The Economic and Social Review, Vol. 50, No. 3, Autumn 2019, pp. 529-556

POLICY PAPER

Have Irish Sovereign Bonds Decoupled from the Euro Area Periphery, and Why?

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Abstract: This paper considers whether Ireland's sovereign bonds have decoupled from other Euro Area sovereigns (Portugal, Italy, Greece and Spain – the 'periphery') with whom it was categorised during the sovereign bond market crisis of the early 2010s. Having initially reviewed yield and sovereign stress indicator data, two econometric methodologies (those of Gibson *et al.*, 2017, and Diebold and Yilmaz, 2012) are applied to long-term bond spread data for the Euro Area 11 countries for the period March 2005 to July 2018. These indicate a shift since around mid-2013 in the Irish sovereign bond market's relationships within the Euro Area, with a higher correlation and interaction with developments in 'core' Member States' markets over those of the periphery Member States now occurring. An econometric model of the determination of the Irish sovereign bond yield spread shows the trend decline in its value since the early 2010s owing to both an improvement in the sustainability of the fiscal position and undue market pessimism dissipating over time. The paper concludes that a combination of emerging fiscal and financial sector vulnerabilities can lead quickly to an upsurge in the sovereign's market bond yields that is justified by these developments and which can be added to by sudden movements in market sentiment from undue optimism to undue pessimism. In such an environment, maintaining a sustainable fiscal path, adhering to fiscal rules, and fostering a resilient banking system are the best means by which the sovereign can help to keep its bond yields from being priced too highly and from varying substantially over time.

Acknowledgements: The authors would like to thank two referees for their comments. The views in this paper are, nevertheless, those of the authors and do not necessarily reflect those of the Central Bank of Ireland, European System of Central Banks, or the Economic and Social Research Institute.

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I INTRODUCTION

The period since 2008 has been one of considerable interest to observers of Euro Area sovereign bond markets. The introduction of the euro on 1 January 1999 was followed by nine years of relatively tranquil activity in those markets, mainly characterised by "convergence trading" as investors bought the bonds of peripheral euro Member States in the expectation of their yields declining to Germany's levels (Arghyrou and Kontonikas, 2012). Signs of distress started to emerge in late 2008 as a global financial crisis took hold in the wake of the collapse of Lehman Brothers. While Euro Area sovereign bond markets in general seemed to benefit from a "flight to quality" from other asset classes in the immediate aftermath of the global financial shocks of 2008 (Caceres *et al.*, 2010), difficulties in some Member States' banking sectors emerged soon after and caused stress in sovereign bond markets. Acharya *et al.* (2011) observe a rise in sovereign Credit Default Swap (CDS) values in the closing months of 2008, indicating, in their view, a shift in default risk from the banking sector to the sovereign. Mody and Sandri (2012) identify the nationalisation of Anglo Irish Bank by the Irish government in January 2009 as particularly important, with financial shocks having greater influence on sovereign bond markets thereafter.

For many analysts, the Euro Area sovereign bond crisis did not become distinct from the more general financial turmoil of the period until late 2009 and early 2010. Caceres *et al.* (2010) see country-specific factors coming to the fore in their influence on Euro Area sovereign bond markets in October 2009. Manasse and Zavalloni (2012) consider the following month, November 2009, when Greece revised its projected fiscal deficit for that year from 5 per cent to 12.7 per cent of GDP, as a critical date in financial markets starting to focus more closely on country-specific developments. Whereas in the early stages of the global financial crisis, Euro Area national sovereign bond markets in general seemed to benefit from adverse developments in other asset classes, idiosyncratic shocks, or shocks common only to a small group of countries, now became more prominent (Garcia-de-Andoain and Kremer, 2017). Arezki *et al.* (2011) report sovereign rating downgrades starting to have statistically significant effects beyond the particular Euro Area country receiving the changed rating around that time. Drago and Sallo (2016) find both upgrades and downgrades affecting the particular country regraded, but only downgrades having a spillover effect to other countries.

With an increased focus by financial markets on country developments, a dichotomy in behaviour between two sub-groups of the Euro Area 11 Member States arose during the sovereign bond crisis, with one group representing the 'core' (Germany, France, Belgium, the Netherlands, Austria and Finland) and the other the 'periphery' (Portugal, Ireland, Italy, Greece and Spain). Peripheral Member States saw their sovereign bonds' spreads over the core widen as financial markets became concerned at the sustainability of their fiscal positions, including from the

effects of deteriorating banking sectors in some of those countries. Dajcman (2015) finds strong bidirectional Granger causality between a selection of core and peripheral sovereign bond markets prior to the sovereign debt crisis with core and peripheral markets then decoupling from one another during the crisis. Among the effects of this division of Member States into two distinct groups, Beetsma *et al.* (2013) observe bad news in a periphery Member State having stronger negative effects on other periphery Member States than on core Member States. Notwithstanding difficulties in defining contagion, the evidence on whether it arose among Euro Area sovereigns during 2009 and the early 2010s is mixed but leans more towards pure contagion arising only sporadically and higher levels of interaction being more common (Beirne and Fratzcher, 2013, Claeys and Vasicek, 2014, Cronin *et al.*, 2016).[1]

Starting in the first half of 2012, a series of policy initiatives seemed to have a positive influence on Euro Area sovereign bond markets with a re-engagement of those markets – both core and periphery Member States – with one another evident from the middle of that year onwards (Cronin, 2014). Those policies included: the second Greece bailout in March 2012; the endorsement of the concept of banking union and acknowledgement of the possibility of direct capitalisation of banks by the ESM in June; ECB President Draghi's "whatever it takes … to preserve the singleness of our monetary policy" speech in July; and the adoption of the Outright Monetary Transactions (OMT) programme by the ECB in August. Garcia-de-Andoain and Kremer (2017) indicate the pronounced influence of country-specific shocks declining after mid-2013, and greater interaction between sovereign bond markets occurring subsequently.

This paper primarily considers the Irish sovereign bond market's relationships to other Euro Area markets since 2012. The main focus is on Irish sovereign bonds relationships to two groups: the other four periphery Member States (Portugal, Italy, Spain, and Greece) with which it was categorised during the crisis and the aforementioned core country grouping. The evidence presented in the following sections indicates Ireland to have become decoupled from the periphery grouping since the crisis with substantially greater interaction occurring between Ireland and the core Member States.[2] In the later part of the paper, an econometric model of

[1] The literature tends to distinguish between "fundamentals-based contagion" and "pure contagion". The former arises where there is an increased correlation between two or more markets owing to fundamental links between them through the real economy or financial sector. Transmission of shocks in this manner is often referred to as "spillover" or "interdependence". Pure contagion arises when increased cross-market correlation arises after these fundamental or common links are accounted for.

[2] This change in sovereign bond relationships was suggested by market commentators from as early as October 2013 when Ireland's ten-year yields were deemed to have "decoupled from fellow bailout struggler Portugal and are trading at more competitive levels than either Spain or Italy" (Smyth, 2013). In June 2015, market analysts noted that Irish long-term bond yields remained broadly unchanged in response to adverse developments surrounding Greece, while the yields on Portugal, Italy and Spain bonds rose; this was attributed to improvements in the Irish economic and fiscal position (Burke-Kennedy and Taylor, 2015).

the determination of Irish sovereign bond spreads provides an explanation of why this has come to pass.

Ireland's relationship with other Euro Area sovereign bond markets is addressed in three ways, and in separate sections, below. Initially, long-term (ten-year) bond yields and a sovereign stress measure provided by the ECB (the Composite Indicator of Sovereign Stress (CISS)) are plotted from 2000/2007 onwards and discussed in Section II. These charts suggest a disengagement of Irish sovereign bonds from the other peripheral Member States' bonds and a closer alignment with core Member States' bonds in recent years. In the following two sections, econometric techniques are applied to long-term bond yield spreads to shed further light on Ireland's relationship to the other Euro Area sovereign bond markets. A time-varying correlation methodology (combining a Bayesian stochastic volatility estimator by Chan and Grant, 2016, with a covariance compilation approach proposed and tested by Gibson *et al.*, 2017) is utilised in Section III, while Diebold and Yilmaz's (2009; 2012) spillover index methodology is applied to the same dataset in Section IV. These models, estimated over the period March 2005 to July 2018, shed light on sovereign bond market behaviour during the pre-crisis and crisis periods, which is of interest in itself as well as providing a background to assessing post-crisis developments. The summary findings of the econometric analysis in Sections III and IV are that, following a decline in its correlation and spillover values with other Euro Area sovereign bond markets (and in particular, the core grouping) during the sovereign bond crisis of 2009-2012, Ireland's relationship to other sovereign bond markets rebounded to close to pre-crisis levels thereafter. Moreover, its interaction with the core Member States has been much stronger than with the periphery countries in recent years.

