed a special spotlight on domestic financial vulnerabilities. As suggested by the model, in countries with the largest loss in competitiveness and lowest medium-term growth prospects, a weaker financial sector translated into the greatest increase in sovereign spreads. As a reminder, lower growth prospects tend to increase the public debt-to-GDP ratio and make a country more liable to go above the debt threshold following negative surprises. The results, moreover, show that the relationship between financial vulnerability and sovereign spreads moderates smoothly as we move across country groups from

the greatest to the lowest pre-crisis real exchange rate appreciation. To be clear, this relationship remains statistically significant for all country groups—even the countries with the best prospects experienced in a significant manner an increase in spreads when their financial sectors were under stress. However, both the "short-term" impact—reflected in the sum of the coefficients on the F-index—and the "long-term" impact (that accounts for the overshooting reflected in the lagged terms of the sovereign spreads) decline in potency as the competitive and growth position improves.

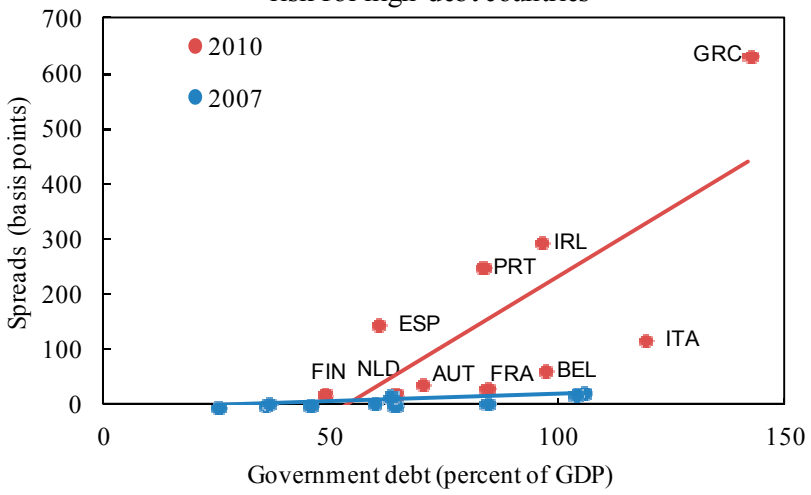
In the post-Anglo Irish phase, the results are both technically reassuring and economically supportive of the hypotheses sketched by our model. The tendency for spreads to overshoot goes down, as if the "learning" phase were over. The correlation between sovereign spreads and the financial sector index becomes contemporaneous for all countries. Our overall results were thus not driven by a select group of countries, but this new phase was experienced throughout the eurozone. What differed was the strength with which it was experienced, being strongest for countries with the weakest competitive and growth prospects. Also, after Anglo Irish, global factors become again significant. As in the previous regressions that did not differentiate between countries, the evolution of U.S. yields absorbs the statistical significance of CDS spreads prior to Bear Stearns. But again, the coefficient on the U.S. yields declines in absolute value from the weakest to the strongest growth prospects, implying that the flight to quality was most sizeable and significant when the countries with the weakest growth prospects were affected.

B. The Role of Public Debt

The impact of financial stress on sovereign spreads should also be shaped by the government's fiscal position. The model revealed that negative shocks to the financial sectors

should translate into a much larger increase in sovereign spreads for countries with high levels of public debt (Figure 6). Consistent with this proposition, is the change in the relation between spreads and government debt during the course of the financial crisis from 2007 to 2010 (Figure 10). The re-pricing of sovereign risk during the financial crisis has indeed been much larger for countries with high public debt to GDP ratios, as emphasized also in von Hagen et al. (2011). Our analysis goes a step further. An implication of our theoretical analysis is that financial shocks should have a larger impact on spreads in countries with higher public debt; moreover, this adverse relationship is further amplified in countries with lower growth potential. Do the econometrics support these hypotheses?

Figure 10: During the crisis, stronger repricing of sovereign risk for high-debt countries



Using again the real exchange rate appreciation as a proxy for weaker growth prospects, the question being posed in the next econometric exercise is whether countries *within* particular competitiveness-loss categories are differentiated by their debt ratios. More specifically, the question posed to the data is whether the impact of financial shocks on sovereign spreads is increasing in the country's *level* of public debt as a percentage of GDP. Moreover, according to the model the magnifying effect of public debt should be stronger in countries that experienced high appreciation and whose growth prospects are therefore weaker. Empirically, this means

augmenting the specification used thus far with terms that interact the domestic financial index with the public debt-to-GDP ratios. As such, country dummies are not included in these regressions.

