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The fiscal and monetary determinants of sovereign bond yields in the Euro Area

Abstract:
This paper investigates the determinants of sovereign bond yields in the Euro Area through the lens of the expectations hypothesis adjusting for measures of risk. This allows us to see the extent to which monetary policy, which controls the path of short-term nominal interest rates, is a driver of longer-term sovereign yields. To do this we include a forward-looking measure of expectations of overnight interest rates alongside debt-GDP in an error-correcting panel framework. We find that the expected path of the short-term nominal interest rate is a significant long-run determinant of 10 year sovereign bond yields in the Euro Area and that this relationship is robust to a wide range of alternative specifications and controls, especially in the Northern Euro Area economies. This result implies that the reduction in Northern Euro Area sovereign bond yields in recent years has been driven by the current and expected future loose stance of monetary policy. In the periphery economies this effect appears to have been dominated by other factors, such as default risk.

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1 Introduction

The processes that drive fluctuations in sovereign bond yields have received particular attention in recent years, above all in the Euro Area where yields have been especially volatile compared to other advanced economies.

Often the focus is on determinants associated with the fiscal policymaker, such as the level of debt-GDP. However, decisions made by the monetary authority also have implications for the borrowing costs faced by sovereigns. By controlling the short-term interest rate, and guiding expectations of its future path monetary policymakers can play a large part in determining yields at longer terms and on a wider spectrum of assets within the economy. This is a widely accepted and central tenant of monetary policy, but is rarely accounted for in any strong sense in analysis of the determinants of sovereign debt.

This paper looks to place monetary policy at the centre of an analysis of sovereign bond yields in the Euro Area. To do this we build on the theoretical framework of the expectations hypothesis, adjusting for some more traditional fiscal factors. We then look to empirically test this framework by introducing a forward-looking measure of market expectations of the path of monetary policy into a series of panel estimations. We find support for our theoretical premise that these expectations of short-term interest rates are a significant driver of long-term yields on Euro Area sovereign debt, a result that is robust to numerous alternative specifications and controls. This relationship is more robust for Northern Euro Area economies, especially in the post-crisis world where other factors such as default risk, uncertainty and bailouts are likely to have distorted developments in stressed periphery economies.

The paper begins with a brief and by no means comprehensive history of developments in Euro Area sovereign debt markets by way of context before detailing a number of specific elements of the European Central Bank's monetary policy which have direct implications for these markets. It then lays out the theoretical arguments for both the traditional macroeconomic determinants of sovereign bond yields and, importantly, the ways in which monetary policy can be motivated as a key driver. After a survey of the existing literature the econometric specification is outlined and the results of a range of regressions are presented. Finally we draw conclusions from these results and discuss areas of useful extension for this research agenda.

2 A recent history of Euro Area sovereign bond yields

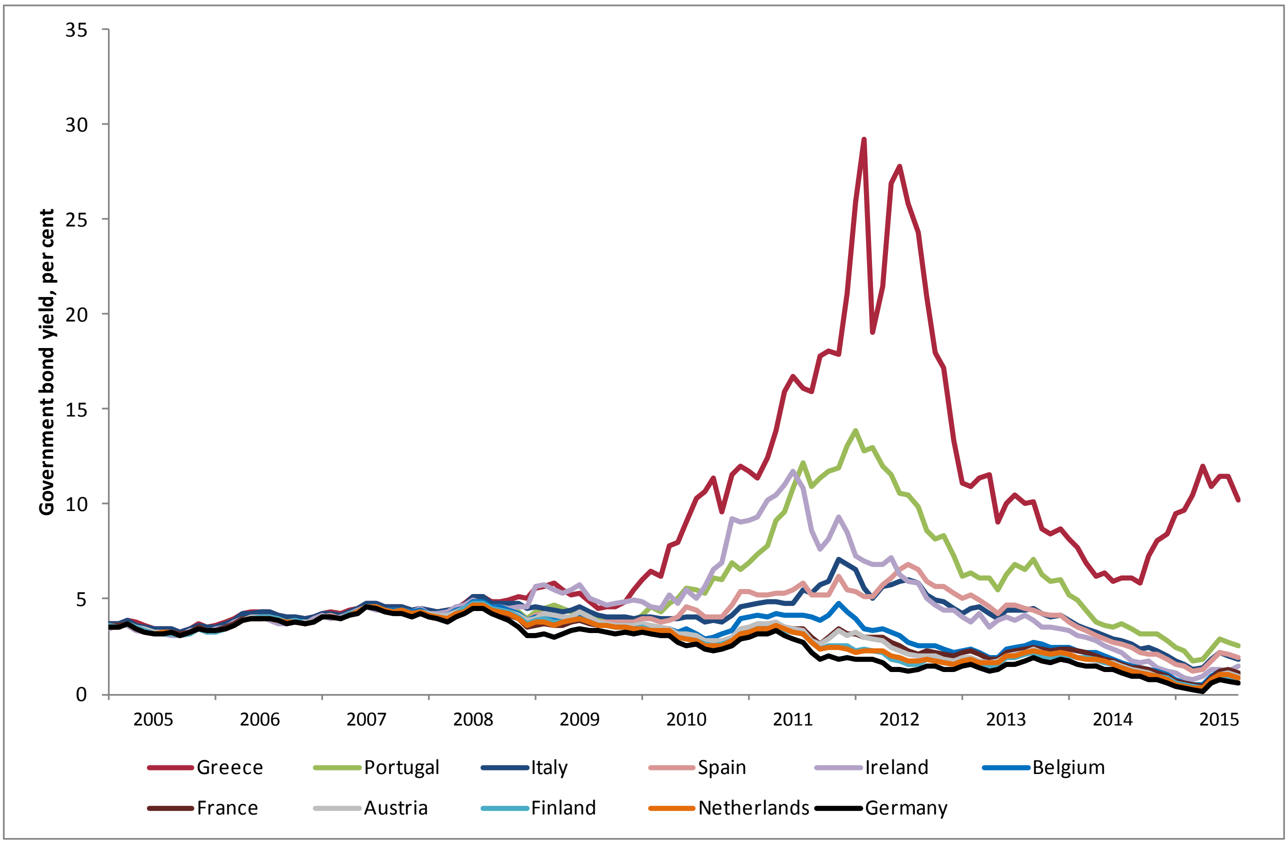
This section will provide some context of recent developments in Euro Area sovereign bond markets. It is however, far from comprehensive. For a more detailed analysis see Lane (2012).

From the inception of the single currency to mid-2008 the cost of borrowing for Euro Area sovereigns was relatively uniform across member states. The mean 10 year yield was relatively stable around 4 per cent and the spread between the yield of the highest sovereign and the lowest never exceeded 80 basis points and averaged closer to 40, Figure 1.

This was despite some rather wide differences in fiscal fundamentals in each member state. Debt-GDP ratios varied from around 25 per cent in Ireland to almost 100 per cent in Belgium and Greece, Figure 2. Under the Maastricht Treaty, members of the European Union were supposed to keep their debt levels to below 60 per cent of GDP and their annual budget deficit to less than 3 per cent of GDP. However, at the start of 2008 Austria, Belgium, Greece, France, Italy, Portugal and even Germany exceeded the debt limit.

Notably, Ireland and Spain, two of the economies that would go on to become some of the most embattled of the sovereign debt crisis had some of the lowest debt-GDP figures in the Euro over this period.

Figure 1: 10 year benchmark government bond yields



Crucially, these differences were seemingly not priced in to sovereign bonds.[2]

