Asset Purchase Rules in the Euro Area and their Effects on Bond Markets
Preliminary

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Abstract

Asset purchase policies are a dynamic state-contingent plan instead of a succession of independent interventions. We apply this view to the experience of asset purchase programs in the Euro area. Our evidence suggests that the market expects interventions in large part based on sovereign spreads and the total supply of sovereign credit risk. In turn, this provides a powerful ex-ante mechanism to lower spreads in the Euro area: because interventions typically occur when spreads, debt issuance, and dislocations are high, purchases provide ex-ante insurance to bond investors by stabilizing future sovereign spreads. This increases demand and lowers credit risk premiums on sovereign bonds. We illustrate this channel using both low frequency data and event study analysis, including using option prices to assess the state-contingent nature of interventions.

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1. Introduction

Central banks have increasingly used asset purchase policies to affect financial markets, becoming dominant players in bond markets over the past two decades. For example, the European Central Bank's (ECB) balance sheet grew to over 60% of Euro area GDP in 2021 and stands at around 40% of Euro area GDP as of 2024. These expansions and contractions have largely come from purchases of Euro area sovereign bonds through programs that included the public sector purchase programme (PSPP), pandemic emergency purchase programme (PEPP), and securities markets programme (SMP). Purchase programs have been used in bad economic states for the Euro area – for example to fight the sovereign debt crisis in 2010-2012, or the pandemic in 2020.

We evaluate asset purchase policy in the Euro area as a "rule" – that is, a dynamic and state-contingent plan – rather than a series of one-off interventions. Specifically, once the ECB uses these policy tools, bond markets have expectations about future balance sheet expansions via sovereign bond purchases in the case of a crisis, as well as balance sheet reductions in good economic times, consistent with the Euro area experience. Large bond purchases in a given period raise bond prices in that period, which we refer to as the static effect of purchases. However, this means that expected *future* purchases in bad states of the world raise expected bond prices in these states, relative to the case of no purchases. From an ex-ante perspective, this provides insurance to bond investors and generates a dynamic effect of the state-contingent purchase rule. A fundamental insight of asset pricing is that relatively higher prices in bad economic states provide insurance that makes an asset safer and thus more valuable today. This dynamic channel increases the demand for bonds ex-ante, pushing up prices and lowering yields today.

We argue that this dynamic and state-contingent view of purchases in the Euro area has kept sovereign spreads lower and relatively more stable than they would be without a purchase policy in place. By purchasing bonds when sovereign yield spreads typically

widen substantially, purchases act as a stabilizing force on these spreads, making bonds of higher risk countries relatively safer to investors. This effect pushes down unconditional risk premiums.

Announcement effects of purchase programs show a clear sovereign credit risk premium channel: effects on yields across purchase programs are much stronger for riskier countries with higher average yields. That is, ECB purchase programs appear to primarily affect sovereign spreads rather than long-term risk free rates. Empirically, countries like Greece and Italy respond very strongly to asset purchases while low-yield countries like Germany show little to no response.[1] We show that ECB purchases have absorbed a large quantity of sovereign risk for all programs we study (the SMP, PSPP, and PEPP). While the SMP targeted higher-yield countries directly, and thus directly absorbed sovereign risk, the PSPP and PEPP were broader in scope. For example, the PSPP bought sovereign bonds based on the capital key with weights based on GDP and population. We weight actual purchases by sovereign spreads as a measure of the total quantity of sovereign risk held by the ECB. Taking this as a fraction of total sovereign risk (debt outstanding for each country weighted by spreads), we find that the ECB has held an increasing share of sovereign risk over time, peaking at nearly 30% of the total supply. The PSPP and PEPP contributed significantly to this increase based on the sheer size of their holdings, which included both high and low yield countries. We find that the amount of sovereign risk absorbed by the ECB increases when the total quantity of sovereign risk increases. Given that an increased supply of total risk tends to push sovereign yields up, purchases then lean against risk from a bondholders perspective.

Looking at the response to announcements in more detail reveals that bond markets believe asset purchase policies will be both dynamic and state-contingent.