The results confirm the model implications. Columns 1 to 3 in Table 6 consider the period between Bear Stearns and Anglo Irish. To facilitate the interpretation of the results and their comparability with the post-Anglo phase, we include in the regression only the first lag of the change in the domestic financial index and its interaction with the debt level. The coefficient on the interaction term is negative and highly statistically significant, thus confirming that a higher stock of public debt magnifies the impact of financial shocks on spreads. Furthermore, the relevance of the interaction between debt and financial shocks on countries' risk premia declines monotonically according to the extent of the real exchange rate appreciation. This is clearly visible in Figure 11 that uses the regression estimates to plot the impact of a unitary reduction in the financial index on spreads as a function of the stock of debt. The red and blue dashed lines refer respectively to the countries with high (Ireland, Greece, and Spain) and medium appreciation (Belgium, France, Italy and Portugal) in the period before Anglo Irish. The impact on spreads is larger for countries with high debt and lower growth prospects, exactly as predicted by the model in Figure 7.

The presence of negative synergies between financial shocks, low growth and high debt is detected even more strongly in the post-Anglo phase. In columns 4 to 6, debt is interacted with the contemporaneous change in domestic financial conditions and the estimation results confirm its relevance in the transmission of financial shocks to sovereign spreads, particularly in high-appreciation countries. The continuous lines in Figure 11 are based on the regression estimates in this post-Anglo period. The impact of financial shocks on spreads is now even larger, especially for the countries that experienced the highest appreciation. These results are strongly supportive

of our model implications and of the idea that after Anglo the crisis evolved is a more much sensitive stage where nonlinearities and negative synergies dangerously amplify the effects of shocks.