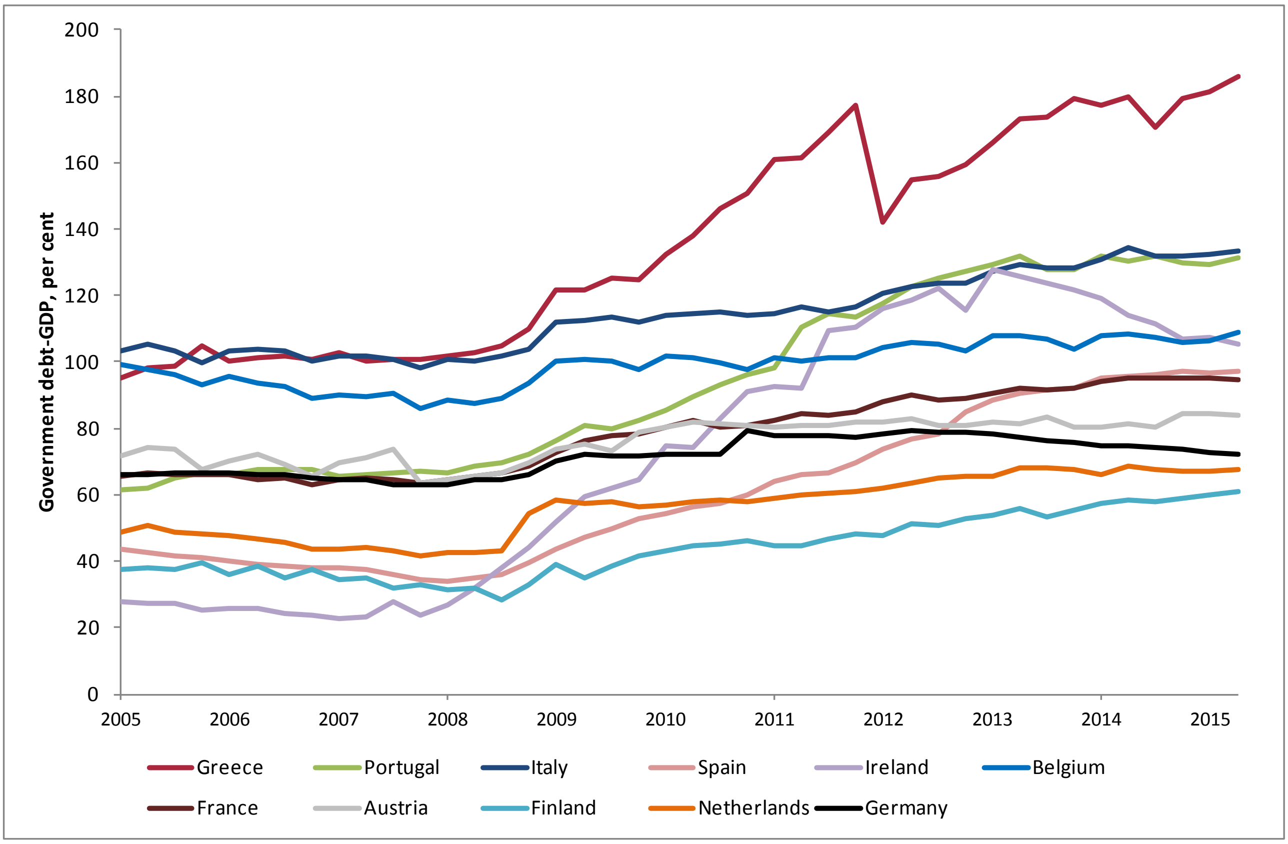
When the financial crisis intensified in the second half of 2008 this period of comoving, tight spreads between Euro Area sovereign bond rates began to break down, Figure 1. Yields in Greece and Ireland began to increase, while yields in some Northern European economies actually fell.

The divergence in bond yields really took hold in late 2009 with Greece and Ireland the first casualties. It became apparent that misleading accounting practices in Greece had been used to hide excessive deficits and a build up of public debt. Once the incoming government corrected for these irregularities, the budget deficit for 2009 doubled from previous estimates to almost 13 per cent of GDP. The debt-GDP ratio based on the corrected figures was 113 per cent.

In the years before the financial crisis the Irish government had been reasonably prudent, maintaining a debt stock around 25 per cent of GDP. However, the Irish banking system was extremely large relative to the size of the economy and had become highly leveraged and exposed to the housing market. When the crisis struck in 2008, Irish banks were hit hard and the Irish government was forced to step in and bail them out. This saw the fiscal position worsen rapidly, with debt reaching 65 per cent of GDP by the end of 2009.

[2] Coeure (2012) discusses why this may have been the case. His reasons include a lack of credibility in the no-bailout clause of the Maastricht Treaty, a misperception of risk as investors expectations were extrapolated from the great Moderation and a general complacency and lack of forward-looking behaviour on the part of markets.

Figure 2: Debt-GDP of Euro Area sovereigns



Through 2010 the situation in Greece deteriorated. In May 2010, the Greek government agreed a bail-out deal with the IMF and other Euro Area member states which imposed a programme of fiscal austerity as a condition of receipt. The Irish budget deficit exceeded 30 per cent of GDP, in large part due to the costs associated with nationalising large swathes of its banking sector, and in November 2010 the Irish government also applied for a bailout from the IMF and Euro Area member states. As with Greece, the funds came with conditions that force the implementation of fiscal austerity.

By the end of 2010 and early 2011, yields on government debt were also beginning to rise in Portugal, Italy and Spain. Investors began reassessing risk and noted that Portugal's debt-GDP was well in excess of the Maastricht criteria and her growth outlook was weak. Their fears were proved right when in May 2011, Portugal applied for and received a bailout of its own from the IMF and Euro Area member states.

The Spanish economy had been severely weakened by the bursting of the enormous housing market bubble that had built up over the Great Moderation. Although its debt-GDP level was relatively low by Euro Area standards, its growth prospects were poor and thus investors began to question the sustainability of its debt.

At the end of 2010 Italy had the second highest debt-GDP in the entire Euro Area, only falling behind Greece. It was also hit with a number of political scandals and a sluggish growth outlook from its inability to implement structural reforms.

As markets turned their attention to these three economies, rising yields exacerbated the existing fiscal problems by amplifying the interest burden of large debt stocks. What is more, there was a growing sense that the single currency was unsustainable, and one or more economies would eventually have to leave and likely default on their debt. This redenomination risk lead yields in all member states, but especially the periphery economies to rise to unprecedented levels in the first half of 2012.

Since the middle of 2012 and ostensibly Mario Draghi's commitment to do "whatever it takes", spreads of periphery sovereigns over the bund or the ECB's risk-free rate have been on a downward trajectory. Portugal and Ireland have exited their bailout programmes and the perception of a general dissolution of the single currency has receded. More than this, and at the heart of the narrative of this paper, is that risk-free rates and the rate on Northern European sovereign debt has also been falling. This is likely due to increasingly loose monetary policy by the ECB, which we will discuss below.

3 Recent Euro Area monetary policy

The last decade has also been a period of dramatic change for monetary policy in the Euro Area. Prior to 2008 the ECB's main policy instrument had been the short-term nominal interest rate it charged to lend to banks, the main refinancing operations (MRO) rate. Between July 2008 and May 2009, the ECB cut this rate from 4.25 per cent to 1 per cent in an attempt to stimulate the Euro Area economies, Figure 3. Following a brief period of monetary tightening in 2011, the ECB loosened the stance of its traditional policy instrument further, matching and recently even exceeding the unprecedented lows of other central banks. In June 2014 one of the other key rates that determine policy, the deposit rate, entered negative territory and now sits at -0.3 per cent. This means that banks are willing to pay in order to hold cash on deposit with the ECB.

These traditional monetary policy operations have implications for sovereign bond yields. However, alongside these, the ECB, like many other central banks in recent years, has employed a number of more unconventional balance sheet measures, some of which have involved them directly intervening in the sovereign debt markets of member states.

