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ABSTRACT

We investigate the role of both ECB's asset purchases and market sentiment in the Eurozone sovereign debt crisis context. We explain the evolution of long-term interest rates in the Eurozone and in some Member States since the ECB started to purchase various securities for monetary policy purposes. We control for four categories of fundamentals: macroeconomic, international, financial and expectations. We show that unconventional monetary policies and country-specific market sentiment have significant negative and positive effects respectively. Our results suggest that ECB's unconventional policies have been effective in mitigating the disruption in the channels of transmission across the different Eurozone countries.

KEY WORDS

Asset purchase programmes, ECB, sovereign yields, unconventional monetary policies, CISS.

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E52, E58.

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1. Introduction

The objective of this paper is to assess the role of market sentiment and European Central Bank (ECB)'s policy of asset purchases on sovereign yields in the Eurozone and in 4 Eurozone countries (Germany, France, Italy and Spain). Since 2007, the ECB implemented a range of monetary policy decisions to deal with the multiple dimensions of the crisis. Some of those measures have been considered as unconventional as they went beyond cutting down the short-term policy rate and providing liquidity at a short-term maturity to the banking system. The ECB changed the conditions and the maturity of liquidity operations and proceeded to purchases of different classes of financial assets. The APP (assets purchase programme) implemented since March 2015 is the most recent example of unconventional measure, which is close to what was done earlier by the Federal Reserve and the Bank of England.[1] Empirical evidence on unconventional measures has suggested that they have been effective at reducing long-term interest rate in the United States and the United Kingdom either through the signalling or the portfolio balance channels.[2]

In contrast, several measures implemented by the ECB were designed to address the specific features of the crisis in the Eurozone and of its institutions (Cour-Thimann and Winkler, 2012). Not only was the Eurozone confronted to a banking crisis in 2007-2008 but it also faced a sovereign debt crisis which started with the Greek episode in 2010 and resulted in a sharp increase of sovereign yields in Ireland, Portugal, Spain and Italy, thus impairing the transmission of the common monetary policy in peripheral countries.[3] According to De Grauwe and Ji (2012 and 2013), the rise in the sovereign spreads against Germany is hardly explained by fundamentals. Consequently, they argue that the bulk of the rise can be attributed to a change in market sentiment. They emphasize the intrinsic fragility of the Euro, a currency without a sovereign, and of the Eurozone where national government issue debt in a currency over which they do not have perfect control, exposing them to an acute risk of self-fulfilling liquidity crisis driven by market sentiment. The outbreak of the Greek crisis would have triggered contagion effects on other Eurozone countries via sovereign yields (Arghyrou and Kontonikas, 2012).

This situation caused the launch of the Securities market programme (SMP) in May 2010, under which the ECB started purchasing Treasury securities from crisis countries. Contrary to the assets' purchases in the United States and in the United Kingdom during the same period, the main objective of the SMP was not primarily monetary easing but most and foremost to improve its transmission across Eurozone countries and therefore implicitly to thwart the forces of market sentiment.[4] Several other measures followed and notably the OMT (Outright monetary transaction) announced in August 2012.[5] Before that in December 2011 and March 2012, the VLTRO (Very long-term refinancing operation) provided liquidity to the banking system at a 3-year maturity. It enabled to secure access funding to the banking

[1] The APP actually includes all purchase programmes implemented since September 2014. It started with the third covered bond purchase programme (CBPP3) and the ABSPP (Asset-backed purchase programme) and was then followed by PSPP (Public sector purchase programme) and CSPP (Corporate sector purchase programme). It must also be reminded that the Bank of England relaunched its assets purchase programme in August 2016 after the vote for the Brexit.

[2] An exhaustive list of contributions can be found in Borio and Zabai (2016). Early evidence for the US and the UK was notably provided by Joyce et al. (2011), Wright (2012) and Christensen and Rudebusch (2012). For the euro area, the impact of the asset purchase programme launched by the ECB is assessed by De Santis (2016).

[3] See Arghyrou and Tsoukalas (2011) for a detailed analysis of the Greek crisis and its different stages.

[4] Assets purchases implemented with the APP aimed at making monetary policy stance more accommodative.

[5] Technical details of the OMT were provided one month later.

system. The VLTRO aimed at avoiding a systemic liquidity crisis but also at breaking the vicious feedback loop between the banking and sovereign debt crises.[6] Consequently, most of the measures undertaken by the ECB during the crisis were expected not only to have an impact on long-term interest rate but also to mitigate fragmentation across the domestic government bond markets. Asset purchases were expected to have differentiated effects across sovereign assets in the Eurozone: stronger for peripheral countries than for core countries. Furthermore, another difference with US and UK monetary policies is institutional. Within the Public sector purchase programme (PSPP), the ECB buys different domestic sovereign bonds whereas the Federal Reserve purchased a set of homogenous assets, Treasuries or Mortgage-Backed Securities. The transmission channels of ECB's policies are specific in this regard.

Thus, we estimate the aggregated and country-specific impacts of the unconventional measures implemented by the ECB and of market sentiment on sovereign yields. We expect the impacts to be stronger in Spain and Italy while being less (or not) significant in Germany. The French case may be less clear-cut as France was not considered as a peripheral country but however experienced a moderate increase of its spread against German Bunds.