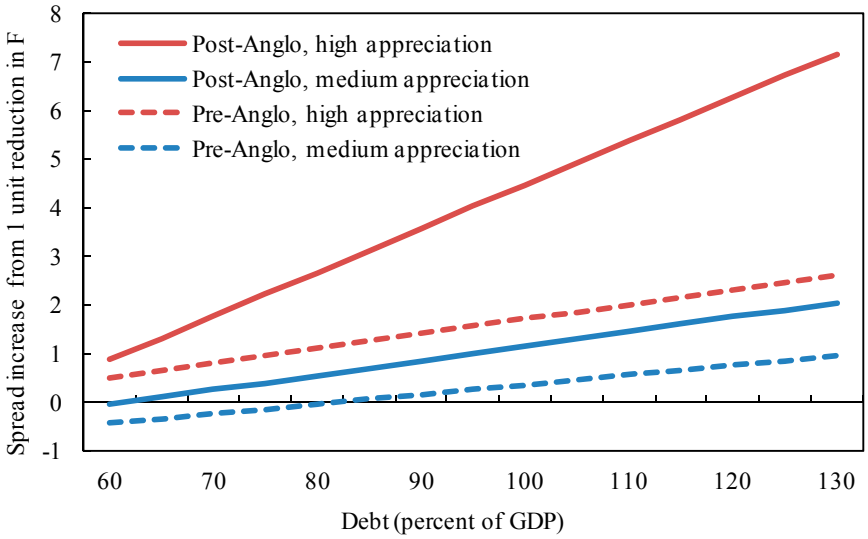
Table 6: The role of public debt

	(1)	(2)	(3)		(4)	(5)	(6)
	From Bear Stearns to Anglo Irish				After Anglo Irish		
	IRL, ESP, GRC	BEL, FRA, ITA, PRT	NLD, AUT, FIN		IRL, ESP, GRC	BEL, FRA, ITA, PRT	NLD, AUT, FIN
VARIABLES	Δ.S	Δ.S	Δ.S	VARIABLES	Δ.S	Δ.S	Δ.S
LΔ.S	-0.05	-0.28***	-0.16	LΔ.S	-0.22***	-0.24***	-0.03
	(0.10)	(0.11)	(0.10)		(0.08)	(0.09)	(0.06)
L2Δ.S	-0.25**	-0.32***	-0.38***	L2Δ.S	0.02	-0.02	-0.12**
	(0.10)	(0.11)	(0.11)		(0.08)	(0.08)	(0.06)
LΔ.F	1.29***	1.64**	-0.02	Δ.F	4.53*	1.85	-0.65
	(0.27)	(0.76)	(0.85)		(2.42)	(1.40)	(0.95)
LΔ.F*Debt/GDP	-2.89***	-2.16**	0.13	Δ.F*Debt/GDP	-9.15***	-2.92**	0.14
	(0.59)	(1.10)	(1.38)		(3.50)	(1.34)	(1.41)
Debt/GDP	2.34	2.24	3.00*	Debt/GDP	7.53	-2.95	0.52
	(1.59)	(1.90)	(1.80)		(7.40)	(3.62)	(1.83)
D.US_yields	-7.51	-5.06	-3.14	D.US_yields	-28.63	-22.80***	-10.09***
	(4.73)	(4.28)	(2.89)		(21.47)	(7.83)	(2.37)
D.CDS_US_banks	-0.02	0	-0.01	D.CDS_US_banks	0.18	0.11**	0.08***
	(0.01)	(0.01)	(0.01)		(0.13)	(0.05)	(0.01)
LD.CDS_US_banks	0	0.01	0.00	LD.CDS_US_banks	0.07	0.08	0.03**
	(0.01)	(0.01)	(0.01)		(0.13)	(0.05)	(0.02)
Lehman to Anglo-Irish	5.12***	3.31**	3.09***				
	(1.79)	(1.50)	(1.12)				
Constant	-0.88	-1.37	-1.26	Constant	-2.34	3.9	-0.43
	(1.14)	(1.43)	(0.98)		(4.57)	(4.09)	(1.01)
Observations	132	176	132	Observations	309	412	309
R-squared	0.39	0.24	0.24	R-squared	0.17	0.16	0.39

Panel-corrected standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Δ is the difference operator; L, and L2 are the first, and second lags respectively.

Figure 11: The impact of a reduction in the F index on spreads is larger in low-growth and high-debt countries



As with any taxonomy of countries, the groupings discussed here does not do justice to the further more graded and nuanced variations. Nevertheless, the results do reveal an important pattern: where external competitiveness has been lost, and, hence, growth potential has been compromised, domestic weaknesses took on a more worrying role. As such, although the crisis was global, domestic vulnerabilities came to matter. Within the large and moderate competitiveness loss groups, countries were differentiated both by the developments in their domestic financial sectors and by the interaction with their public debt ratios. These regressions help, for example, to differentiate Ireland and Greece, two countries with the largest increases in sovereign spreads. In Ireland, the proximate correlate of the increase in spreads has been the weakening of the financial sector. In Greece, where the markets have been less pessimistic about the financial sector, spreads in the post-Bear Stearns phase have been driven to a greater extent by a reevaluation of the prospects for servicing high levels of public debt and the amplifying effects on financial stress. Similarly, the Italian rise in spreads is better accounted for when the differentiation by debt ratios is incorporated into the analysis. In countries with the least loss of

competitiveness, financial vulnerability has had a statistically-significant effect but the economic effects are smaller; and the markets have not focused on their public debt dynamics.

VII. CONCLUSIONS

We use the rise and dispersion of sovereign spreads to tell the story of the emergence and escalation of financial tensions within the eurozone. After the introduction of the euro in January 1999, the fall in risk premia on the bonds of eurozone sovereigns compressed them into a narrow range across the member countries (Ehrmann et al., 2011) within which short-term movements were essentially random. Markets judged the probability of default by eurozone sovereigns to be negligible. That changed with the start of the Subprime crisis in July 2007, at which point a eurozone crisis took shape as an offshoot of the global crisis. But soon thereafter, starting in March 2008 with the rescue of Bear Stearns, the presumption that sovereigns would ride to the rescue of their domestic banking sector, linked the projection of a eurozone member's sovereign debt to its domestic financial vulnerabilities: sovereign spreads now rose in response to perceived weakness of domestic banks. And when the fiscal space to deal with those vulnerabilities narrowed, as appears to have occurred around the nationalisation of Anglo Irish, the fates of financial sectors and sovereigns became intertwined.