[1]These findings of a lack response in long-term risk-free rates are also in Krishnamurthy et al. (2018) and the findings that responses are mostly in spreads is in line with a larger literature on ECB purchases. See Bhattarai and Neely (2022) for a review.

First, the early announcements should be significantly more powerful because they signal a willingness to intervene in future bad states of the world as bond markets learn about the state-contingent policy. Yields will respond more than implied by the initial purchases of the program because the intervention signals a willingness to backstop bond markets. Later announcements appear weaker because bond markets already expect interventions based on the state of the economy, i.e., they have "priced in" that the policy is dynamic and state-contingent.

Second, state-contingent interventions imply that announcements should affect the entire distribution of future asset prices and not only their levels. We use option prices and the methodology in Haddad et al. (2025) to assess this channel and find strong evidence of state-contingency across ECB purchase announcements. Announcements of purchases appear to affect left tail risk in asset price distributions, consistent with the backstop view. In which specific states of the world do bond markets expect purchases in the Euro area? We argue that purchases depend in large part on the sovereign credit risk premium – i.e., on sovereign spreads. To further corroborate this view, we use the March 12th, 2020 press conference in which President Lagarde stated "we are not here to close spreads." The 10-year Italian bond yield rose 60 basis points relative to 10-year German bunds on the news. We use option prices on 10-year bond futures for Italy, France, and Germany to assess how this event changed the entire distribution of bond prices in future states of the world. We find that much of the rise in Italian yields on the news came from a reduction in perceived ECB price support in left-tail states where future Italian yields would rise. That is, the statement was read as a reduction in an "ECB put," or backstop, on Italian yields, whereas no such effect is present for German bonds. The response of French bonds are somewhere in between these two. We find similar state-contingent effects for other ECB announcements including the SMP which targeted the sovereign debt crisis: option price reactions to these announcements show the strongest effects in left tail states.

We next zoom out and explore how a purchase rule can affect sovereign yield dynamics and levels at lower frequency. We show that sovereign spreads are less sensitive to total sovereign debt supply since the purchases occurred. For example, Italy has seen a large increase in debt to GDP over the past decade, but Italian yields have not risen as much as would be predicted by this increase in debt supply based on regressions of yields on debt to GDP in the period before purchases were large. We show that net debt – total debt of a country less the ECB's bond holdings of a country – has remained stable for Italy since 2015, implying that private investors have not had to absorb increased debt supply. This can help explain the apparently weaker relationship between total debt supply and yields in the later part of the sample. This approach predicts that spreads in relatively higher risk countries (Italy, Spain, etc) would be significantly higher than they are today without the ECB's holdings.

Our lens to see these interventions as a rule is similar to the view in Haddad et al. (2024) that has been used to understand asset purchase policies in the US based on models where debt supply affect yields (Greenwood and Vayanos, 2014) . We adapt that approach to the European context by introducing sovereign credit risk premiums as well as the duration-risk channel studied in the US, as in Altavilla et al. (2015). We argue that while ECB interventions were often guided to have broad effects as they mostly bought bonds in proportion to GDP, the actual effects work mostly through the sovereign credit-risk premium channel and not the traditional duration channel in Vayanos and Vila (2021). This might appear puzzling given what the ECB bought – but the rule view emphasizes that just as important as what you buy is when you buy it. The market reactions suggest the market saw the ECB intervening broadly because spreads were high in a variety of countries. It is this expectation of further buying if spreads were to widen that has the powerful effects of narrowing spreads today.

The ECB has also purchased long-term bonds of low risk countries which can affect the supply of duration risk. Each countries' bond yield can be decomposed into a risk-free

rate of the same maturity and a spread component due to credit or other factors. Therefore purchases of long-term bonds absorb a substantial amount of duration risk and can affect term premiums. We find that while the ECB has indeed absorbed substantial duration risk – particularly due to the PSPP and PEPP programs – there are only modest affects on term premiums. This can be for two reasons: first, the elasticity of risk-free yields to purchases has been found to be much lower than that of credit risk. Bond investors are more willing to absorb the same amount of supply on risk-free securities without a substantial yield increase. A growing literature comes to this conclusion in US data, comparing bonds of different credit ratings (for example, Chaudhary et al. (2023)). Second, it is not only what is purchased but when purchases occur that matter in our framework. Purchases that occur in future states where sovereign spreads rise will provide more ex-ante insurance for sovereign spread risk, which compresses ex-ante sovereign yield spreads. If expected future purchases are more dependent on sovereign spreads rising than on term premiums rising, then the dynamic purchase policy will affect ex-ante sovereign spreads substantially more.