The paper is related to the literature in several respects. The impact of the SMP was analysed by Gibson et al. (2016) based on panel estimations on a sample of Eurozone countries. They use confidential data from the ECB on the breakdown amount of sovereign bonds for countries that were concerned by the programme (Greece, Portugal, Ireland, Spain and Italy). The impact on spreads, after controlling for fundamentals, ranges between 126 and 197 basis points in Spain, and between 292 and 456 basis points in Italy. Ghysels et al. (2016) find similar impacts on Spanish and Italian sovereign yields estimating a VAR model at intra-daily frequencies. Eser and Schwab (2016) report a significant but smaller impact of the SMP on the daily changes of sovereign yields. Altavilla et al. (2014) and Szczerbowicz (2015) resort to an event-study approach to estimate the impact of the different measures implemented by the ECB on the day of their announcement. Whereas Altavilla et al. (2014) only focus on the OMT, the analysis provided by Szczerbowicz (2015) encompasses all measures undertaken from 2008 to September 2012. It notably includes: the fixed-rate/full-allotment, the SMP, the OMT, the VLTRO, the CBPP (Covered bond purchase programme) and the decline of the deposit rate at 0 %. Both studies find stronger results in crisis countries. Although the APP has been implemented only recently, De Santis (2016) argues that the APP has been expected since the summer 2014 and finds that most of the impact took place before its announcement and implementation.

The role of market sentiment has been extensively documented by De Grauwe and Ji (2012, 2013, 2014 and 2015) and Favero and Missale (2012). De Grauwe and Ji (2012) emphasize significant mispricing in sovereign spreads during the crisis in a model accounting for fundamentals – current account to GDP ratio, debt to GDP ratio and real effective exchange rate – only. The unexplained component vanishes when they introduce a common time dummy variable, capturing market sentiments, in the estimations. Favero and Missale (2012) contrast market sentiment with fiscal fundamentals and advocate the development of Eurobonds when markets are "irrational". Finally, Afonso et al. (2014) and Kinateder and Wagner (2017) show that the contagion effect explains sovereign spreads in the Eurozone.

[6] From the outbreak of the crisis the ECB was concerned with the situation of the banking system. The maturity of long-term refinancing operations had already been extended to 6 months and 1 year. The ECB also purchased covered bonds through the CBPP (Covered-bond purchase programme) to ease funding access and costs for banks.

The contribution of this paper is to estimate a model of interest rate determination to assess *simultaneously* the role of market sentiment and the impact of *all* asset purchase programmes implemented by the ECB. Contrary to the existing literature, we do not consider these unconventional measures separately but resort to an overall assessment of their effect. To that end, monetary policy is measured by the variable "*Securities held for monetary policy purpose*" (SHMPP) and market sentiment by the "*Composite indicator of systemic risk*" (CISS) computed by the ECB for the Eurozone as a whole and for individual countries. The equations for interest rate determination are estimated for the Eurozone sovereign yield, the German, French, Italian and Spanish sovereign yields and for the Eurozone corporate sector yield. Estimating interest rate equations country by country, we can assess whether the impact of unconventional measures is different across countries after we have accounted for a (possible) country-specific effect of the market sentiment.

Moreover, it is important to circumvent the endogeneity response of the monetary policy process and of market sentiment to sovereign yield dynamics. For instance, the transactions carried out by the ECB under the SMP were directly related to the tensions on sovereign markets. Greek, Portuguese and Irish bonds were initially concerned from May 2010 until the beginning of 2011 during the first stage of the SMP.[7] The programme was then relaunched in August 2011 and primarily involved Irish, Portuguese, Italian and Spanish bonds. Standard OLS estimates would be biased and capture the positive correlation between SMP transactions and sovereign yields instead of the causal impact that we expect to be negative in theory.

Ghysels et al. (2016) address the endogeneity issue by looking at the intra-daily response – at a 15-min frequency – of the sovereign yield. Eser and Schwab (2016) argue that a panel estimation may reduce the problem if it accounts for common factors proxying tensions on sovereigns. In contrast, we correct the potential endogeneity bias of monetary policy by removing the contribution of the market sentiment and of Eurozone aggregate and country-specific sovereign yields. In parallel, we account for the endogeneity of each country-specific systemic risk indicator by removing the contribution of asset purchases and of a global financial stress indicator (the VIX). Stated differently, we isolate the exogenous innovations to unconventional monetary policies and risk respectively.

The main result of the paper is that innovations to unconventional monetary policies have contributed to lower long-term interest rates overall and in all countries, suggesting that they may have mitigated the disruption in the transmission of ECB policy across domestic financial markets. Besides, innovations to indicators of financial stress have positively impacted long-term interest rates in France and Spain only.

The remainder of this paper is organized as follows. Section 2 presents the usual determinants of interest rates. Section 3 presents the identification strategy to deal with the endogeneity bias. Estimates are presented and discussed in section 4. Section 5 concludes.

[7] See Figure 1 in Eser and Schwab (2016).

2. The framework

2.1. Theoretical background on interest rate determination

There has long been an opposition between the loanable funds theory and the liquidity preference theory to govern the interest rate. According to the former, the interest rate is set at the balance between domestic savings and investment whereas according to the latter, it is set at the balance between money supply and money demand. The loanable funds theory highlights the incidence of the structural environment on interest rates – those variables which influence either savings, like demography, or investment, like the future yields on capital- whereas the liquidity preference theory highlights that of monetary policy and short run output (following the well-known LM curve).