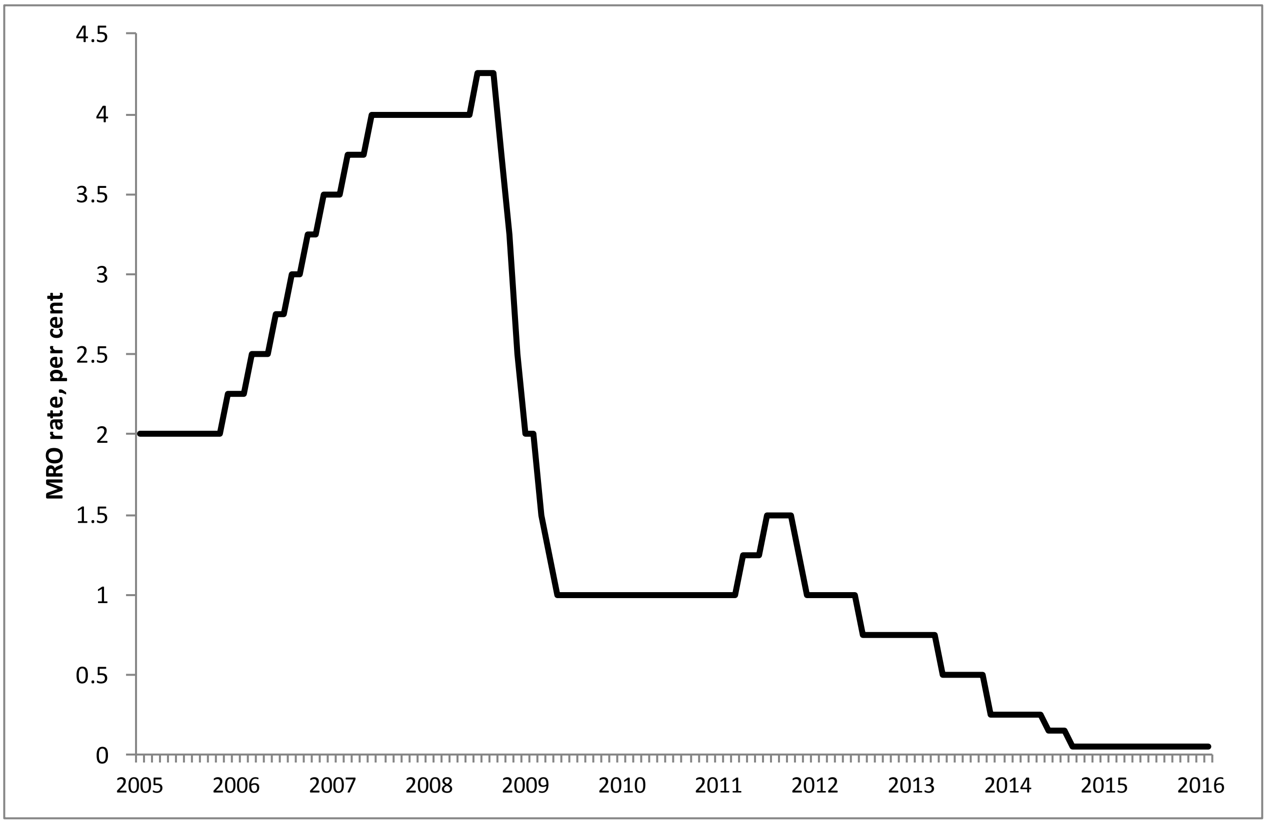
3.1 The Securities Market Programme

On 10th May 2010, the ECB launched the Securities Market Programme (SMP) under which it would purchase sovereign debt of member states in the secondary market, paid for by newly created central bank reserves. The aim of the SMP was explicitly not to loosen the stance of monetary policy. Instead it was intended to alleviate strains in sovereign debt markets that might be hampering the usual monetary transmission mechanism.[3] In this way it differed from the quantitative easing programmes of other major central banks, and this was reflected in its design. First, purchases were made on an ad hoc basis as deemed necessary, rather than in pre-announced quantities over a defined period. Second, the purchases themselves were sterilised, meaning that the extra liquidity provided by the SMP purchases was offset by the issuance of short-term (one week) interest bearing deposit certificates from the ECB. All the while these fine-tuning operations were rolled over the SMP was not expanding the monetary base, and so created no quantitative easing.

Initially purchases were made of Greek, Irish and Portuguese government securities, but this was expanded in August 2011 to include Italian and Spanish government debt as well. In September 2012, when the policy was at its largest, the SMP held EUR218 of Euro Area sovereign bonds, approximately half of which were Italian. Although no more bonds were bought after this point, the bonds bought prior to this have been held to maturity, and so the SMP is unwinding naturally as securities mature off of the balance sheet.

[3] See for example Gonzalez-Paramo (2011)

Figure 3: ECB's Main Refinancing Operations rate



3.2 Outright Monetary Transactions

In the first half of 2012, fears began to grow that the problems plaguing the single currency were insurmountable without a fundamental restructuring of the Eurosystem, and potentially even a break-up of the monetary union itself. This led yields on sovereign borrowing costs in most Euro Area member states, but especially those in the GIIPs to rise from their already elevated levels.

The ECB's answer was to announce a programme of Outright Monetary Transactions (OMTs) that would replace the SMP. OMTs were designed to "eliminate the unwarranted and self-fulfilling fears of a Euro Area break-up", Coeure (2013).

Like the SMP, OMTs would consist of purchases of Euro Area government debt from the secondary markets. Also like the SMP, they would be sterilised. However, unlike the SMP, OMT purchases were subject to conditionality. The state whose bonds were being purchased had to be in receipt of aid from one of the Euro Area's bailout funds. These bailouts came with their own conditions on structural reform and to qualify for inclusion in the OMTs the state in question had to adhere to these bailout terms. The economy must also prove it was capable of raising funds in private markets by successfully issuing at least a 10 year government bond. If all of these conditions were met, and the ECB deemed it necessary, then purchases could be made of the state's sovereign debt with a residual maturity of 1-3 years.

An important design feature of OMTs was that the ECB ranked pari-passu with other creditors in the event of a default. This meant that they received no special treatment and if the sovereign defaulted they would lose alongside the private sector. This was designed to instil confidence in the market that the ECB would not allow a sovereign to default on its debt.

Perhaps the most crucial aspect of the OMTs was that there was no ex-ante quantitative limit. When the policy was announced Mario Draghi now famously said that the ECB would do "whatever it takes to save the Euro", Draghi (2012). This commitment in of itself was a powerful signal to the market and was undoubtedly effective as yields on periphery debt fell significantly and stayed down for much of the next 12 months despite not a single bond ever being purchased under the OMT programme. By committing to act in an unlimited capacity should the need arise the ECB seemingly removed the need to intervene at all.

3.3 Public Sector Purchase Programme

In January 2015 the ECB finally announced that it would undertake a large-scale programme of purchases of public sector assets backed by the unsterilised creation of central bank reserves, commonly termed quantitative easing. Motivated by fears that medium term inflation expectations were beginning to decouple from a level consistent with the ECB's mandated target, they introduced the Public Sector Purchase Programme (PSPP). Under its quantitative easing programme, the ECB has committed to purchase around EUR60bn of assets a month, around 75 per cent of which will be sovereign debt bought under the PSPP.[4] Initially the purchased were scheduled to continue until at least September 2016, but this has since been extended to March 2017. This means that the total quantity of assets purchased under the programme will be far in excess of EUR1trn.

Purchases are allocated according to the weighting of member states in the ECB's capital key with the restrictions that the ECB cannot hold more than 33 per cent of any particular security nor of the total debt market of any given member state. As discussed by Baker and Meaning (2015) these restrictions may eventually force the ECB to deviate from the capital key weightings. Securities are also ineligible for purchase if they yield a rate of interest below the prevailing deposit rate, set by the ECB. This currently stands at -0.3 per cent, but still around 20 per cent of the total Euro Area sovereign debt market is rendered ineligible by this constraint.

Greece is also currently unable to participate in the PSPP programme due to uncertainty around its solvency.

4 Theory of sovereign debt and monetary policy

4.1 The macroeconomic determinants of bond yields

Many traditional studies of sovereign bond yields have at their basis three key determinants; inflation, or expectations thereof, potential output growth and debt-GDP.

The first of these is simply motivated. What matters for investors is the real return they receive and as such they adjust nominal yields by the expected change in prices over the life of the investment. Therefore one would expect to observe a positive relationship between the two, with nominal yields increasing to compensate investors for higher inflation.

The theoretical motivation for including potential output growth can come from a number of channels. First, as shown by Laubach (2009), it can be derived from the standard Euler equation of a utility maximising household. The real rate of interest balances the discounted marginal utility of future consumption to the marginal utility of consumption in the current period.

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[4] The EUR60bn figure also encompasses purchases made under the pre-existing Asset-backed Securities Purchase Programme (ABSPP) and the Corporate Bond Purchase Programme (CBPP).

$$\frac{\partial u_t}{\partial c_t} = \beta R_t E_t \left(\frac{\partial u_{t+1}}{\partial c_{t+1}}\right) \quad (1)$$

Where β is the intertemporal discount factor.

In a closed economy model, consumption and output are equivalents and so this can be rearranged to write the real interest rate as a positive function of expected output growth.[5]

$$R_t = \frac{1}{\beta} E_t \left[\left(\frac{c_t}{c_{t+1}}\right)^{-\theta}\right] \quad (2)$$

Where θ is the degree of relative risk aversion.

Potential output growth can also be motivated through the lens of an economy's future returns. Higher potential output implies greater future returns to investment, which increases investment demand and pushes up on real interest rates.

Both of these theoretical channels suggest a positive relationship between potential output/expected output growth and interest rates on government debt.

Debt-GDP is included most commonly as a proxy for the level of default risk. As the debt burden rises relative to the economy's income, the debt is assumed to be less sustainable and thus the probability of default, and therefore the riskiness of the debt itself, increases. Investors require a premium to compensate them for this which pushes up on nominal bond yields. It may also be that the increased public spending associated with higher levels of public debt-GDP crowds out private sector investment, lowering the capital stock and all else equal increasing the marginal product of capital. Both of these channels would give rise to a positive relationship between debt-GDP and nominal yields on sovereign debt.

Another consideration is the extent to which debt is held domestically or by foreign investors. The theoretical premise is that default risk is higher in an economy where a larger proportion of the debt is held externally because a sovereign that defaults on its own citizens is likely to inflict damage on its own tax base, as well as the electorate. If the debt is owned by foreign investors, then a default may have less severe second-round effects for the sovereign, and so there is less of a disincentive to default. Similarly, domestic holders of sovereign debt know that if the sovereign were to default on them it would reduce the value of their claims on the government, but equally reduce the future tax burden they face as the ultimate backers of the fiscal authority. In a Ricardian equivalent world they should therefore be indifferent between the two and as such should require little to no additional premium to compensate for the risk of such a default.[6]

4.2 Traditional monetary-fiscal interaction

Prior to the 2008 financial crisis the predominant instrument for monetary policy was the short-term nominal interest rate. Central banks controlled this by conducting open market operations in the money

[5] This precise formulation is based on a CES utility function with CRRA

[6] There are a number of reasons why this may be less than true. For instance, in a world of multiple agents, investors trading in sovereign debt, even domestically may not be the same as those exposed to future tax changes and so would not view outcomes as equivalent in terms of their personal payoffs.

market and either determining the aggregate quantity of central bank reserves in the system so that the money market cleared at a given rate, or similarly setting the rate at which it would provide reserves perfectly elastically and allowing the market to determine the quantity that cleared at that rate.