We provide a framework similar to Greenwood and Vayanos (2014) with an asset purchase rule as in Haddad et al. (2024) to outline these channels, but we add credit risk in addition to duration risk to this framework. Our framework allows us to make the separate forces of duration risk and sovereign spread risk precise and shows that purchase rules that depend on sovereign spreads have strong ex-ante effects on the yields of high risk countries. While our main goal is to establish the potency of state-contingent asset purchase rules, our findings have implications for work on optimal asset purchase policy more generally. Gertler and Karadi (2011) and Sims et al. (2023) study optimal QE policy in New Keynesian models with financial frictions.

A main precursor to our paper is Krishnamurthy et al. (2018) who study announcement effects of ECB purchases and decompose them into several distinct channels. They primarily find a role credit risk premia and segmentation effects, while they find a small

role for term premia and a modest or small role for redenomination risk. Fratzscher et al. (2016) also find strong evidence of a credit risk channel. We focus on the channel through which credit risk premia and sovereign spreads are lowered through a purchase rule, since this appears to be a main channel through which these policies affected markets. We also lean on their results of broad responses in equity markets in Europe. We define credit risk and credit risk premia based on sovereign spreads, recognizing that this could partly include various risks such as redenomination risk that are not technical default but still result in potential losses for bondholders as well as liquidity risk. We do not further separate sovereign yield spreads into other potential channels such as convenience yields Jiang et al. (2020) or liquidity.

There is of course a much larger literature studying announcement effects of asset purchase programs and quantitative easing, including Joyce and Tong (2012), Vissing-Jorgensen and Krishnamurthy (2011), Meaning and Zhu (2011),Swanson (2011), Gagnon et al. (2018), Vissing-Jorgensen (2021), Ray et al. (2023), D'Amico and King (2013), He et al. (2022), and Krishnamurthy et al. (2018). Blotevogel et al. (2024) provide evidence for built-in expectations of purchases in the PEPP and find the program mainly works through decreasing spreads. Eser and Schwaab (2016) find large impacts of the SMP and show effects of lowering risk in bond markets, consistent with our evidence on downside risk through a purchase rule. Bhattarai and Neely (2022) and Dell'Ariccia et al. (2018) provide excellent review articles on asset purchases including theory and empirical results. Altavilla et al. (2015) study the PSPP, which was broad across countries in terms of purchases, and find a significant affect on sovereign spreads. Du et al. (2024) provide evidence on event studies from quantitative tightening across many countries. Relative to this work, we emphasize interpreting the evidence through a state-contingent rule for asset purchases. Bond markets build in expectations of future interventions depending on the state of the economy, and this results in substantial effects at announcement that alter the future distribution of bond yields.

2. Sovereign Spreads and Asset Purchases

2.1 Central bank balance sheets and asset purchase patterns

We begin by plotting the size of central bank balance sheets as a fraction of GDP for the Euro area, US, UK, Japan, and Canada in Figure 1.[2] We highlight two patterns. First, central bank balance sheets have grown to increasingly large levels, ranging between 20-90% of GDP, with an average near 40%.[3] This is primarily the result of asset purchase programs. Second, and importantly for our story, central bank balance sheets expand through new asset purchases during bad economic times. For the Euro area (blue dashed line) we see pronounced increases after the European sovereign debt crisis as well as during the 2020 Covid shock. The US and UK see large increases during the financial crisis of 2008-2009. Thus, purchases by and large increase during bad states of the world.