The usual distinction between both theories has long been related to the time dimension of the interest rate: the loanable funds theory applies to the long-term interest rate whereas the liquidity preference theory applies to the short-term interest rate. The distinction has therefore led to the complete separation of both interest rates and to the conclusion that monetary policy, via the setting of the short-term interest rate, would have no impact on long-term interest rates.

This separation vanishes if the term structure of the interest rate is being introduced. This theory suggests that the long-term interest rate is driven by two key factors: expectations of future short-term rates and the term premium. Under the (perfect) Expectations hypothesis, the long-term interest rate would be a sequence of expected short-term rates. Consequently, current monetary policy decisions would influence the long-term interest rates inasmuch as they change expectations about the future stance of short-term decisions. Unconventional measures signal that the monetary policy stance will remain accommodative for a prolonged period of time and thus reduce future short term interest rates. The expectations / signalling channel is yet not the only transmission channel for unconventional measures. According to the preferred-habitat theory, investors are willing to hold securities of certain maturities. Consequently, assets' purchases from the central bank modify the quantity of assets available to the private sector and modify the term premium component of assets price. Markets for bonds are supposed to be segmented by maturities and a change in quantities triggers a portfolio effect which leads to a price adjustment. Via this channel, corporate yields could also be influenced by central banks' asset purchases as investors seek for substitutes to rebalance their portfolio.

Drawing on these theories – loanable funds, liquidity preference and term structure of the interest rate -, it appears that the determinants of long-term interest rates can be separated into two parts: a macroeconomic part which illustrates the savings-investment nexus and includes current monetary policy and a part dedicated to the expectations of future monetary policies.

The era of globalization, which accelerated in the 1980s has added two new groups of determinants to long-term interest rates: highly opened economies have increased the interactions between foreign and domestic interest rates; they have also led to growing liquidity and many more opportunities of arbitrage between financial markets, between currencies and between maturities. Globalization has then impinged on long-term interest rates via exchange rate variations and intensified their sensitiveness to global shocks.

Finally, these factors related to the domestic fundamentals, monetary policy and external factors may not fully account for the dynamics of interest rates. It remains an unexplained component or mispricing resulting from market sentiment or *animal spirits*. Globalization has probably made long-term interest rates more sensitive to financialization and to financial market sentiment.

In what follows, we propose to estimate a model for long-term interest rates embracing these determinants and accounting for the impact of ECB asset purchases and for the impact of market sentiment.

2.2. The equation for long-term interest rates

We start from a simple model accounting for the determination of long-term interest rates for 6 long-term interest-rates: the 10-year sovereign long-term interest rates for the Eurozone, France, Germany, Italy and Spain, and an index of Eurozone corporate interest rates. As we aim at assessing the role of exceptional monetary policy measures and the role of market sentiment which arises during the recent global crisis, the sample starts in July 2009 and ends in February 2017. Data frequency is monthly. The starting point for the estimations is related to the beginning of the covered bond purchase programme (CBPP).

To that end, we use the following equation where $i_{m,t}$ is the long-term interest rate for a market (m) at time (t):

$$i_{m,t} = \beta'_0 + \beta'_1\, shmpp_t + \beta'_2\, ciss_{m,t} + \beta'_3\, ipi_{m,t} + \beta'_4\, cpi_{m,t} + \beta'_5 debt_{m,t} + \beta'_6 ca_{m,t} + \beta'_7\, eer_t + \beta'_8\, oil_t + \beta'_9\, vix_t + \beta'_{10}\, i_{us,t} + \beta'_{11}\, spf_cpi_t + \beta'_{12}\, spf_gdp_t + \varepsilon'_{m,t} \quad (1)$$

where the principal variables of interest are SHMPP (*Securities held for monetary policy purpose*) and *CISS* (*Composite indicator of systemic risk*). The expected signs of β'_1 and β'_2 are negative and positive respectively indicating that asset purchases from the ECB have contributed to reducing long-term interest rate whereas bond yields have been positively correlated with systemic indicator reflecting market sentiment. The absolute values of β'_1 and β'_2 are also expected to be higher for Italy and Spain than for France and Germany. Equation (1) also includes four categories of fundamentals (macroeconomic, international, financial and expectations). Table A in the appendix describes data and their sources, while Figure A plots their evolution over our sample.

The indicator of monetary policy (*shmpp*) includes all the asset purchase programmes implemented by the ECB since July 2009: SMP, CBPP1, CBPP2, CBPP3, ABSPP, PSPP and CSPP listed in the item 7.1 of the ECB's weekly financial statements.[8] SMP, CBPP1 and CBPP2 are terminated but securities purchased within these programmes will be held to maturity, so that the outstanding amount of assets held in the ECB balance sheet is still positive (above €111 billion on the 23rd of June 2017). The CISS is based on a set of measures of the financial stress for 5 segments of financial system, namely the financial intermediaries sector, money markets, equity markets, bond markets and foreign exchange markets. The systemic dimension of the indicator stems from higher weight put on situation in which the stress prevails in several segments of the market at the same time.[9] It is noticeable that national measures of systemic risk are only based on the bond market.

[8] A full description of the programmes is available from the ECB website.
See: https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html.
[9] See Hollo *et al.* (2012) for details.