Changes in this short-term money market rate then translated in to changes in the full spectrum of interest rates in the economy and either stimulated or dampened incentives for consumption, saving and investment among economic agents.

From the perspective of sovereign bond yields, the key is how these changes in monetary policy transmitted to the price of sovereign debt. Perhaps the most pervasive view in recent years has its roots in the expectations hypothesis, variants of which have been discussed in academic literature since MaCauley (1938). In its purest form, the expectations hypothesis declares that the rate of interest on a long-term security should be equivalent to the expected sum of payoffs from an series of short-term securities that cover the same period, otherwise there would exist an arbitrage opportunity. For instance, the return on a two-period bond should be equal to the return from holding a one-period bond in the first period, and then a second one-period bond in the second period. If there were to be a discrepancy then efficient markets would reallocate resources to the portfolio with the higher pay-off until returns equalised.

Richer versions of the expectations hypothesis allow for deviation from this strict assumption, Sangvinatsos (2008). Some allow for a fixed wedge between the expectations-implied rate and the prevailing rate due to idiosyncratic features of the security such as term or risk, but assume that these do not vary through time. Others allow for the premia to vary through time in response to endogenous changes in factors such as risk-appetite or liquidity preference.

Empirically, the pure expectations hypothesis has been refuted many times. The more complex versions however still operate as a useful theoretical framework and have some support from empirical studies.

In relation to sovereign bond yields, the theory would suggest that term bonds, such as a 10 year benchmark, should be a function of the expected path of short-term interest rates, most notably the monetary policy rate, over those ten years and a premium which itself is a function of many considerations. This is the relationship set out in equation 3 for a bond with maturity N.

$$R_t^N = \sum_{t=0}^{N} i_t + \delta_t \tag{3}$$

Where i_t is the overnight rate, controlled by the monetary authority and δ_t is a time varying premium.

Monetary policy can influence $\sum_{t=0}^{N} i_t$ in a number of ways. Most obviously, any changes in the current policy rate will immediately feed through into $\sum_{t=0}^{N} i_t$. However, the monetary authority can also shape $\sum_{t=0}^{N} i_t$ further out by guiding markets expectations of how it will set policy in the future. This has become commonly known as forward guidance, Dale and Talbot (2013). Lastly, $\sum_{t=0}^{N} i_t$ can be shaped by unconventional monetary policies such as large-scale asset purchases. In fact, as shown by the famous expositions of Woodford (2003) and Eggertson and Woodford (2003), in the canonical New Keynesian model, this is the only way in which unconventional policies can influence longer-term rates such as those on sovereign debt.

Whatever the mechanism by which it is moved, we would expect a positive relationship between this expectational variable and sovereign bond yields.

4.3 Monetary debt management

The recent unconventional monetary policy actions described in Section 3 have looked to directly affect the supply and composition of assets in the market. This manipulation amounts to a form of monetary debt management and breaks from the strict theoretical framework of Woodford (2003). Instead it relies on theoretical ideas that go back to Tobin (1964, 1969), Culbertson (1957) and others who showed relatively intuitively that if there was imperfect substitutability between assets then this would give rise to a less than perfectly elastic demand curve and thus changes in supply would induce movements in the price and yields of assets. Modigliani and Sutch (1966) then began to develop a more rigorous theoretical explanation as to why imperfect substitutability may exist based on the idea that investors had a preference for certain assets or areas of the term structure. For instance, they may wish to hold assets with the same maturity profile as their liabilities or, in an extreme case, be mandated by law to hold assets with certain characteristics.[7]

This requires a number of key assumptions of expositions such as Woodford (2003) to break. For instance, such a result cannot easily be achieved with a representative agent or if Wallace neutrality, a form of Ricardian Equivalence for central bank asset purchases, holds, Wallace (1981). Breaking these assumptions in a theoretically consistent manner has been a challenge to the academic literature in recent years, but increasingly examples can be found, such as the models of Andres et al (2004) and Vayanos and Vila (2009).

Ultimately, the core element of this theoretical strand is that δ_t in equation 3 becomes a positive function of the publicly available supply.

$$\delta_t = f[s_t(+ve)] \tag{4}$$

As such, the central bank can reduce sovereign bond yields by making purchases which withdraw supply from the publicly available market. This has been one of the key motivations for the quantitative easing programmes in many advanced economies, including the PSPP in the Euro Area.

Importantly, it does not mean that expectations of the path of traditional monetary policy are not a significant driver of long-term rates on other assets, but rather provides an additional channel of transmission from monetary policy to interest rates in fiscal debt markets.

Aside from the direct impact on bond yields, such monetary debt management can affect the fiscal position in a number of ways including cash transfers between the monetary and fiscal authorities and netting out of interest payments. These issues are expanded upon in Kirby and Meaning (2015).

5 Empirical literature

Reviewing the entire literature on determinants of sovereign bond yields is beyond the scope of this paper. Instead we will focus on the papers that have directly informed the work which follows, or that focuses on the connection between monetary policy decisions and sovereign yields.

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[7] An obvious example here is that of pension funds who are often required by regulation to hold long-term government securities, or the need to hold liquid assets under the latest Basel Liquidity Coverage Ratio.

The basis for our technical framework draws on Poghosyan (2012) who uses the pooled-mean-group estimation technique of Pesaran et al (1999) to separate the long and short-run determinants of bond yields for a panel of 22 advanced economies. They employ a parsimonious but theoretically motivated long-run relationship that contains just debt-GDP and potential output growth and find that a one percentage point increase in the former is associated with around a 2 basis point increase in 10 year yields while a one percentage point increase in the latter with a 45 basis point increase in yields.

The importance of including forward-looking variables in order to account for the endogeneity of the business cycle is highlighted by Laubach (2009) who uses the Congressional Budget Office's projections of future federal government deficits and debt to analyse driver of long-horizon forward rates in the US. This yields slightly larger quantitative estimate than Poghosyan (2012) with a percentage point increase in projected debt-GDP raising rates by 3-4 basis points. For deficits he finds a percentage point increase leads to 25-30 basis points more on interest rates.

The need to consider both the debt stock and deficits is also highlighted by Ardagna et al (2007). They look at a panel of 16 OECD economies and find that a percentage point increase in debt-GDP leads to just over ½ basis point increase in long yields.

Faini (2006) focuses on a panel of 10 Euro Area economies between 1979 and 2002. They find that debt-GDP has no significant impact on sovereign bond yields for these economies over this period, but that there is a significant impact accounting for all 10 Euro Area economies together. Both Faini (2006) and Ardagna el al (2007) find significant non-linearities in the relationship between debt and sovereign bond yields. In the former case they show sensitivity is to changes in debt-GDP increases above a given threshold (they use 100 per cent of GDP), whilst in the latter accounting for the non-linearity increases their estimates of the impact of a percentage point increase in debt-GDP to between 2 ½ and almost 4 basis points.

De Grauwe and Ji (2012) also include a non-linear term in their regression on Euro Area sovereign bond yields and find it to be of importance. Its inclusion significantly increases the fit of their estimated model when compared to the purely linear specification.

The literature on the monetary dimension of sovereign bond yields is less developed, though rapidly expanding since the introduction of large-scale interventions in sovereign debt markets by central banks.

D'Amico and King (2010) use a panel of data at the individual security level to investigate how the price of nominal US Treasury securities moved in response to purchases of that security, or purchases of securities deemed as relative substitutes for it, by the Federal Reserve throughout the first Large-Scale Asset Purchase Programme (LSAP) in 2009. Meaning and Zhu (2011, 2012) extend this methodology to cover the second LSAP and the maturity Extension Programme in the US, and the Bank of England's first quantitative easing programme in the UK. Both studies find a significant positive relationship between purchases of government debt made by the central bank and the price of that debt and as such, an inverse relationship with the yield.

Joyce et al (2011) use an event study methodology to look at the transmission mechanisms of announcements relating to interventions in the UK gilt market by the Bank of England. The observe changes in yields at the moment that information on these interventions is released to the market and compare that to the changes in overnight index swap rates over the same period. They attribute the change in overnight index swap rates to shifts in markets' expectations of future policy rates, while the remainder of the change in gilt yields is assigned to portfolio rebalancing and supply effects.

Turning to the Euro Area, Eser and Schwaab (2013) undertake an assessment of the ECB's SMP. They use time-series panel techniques to isolate and identify the impact on five year bond rates of participating member states and find it to be significant and quantitatively around a 3 basis point reduction for every 1/1000 of the respective debt market that was purchased.

De Santis (2015) looks specifically at the role redenomination risk, that is the risk that the single currency will break up and existing debt will be repaid in a new currency, plays in determining Euro Area bond yields. He finds that this was a vital determinant of movements in sovereign spreads for the periphery member states in recent history.

6 Econometric specification

There are a number of elements of our theoretical framework that inform our choice of econometric specification. First, we want to investigate the validity of the hypothesis that there exists a fundamental relationship between the expected path of short-term interest rates and long-term rates, consistent with the arguments of Woodford (2003). Second, although we expect this relationship to hold in the long-run, we expect a degree of deviation in the short-run. To this end, the appropriate econometric specification should be one that allows for both of these, most obviously an error-correcting model.