With financial data pointing to Irish sovereign bonds having decoupled from the periphery and having become more engaged with the core Member States of late, the question arises as to whether this reflects an improvement in the sustainability of the Irish fiscal position and/or other factors. In Section V, the results of an econometric model of the determination of Irish sovereign bond spreads, drawing on De Grauwe and Ji (2012; 2013), are presented. These indicate that the sharp rise in the risk premium on Irish government bonds during the sovereign bond crisis was dependent in large part on the bank guarantee enacted by the Irish government at end-September 2008. Over the next few years, the market was overly pessimistic towards Ireland, such that the rise in the observed spread was greater than the increase warranted by the effects of the guarantee and the deterioration in the fiscal position. After 2011, the spread declined as both fiscal and banking conditions improved and undue pessimism dissipated. Since early 2017, the model estimates indicate the observed and fundamental-based spread being of broadly similar value and at their lowest levels in ten years.

Section VI concludes by discussing the policy implications of these findings. The empirical analysis in the paper shows the potency of financial markets: their

capacity to react sharply, and to over-react, to both deteriorations and improvements in fiscal fundamentals, and to move quickly in shifting a sovereign like Ireland between different country groupings over time. In this environment, government setting out and adhering to a budgetary programme that establishes a sustainable path for the public finances is the best means of regaining or maintaining market confidence in the sovereign. Avoiding financial sector imbalances that may lead to significant contingent liabilities on behalf of the sovereign is also important in retaining market confidence.

II PRELIMINARY ANALYSIS

The three panels of Figure 1 show ten-year sovereign bond yields for the Euro Area 11 Member States over the period from January 2000 to end-July 2018, with Ireland yields shown in each panel.[3] The panels, in common with most of the subsequent charts, have shaded areas representing an *a priori* dating of the Euro Area sovereign bond crisis chosen by Cronin and Dunne (2019a). It extends from November 2009, when Greece indicated a sharp upward revision to its deficit projections, to August 2012, when OMT was adopted and Draghi's "whatever it takes" speech had been delivered. This shaded area serves as a reference point for the discussion that follows, including of the econometric results in later sections (in Section V, which uses quarterly data, the shaded area covers Q4 2009 to Q3 2012). A vertical line is also added at end-September 2008 (Q4 2008 in Figures 7 and 8) to indicate when the Irish government agreed to provide a broad guarantee of Irish domestic banks, covering their liabilities for two years thereafter, and with the intention of recapitalising them to allow them to continue lending. The analysis in Section V indicates this to have exerted a critical influence on subsequent Irish sovereign yield values.

Common to all three panels in Figure 1 is the lack of any relative variation in yields over time and across countries up to mid-2008. There is some upward movement in yields for the periphery Member States in late 2008 but this is small compared to what transpires during the crisis period broadly indicated by the shaded area in the panels. Both panel (a), where Greece is included among the five periphery countries, and panel (b), where it is excluded to assist visual inspection of the other four, show sharp rises in yields in 2010 and 2011. In contrast, the core Member States in panel (c) see their bond yields decline at first before experiencing a mild increase. After this blip, their sovereign yields continue to fall over time. The sovereign yields of the individual periphery Member States reach a peak

[3] The Member States, with each's country mnemonic in brackets, are Austria (AT), Belgium (BE), Germany (DE), Greece (EL), Spain (ES), Finland (FI), France (FR), Ireland (IE), Italy (IT), the Netherlands (NE) and Portugal (PT).

between mid-2011 and early 2012 before declining thereafter. Panels (a) and (c) show the five periphery Member States' bond yields and those of the six core Member States declining thereafter up to end-2016 with only Greece and Portugal experiencing a temporary upward shift in yields during that period.

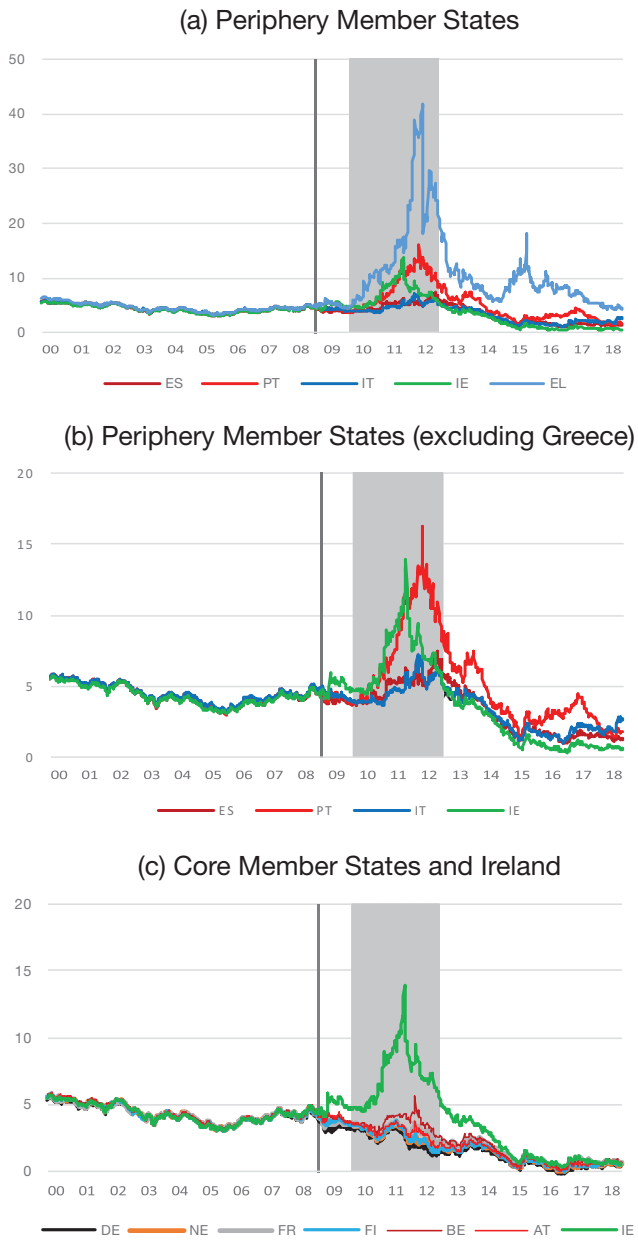
Panels (b) and (c) compare Ireland's yields over time to those of the periphery Member States, excluding Greece, and the core Member States, respectively. By April 2015, its yields are below those of the other periphery countries and its spread over the core Member States has declined to 50 basis points or less. This compares to less than five years previously when its spread over Germany exceeded 11 percentage points during July 2011. Ireland's bond yield then moved from a position of being the second highest among the Euro Area 11 at times in 2011 to being closer in value to Germany's than that of Portugal, Italy, Greece and Spain by end-2015. This situation has been broadly maintained since.

Figure 2 also illustrates Ireland's favourable bond market performance of recent years. It shows composite indicator of sovereign stress (CISS) values, as developed by Hollo *et al.* (2012) and calculated by the ECB on a monthly basis from January 2007 onwards. This indicator measures the level of stress in sovereign bond markets, for each Member State and for the Euro Area as a whole, using two-year and ten-year bond yield spreads over the euro swap interest rate, realised yield volatilities, and bid-ask bond spreads. Those data are aggregated into composite indicators based on time-varying cross-correlations between individual stress indicators, with the calculated stress level being in a range of 0 to 1.