For the set of controls, we first include macroeconomic variables. The industrial production (ipi) and the inflation rate (cpi) capture fundamentals linked to the macroeconomic outlook of the Eurozone and of Eurozone countries while macroeconomic risk will be captured by public debt and the current account.[10] Second, long-term interest rates may be influenced by international factors. Effective exchange rates (eer) and oil prices are thus taken into account. We also include the US 10-year sovereign interest rate (i_{us}) to capture spillovers stemming from the US money and financial markets. Third, financial risks can explain the long-term interest rates. As is standard now, international risk is measured by the US volatility index (VIX).[11] Fourth, the influence of expectations is represented by two variables, the forecast of inflation (spf_cpi_2y) and the forecast of GDP growth (spf_gdp_2y) both at a 2-year horizon. These variables are released in the Survey of professional forecasters published by the ECB. They may influence long-term interest rates through their information content on the future economic environment and on future monetary policy.

3. The identification issue

Because long-term interest rates, the CISS and the asset purchase programmes are likely to be endogenous to each other, the estimation of the β'_1 and β'_2 parameters in equation (1) is likely to be biased. Some of the asset purchase programmes were implemented because of financial stress in the Eurozone and because of the surge in sovereign spreads. As the CISS captures the risk of self-fulfilling liquidity crisis, it may be influenced by monetary policy decisions. De Grauwe and Ji (2013) point to the intrinsic fragility of the European monetary union and the ability of central banks – through liquidity provisions – to mitigate market sentiment. To overcome the endogeneity issue, we perform two first-stage regressions to remove the contribution of the endogenous factors that underlies the evolution of these two variables and isolate the exogenous innovations to $shmpp_t$ and $ciss_{m,t}$.

Starting with the identification of the exogenous component of $shmpp_t$, we estimate the following equation:

$$shmpp_t = \alpha_0 + \alpha_1\, ciss_{ez,t-1} + \alpha_2\, i_{ez,t-1} + \alpha_3\, i_{fr,t-1} + \alpha_4\, i_{de,t-1} + \alpha_5\, i_{it,t-1} + \alpha_6\, i_{es,t-1} + \epsilon_{shmpp,t} \quad (2)$$

We assume that changes in $shmpp_t$ are driven by the lagged value of the Eurozone CISS ($ciss_{ez,t-1}$) and by lagged values of long-term interest rates of the Eurozone aggregate index and of individual countries.

We identify exogenous shocks to $ciss_{m,t}$ by removing the contribution of the contemporaneous value of the SHMPP and of the lagged value of a global financial stress indicator (the VIX) from the dynamics of the CISS. Thus, we have:

$$ciss_{m,t} = \gamma_0 + \gamma_1\, shmpp_t + \gamma_2\, vix_{t-1} + \epsilon_{ciss,m,t} \quad (3)$$

Therefore, the timing of the variables enables implicitly exogenous shocks to $shmpp_t$ to impact contemporaneously the CISS and long-term interest rates while an exogenous shock to the CISS would impact contemporaneously the long-term interest rates and the SHMPP with a lag. This is consistent with the fact that the central bank decision-making process is

[10] See Bernoth and Erdogan (2012), De Grauwe and Ji (2014), and Favero and Missale (2012).
[11] See Afonso, Arghyrou and Kontonikas (2014) for example.

not instantaneous and the response of policymakers to shocks to financial stress occurs with a lag whereas financial markets react more rapidly to monetary policy shocks.

Equation (1) is therefore modified to avoid endogeneity bias and is estimated as follows:

$$i_{m,t} = \beta_0 + \beta_1 \epsilon_{shmpp,t} + \beta_2 \epsilon_{ciss,m,t} + \beta_3\, ipi_{m,t} + \beta_4\, cpi_{m,t} + \beta_5 debt_{m,t} + \beta_6 ca_{m,t} + \beta_7\, eer_t + \beta_8\, oil_t + \beta_9\, vix_t + \beta_{10}\, i_{us,t} + \beta_{11}\, spf_cpi_t + \beta_{12}\, spf_gdp_t + \varepsilon_{m,t} \quad (4)$$

Equation (4) is estimated with OLS. Because our dependent variables are financial market variables that are likely to introduce heteroskedasticity and autocorrelation, we compute heteroskedasticity and autocorrelation robust Newey-West standard errors assuming that the autocorrelation dies out after three lags.[12] The sign of the β_1 and β_2 parameters should shed light on our question. In addition, we compute the variance contribution of $\epsilon_{shmpp,t}$ and $\epsilon_{ciss,m,t}$ using partial R^2 that indicates the fraction of the improvement in R^2 that is contributed by the excluded covariate.

4. The role of monetary policy and market sentiment

4.1. Baseline results

Table 1 reports the results of the 6 baseline estimations. First, the R^2 suggests that fundamentals together with innovations to the CISS and SHMPP explain most of the variance of long-term interest rates in all specifications.

Second, unconventional monetary policies have a significant and negative impact on all long-term interest rates but corporate long-term interest rates. The lack of impact may be explained by the fact that the bulk of the ECB's asset purchases consists in sovereign assets. In June 2017, ECB holdings of corporate securities amounted to €95 billion whereas holdings of sovereigns under the PSPP reached €1,604 billion.[13] The corporate sector purchase programme has been implemented since June 2016 and includes only high-graded corporate bonds. Consequently, it may be too early to identify a positive impact of unconventional policies on corporate bond yields. However, it might have been contemplated that other asset purchase programmes would have triggered a negative effect on corporate bond yields due to the portfolio rebalancing channel.[14] Investors would seek close substitutes for sovereign bonds. Our results suggest that it did not happen for high yield corporate assets in the Eurozone.