If government bond purchases in a given period raise bond prices, then a dynamic policy that repeatedly purchases in bad economic states will make bonds safer to investors ex-ante because prices will be relatively higher in bad economic states where purchases are concentrated. This improves the insurance properties of long-term bonds and, in equilibrium, should reduce yields. Thus, forward-looking measures of risk, and also bond yields, should be lower if investors see these policies as recurring. Further, the dynamics of bond prices (or yields) will also change. While the broad patterns of central bank balance sheet behavior helps provide intuition for these mechanisms, we now turn to direct empirical evidence on the asset purchases in the Euro area and the behavior of sovereign yields.

[2] Data are from Fred and various central banks.

[3] Scaling by the stock of public debt, rather than GDP, produces an average closer to 30-35% but still shows an upward trend.

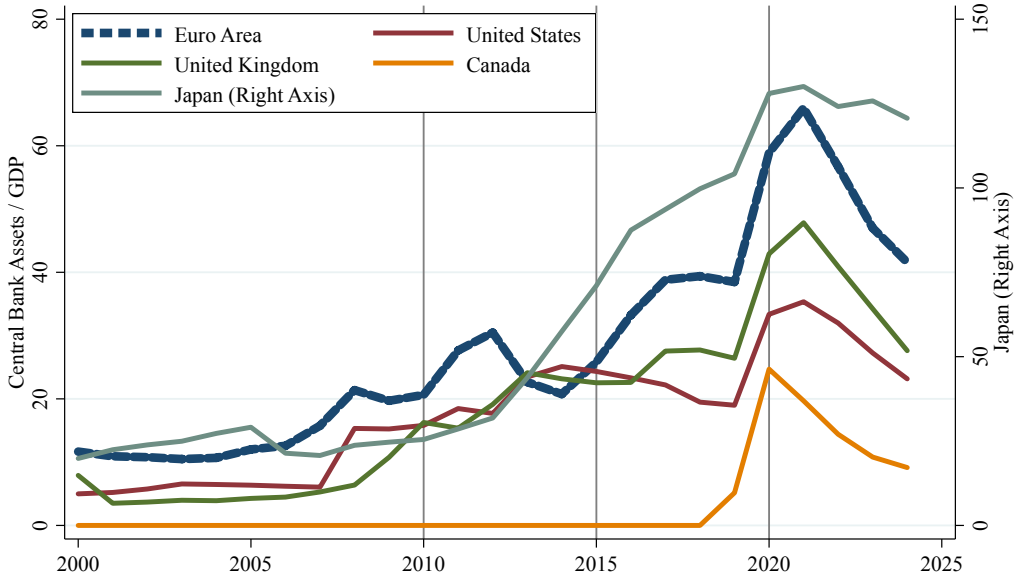


Figure 1: Central Bank Balance Sheets.
All data series from Fred. Gray dashed lines in 2010, 2015, and 2020 mark the start of the SMP, PEPP, and PSPP programs in the Euro area.

2.2 Asset purchase patterns in the Euro area

Figure 2 plots debt to GDP for a select few Euro area countries including Italy, Spain, France, and Portugal. We then recompute debt to GDP by subtracting ECB holdings of government bonds in each country. Two patterns emerge, particularly for the cases of Italy, Spain, and France. First, debt to GDP levels have risen substantially in the last decade. Italy, Spain, and France have increased debt to GDP levels by around 20 percentage points since 2015. However, when netting ECB holdings, these debt to GDP ratios have remained much more stable, with almost no change or if anything a slight decline since 2015. Our measure of ECB holdings come from holdings of sovereign bonds through the SMP, PEPP, and PSPP programs. This implies that new issuance since 2015 has largely been absorbed though ECB purchases across these countries.