Consistent with the stylized model presented, financial shocks had a more severe impact on sovereign spreads where public debt-to-GDP ratios were higher—and this effect became more pronounced after the rescue of Anglo Irish by when growth and public debt projections had worsened. These feedback loops can also act in a positive direction. The immediate aftermath of the Anglo Irish nationalisation brought a short period of relief. Financial prospects seemed to improve and so did those of the sovereign. However, with the untenable nature of the Anglo Irish

rescue becoming evident and the Greek fiscal concerns in Fall 2009, a rapid and virtually relentless increase in sovereign and banking vulnerabilities ensued.

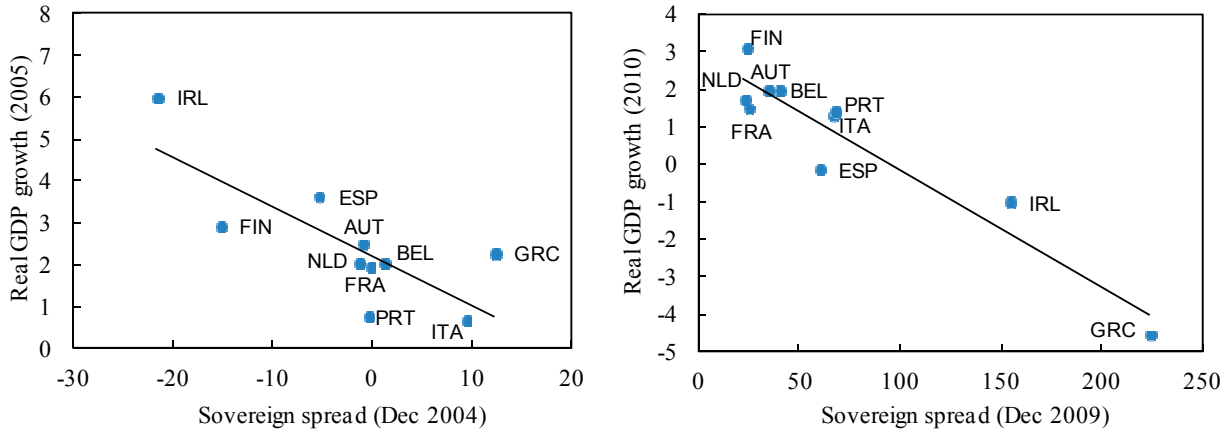
The evolving assessment of global growth potential as well as the differences in growth prospects across countries played a key role in influencing these dynamics. The rescue of Bear Stearns occurred during a period of worsening growth prospects; hence, the expected costs of bank bailout costs increased just when the weaker growth outlook was already threatening to push up debt ratios. The process intensified after the Lehman bankruptcy as markets further downgraded the prospects of the financial sector, which, in turn, reinforced the likelihood of weaker growth and higher public debt. Across countries too, we find strong evidence that countries that entered the crisis with weaker growth prospects and higher public debt-to-GDP ratios were more likely to be hurt by domestic financial sector stress.

Until the nationalization of Anglo Irish, the nature of crisis was rather straightforward, primarily driven by financial shocks. Policies targeted to supporting the financial sector had therefore a clear potential to alleviate the crisis. Such policies carried the risk of perpetuating the incentives of bankers to behave irresponsibly in the future, and were especially prone to errors in judgment on the scale of help needed. The size and scope of the guarantees provided by the government to ensure liquidity for banks has indeed proved controversial. And an orderly winding down of Anglo Irish, rather than its nationalisation, would certainly in retrospect have been the superior course of action. But most countries had at the time enough fiscal space to finance these interventions, and the reductions in spreads after the rescue of Bear Stearns and even after the nationalization of Anglo, tended to support such activism.

The dynamics of the crisis and the policy options available, however, changed markedly during 2009. The contemporaneous association between spreads and domestic fiscal stress suggests that the crisis entered a full-blown phase where sovereign spreads, the health of the

financial sector, and growth prospects supported a mutually reinforcing regime.[20] The financial sector ceased to be the clear driver of the crisis. Rather, the crisis took on a larger scope involving fiscal and competitiveness problems. Fiscal problems, in turn, had feedback effects. Higher sovereign spreads increased the borrowing costs of domestic banks and generated capital losses on the holdings of public debt, contributing to lower growth. Figure 12 shows indeed that higher sovereign spreads are strongly correlated with future lower growth. With the fiscal room for intervention much more limited, the eurozone economies have moved to a new, more stressed regime from which there is no quick return.