Third, we find that the negative impact of monetary policy has been differentiated among the 4 main Eurozone countries. The highest coefficient is observed for Spain and the lowest for the German sovereign yield. The negative effect for Italy is weaker than for Spain and close to the effect estimated for France. Altavilla *et al.* (2014) and Szczerbowicz (2015) obtain similar findings for the OMT and the SMP respectively. These results are consistent with the objective of the SMP and to a lesser extent with the PSPP, which aim to alleviate the burden of public debt for crises countries like Spain. Szczerbowicz (2015) also find a slightly lower

[12] This correction also enables to circumvent the "generated regressor" bias that our explanatory variables of interest (innovations to asset purchases and CISS) might introduce in the estimation of standard errors.
[13] Holdings of sovereign securities are even higher if we account for securities purchased in the context of the SMP which amounted to € 98 billion in June 2017.
[14] See Christensen and Rudebusch (2012), Wright (2012) or Rogers et al. (2014) for evidence on the US and UK.

impact of the SMP for Italy.[15] The negative and significant impact of innovations to SHMPP on German sovereign yield suggests that Germany has also benefited from the unconventional measures implemented by the ECB. The transmission channel may stem from the PSPP specifically as the breakdown of purchases has been set according to the share of Eurozone countries in the capital of the ECB with Germany having the largest.

Fourth, risks measured with the CISS have the expected positive impact on bond yields though it is less systematically significant. The highest impact is for the Spanish sovereign bonds. The CISS is also significantly positive for France but not for Italy and Germany. However, we find that the impact of the VIX, measuring global risk, is higher, and significant, for Italy. It suggests that Italian sovereign yields have been more sensitive to global risk than to country-specific systemic risk.

Fifth, analysing the variance decomposition of bond yields, our findings suggest that the contribution of innovations to SHMPP is stronger than the contribution of innovations to the CISS, except for Spain where the two contributions are very close (Table 1).

Turning to the effects of control variables, the estimations generally suggest a positive relationship between long-term interest rates and inflation or expected inflation. A rise in the debt-to-GDP ratio increases sovereign yields for all countries but France. The impacts are only slightly significant (at the 10% level). The impact is significantly negative for the corporate bond yield, suggesting a crowding-in effect. The link between the effective exchange rate and the long-term interest rate is negative for all countries but France indicating that an appreciation is associated with a reduction in the interest rates.[16] Our estimates confirm that current account imbalances since 2009 have a significant impact in Germany, France and Spain. An improvement in the current account balance reduces the sovereign yield. The impact of the industrial production is counterintuitive but expected GDP growth has a significant positive impact.

Finally, international spillovers from the US Treasury securities market are also significant. A rise in the US 10-year interest rate is positively correlated with all European long-term interest rates and especially with the German bond rate. More generally, the correlation is larger in the core countries than in the periphery and not significant for the Eurozone corporate bond market.

4.2. Robustness checks

As mentioned above the dependent variables are determined by financial market variables and are likely to exhibit heteroscedasticity. We propose to estimate equation (4) with an ARCH model. Results are presented in table B in the Appendix and are mostly in line with the baseline results. The impact of SHMPP is lower than in the baseline but remains significant for all markets but German sovereign bond and corporate sector bond. The strongest effect is still identified for Spain. For the CISS, it is significant for Spain and France only. For control variables, we also find similar results overall.

[15] There is no significant impact of the SMP for France, which is not surprising as French sovereign bonds were not concerned by this programme.

[16] De Grauwe and Ji (2012, 2013, 2014 and 2015) find contrasting results for this variable. The negative link between the real effective exchange rate and the long term interest rate may stem from capital inflows which would appreciate the currency. Capital flows would ease long-term interest rates.

Finally, we also assess the robustness of our results over a longer sample, starting in January 1999. For these estimations, we introduce the EONIA rate to account for the effect of standard monetary policy (see table C in the Appendix). Here again, the effect of the two variable of interest is still significant. The relative impact of innovations to SHMPP is even more striking with the highest effect for Spain followed by Italy, France and Germany. The same holds for the impact of innovations to CISS indicating that higher country-specific risk increases sovereign yields.

5. Conclusion

This paper aims at assessing the impact of asset purchases from the ECB in the sovereign crisis context. To that end, we estimate an equation for long-term interest rates controlling for four categories of fundamentals: macroeconomic, international, financial and expectations. Our results suggest that innovations to unconventional policies, measured by *Securities held for monetary policy purpose*, and country-specific systemic risk, measured by the innovations to the *Composite indicator of systemic risk*, have significant negative and positive effects on sovereigns yields respectively. Besides, not only did assets purchase succeed in reducing all sovereign yields in the Eurozone but it also had a differentiated impact as the effect was stronger for Spain and to a lesser extent for Italy than for France and Germany. Consequently, the measures implemented by the ECB were also effective at mitigating the disruption created by the sovereign debt crisis in the transmission of monetary policy across Eurozone countries.