The edges of the shaded area in Figure 2 represent the highest and lowest CISS values among the Euro Area 11 Member States for each month. Ireland's CISS values were amongst the highest of those countries between September 2010 and August 2011 before falling rapidly thereafter. Ireland had the lowest CISS value among the Member States by March 2015 and has remained close to that standing since. The range of CISS values across Member States declined after mid-2015 and had reached a narrow range by late 2017.

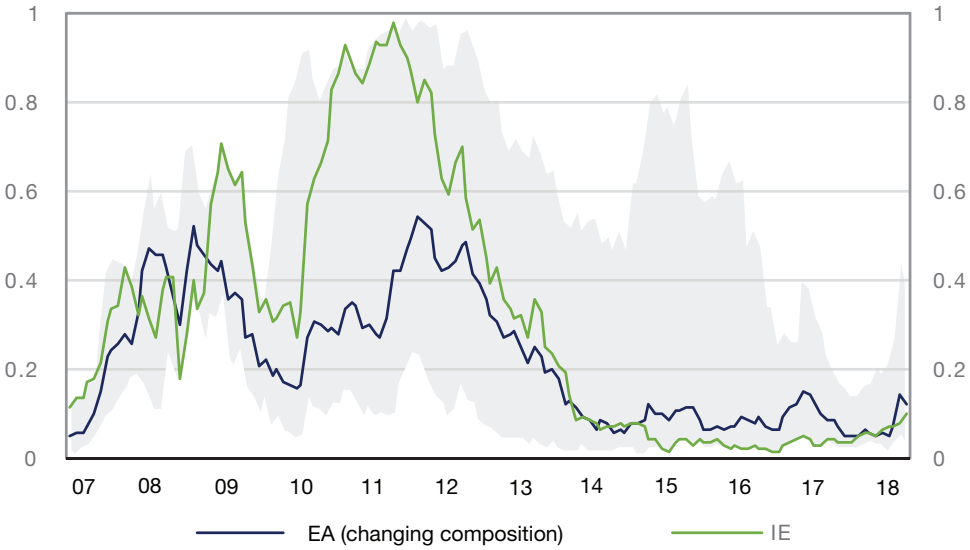
The data in both Figures 1 and 2 then suggest Ireland moved from a position of being one of the most stressed Euro Area sovereigns in 2011 to being closer in behaviour to that of the core Member States in 2015 and later. In the next two sections, econometric techniques are used to examine Ireland's relationship to both groups more formally.

Figure 1: Sovereign Bond Yields, Ten-Year Maturity – Euro Area 11 Member States (January 2000 – July 2018)



Source: Thomson Reuters Datastream.
Note: Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

Figure 2: Composite Indicator of Sovereign Stress (January 2007- July 2018)



Source: ECB Statistical Data Warehouse.
Note: The Composite Indicator of Sovereign Stress aims to measure stress levels in Euro Area (EA) sovereign bond markets and in individual Member States, including Ireland (IE). The shaded area reflects the range of indicator values in each month among the following Member States: AT, BE, DE, EL, ES, FI, FR, IE, IT, NE, PT.

III CONDITIONAL CORRELATION ANALYSIS

Measuring how correlation values between pairs of sovereigns vary over time is one means of assessing the level of engagement between them, with an increased correlation suggesting a stronger relationship arising and a lower value to some disengagement from one another. Unconditional correlation estimates, however, have the disadvantage of being biased upwards during periods of high volatility in asset returns, such as often arise during financial crises. Consequently, methods that address this have to be applied to datasets such as that here, where day-to-day and week-to-week changes in bond spreads are used, and where periods of relative calm and of turbulence arise.

Conditional correlation methodologies (e.g., the DCC-GARCH model of Engle, 2002) are one means of accounting for the time-varying behaviour of financial data. In this section, a recent approach to compiling covariance measures from conditional variance estimates, suggested and tested by Gibson *et al.* (2017), is applied to a dataset comprising changes in the spreads of the ten-year sovereign bond yield of each of the Member States over EONIA for the period 28 March 2005

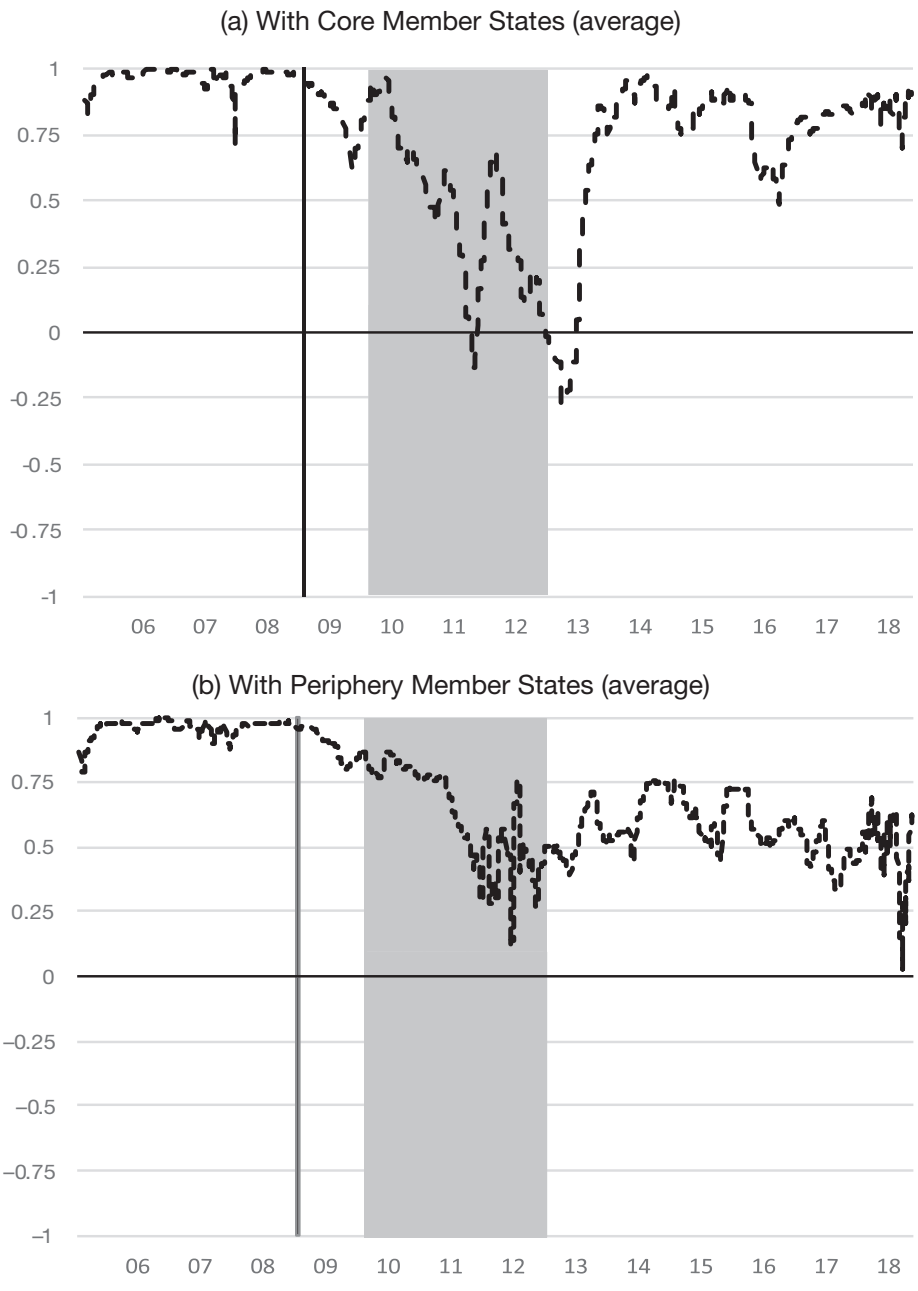
to 31 July 2018.[4] Since the simulation approach is time-consuming, weekly yield spread changes (and the relevant sums of pairs of such changes) are used up until 20 October 2017, and daily observations thereafter up to 31 July 2018. The daily data provide more clarity concerning how each of the peripheral country sovereign yields responded to political developments in Italy towards the end of the sample when Ireland's greater attachment to the core is apparent. The start of the daily observations coincides with the re-listing of Monte Dei Paschi Di Siena shares (which helped to identify the cost of bank bailouts to taxpayers). Those data cover a period when the political legacy from such bank bailouts and other fiscal matters became the main feature driving Italian sovereign yields after the general election in that country in March 2018. (The technical details of the time-varying correlation methodology are outlined in Appendix A).