Figure 12: Higher sovereign spreads anticipate lower growth



With pressure to consolidate, new sources of growth will need to be identified, but achieving higher growth will take time. In the meantime, consolidation pressures will lower short-term growth prospects. To the extent that markets "penalize" slow consolidation, the short-term challenge will only become worse. Thus, while in the pre-crisis phase, the policy laxity fostered by markets was ultimately harmful, the stringency demanded now may delay the return to normalcy. Monetary policy faced a challenge even before the crisis. Real interest rates were clearly too low in some countries. But now they may be too high. Moreover, where sovereign

[20] A similar argument is presented in Acharya et al. (2011).

spreads are high, the ability of monetary policy to lower the rates paid by businesses and households may be limited.

Thus, despite the changed circumstances, the greatest policy leverage likely still lies in dealing with the legacy of the financial crisis. Here, our analysis suggests that additional fiscal costs for strengthening banks can pay off through higher growth. This immediate challenge needs to be dealt with, quite independently of regaining competitiveness, which is a longer-term process. The form that bank support takes and the most efficient way of achieving that goal remain matters of active debate. Our point simply is that this must remain the priority even now when other competing claims demand attention. Equally, the crisis has shown that delays are costly, and prompt (although deliberate) action is needed. Whether these challenges will elicit the necessary and pragmatic policy responses remains a matter of more than academic interest.

References

Acharya, Viral V, Itamar Drechsler, and Philipp Schabl, 2011, "A Pyrrhic Victory? – Bank Bailouts and Sovereign Credit Risk", *NBER Working Paper* 17136.

Beck, Nathaniel and Jonathan N. Katz, 1995, "What to do (and not to do) with Time-Series Cross-Section Data," *The American Political Science Review* 89(3): 634-647.

Bolton, Patrick and Olivier Jeanne, 2011, "Sovereign Default Risk and Bank Fragility in Financially Integrated Economies", *IMF Economic Review*, forthcoming.

Caceres, Carlos, Vincenzo Guzzo, and Miguel Segoviano, 2010, "Sovereign Spreads: Global Risk Aversion, Contagion or Fundamentals?", *IMF Working Paper* 10/120.

Codogno, Lorenzo, Carlo Favero, Alessandro Missale, 2003, "Yield Spreads on EMU Government Bonds," *Economic Policy* 18(37): 503-532.

Eaton, Jonathan and Mark Gersovitz, 1981, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Studies* 48(2): 289-339.

Ehrmann, Michael, Marcel Fratzscher, Refet S. Gürkaynak, and Eric T. Swanson, 2011, "Convergence and Anchoring of the Yield Curves in the Euro Area", *The Review of Economics and Statistics*, 93(1): 350-364.

Eichengreen, Barry, and Ashoka Mody, Milan Nedeljkovic, and Lucio Sarno, 2009, "How the Subprime Crisis Went Global: Evidence from Bank Credit Default Swap Spreads," *NBER Working Paper* 14904.

Ejsing, Jacob and Wolfgang Lemke, 2011, "The Janus-Headed Salvation: Sovereign and Bank Credit Risk Premia during 2008-2009", *Economic Letters*, 110: 28-31.

Gennaioli, Nicola, Alberto Martin and Stefano Rossi, 2011, "Sovereign Default, Domestic Banks and Financial Institutions", Manuscript, CREI, Universitat Pompeu Fabra.

Pagano, Marco and Ernst-Ludwig von Thadden, 2004, "The European Bond Markets Under EMU," *Oxford Review of Economic Policy* 20(4): 531-554.

Reinhart Carmen M. and Kenneth S. Rogoff, 2009, "Banking Crises: An Equal Opportunity Menace", *NBER Working Paper* 14587.

Reinhart Carmen M. and Kenneth S. Rogoff, 2011, "From Financial Crash to Debt Crisis", *American Economic Review* 101(5):1676-1706.

Reinhart, Vincent, 2011, "A Year of Living Dangerously: The Management of the Financial Crisis in 2008", *Journal of Economic Perspectives* 25(1): 71-90.

Sgherri, Silvia and Edda Zoli, 2009, "Euro Area Sovereign Risk During the Crisis", *IMF Working Paper* 09/22.

Von Hagen, Jürgen, Ludger Schuknecht and Guido Wolswijk, 2011, "Government Bond Risk Premiums in the EU Revisited: The Impact of the Financial Crisis", *European Journal of Political Economy* 27: 36-43.