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Table 1 - The determination of long-term interest rates

	(1) EZ_s10y	(2) DE_s10y	(3) FR_s10y	(4) IT_s10y	(5) ES_s10y	(6) EZ_c10y
ϵ_{SHMPP}	-0.154**	-0.137*	-0.222***	-0.241**	-0.431***	-0.058
	[0.06]	[0.08]	[0.06]	[0.12]	[0.10]	[0.18]
ϵ_{CISS_m}	0.056	0.015	0.145***	0.181	0.462***	0.132
	[0.08]	[0.04]	[0.05]	[0.16]	[0.16]	[0.23]
IPI_*m*	-0.237***	-0.092**	-0.171***	-0.175***	-0.297***	-0.980***
	[0.04]	[0.04]	[0.04]	[0.05]	[0.11]	[0.12]
CPI_*m*	0.372***	-0.046	0.282***	1.020***	0.087	0.762**
	[0.13]	[0.08]	[0.07]	[0.20]	[0.20]	[0.34]
Debt_*m*	0.154*	0.123*	-0.159*	0.364*	0.503**	-1.221***
	[0.08]	[0.06]	[0.09]	[0.19]	[0.23]	[0.22]
CA_*m*	-0.281***	-0.037	-0.03	0.005	-0.223**	0.132
	[0.10]	[0.02]	[0.02]	[0.08]	[0.11]	[0.23]
EER	-0.065	-0.082**	-0.012	0.086	-0.237**	-0.280**
	[0.05]	[0.03]	[0.05]	[0.09]	[0.11]	[0.13]
Oil	-0.002	0.053**	-0.014	0.018	0.039	0.055
	[0.02]	[0.02]	[0.02]	[0.05]	[0.05]	[0.06]
VIX	0.159***	0.158***	0.107**	0.276***	0.154*	0.836***
	[0.04]	[0.03]	[0.05]	[0.08]	[0.09]	[0.12]
US_s10y	0.569***	0.797***	0.634***	0.603***	0.536***	0.258
	[0.07]	[0.03]	[0.08]	[0.13]	[0.14]	[0.16]
SPF_CPI_2y	0.349***	0.433***	0.299***	0.348**	1.164***	0.151
	[0.12]	[0.08]	[0.09]	[0.17]	[0.20]	[0.34]
SPF_GDP_2y	-0.089*	-0.041	-0.031	-0.261***	-0.177**	0.012
	[0.05]	[0.04]	[0.04]	[0.08]	[0.07]	[0.10]
constant	2.445***	1.589***	2.107***	3.597***	3.694***	6.554***
	[0.04]	[0.03]	[0.04]	[0.06]	[0.08]	[0.10]
N	89	89	89	89	89	89
R^2	0.97	0.97	0.97	0.93	0.93	0.95
Partial R^2 - Variance decomposition						
ϵ_{SHMPP}	0.08	0.07	0.19	0.05	0.14	0.00
ϵ_{CISS_m}	0.01	0.00	0.10	0.03	0.13	0.01

Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Each column corresponds to the estimation of equation (4) for a given market *m* (EZ, FR, DE, IT, ES) of long-term interest rates.

APPENDIX

Table A - Data description

	Source	Frequency	Sample
Interest rates			
Sovereign yields (EZ, DE, FR, IT & ES)	ECB	Monthly	1999M1 - 2017M3
Corporate yield (Euro High Yield Index)	FRED (BAML)	Monthly	1999M1 - 2017M3
Eurozone monetary policy			
EONIA	ECB	Monthly	1999M1 - 2017M3
Securities held for monetary purpose (shmpp)	ECB	Monthly	2009M7 - 2017M3
International factors			
Euro Effective exchange rate	ECB	Monthly	1999M1 - 2017M3
Oil price	FRED	Monthly	1999M1 - 2017M3
US long-term sovereign yield	FRED	Monthly	1999M1 - 2017M3
Eurozone Macroeconomic fundamentals			
Industrial production (EZ, DE, FR, IT & ES)	Eurostat	Monthly	1999M1 - 2017M3
Consumer price Index (EZ, DE, FR, IT & ES)	Eurostat	Monthly	1999M1 - 2017M3
Eurozone Current account (EZ, DE, FR, IT & ES)	Eurostat	Monthly	1999M1 - 2017M2
Eurozone Public debt (EZ, DE, FR, IT & ES)	Eurostat	Quarterly	2000Q1 - 2016Q4
Financial factors			
VIX	FRED	Monthly	1999M1 - 2017M3
CISS (EZ, DE, FR, IT & ES)	ECB	Monthly	2000M9 - 2017M3
Expectations			
Eurozone 2-year ahead expected inflation	ECB (SPF)	Quarterly	1999Q1 - 2017Q1
Eurozone 2-year ahead expected GDP growth	ECB (SPF)	Quarterly	2000Q1 - 2017Q1