Having estimated Ireland's correlations with each of the other ten Member States by these means, panels (a) and (b) of Figure 3 show its average correlations to the six core Member States and to the four periphery countries, respectively. Prior to the 2009-2012 crisis, both groups had high correlation values to Ireland. Those between Ireland and the core then declined sharply during the crisis, tipping into low, negative values for a short period in the summer of 2011 before recovering briefly and then falling in value once more. From a correlation value of -0.28 in December 2012, the correlation between Irish and core sovereign bonds rose to 0.9 or greater some 12 months later. Apart from a temporary decline during 2016, the Ireland-core correlation value remained at just a little below pre-crisis levels thereafter.

The average correlation values between Ireland and the four periphery countries behave somewhat differently. Like the Ireland-core relationship, there was a decline in correlation values during the crisis, but to a lesser extent with no negative correlations arising. After mid-2012, the recovery in correlation values was much less than what occurred between Ireland and the core. For the period between June 2013 and July 2018, the correlation values between Ireland and the core are always higher than between Ireland and the periphery, with an average difference of 0.26 arising.

[4] A shorter time series sample was chosen given that much of the 2000-2008 sample involved little variation in yield values. The pre-2008 sample included, however, is long enough to show sovereign bond market behaviour during that era.

Figure 3: Ireland – Mean Correlation to Others



Source: Authors' estimations.
Note: Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

IV SPILLOVER ANALYSIS

Diebold and Yilmaz (2009; 2012) provide a spillover index approach to measuring the interconnectedness of financial markets. It uses forecast error variance decompositions from vector auto-regressions (VARs) to quantify the relative importance of own-market and cross-market shocks to a financial variable modelled within a system of variables. A total spillover index (TSI) and its components can be presented, with a lower (higher) TSI indicating less (more) interaction occurring on average across the markets being studied. The index approach is particularly informative when estimated on a rolling-window basis, as variations in interconnectedness can then be assessed over time. The Diebold-Yilmaz methodology has been applied previously to Euro Area sovereign bond markets by Claeys and Vasicek (2014), Conefrey and Cronin (2015) and Fernandez-Rodriguez *et al.* (2016).

The variant of the Diebold-Yilmaz approach used here follows their 2012 article where generalised forecast error variance decompositions are employed. In this case, there is no *a priori* ordering imposed on the variables that would restrict shocks in some variables, having no effect on other variables in the initial period. The same dataset employed in the correlation analysis, albeit with day-to-day spread changes throughout the sample, is also used here. The VAR lag length is 4 and the forecast horizon for the error variance decompositions is 10 days (the charts in Appendix B show that the rolling TSI is insensitive to these choices of lag length and forecast horizon).

Table 1 shows the full sample (25 March 2005 to 31 July 2018) estimate of the TSI and its components. Looking at the row for Ireland, the on-diagonal entry indicates that prior shocks in its own past yields (own-shocks) account for 16.2 per cent of its development over time. The remainder is owing to the other ten bond markets, with the contribution from each of those occurring in a relatively narrow range of 7.7 per cent (Portugal) to 10.1 per cent (Belgium), with the exception of Greece, which has a spillover of 0.4 per cent. Each country row can be read in a similar manner. The most notable feature of the table is the extent to which own shocks (at 82.5 per cent) account for Greece's decomposition. The last column of the table (marked "From others") adds up the cross-shocks percentages in each country row and the TSI entry of 79.4 per cent at the bottom of the column is the average of those across all Member States. The country columns capture the extent to which shocks from each particular Member State spill over to others and the row marked "Contribution to others" sums up those off-diagonal entries, with the highest being France at 99.1 per cent.

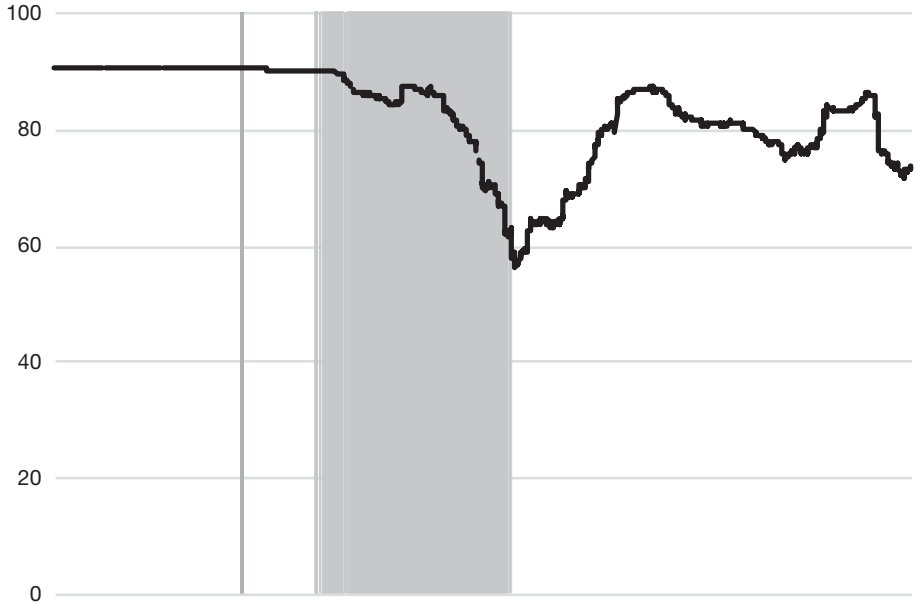
Figure 4 shows TSI values estimated on a 200-day rolling window basis, with the initial window ending on 2 January 2006 and the final window on 31 July 2018 (3,281 windows in total). The TSI remains high, at around 90 per cent, to March 2010 before starting to decline slowly up to September 2011 and then falling more

Table 1. Total Spillover Index and Components – Full Sample Estimate

	DE	*FR*	*FI*	*BE*	*AT*	*ES*	*PT*	*NE*	*IT*	*IE*	*EL*	*From Others*
DE	**13.0**	12.0	12.5	11.2	12.0	8.0	4.2	12.5	7.6	6.9	0.1	87.0
FR	11.5	**12.4**	11.6	11.6	11.9	8.7	4.5	11.8	8.6	7.1	0.2	87.6
FI	12.3	11.9	**12.7**	11.3	11.9	8.2	4.3	12.3	7.9	7.0	0.2	87.3
BE	10.9	11.7	11.1	**12.4**	11.5	9.2	4.9	11.3	9.2	7.5	0.2	87.6
AT	11.6	12.0	11.8	11.5	**12.5**	8.6	4.5	11.9	8.4	7.1	0.2	87.5
ES	9.0	10.2	9.3	10.7	9.9	**14.2**	6.5	9.5	12.0	8.3	0.4	84.8
PT	7.4	8.1	7.7	8.6	8.0	9.8	**22.1**	7.8	9.5	10.4	0.8	77.9
NE	12.1	12.0	12.2	11.3	11.9	8.3	4.3	**12.6**	8.0	7.0	0.2	87.4
IT	8.7	10.3	9.1	10.9	9.9	12.3	6.5	9.4	**14.6**	8.1	0.4	85.4
IE	9.1	9.6	9.4	10.1	9.5	9.6	7.7	9.4	9.1	**16.2**	0.4	83.8
EL	1.1	1.3	1.2	1.5	1.3	2.6	3.0	1.2	2.3	2.1	**82.5**	17.5
Contribution to others	93.7	99.1	95.9	98.7	97.8	85.3	50.4	97.1	82.6	71.5	3.1	873.8
Contribution including own	106.7	111.5	108.6	111.1	110.3	99.5	72.5	109.7	97.2	87.7	85.6	
												TSI = 79.4%

Source: Authors' estimations.