Given our interest in commonalities or differences across Euro Area economies, single-equation estimation on a country-by-country basis is likely to miss some key points of interest.

As such, we elect to use an error-correcting panel estimation technique, pooled mean group estimation (PMG), as outlined in Pesaran et al (1999), the specification of which can be seen below.

$$\Delta y_{it} = \alpha_i^1 \Delta O_{it} + \alpha_i^2 \Delta GDR_{it} + \delta_i [y_{it-1} - \beta^1 O_{it-1} - \beta^2 GDR_{it-1}] + \varepsilon_{it} \qquad (5)$$

The dependent variable is the change in the 10 year government bond yield for country i. The long-run relationship is captured by the terms in square brackets, which in our benchmark regression will be the overnight index swap rate and the level of debt-GDP. Once it has deviated from this long-run relationship, the sovereign bond yield corrects back to it at a speed dictated by δ_i. For the relationship to be stable δ_i should be between -1 and 0. Additional controls are added to describe the short-run dynamics around the long-run.

PMG blends elements of panel and time series techniques, which makes it appropriate for a dataset such as ours in which we have a large number of countries and also a relatively long time dimension. By framing the panel estimation in an error-correction model, PMG allows us to estimate a long-run relationship to which the model gravitates, as well as short-run dynamics. What is more, the error-correcting nature of the regression removes concerns over the inclusion of I(1) or cointegrated variables.

A fundamental assumption of the PMG methodology is that it restricts the coefficients within the long-run relationship to be homogenous across countries. We might expect this to be a valid assumption under our theoretical premise, as the long-run coefficient on the expected path of interest rates should be unity in all cases. However, we can and will test this validity by means of a Hausman test. This tests the hypothesis that the restricted model is indifferent to an unrestricted version estimated using mean-group estimation

(MG). If there is no significant difference between the two, then the restrictive assumption is validated. Should the PMG estimation prove less efficient than the MG estimation then the more flexible MG estimator is more appropriate and the implication is that the long-run coefficients are heterogeneous across countries.

6.1 Data

We build a data set of information on 11 Euro Area economies; Austria, Belgium, Finland, France Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. This panel covers 98 per cent of nominal Euro Area output and, perhaps more importantly, the economies which account for 99 per cent of Euro Area sovereign securities outstanding.

For the majority of the analysis presented in this paper, the data is at a quarterly frequency. The frequency of data is one of the largest limitations of studies of sovereign bonds. Sovereign debt markets, like most financial markets, evolve quickly with significant data being internalised and traded on in seconds, if not quicker. This means that studies that use lower frequency data are likely to miss important information contained in these higher-frequency dynamics. A clear example is Poghosyan (2012) who discusses short-run dynamics in sovereign bond yields, but using annual data. The change of yields over a 12 month period can hardly be considered a short-term movement for such assets. This is why we aim to use the highest frequency data we can. The nature of data on debt-GDP limits regressions including this variable to a quarterly frequency, which is already an improvement on annual studies. However, by using differing proxies for default risk that are available at a higher frequency, we can capture the same theoretical channel as debt-GDP while also including these faster moving dynamics. We attempt to do this towards the end of the paper with regressions run using monthly data, but in fact, some of the proposed specifications could even be estimated on data at a daily frequency.

Our benchmark sample period runs from the third quarter of 2005 to the second quarter of 2015.

The series we include are benchmark nominal 10 year government bond yields, sourced from the OECD, 10 year Euro overnight index swap rates from Datastream and the ratio of debt-GDP based on the consolidated gross debt stock of the general government, as reported by Eurostat. While the government bond yield and debt-GDP series vary between economies, the nature of the monetary union is that the 10 year OIS series is common to all economies.

A point of note here is that the analysis carried out in this paper is based in the current vintage of statistical data available at the time of publication. As highlighted by the case of Greece in 2009, this data has often been revised from the first outturn, sometimes heavily. As such markets may have been reacting to and pricing sovereign bonds at any given moment from information on variables that has differs from what we observe with hindsight. An interesting extension to the work presented in this paper would be to construct a real time data set and re-run the analysis that follows to see how it is affected by using data as markets saw it at the time.

6.1.1 The importance of OIS rates

One series within our dataset deserves some additional discussion. We use the 10 year overnight index swap rate to capture the forward-looking expectation of the path of the short-term nominal interest rate. This is an important development for characterising the stance of monetary policy.

Overnight index swap contracts are an agreement to exchange a fixed rate of interest for the geometric average of the overnight rates that prevail over the life of the contract. Therefore they are often considered as a reasonable proxy for market expectations of interest rates, see Brooke et al (2000).

Importantly, these contracts can be agreed over differing terms, and so it is possible to get an expectation of the path of short-term rates over different terms as well. This means that, unlike when using the contemporaneous monetary policy rate which is the same for bonds of any maturity, OIS rates allow for a bespoke measure of the stance of monetary policy that can be matched directly to the maturity of the bond in question.

This provides a number of benefits. First, it is theoretically consistent. Second, it provides a richer view of changes in the monetary stance. Policy can be looser or tighter even if the headline policy rate is not cut. This is of particular relevance in the recent environment of interest rates near their lower bound and forward-guidance and other unconventional policy measures. Rather than the narrow view provided by the simple overnight spot rate, our measure of monetary policy will adjust equally should the ECB move policy rates in the traditional way, look to shape expectations through market announcements or through signalling a commitment to keep rates lower for longer with large-scale asset purchases. Thus even when the MRO is held constant for a prolonged period, OIS rates allow us to capture the ever changing stance of policy.

7 Results

7.1 Benchmark regression

The results of our benchmark specification are presented in Table 1. We include interest rate expectations and debt-GDP in the long-run relationship, and changes in the same two variables for the short-term dynamics. This is a deliberately parsimonious specification as, if our theoretical hypothesis is to be validated bond yields in the long-run must be largely described by these two factors. We will look in the next section at a range of alternative specifications which introduce various additional controls, but find the key results of this initial benchmark generally remain robust.

What we can see is that our long-run coefficient on interest rate expectations is significant and close to unity. This is consistent with the prediction of our theoretical framework. What is more, the estimated long-run coefficient on debt-GDP is also significant and positive. Quantitatively the implied impact is that every one percentage point increase in debt-GDP should increase sovereign bond yields in the Euro Area by 1.2 basis points, a figure in line with a number of the studies discussed in Section 5.

Importantly, the Hausman test validates the imposition of common long-run parameter values across Euro Area members.

Turning to the short-run dynamics, we can begin to discuss heterogeneity of parameters between economies. The first thing to note is that the error-correction parameters in all instances are between -1 and zero, implying that the long-run relationship we have identified is stable. The speed of adjustment back to this long-run relationship is notably faster in Northern European economies, such as Germany, the Netherlands and France. Conversely, the Southern European economies deviate from their long-run level much more persistently with Italy, Spain and Portugal moving just a tenth of the way back to equilibrium each quarter. The adjustment in Greece and Ireland is even slower, but the coefficients prove to be insignificant at the 10 per cent confidence level.

In all cases except Greece, the estimated coefficient on the change in OIS rates is significant and positive, suggesting a short-term amplification of a change in interest rate expectations over and above that implied by the long-run relationship. These vary between economies, but fall within a range of 0.66 to 1.10, with a rough rule of thumb being that the Northern European economies are closer to unity while their southern counterparts fall towards the lower end of the distribution.

Changes in debt-GDP are significant and positive in around half of the economies in our sample, but insignificant for the rest.

7.2 Additional specifications

7.2.1 Removing Greece

Given the myriad of developments that are highly specific to the Greek case over our sample period, and the slightly perverse results for Greece in our benchmark specification, we estimate the same regression as in equation 5 but this time removing Greece from the sample. What we find is that the key long-run relationship is unchanged to the second decimal place, Table 2.

7.2.2 Removing Germany

Many empirical studies of Euro Area sovereign bond yields analyse the spread of bond rates over the equivalent German bund rate. The motivation is that the German bund can act as a proxy for a risk-free benchmark. This does however remove the ability to analyse drivers of German sovereign bond yields independently. Our specification allows for the inclusion of the 10 year bund rate, but as a check of the influence of this decision, and a counter to the removal of Greece in the previous example, we reintroduce Greece and remove Germany from our sample before running the same regression again.

Both the parameters in the long-run relationship increase from our benchmark specification. They now imply that government bond rates overreact to changes in interest rate expectations, although the coefficient is still close to unity. The implication from this estimation is that a one percentage point increase in debt-GDP leads to around a 4 basis point increase in bond rates, more than 3 times the sensitivity when Germany is included, Table 3.

7.2.3 North-South divide

A distinction has often been drawn in recent history between the Northern European economies and the Southern. As a rule of thumb, the former have not seen significant spikes in their borrowing costs since 2008, in fact in many cases they have fallen. The latter have experienced the worst of the interest rate increases and been the focus of much of the discussion over default risk and debt sustainability.