Table B - An ARCH representation of long-term interest rates

	(1) EZ_s10y	(2) DE_s10y	(3) FR_s10y	(4) IT_s10y	(5) ES_s10y	(6) EZ_c10y
			Main equation			
ϵ_{SHMPP}	-0.165***	-0.061	-0.100***	-0.185***	-0.350***	0.086
	[0.03]	[0.05]	[0.02]	[0.07]	[0.04]	[0.08]
ϵ_{CISS_m}	0.028	-0.027	0.256***	0.16	0.346***	-0.064
	[0.04]	[0.05]	[0.04]	[0.12]	[0.09]	[0.21]
IPI_*m*	-0.177***	-0.143***	-0.085***	-0.235***	-0.165***	-0.917***
	[0.05]	[0.03]	[0.02]	[0.03]	[0.05]	[0.11]
CPI_*m*	0.282***	-0.092**	0.252***	0.896***	0.328***	0.882***
	[0.07]	[0.04]	[0.03]	[0.11]	[0.05]	[0.13]
Debt_*m*	0.168***	0.202***	-0.254***	0.318***	0.091*	-1.220***
	[0.05]	[0.05]	[0.05]	[0.12]	[0.05]	[0.12]
CA_*m*	-0.298***	-0.045***	-0.028**	0.065	-0.070**	0.027
	[0.08]	[0.01]	[0.01]	[0.05]	[0.03]	[0.27]
EER	-0.007	-0.075***	0.117***	-0.068*	-0.137***	-0.401***
	[0.03]	[0.01]	[0.03]	[0.04]	[0.02]	[0.07]
Oil	0.002	0.021	-0.039	-0.018	0.039*	-0.001
	[0.01]	[0.02]	[0.03]	[0.03]	[0.02]	[0.03]
VIX	0.182***	0.121***	0.028	0.251***	0.207***	0.863***
	[0.02]	[0.02]	[0.02]	[0.06]	[0.05]	[0.08]
US_s10y	0.566***	0.797***	0.541***	0.581***	0.336***	0.103
	[0.04]	[0.04]	[0.05]	[0.07]	[0.06]	[0.29]
SPF_CPI_2y	0.370***	0.440***	0.123***	0.557***	0.829***	0.195*
	[0.05]	[0.06]	[0.02]	[0.05]	[0.03]	[0.11]
SPF_GDP_2y	-0.118***	0.018	-0.032**	-0.142**	-0.196***	-0.1
	[0.01]	[0.03]	[0.02]	[0.06]	[0.06]	[0.13]
constant	2.419***	1.587***	2.217***	3.588***	3.646***	6.587***
	[0.03]	[0.04]	[0.01]	[0.05]	[0.02]	[0.09]
			Variance equation			
ARCH(1)	1.385***	1.216***	1.206***	1.140*	1.846	1.202***
	[0.40]	[0.46]	[0.30]	[0.61]	[1.69]	[0.34]
constant	0.007*	0.005	0.004*	0.032	0.006	0.06
	[0.00]	[0.00]	[0.00]	[0.03]	[0.02]	[0.04]
N	89	89	89	89	89	89

Note: Heteroskedasticity robust standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to the estimation of equation (4) for a given market *m* (EZ, FR, DE, IT, ES) of long-term interest rates.