Figure 4: Total Spillover Index, Rolling Window Estimation: January 2006–July 2018



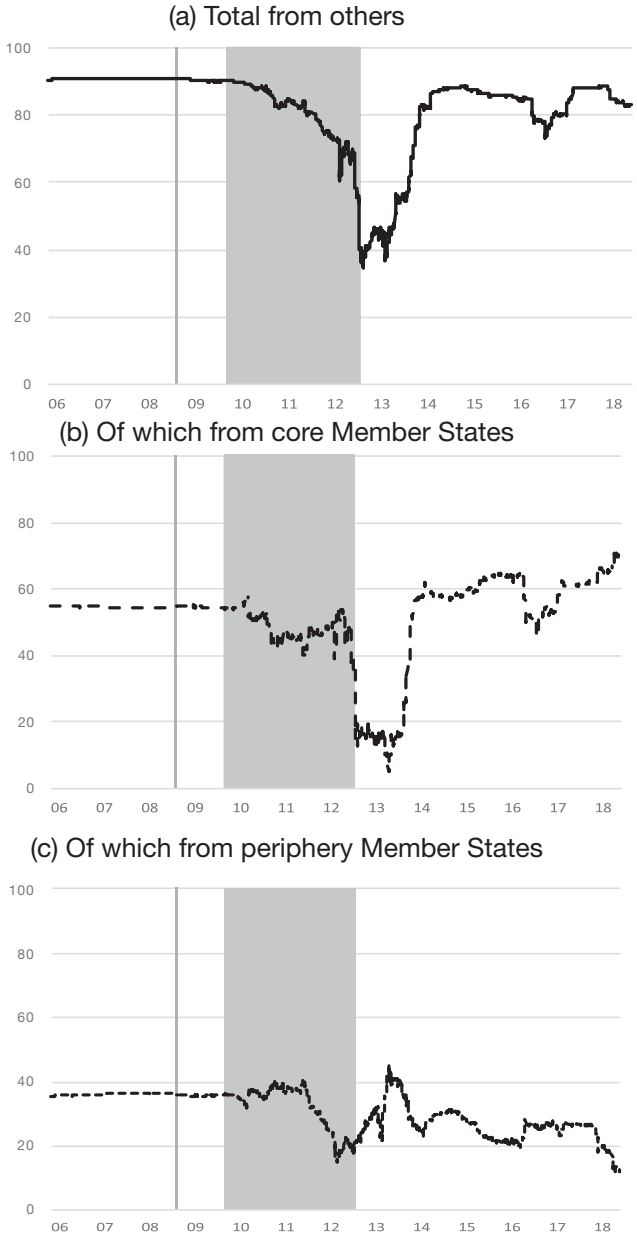
Source: Authors' estimations.
Note: Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

sharply over the next twelve months to values close to 57 per cent in early October 2012. The relatively large spillover effects before spring 2010 are explained by McDonald *et al.* (2018) as "news surprises" having pan-Euro Area effects, reflecting strong bi-directional links between Member States' sovereign bond markets at that time. Subsequently, they argue that Euro Area sovereign bond market behaviour is characterised by stress transmission occurring primarily within the core and periphery groupings of countries and investors shifting their portfolio positions towards safer investments in general.

After October 2012, the TSI undertakes a comparatively acute rise to close to pre-crisis levels by early 2014. This is in line with Cronin (2014) who finds that a decline in engagement between Member States' sovereign bond markets during the previous two years began to be reversed in autumn 2012 following ECB President Draghi's "whatever it takes" speech and the introduction of the OMT programme. TSI values remain above 80 per cent for most windows through 2014-2017 before declining in the first half of 2018.

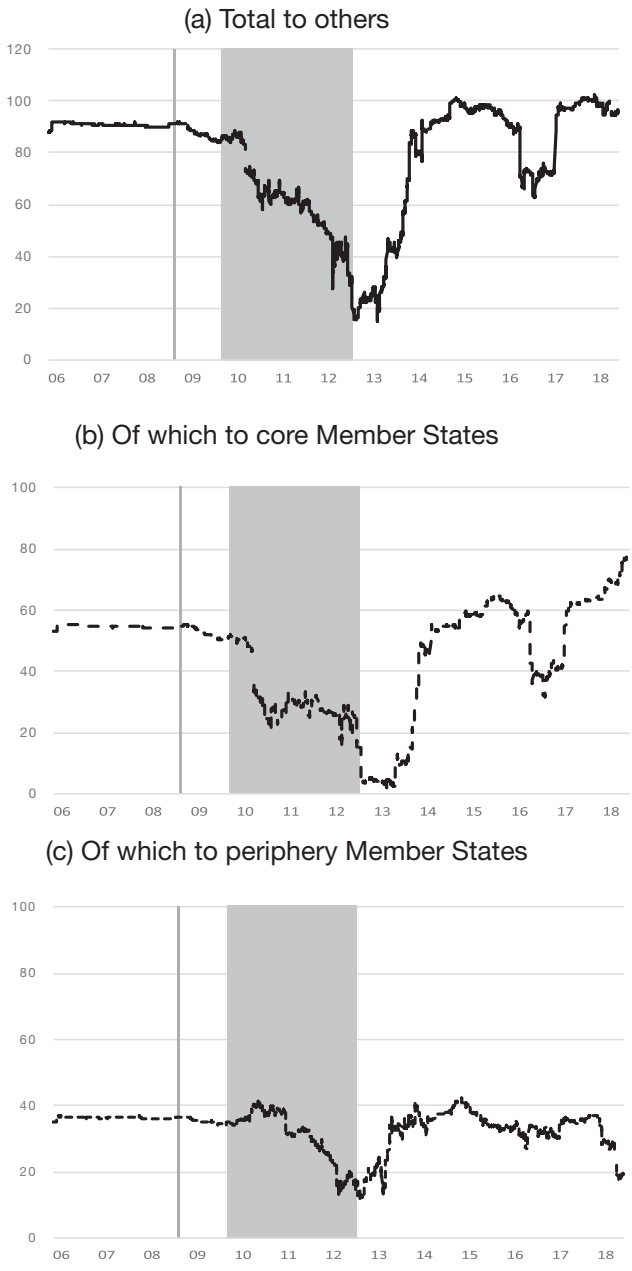
In Figures 5 and 6, Ireland's spillover from others and to others are plotted in turn. In both, panel (a) is the sum of its spillover from/to the previously-identified six core Member States (panel (b)) and the four periphery Member States (panel (c)).

Figure 5: Ireland – Spillover from Others, Rolling Window Estimation: January 2006–July 2018



Source: Authors' estimations.
Note: Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

Figure 6: Ireland – Spillover to Others, Rolling Window Estimation: January 2006–July 2018



Source: Authors' estimations.
Note: Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

Panels (a) of Figures 5 and 6 have a similar qualitative shape to the TSI in Figure 4, with Ireland's interaction with other Member States declining between early 2010 and mid-2012 before recovering towards pre-crisis levels over the following 18 months or so. The sharpest slide in spillover from others to Ireland (Figure 5) occurs somewhat later than for the TSI in Figure 4, and seems to owe mainly to the spillover of shocks from the core. Ireland's spillover to the core (Figure 6, panel (b)) falls away in two stages in the sovereign bond market crisis: at the same, later junction as occurs in Figure 5 panel (b), but also early in the crisis. By late 2012, its spillover to the core is close to zero. The spillover-from and -to the periphery Member States (panels (c) of Figures 5 and 6) during the crisis have a broadly similar pattern to one another with a more gradual and less substantial decline in spillovers than occurs between Ireland and the core countries.

Turning to the immediate post-crisis period (up to early 2014), Figures 5 and 6 show that the recovery in Ireland's spillovers to and from the core is much stronger than to and from the periphery, indicating it becoming more strongly interconnected with the former group. From early 2015 onwards, Ireland's spillovers to/from the periphery were broadly unchanging, while those to/from the core have continued to rise, with the exception of a dip during the middle six months of 2016. By end-2017, Ireland's gross spillovers to and from the core Member States were at a high point. In contrast, those with the periphery countries were much lower (panels (c) of Figures 5 and 6). Ireland's total gross spillover values were also at or close to historical highs, reflecting the levels of interaction with the core.