An interesting way to cut our data is therefore along this North-South divide, to see if there is any evidence of structural differences between the two. We define Northern Euro Area economies as Austria, Belgium, Finland, France, Germany and the Netherlands. Southern Euro Area economies are Greece, Ireland, Italy, Portugal and Spain (GIIPs).

For the Northern Euro Area economies, our benchmark result holds true. The long-run parameter on interest rate expectations remains significant and close to unity and a one percentage point increase in debt-GDP positively relates to around a 1 ½ basis point increase in 10 year rates, Table 4. In the Southern Euro Area economies though, the relationship breaks down, with almost no significant parameters, Table 5.

7.2.4 Pre- and post-crisis samples

A simple visual analysis of Figure 1 suggests that the intensification of the financial crisis in the third quarter of 2008 represented a dramatic change in the evolution of Euro Area sovereign bond yields. An obvious question is then; did this represent a structural change in the underlying relationships which govern bond movements, or was it simply the extreme movements in the drivers themselves?

To investigate this question we maintain our North-South sample break and estimate the relationship for both sub-samples for the period prior to the third quarter of 2008, Tables 6 and 7, and then again for the period from 2008 Q3 onwards, Tables 8 and 9.

What we can see is for the Northern Euro Area economies, the long-run relationship is little changed with the long-run parameter on interest rate expectations shifting from 0.9 to 1.1. Also, in the post-crisis sample we can see that debt-GDP is not significant in the long-run, but is positive and significant in a number of economies as part of the short-run dynamics. In Germany however, the estimated parameter is negative, although it narrowly falls out of statistical significance at the 10 per cent threshold. This may weakly suggest there has been a form of safe haven/flight-to-safety effect in Germany, a possibility we discuss in our monthly regressions presented later.

In the Southern Euro Area economies the estimations are weakly supportive of our theoretical premise prior to the crisis, with the long-run coefficient on interest rate expectations positive and significant. However, even this weak result breaks down in the post-crisis sample with no variables in our benchmark specification proving to be significant.

7.2.5 Alternative fiscal measure

Government debt is not the only measure that contains information on the current fiscal stance of an economy. Under the Maastricht Treaty, not only were European sovereigns required to keep the stock of debt relative to GDP under a specified limit, but also the flow on to that stock, the budget deficit. To see if our specification is robust to the use of this alternative measure of the fiscal stance we introduce it into both the long-run relationship and the short-run dynamics in place of debt-GDP.

The long-run coefficient on the deficit ratio is significant and negative, Table 10. This is in line with what our theoretical framework would predict. If a sovereign is running a larger deficit (a negative budget balance) then this will be viewed as a less sustainable fiscal position and as such increase the risk of default in the same way as increased debt-GDP. Quantitatively the implication is that a one percentage point increase in the budget deficit-GDP will increase the sovereign's 10 year bond rate by almost 5 basis points.

Importantly, the long-run coefficient on interest rate expectations is robust to the change of fiscal variable, significantly positive and marginally under unity.

7.2.6 External debt position (net asset ratio)

As discussed in Section 4, there is a theoretical basis for why it may matter if debt is held domestically or by external investors. The net debt position of the economy as a whole may be considered a proxy for this channel as any debt issued by the sovereign and held by domestic investors would be netted out.

The net debt position vis-a-vis the rest of the world may also be a useful indicator of the indebtedness of the economy as a whole. Given that the private sector is the ultimate backer of the fiscal authority, if they are also heavily indebted this could be considered a risk-factor, making default more likely. Similarly, even if the public sector has a relatively strong fiscal position, if the private sector is heavily indebted this increases the probability of private sector defaults which would have implications for economic activity and thus the future fiscal position. A case in point would be the Irish economy. Before the financial crisis, the sovereign's debt-GDP was relatively low, but the private sector, specifically the banking system, was hugely leveraged and when losses began to materialise the sovereign was forced to step in and absorb the burden.

De Grauwe and Ji (2012) proxy for this external debt position by using the current account balance. Other studies including Gors and Alcidi (2011) elect to use the cumulated current account balance. For our analysis we prefer to use the net asset position of the economy as a ratio to GDP. This has the benefit of taking in to account revaluations of assets.

Including the change in the net asset ratio (NAR) as a control in our short-run dynamics renders the debt-GDP statistically insignificant in our long-run relationship. We therefore exclude it from the regression, but continue to control for the change in the debt-GDP ratio. Interest rate expectations remain significant and positive, with parameters at close to unity in the long-run and varying between 0.4 and 1 in the dynamics, Table 11. The estimated parameters on the net asset ratio prove to be significant and positive for Spain and Italy.

7.3 Monthly regressions

As mentioned in Section 6.1, the relatively low frequency of data on macroeconomic variables such as debt-GDP presents a problem when trying to fully understand the dynamics of fast-moving financial markets, such as those for sovereign debt. Better would be to find series of a higher frequency that contained the equivalent information about the same channels. This requires us to think about exactly what we are trying to capture with our current quarterly series.

Debt-GDP is predominantly trying to proxy for the risk of default and sustainability of the fiscal position. The obvious candidate series to look at this at a higher frequency would seem to be the credit default swap (CDS) rate. CDS are insurance contracts that promise to pay the holder the value of the underlying security should the issuer of that security default either partially or completely. In the same way that an insurance premium is high when the risk is higher, the price of CDS contracts is positively correlated with the probability of default. In fact, it is possible to derive a measure of the market expectation of default with a given time horizon from the CDS price, Korner (2015). As such, CDS rates can be considered a measure of default risk, arguably more precisely than debt-GDP, and as they are available at a much higher frequency do not limit the frequency of the dataset in the same way.

We therefore estimate our benchmark regression of equation 5 but using monthly data and substituting out debt-GDP for the bid price of a CDS contract on the 5 year sovereign debt of the economy in question.[8] Estimating over the full sample of August 2005 to August 2015, we find that the long-run coefficient on CDS contracts is both significant and positive, consistent with our theoretical hypothesis, Table 12. It implies that a 1 percentage point increase in the CDS rate leads to a 65 basis point increase in 10 year yields.

[8] Due to data limitations we could not access 10 year CDS rates which would have more closely matched the rest of our analysis.

Importantly, the long-run parameter on interest rate expectations is significant and unity to the third decimal place, supporting the key result of our quarterly regressions.

Turning to the short-run dynamics, we see that the long-run relationship is stable and significant in all economies except Greece. Speed of adjustment parameters follow a similar pattern to those found in our quarterly regressions; they are larger and therefore quicker to adjust in Northern European economies, and more sluggish in Southern Euro Area economies.

The estimated coefficients on the change in CDS rates are mostly positive and significant, implying they accentuate any deviation. Of note is that Germany has a significantly negative coefficient, which may be explained by a flight to safety effect as the German CDS is tied in to fears of a general breakup of the Euro, but with Germany being seen as a safe haven in the event of such a occurrence.

We also estimate a pre- and post-August 2008 sample using our monthly data, to consider the possibility of a structural break, Tables 13 and 14. The first point of note is that prior to the financial crisis, the parameters driving the Greek sovereign bond yield were much more in line with the rest of the Euro Area economies. The long-run relationship is little changed, though the sensitivity to changes in the CDS rate is larger, and it is stable across all economies. As per our previous results, the speed of adjustment is higher in Northern Euro Area economies than Southern.

In every economy apart from Greece, the change in CDS rates is insignificant in the pre-crisis sample. However, looking at the post-crisis estimation, this clearly changes. We now get an interesting heterogeneity in responses to a change in the CDS rate, which can be grouped in to three broad categories; the GIIPs, Belgium and Austria all have a significantly positive response, meaning that an increase in the CDS rate leads to a rise in the bond yield in excess of that implied by the correction of the long-run relationship; Finland, France and the Netherlands have no significant connection outside of the long-run ; finally, Germany has a significantly negative relationship, probably connected to flight-to-safety. This result is highly indicative of the fact that prior to the crisis, investors paid little attention to default risk in the Euro Area, and to the extent they did, they believed the relationship to be homogenous across member states. However, since the crisis, these relationships have been re-evaluated and clear heterogeneity introduced.

As highlighted by De Grauwe and Ji (2012), there is a danger of endogeneity between sovereign bond yields and CDS rates. This would arise if increases in sovereign bond yields worsened the fiscal situation, for example by increasing the interest rate burden on the government, and as such increased the perceived chance of default, leading to a rise in the CDS rate. This seems like a plausible transmission mechanism, at least for some of the Euro Area member states, at least for parts of the crisis. O'Kane (2012) investigates the two-way relationship between sovereign bonds and CDS rates within the Euro Area. He finds that Granger causality is at best ambiguous between economies, with CDS Granger causing movements in bond yields in some Euro Area economies and the reverse happening in others. Similarly, Fontana and Scheicher(2010) undertake a lag-lead analysis of Euro Area CDS and sovereign bond yields to see in which market price discovery occurs. They find that post-2008, price discovery occurs in the bond market for the Northern European economies, meaning that this leads the CDS market. However, for Southern European economies, price discovery occurs in the CDS market and is then translated into moves in the bond market.