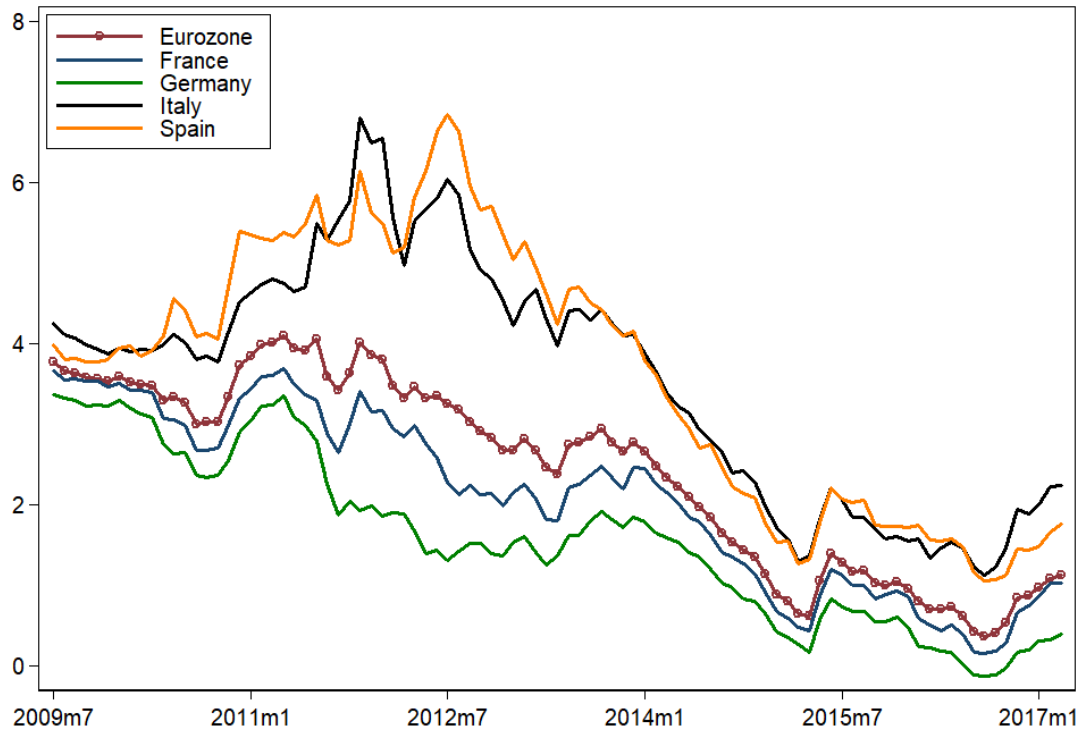
Table C - Longer sample

	(1) EZ_s10y	(2) DE_s10y	(3) FR_s10y	(4) IT_s10y	(5) ES_s10y	(6) EZ_c10y
ϵ_{SHMPP}	-0.270***	-0.142*	-0.211***	-0.321***	-0.511***	-0.556**
	[0.07]	[0.08]	[0.05]	[0.09]	[0.14]	[0.27]
ϵ_{CISS_m}	0.276**	-0.106	0.274***	0.503***	0.872***	0.848**
	[0.11]	[0.18]	[0.07]	[0.13]	[0.20]	[0.36]
IPI_*m*	-0.262***	-0.110	-0.089**	-0.221***	-0.372***	-2.312***
	[0.04]	[0.07]	[0.03]	[0.05]	[0.07]	[0.27]
CPI_*m*	0.349***	0.003	0.220***	0.595***	0.234*	0.770*
	[0.07]	[0.06]	[0.04]	[0.10]	[0.12]	[0.39]
Debt_*m*	-0.215	-0.031	-0.833***	0.053	0.211	-1.805***
	[0.16]	[0.19]	[0.12]	[0.21]	[0.17]	[0.67]
EER	0.107**	0.115***	0.120***	0.140***	0.111	-0.368***
	[0.05]	[0.04]	[0.03]	[0.05]	[0.08]	[0.13]
Oil	-0.011	0.033	-0.02	-0.018	-0.023	-0.076
	[0.02]	[0.02]	[0.02]	[0.03]	[0.04]	[0.10]
VIX	0.111***	0.132**	0.092***	0.105**	0.047	2.266***
	[0.04]	[0.06]	[0.03]	[0.04]	[0.06]	[0.21]
US_s10y	1.123***	1.137***	0.937***	1.114***	1.076***	1.487***
	[0.09]	[0.12]	[0.07]	[0.09]	[0.12]	[0.48]
SPF_CPI_2y	0.376***	0.373***	0.236***	0.368***	0.738***	0.172
	[0.08]	[0.07]	[0.05]	[0.09]	[0.17]	[0.31]
SPF_GDP_2y	0.380***	0.223**	0.160**	0.254**	0.567***	1.626***
	[0.09]	[0.11]	[0.06]	[0.11]	[0.18]	[0.42]
EONIA	-0.052	0.000	0.042	0.045	-0.083	0.635**
	[0.06]	[0.07]	[0.04]	[0.07]	[0.08]	[0.31]
EONIA * ZLB	-0.011	0.688**	-0.100	-0.184	-0.112	-2.462***
	[0.30]	[0.28]	[0.18]	[0.39]	[0.56]	[0.81]
ZLB	1.663***	0.007	1.872***	2.519***	2.560***	8.025***
	[0.37]	[0.30]	[0.21]	[0.40]	[0.53]	[1.80]
constant	2.893***	3.054***	2.487***	2.947***	3.121***	4.694***
	[0.20]	[0.19]	[0.13]	[0.22]	[0.23]	[0.94]
N	202	202	204	204	204	202
R^2	0.95	0.96	0.98	0.90	0.85	0.92

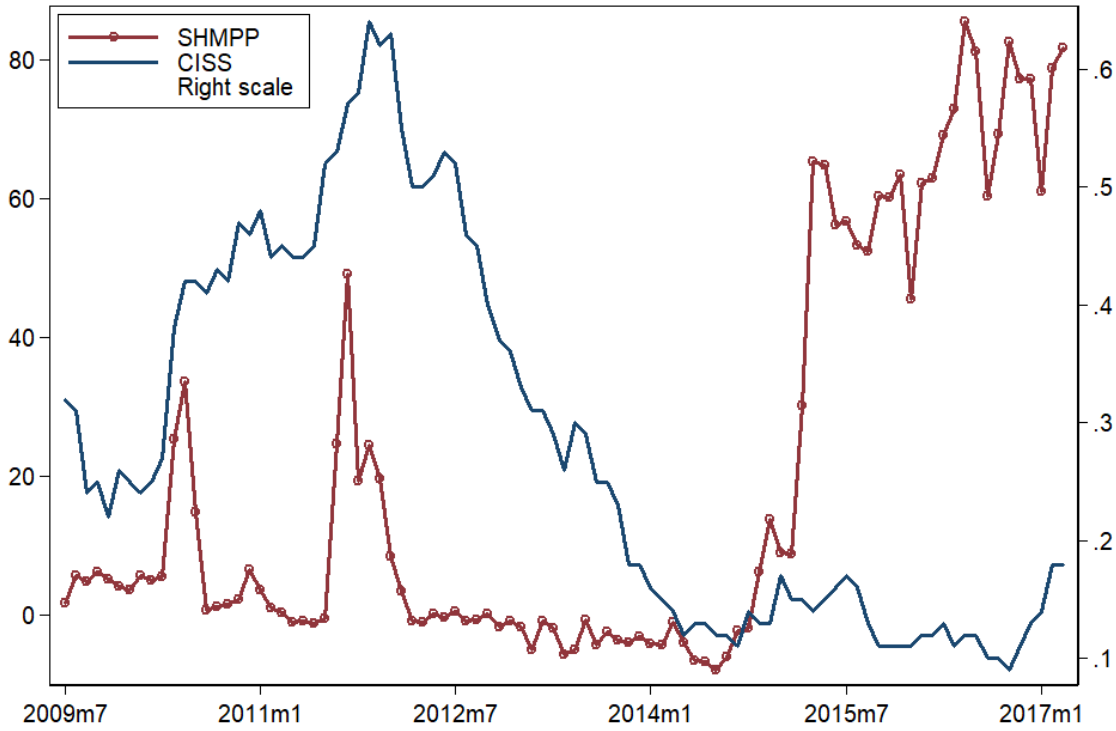
Note: Heteroskedasticity and autocorrelation robust Newey-West standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each column corresponds to the estimation of equation (4) for a given market *m* (EZ, FR, DE, IT, ES) of long-term interest rates.

Figure A – Time series of the main variables

Sovereign yields (in %)



Monthly change in SHMPP (in €Bn) and CISS (index)



Source: ECB Statistical Data Warehouse.

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