In 2018, Ireland's interaction with the core strengthened further and that with the periphery continued to decline. May 2018 saw substantial disruption in the Italian sovereign bond market as investors became nervous about the fiscal implications of a new government being formed there. The representative yield on ten-year Italian bonds increased from 1.9 per cent on 15 May to 3.1 per cent two weeks later. These developments had no noticeable effect on long-term Irish sovereign bond yields, nor on their spillover and correlation values.[5]

V AN ECONOMETRIC MODEL OF IRISH SOVEREIGN BOND SPREADS

The evidence in the previous sections indicates Irish sovereign bonds having effectively decoupled from other Euro Area periphery bond markets in recent years, summed up in Irish long-term bond spreads declining from a peak average value of 9.2 per cent in Q2 2011 to close to 1 per cent during 2018. This raises the question as to whether the reduction in market spreads and the change in relationship

[5] Cronin and Dunne (2019b) consider the Italian sovereign bond market's interaction with the other Euro Area 11 Member States' markets during 2018.

between Ireland and other Euro Area sovereign bond markets reflects an improvement in the fundamentals of the Irish economy and, in particular, the sustainability of its fiscal position. A yield spread captures the financial market's view of the sovereign's ability to meet repayment obligations on its debt. This should be informed principally by the government debt position and the ability of the economy to service that debt.

De Grauwe and Ji (2012; 2013) use this as their guiding principle in modelling sovereign risk within the Euro Area, with the yield spread being modelled as a function of a number of fundamental variables. Any deviation of the observed spread from that determined by such factors serves as a measure of mis-pricing by the market: if the actual spread is less than the fundamental factors-determined value, the market is seen as unduly optimistic about the country's fiscal prospects and, likewise, if the difference is positive, it is too pessimistic.[6] In this section, an econometric specification based on De Grauwe-Ji is estimated for Irish sovereign bond spreads, at a quarterly frequency, over the period Q1 2000 to Q1 2018 with a customisation to reflect the direct link between the sovereign and the Irish banking sector that arose from Q4 2008 (when the bank guarantee took effect) onwards. The bank guarantee exposed the Irish sovereign to potential losses in the banking sector and could be expected to have had a significant effect on its bond spread from that time.

Two variables that fit within the De Grauwe-Ji modelling approach are the government debt-to-national output ratio (the sovereign debt burden within the economy) and a measure of national output or income (to capture the ability of the economy to support the fiscal position of the state). Here, the ratio of General Government debt-to-GNI* and real disposable income are used as those variables, respectively.[7] It can be seen in panel (a) of Figure 7 that the government debt ratio declined slowly over time up to Q4 2006 before starting to rise thereafter, reaching a peak of 170 per cent of GNI* in Q1 2013 before starting to fall. In panel (b), real disposable income decreased from Q4 2008 through to Q3 2011, remaining broadly unchanged thereafter until Q4 2014, and then rising subsequently.

Another variable that should have been affecting Irish bond spreads since Q4 2008 is the direct exposure of the State to the banking sector after the enactment of the bank guarantee at that time. While the sub-prime crisis was one of the major determinants of the international financial crisis, the main cause of the difficulties

[6] De Grauwe and Ji (2012, p. 870) argue against using too many variables in explaining the spread. For one thing, variables such as ratings changes are unlikely to be exogenous as they interact with bond spread movements and thus should be excluded. Policy interventions in EU sovereign bond markets which affect observed, or market, yields, will also not be captured by the model.

[7] The debt ratio shown (in percentage terms) is of General Government debt-to-GNI*, a measure of output activity specific to Ireland that aims to remove the distortionary effects of the activities of multinational enterprises within the GDP-based measure of national output. Real household disposable income is calculated as household disposable income divided by the personal consumption deflator.

experienced by Irish financial institutions was more traditional in nature. In particular, the Irish residential and financial sector by 2007 had experienced a substantial credit boom over the preceding half-dozen years or so (for example see McCarthy and McQuinn, 2017, and Honohan, 2010). The introduction of the euro and the gradual easing of regulatory controls aided cross-border lending between European credit institutions. Consequently, from the early 2000s, the Irish banking sector was able to borrow substantially from abroad. This led to a sharp divergence between the stock of lending and traditional deposit levels, as shown by the loan-to-deposit ratio (see Figure 7, panel (c)). While a one-to-one ratio had typically pertained between lending and such deposits prior to the euro's introduction, this ratio rose to a value in excess of two during 2007.

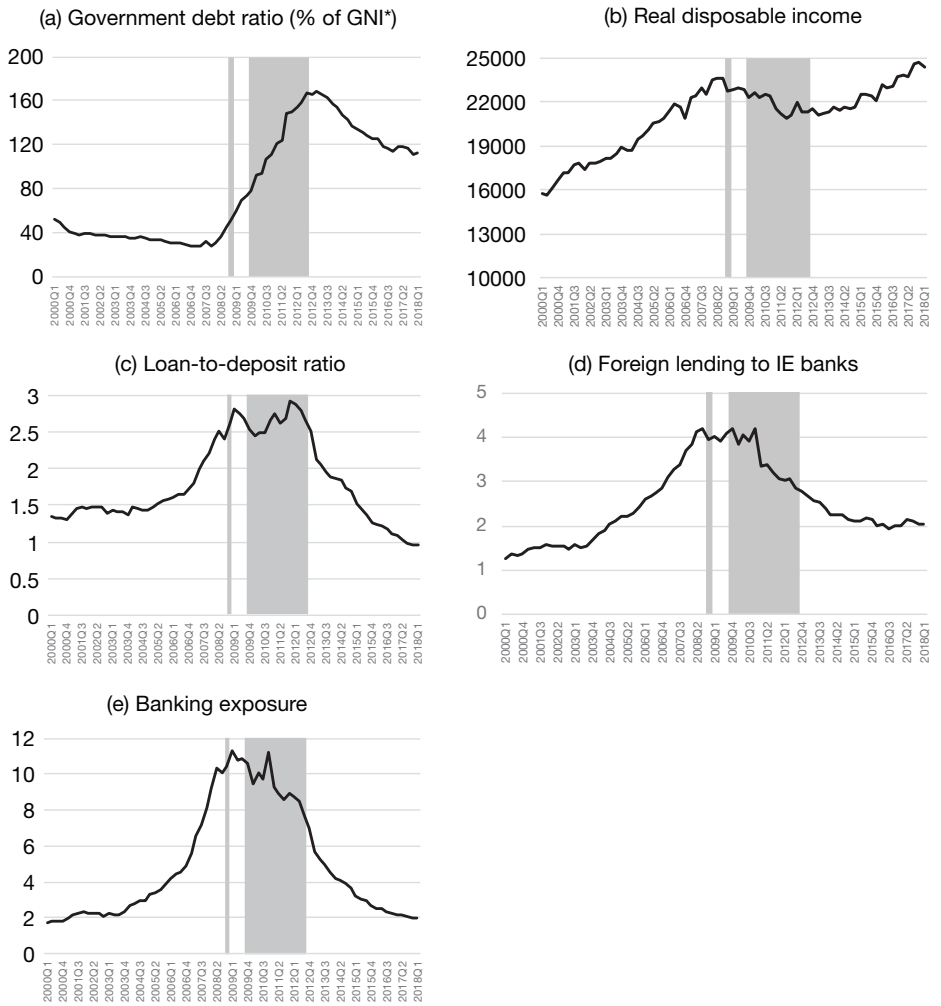
By 2007, house prices in the Irish market were overvalued by somewhere in the region of 35 to 40 per cent (McQuinn, 2014; 2017) and thus, given the volume of lending which had occurred between 2004 and 2007, many Irish-based financial institutions were substantially exposed to the unwinding of this bubble. With concerns surrounding the solvency of the main Irish financial institutions emerging, the Irish government introduced a bank guarantee scheme in late September 2008. The guarantee covered all liabilities of the domestic banking sector and was in respect of all retail and corporate deposits. The full implications of the guarantee were not felt for a while. Critically, the guarantee was given on the presumption that the banks were mainly experiencing liquidity problems. The subsequent sharp decline in house prices essentially meant that the institutions had significant solvency problems (Honohan, 2010). These came into focus in 2010. With Irish credit institutions requiring increasing levels of capital injections from the Irish State to shore up their weakening balance sheets, the growing fiscal problems experienced by the sovereign were compounded by the capital obligations that followed from the bank guarantee scheme. The guarantee then served to link formally the increasing levels of banking sector debt and Ireland's fiscal position.