We do not shy away from the very real danger of endogeneity though, which is why our monthly regressions do not take more prominence in this exposition. However, it should be noted that they do serve to strongly support the results found in the quarterly regressions. What is more, the importance of risk and the probability of default are widely accepted as being central to the evolution of Euro Area sovereign bond yields in recent history, so any analysis which doesn't include a role for them in its narrative is likely to be flawed.

A useful extension to this work would be to find a viable instrument for CDS rates and re-run these estimations with the series created from that to see if the baseline results remains valid. Alternatively it would be possible to estimate a Vector Auto Regressive (VAR) model, or more likely a Vector Error-Correction (VECM) model to allow for exactly the feedbacks that cause the endogeneity problem. This would have the downside of needing to be run on a country-by-country basis, but could conceivably be improved by placing restrictions on the long-run parameters on interest rate expectations in much the same way as is done in PMG estimation.

8 Conclusions

This paper seeks to investigate to what extent sovereign bond yields in the Euro Area follow expectations of short-term monetary policy rates. Our empirical results would seem to support a strong link between market expectations of ECB policy and bond yields that is robust to a range of alternative controls and specifications, especially in the Northern Euro Area economies. The result would suggest that ECB policy has acted to hold down, and even reduce sovereign bond yields significantly for Northern Euro Area economies in recent years. However, our empirical work is less definitive for Southern Euro Area economies where it would seem that this relationship either doesn't exist, or is swamped by other factors.

Our fundamental result serves to highlight the interconnected nature of monetary and fiscal policy, but also to show the limits to which monetary policy can offset variation in bond yields by controlling the path of short-term nominal interest rates.

This result sets the scene for a number of further research questions. The growing literature on central bank purchases of sovereign debt will surely turn its focus to the Euro Area as the march of time increases the length of time series available on the ECB's public sector purchase programme. There is also a definite need to find ways to incorporate information from higher frequency data on sovereign debt markets alongside lower frequency macroeconomic controls. The evolving literature on mixed-frequency VAR models may be of use in this area (see for instance Bluwstein and Canova, 2015). Lastly, it is crucial to find accurate ways in which to account for default and other risk factors in a manner that is not subject to problematic issues of endogeneity.

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Tables

Table 1: Benchmark quarterly regression

	Long Run
L.ois	1.015***
	(0.000)
L.gdr	0.0120*
	(0.053)

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
ec	-0.272***	-0.185**	-0.0908	-0.299***	-0.132*	-0.365***	-0.640***	-0.362***	-0.119*	-0.0963*	-0.0594
	(0.004)	(0.020)	(0.133)	(0.004)	(0.059)	(0.001)	(0.000)	(0.003)	(0.081)	(0.053)	(0.442)
D.ois	0.818***	0.774***	-0.648	0.913***	0.663***	0.892***	1.026***	0.959***	0.473**	0.681*	1.097***
	(0.000)	(0.000)	(0.523)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.028)	(0.075)	(0.004)
D.gdr	0.0219**	0.0142	0.0918*	0.0213**	0.0631	0.0666***	0.00315	0.0244**	-0.00983	0.131**	-0.0176
	(0.047)	(0.397)	(0.075)	(0.040)	(0.195)	(0.001)	(0.802)	(0.022)	(0.801)	(0.016)	(0.578)
_cons	-0.174	-0.128	0.374	-0.119	0.0163	-0.273	-0.619*	-0.196	0.0190	-0.0233	0.121
	(0.302)	(0.386)	(0.447)	(0.302)	(0.880)	(0.258)	(0.085)	(0.291)	(0.881)	(0.901)	(0.473)
N	429										
Hausman p value 0.44											

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 2: Benchmark regression less Greece

Long Run	
L.ois	1.014***
	(0.000)
L.gdr	0.0118*
	(0.059)

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
ec	-0.272***	-0.185**		-0.300***	-0.132*	-0.363***	-0.641***	-0.360***	-0.119*	-0.0962*	-0.0596
	(0.004)	(0.020)		(0.004)	(0.058)	(0.001)	(0.000)	(0.003)	(0.081)	(0.053)	(0.439)
D.ois	0.818***	0.774***		0.913***	0.663***	0.891***	1.025***	0.958***	0.472**	0.681*	1.097***
	(0.000)	(0.000)		(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.028)	(0.075)	(0.004)
D.gdr	0.0219**	0.0141		0.0213**	0.0631	0.0664***	0.00313	0.0244**	-0.00985	0.131**	-0.0176
	(0.047)	(0.398)		(0.040)	(0.194)	(0.001)	(0.804)	(0.022)	(0.801)	(0.016)	(0.578)
_cons	-0.168	-0.123		-0.116	0.0186	-0.264	-0.606*	-0.188	0.0227	-0.0209	0.123
	(0.317)	(0.403)		(0.318)	(0.863)	(0.270)	(0.092)	(0.305)	(0.858)	(0.912)	(0.469)
N	390										

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 3: Benchmark regression less Germany

Long run	
L.ois	1.210***
	(0.000)
L.gdr	0.0382***
	(0.000)

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
ec	-0.254***	-0.183**	-0.101	-0.245***	-0.112	-0.413***		-0.591***	-0.115	-0.103*	-0.0169
	(0.005)	(0.016)	(0.114)	(0.010)	(0.178)	(0.001)		(0.000)	(0.101)	(0.066)	(0.859)
D.ois	0.840***	0.789***	-0.633	0.934***	0.674***	0.950***		1.014***	0.486**	0.701*	1.123***
	(0.000)	(0.000)	(0.531)	(0.000)	(0.001)	(0.000)		(0.000)	(0.024)	(0.067)	(0.003)
D.gdr	0.0251**	0.0168	0.0923*	0.0256**	0.0517	0.0710***		0.0311***	-0.00897	0.134**	-0.0247
	(0.026)	(0.318)	(0.073)	(0.020)	(0.316)	(0.001)		(0.002)	(0.821)	(0.016)	(0.475)
_cons	-0.805**	-0.699**	0.00194	-0.515**	-0.220	-1.377**		-1.503**	-0.388	-0.327	0.0446
	(0.016)	(0.041)	(0.996)	(0.024)	(0.292)	(0.014)		(0.010)	(0.194)	(0.150)	(0.842)
N	390										

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 4: Northern Euro Area economies sub-sample

	Long run
L.ois	1.028***
	(0.000)
L.gdr	0.0149**
	(0.018)

	Austria	Belgium	Finland	France	Germany	Netherlands
ec	-0.276***	-0.186**	-0.288***	-0.384***	-0.628***	-0.387***
	(0.004)	(0.020)	(0.006)	(0.000)	(0.000)	(0.002)
D.ois	0.820***	0.775***	0.915***	0.897***	1.030***	0.962***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
D.gdr	0.0224**	0.0145	0.0216**	0.0681***	0.00340	0.0250**
	(0.043)	(0.388)	(0.039)	(0.001)	(0.788)	(0.018)
_cons	-0.246	-0.189	-0.162	-0.387	-0.759**	-0.286
	(0.178)	(0.242)	(0.173)	(0.155)	(0.036)	(0.182)
N	234					

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 5: Southern Euro Area economies sub-sample

	Long run
L.ois	-0.537
	(0.676)
L.gdr	-0.142
	(0.280)

	Greece	Spain	Italy	Portugal	Ireland
ec	-0.0511	-0.0682	-0.145*	-0.0581	-0.0336
	(0.279)	(0.192)	(0.069)	(0.128)	(0.313)
D.ois	-0.689	0.588***	0.353	0.624	1.017***
	(0.505)	(0.002)	(0.138)	(0.108)	(0.008)
D.gdr	0.0909*	0.0410	-0.0205	0.117**	-0.0264
	(0.084)	(0.339)	(0.601)	(0.029)	(0.356)
_cons	1.494	0.929*	3.191	1.033	0.630
	(0.344)	(0.071)	(0.262)	(0.192)	(0.167)
N	195				

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 6: Northern Euro Area economies pre-crisis sub-sample

	Long run
L.ois	0.918***
	(0.000)
L.gdr	0.0216***
	(0.002)

	Austria	Belgium	Finland	France	Germany	Netherlands
ec	0.0196	0.0935	0.0834	-0.528	-1.765***	-0.0102
	(0.907)	(0.453)	(0.593)	(0.136)	(0.000)	(0.960)
D.ois	0.781***	0.793***	0.848***	0.840***	0.937***	0.858***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
D.gdr	0.00576	0.00343	0.0104	0.0324	0.0306	0.0176
	(0.330)	(0.652)	(0.233)	(0.123)	(0.148)	(0.369)
_cons	0.0643	0.207	0.0851	-0.577	-2.160*	0.0214
	(0.752)	(0.335)	(0.317)	(0.277)	(0.092)	(0.879)
N	72					

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 7: Northern Euro Area economies post-crisis sub-sample

	Long run
L.ois	1.107***
	(0.000)
L.gdr	0.00406
	(0.499)