To capture the extent of the sovereign's exposure to the difficulties in the banking sector, two related variables are used and combined. The first is the aforementioned loan-to-deposit ratio, capturing the divergence between the total stock of credit and the traditional deposit base of the domestic banking sector (see Figure 7, panel (c)). The second is the scale of cross-border lending into the Irish economy (see panel (d) of the same figure). To put the level of external funding in context, it is normalised by the level of GNI* in panel (d). This captures the scale of the funding in terms of overall domestic economic activity.[8] From both graphs, the reliance of the domestic banking sector on cross-border inflows of wholesale

[8] The concept of a credit-to-national output variable has become increasingly popular in macroprudential policy as a means of capturing the ratio of credit to overall economic activity. Such a measure is used, for example, by the Central Bank of Ireland in determining the size of the countercyclical capital buffer (CCCB). For more details, see https://www.centralbank.ie/financial-system/financial-stability/macro-prudential-policy/countercyclical-capital-buffer.

deposits to fund the sizeable increase in lending is apparent in the lead-up to the banking difficulties of 2007-2008. Thereafter, as the economic crisis in Ireland escalated, there was a sizeable outflow of funds from the domestic banking sector as significant deleveraging occurred.

Figure 7: Government Debt, Real Disposable Income and Banking Variables, Q1 2000–Q1 2018



Source: Authors' estimations based on Bank for International Settlements, Central Bank of Ireland and CSO data.
Note: Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

The product of the loan-to-deposit ratio and the foreign lending to Irish banks variables captures the extent to which the changing liability side of the Irish banking system is funded by interbank deposits from abroad. The variable is used here to capture the burden that the banking system imposed on the sovereign after the guarantee was enacted and can be seen in panel (e) of Figure 7 as the "banking exposure" variable that is used in the econometric estimations below.

The econometric specification then used is:

$$spread_t = \alpha + \gamma * debt_t + \varphi * tjdi_t + \theta * (DV_t * bamking_t) + \mu_t$$

where *spread* is the average within-the-quarter daily yield spread of the Irish sovereign ten-year bond over EONIA; *debt* is the General Government debt-to-GNI* ratio; *rhdi* is real household disposable income (included to capture the ability of the economy to support the fiscal position); *banking* is the banking exposure variable described in the previous paragraph; *DV* is a dummy variable whose value is zero from Q1 2000 to Q3 2008 and whose value is one from Q4 2008 to Q1 2018; α is a constant term; and μ is a residual term.[9]

The OLS estimates of the coefficients of this regression are shown in Table 2. The coefficients have the expected sign with both *debt* and *banking* having positive signs (higher debt and banking burdens raise the spread) and *rhdi* a negative coefficient (i.e. higher income indicates a greater ability of the economy to support the sovereign, hence reducing default risk and, consequently, the fitted spread). The goodness-of-fit measure is 0.74.

Figure 8a plots the fitted values from this regression and the observed spreads (i.e. the left hand side variable in the regression). Looking at the fitted values, it can be seen that they decline over the period Q1 2000 to Q3 2008 to close to zero before ratcheting up sharply in Q4 2008, to 5 per cent. The fitted spreads remain above that value up to Q3 2012 before declining slowly thereafter. The sharp rise in Q4 2008 coincides with the bank guarantee, while the government debt ratio had

Table 2: Irish Sovereign Bond Spread, Q1 2000 - Q1 2018[10]

	Coefficient estimate (T-ratio)	
Constant term	6.649	(4.87)
Debt	0.009	(2.55)
rhdi	–0.003	(–4.48)
banking	0.47	(10.45)
R-square = 0.74		

Source: Authors' estimations.

[9] The dummy variable is used to render the banking variable in the regression estimation taking a zero value from Q1 2000 to Q3 2008 in the regression estimation, as the State was not "on the hook" for the banking sector during that time.

[10] The time series properties of the variables are examined in a table in Appendix C.

also started to increase by then. The banking exposure variable starts to fall after Q4 2010, and both it and the debt ratio are decreasing after Q3 2013.

These shifts in the explanatory variables over time are broadly mirrored in those of the observed spreads but large differences do arise between actual and fitted spreads during the period Q4 2008 to Q3 2012, with these (the regression residuals) shown in Figure 8b. In Q4 2008 and Q1 2009, the actual spread is substantially less than warranted by fundamentals; in De Grauwe-Ji parlance, the market was taking

Figure 8a: Actual Spreads and Fitted Values

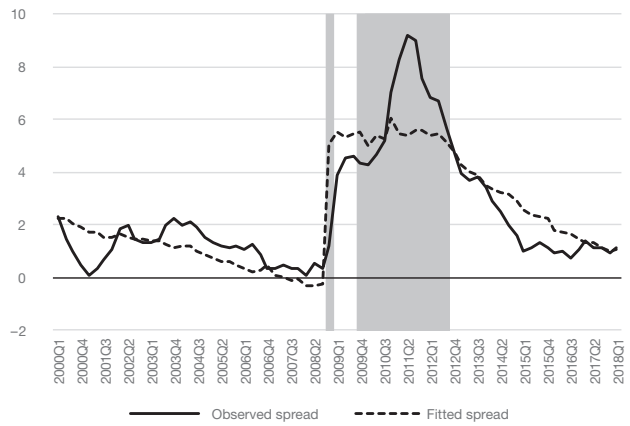
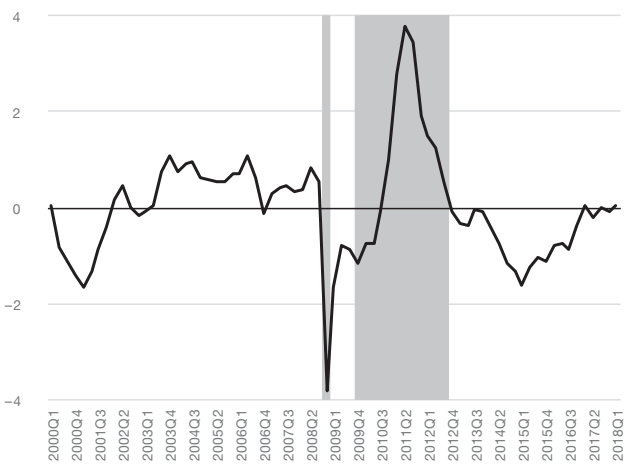


Figure 8b: Regression Residuals



Source: Authors' estimations.
Note: The initial shaded column refers to Q4 2008 (bank guarantee takes effect) and the latter column Q4 2009-Q3 2012 (Euro Area sovereign bond crisis).

an irrationally optimistic view of Irish sovereign bonds given the fundamentals. The opposite holds from late 2010 to mid-2012 where the market is overly pessimistic towards Ireland, with the observed spread rising some 3.8 percentage points above the fitted value in Q2 2011. In the latter part of the crisis period and from Q4 2012 onwards, both the market and fitted spreads decline over time, indicating that improvements in Ireland's government debt and banking exposure positions, supported by higher income levels, were recognised by the market. At the same time, the tendency for market rates to deviate from fundamental values even in more 'normal' times is illustrated by the market spread being under-priced from 2013 through to mid-2017 by reference to fundamentals by as much as 1.6 percentage points (although the deviations post-crisis are much smaller in absolute terms than what arose during the sovereign bond crisis).

VI CONCLUSION

While European policy initiatives may have contributed to the reduction in Irish and all other Euro Area Member State bond yields since the 2009-2012 sovereign bond market crisis, the evidence in this paper shows Ireland disengaging from the periphery Member States and interacting more strongly with core Member States' sovereign bond markets in recent years. The final econometric results indicate Irish sovereign bonds having benefitted in the post-crisis era from improved domestic fiscal fundamentals, the mitigation of banking factors' impact on the sovereign, and the correction of undue pessimism by the market towards Ireland. These factors, through driving the risk premium substantially lower, have allowed Irish sovereign bonds become more closely aligned with those of core, rather than periphery, Member States.

There are policy lessons to be drawn from this study of sovereign bond market behaviour. A combination of emerging fiscal and financial sector vulnerabilities, including where the state assumes a guarantor role in the banking system, can quickly lead to an upsurge in sovereign bond yields. In Ireland's case, its headline fiscal position (as shown in its budget balance and debt ratios) during the early- to mid-2000s hid a fragility where tax revenue was dependent on unbalanced, and unsustainable, economic activity (Addison-Smyth and McQuinn, 2010). The deterioration in the fiscal position in Ireland that followed the unravelling of structural imbalances in the Irish economy occurred alongside the bank guarantee put in place in September 2008. As shown here, the sharp rise in Irish sovereign bond spreads in late 2008 and early 2009 was broadly justified by both these factors and the change in the economy's ability to support the sovereign through income growth. Financial sector imbalances, mainly due to a credit-fuelled bubble in the domestic residential property market, eventually exposed the sovereign to substantial losses in that sector. (From a methodological perspective, the paper shows the importance of accounting for financial sector variables, as appropriate

to each country case, in estimating the fundamental spread within the De Grauwe-Ji modelling framework.)

Beyond the warranted increase in Irish spreads in 2008-2009, financial markets came to take an overly pessimistic view of Irish fiscal sustainability that caused the observed, or market, spread to rise even higher. This was, at least in part, due to a broader, overly negative sentiment towards periphery Member States (De Grauwe and Ji, 2012; 2013) but it may also reflect a lack of clarity on the fiscal and banking policy direction that Ireland was taking at that time. Subsequently, the strict implementation of the 2010 EU-IMF bailout programme, the maintenance of fiscal discipline after exiting the programme, and a series of banking policies may have helped to reassure sovereign bond investors. Significant reforms of the financial sector, including an overhaul of the regulatory system both domestically and at the EU level, also help to separate the consequences of any capital/solvency issues in the banking sector from the State.

The other important factor to recognise is the vagaries of market sentiment, that is the financial market's tendency to move often quickly from a state of undue optimism to undue pessimism (and vice versa). In such an environment, there can be little scope for being complacent about the success of a fiscal programme by judging it against prevailing sovereign bond market prices. Maintaining a sustainable and well-signalled fiscal path, adhering to fiscal rules, and fostering a stable banking system are the best means by which a sovereign can help to keep its bond yields from being priced too highly and from varying substantially over time.

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APPENDIX A TIME-VARYING CORRELATION METHODOLOGY

Gibson *et al*. (2017) note that the extension of univariate conditional variance models to a multivariate application poses the practical difficulty that a large number of parameters need to be estimated. They provide a computationally advantageous approach that allows conditional covariance matrices of unlimited size to be formed, but which still requires the econometrician to estimate only univariate conditional variances. Their methodology is employed here in combination with conditional variance estimates obtained from a stochastic volatility model developed by Chan and Grant (2016).

The dataset being used here can help explain the methodological approach. The covariance between any pair of sovereign bond yields is constructed as a function of the volatility of the individual sovereign bond yield spread changes and the volatility of the sum of the respective pair of sovereign bond yield spread changes. This is based on a rearrangement of the definition of the variance of a sum of two mean-zero random variables. For example, for two variables $x \sim N(0, \sigma_x^2)$ and $y \sim N(0, \sigma_y^2)$, with covariance σ_{xy};

$$\sigma_{x+y}^2 = \sigma_x^2 + \sigma_y^2 + 2\sigma_{xy}$$

which implies that

$$\sigma_{xy} = 0.5(\sigma_{x+y}^2 - \sigma_x^2 - \sigma_y^2)$$

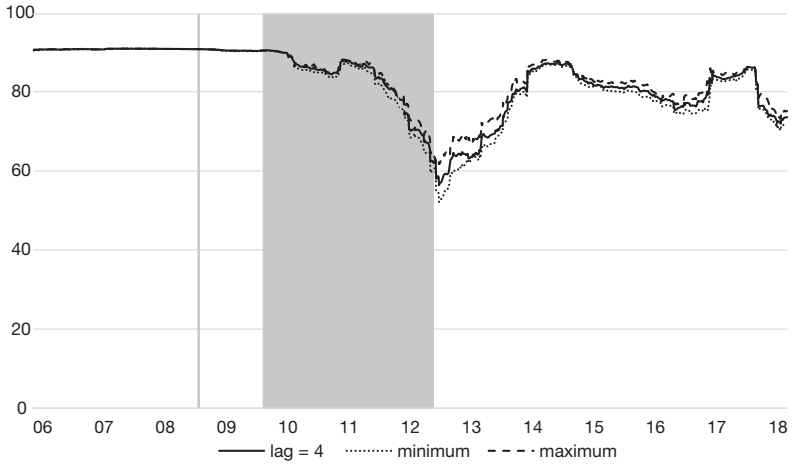
A simple division of the covariance by the product of time-varying conditional standard deviations then produces a conditional correlation estimate.

The Bayesian approach of Chan and Grant (2016) to estimating the time-varying variances required in these relations is used to implement the Gibson *et al.* approach here. More specifically, a stochastic volatility model with a moving-average mean process (SVMA model) is used, which Chan and Grant find to be the best-fitting model among 14 different alternative approaches that they apply to daily energy market data. The Bayesian stochastic volatility modelling approach generates posterior draws for the log of the standard deviation at each date using Bayes' rule to update "priors" obtained by application of the same Bayesian rule in previous periods while imposing a smoothness prior on the size of changes in volatility through time. The starting priors are set at the mean over a pre-sample period and the first 1,000 burn-in draws are discarded. The mean of 10,000 posterior draws is used as the estimate of volatility. The conditional volatilities are combined using the formulas above to construct correlations. If the estimated correlation exceeds 1, its reported value is given as 1.[11]

[11] The Matlab code provided by Chan and Grant (2016) is used here. It is available on Joshua Chan's website (http://joshuachan.org/code/code_GARCH_SV.html).

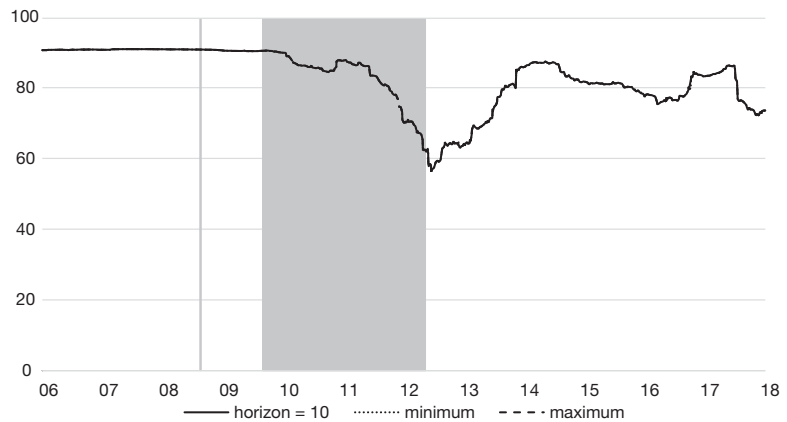
APPENDIX B SENSITIVITY TESTS

Figure B.1a: Sensitivity of TSI to Chosen Lag Length



Source: Authors' estimations.
Note: The lag length of the VAR was allowed to vary between one, and one to eight days. Alongside the TSIs of the baseline lag length of 4, the charts shows "minimum" (the lowest TSI on each day among those lag length options) and "maximum" (the highest TSI on each day). Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

Figure B.1b: Sensitivity of TSI to Chosen Forecast Horizon



Source: Authors' estimations.
Note: The forecast horizon of the VAR was allowed to vary between eight and 12 days ahead. Alongside the TSI of the baseline forecast horizon of ten days, the charts shows "minimum" (the lowest TSI on each day among those horizon options) and "maximum" (the highest TSI on each day). Shaded area represents Euro Area sovereign bond crisis. Vertical line indicates introduction of bank guarantee.

APPENDIX C UNIT ROOT TESTS

Table C.1: Unit Root Tests for Variables Used in Table 2

Variable	*ADF test (5 per cent critical value –2.89)*	*ADF Z test (5 per cent critical value –13.7)*
spread	–2.174	–9.573
debt	–2.011	–8.171
rhdi	–1.610	–2.590
banking	–0.765	–1.090

Source: Authors' estimations.