	Austria	Belgium	Finland	France	Germany	Netherlands
ec	-0.521***	-0.269**	-0.760***	-0.381***	-0.680***	-0.794***
	(0.001)	(0.029)	(0.000)	(0.005)	(0.000)	(0.000)
D.ois	0.952***	0.805***	1.063***	0.987***	1.182***	1.049***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
D.gdr	0.0376*	0.0109	0.0213	0.0509*	-0.0212	-0.00143
	(0.074)	(0.639)	(0.269)	(0.058)	(0.195)	(0.926)
_cons	-0.0353	0.0249	-0.0837	-0.0538	-0.350	-0.108
	(0.902)	(0.899)	(0.762)	(0.814)	(0.304)	(0.761)
N	162					

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 8: Southern Euro Area economies pre-crisis sub-sample

	Long run
L.ois	0.782***
	(0.000)
L.gdr	-0.0416
	(0.104)

	Greece	Spain	Italy	Portugal	Ireland
ec	0.0108	-0.783*	-0.158	-0.0767	-0.314*
	(0.947)	(0.085)	(0.348)	(0.609)	(0.081)
D.ois	0.772***	0.741***	0.765***	0.691***	0.767***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
D.gdr	0.00666	0.0730	0.0171	0.00353	0.0200
	(0.612)	(0.126)	(0.154)	(0.890)	(0.134)
_cons	-0.00223	1.961**	0.886	0.339	0.648*
	(0.998)	(0.025)	(0.340)	(0.546)	(0.069)
N	60				

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 9: Southern Euro Area economies post-crisis sub-sample

	Long run
L.ois	4.565
	(0.144)
L.gdr	-0.110
	(0.625)

	Greece	Spain	Italy	Portugal	Ireland
ec	-0.0531	-0.0267	-0.0369	-0.0569	-0.104
	(0.392)	(0.342)	(0.291)	(0.225)	(0.287)
D.ois	-1.176	0.669**	0.425	0.998*	1.899***
	(0.475)	(0.035)	(0.221)	(0.097)	(0.001)
D.gdr	0.0862	0.00131	-0.0533	0.0887	-0.0745*
	(0.184)	(0.985)	(0.332)	(0.203)	(0.059)
_cons	0.795	0.0541	0.300	0.337	0.914
	(0.702)	(0.916)	(0.775)	(0.801)	(0.656)
N	135				

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 10: Regression including budget deficit ratio

	Long Run
L.ois	0.955***
	(0.000)
L.gbr	-0.0486***
	(0.000)

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
ec	-0.288***	-0.211**	-0.0972	-0.502***	-0.0964	-0.272***	-0.897***	-0.617***	-0.123*	-0.0740	-0.234***
	(0.005)	(0.015)	(0.110)	(0.001)	(0.116)	(0.009)	(0.000)	(0.000)	(0.053)	(0.134)	(0.002)
D.ois	0.818***	0.770***	-0.909	0.928***	0.626***	0.857***	1.007***	0.927***	0.464**	0.527	0.863**
	(0.000)	(0.000)	(0.382)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.031)	(0.202)	(0.014)
D.gbr	-0.112*	-0.0672	0.141	-0.110***	-0.0123	-0.0371	-0.0571*	-0.114***	0.0672	0.111	0.115**
	(0.062)	(0.336)	(0.579)	(0.005)	(0.870)	(0.557)	(0.094)	(0.001)	(0.747)	(0.473)	(0.017)
_cons	0.0954*	0.119*	0.717	0.151***	0.138	0.0753*	0.00725	0.128***	0.178	0.217	0.443**
	(0.051)	(0.069)	(0.178)	(0.006)	(0.215)	(0.079)	(0.844)	(0.003)	(0.151)	(0.280)	(0.018)
N	429										

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 11: Regression including the net asset ratio

	Long Run
L.ois	0.957***
	(0.000)

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
ec	-0.252***	-0.193**	-0.0770	-0.320***	-0.124**	-0.296***	-0.588***	-0.221**	-0.107*	-0.0925**	-0.0821
	(0.005)	(0.014)	(0.186)	(0.002)	(0.022)	(0.001)	(0.000)	(0.027)	(0.066)	(0.047)	(0.236)
D.ois	0.781***	0.764***	-0.667	0.908***	0.635***	0.878***	1.012***	0.907***	0.460**	0.667*	0.990**
	(0.000)	(0.000)	(0.505)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.016)	(0.079)	(0.011)
D.gdr	0.0151	0.0162	0.0849*	0.0187*	0.0551	0.0633***	0.00462	0.0164	0.0108	0.129**	-0.00731
	(0.183)	(0.335)	(0.098)	(0.064)	(0.184)	(0.002)	(0.718)	(0.134)	(0.759)	(0.017)	(0.820)
D.nar	0.0152	-0.00769	0.0583	0.00403	0.0462***	0.0190	0.00254	-0.00869*	0.101***	0.0241	0.0161
	(0.181)	(0.313)	(0.254)	(0.381)	(0.001)	(0.439)	(0.344)	(0.065)	(0.001)	(0.411)	(0.349)
_cons	0.101*	0.132*	0.552	0.0918**	0.177*	0.108*	0.0271	0.0789*	0.195*	0.123	0.230
	(0.067)	(0.060)	(0.307)	(0.047)	(0.064)	(0.053)	(0.507)	(0.051)	(0.094)	(0.549)	(0.251)
N	429										

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 12: Benchmark monthly regression

Long Run	
L.Ois	1.000***
	0
L.cds	0.00647***
	0

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
Ec	-0.295***	-0.241***	0.0262***	-0.188***	-0.0432*	-0.222***	-0.0958**	-0.190***	-0.087***	-0.0412*	-0.153**
		0	0	0	-0.076	0	-0.012	0	-0.01	-0.073	-0.012
D.ois	0.770***	0.693***	-1.192*	0.726***	0.652***	0.747***	0.810***	0.781***	0.64***	0.640***	0.758***
	0	0	-0.083	0	0	0	0	0	0	0	-0.007
D.cds	0.00283***	0.00430***	-0.0003***	-0.0018	0.00617***	0.00192**	-0.0026**	-0.000344	0.006***	0.006***	0.00579***
	0	0	0	-0.192	0	-0.031	-0.013	-0.682	0	0	0
_cons	-0.005	0.0145	0.188	0.0015	0.0189	-0.0025	-0.0301**	-0.0118	0.041*	0.0408	0.150*
	-0.79	-0.442	-0.156	-0.905	-0.326	-0.876	-0.022	-0.327	-0.08	-0.242	-0.06
N	1288										

Sample period runs from August 2005 to August 2015

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 13: Monthly regression pre-crisis sub-sample

Long Run	
L.Ois	0.894***
	0
L.cds	0.0515***
	0

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
Ec	-0.299**	-0.0861**	-0.0503***	-0.221**	-0.0478**	-0.153**	-0.115	-0.141**	-0.0611**	-0.0588**	-0.360**
	-0.017	-0.024	-0.008	-0.026	-0.022	-0.029	-0.11	-0.04	-0.02	-0.017	-0.047
D.ois	0.778***	0.674***	0.724***	0.712***	0.705***	0.755***	0.740***	0.749***	0.722***	0.688***	0.701***
	0	0	0	0	0	0	0	0	0	0	0
D.cds	0.0112*	-0.0032	0.00278*	-0.0078	0.00131	-0.0009	0.00288	0.000932	0.0025	0.00345	-0.0035
	-0.089	-0.423	-0.09	-0.431	-0.594	-0.876	-0.504	-0.883	-0.273	-0.139	-0.682
_cons	0.0582	0.028	0.00766	0.0508	0.0131	0.0335	-0.0063	0.0313	0.00835	0.00954	-0.154
	-0.358	-0.153	-0.606	-0.262	-0.323	-0.305	-0.817	-0.297	-0.618	-0.536	-0.362
N	353							Sample period runs from August 2005 to July 2008			

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Table 14: Monthly regression post-crisis sub-sample

	Long Run
L.Ois	1.018***
	0
L.cds	0.00528***
	0

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
Ec	-0.420***	-0.294***	0.0360***	-0.246***	-0.0198	-0.301***	-0.122**	-0.242***	-0.056	-0.0274	-0.115**
	0	0	-0.002	0	-0.533	0	-0.01	0	-0.168	-0.285	-0.03
D.ois	0.798***	0.688***	-2.058**	0.737***	0.615***	0.754***	0.826***	0.794***	0.605***	0.632***	0.749**
	0	0	-0.041	0	0	0	0	0	0	-0.003	-0.016
D.cds	0.00246***	0.00406***	-0.000313***	-0.0019	0.0063***	0.00161	-0.00269**	-0.000588	0.00581***	0.00615***	0.00555***
	-0.001	0	0	-0.208	0	-0.116	-0.022	-0.531	0	0	0
_cons	0.0246	0.0546**	0.16	0.00903	0.00741	0.0203	-0.0432***	-0.00745	0.0356	0.0419	0.149
	-0.329	-0.048	-0.394	-0.567	-0.843	-0.35	-0.01	-0.597	-0.418	-0.498	-0.103
N	935							Sample period runs from August 2008 to August 2015			

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*