Because purchases have largely offset new issuance, they have made the net supply

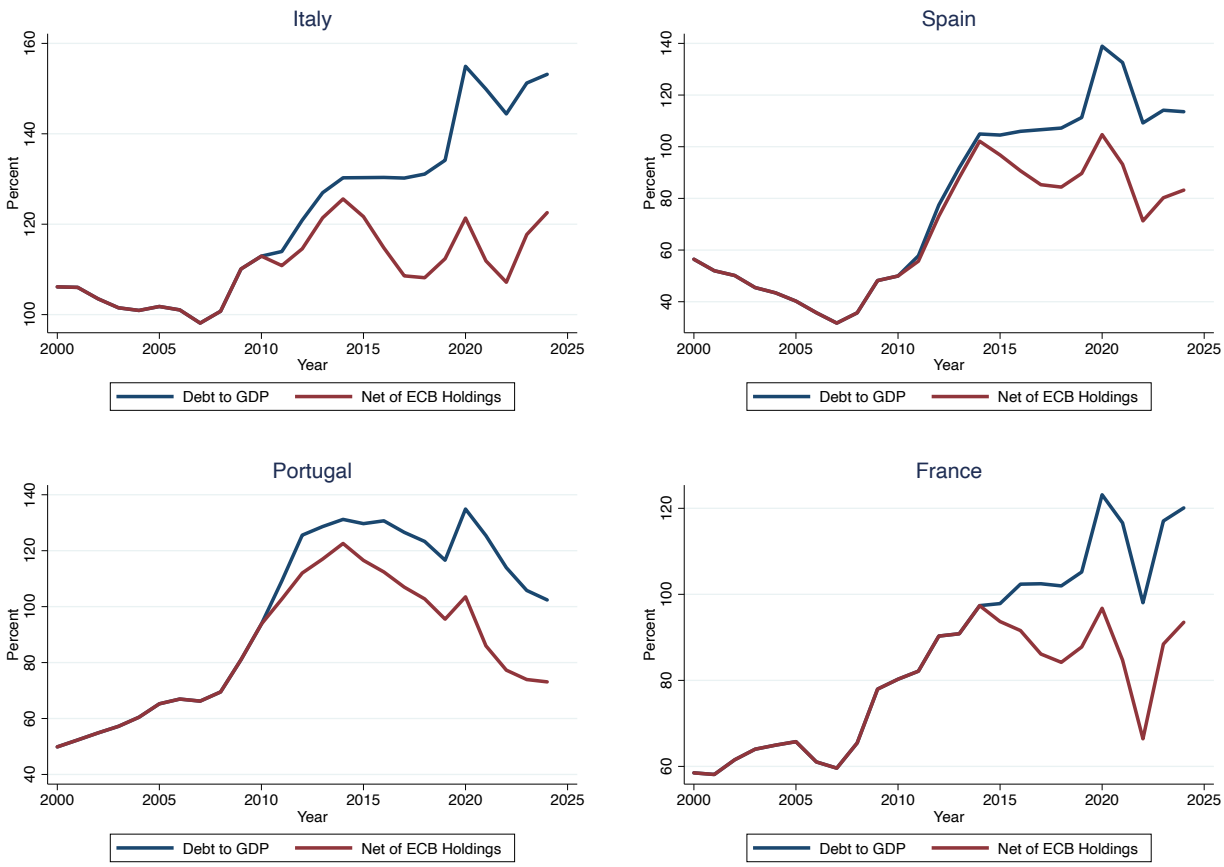


Figure 2: Debt, and debt net of ECB holdings, for select Euro area countries
This figure plots total debt as well as total debt less holdings from the ECB for select Euro area countries. We take holdings from the ECB from three programs: the SMP, PEPP, and PSPP. Data are from global macro database and the ECB.

of government debt held by private investors more stable over time. That is, private investors have not had to absorb additional increases in supply. If investors require a premium for increasing their holdings of government bonds, then bond yields will increase when the supply held by private investors increases and vice versa. Stabilizing net supply therefore helps to stabilize fluctuations in bond yields.

Figure 3 shows purchases by country across the SMP, PEPP, and PSPP programs as a share of country GDP. We focus on Germany, France, Italy, Spain, Portugal, and Ireland. We note that, aside from the SMP which targeted vulnerable countries affected by the

sovereign debt crisis, the other programs were broad across Euro area countries and purchases through these programs were roughly in line with GDP and population, resulting in a relatively small amount of variation across countries in terms of GDP. The variation in the figure is thus largely determined by GDP per capita – countries with higher GDP per capita have relatively lower shares because population weights skew the purchases towards countries with a high population relative to country GDP.[4]

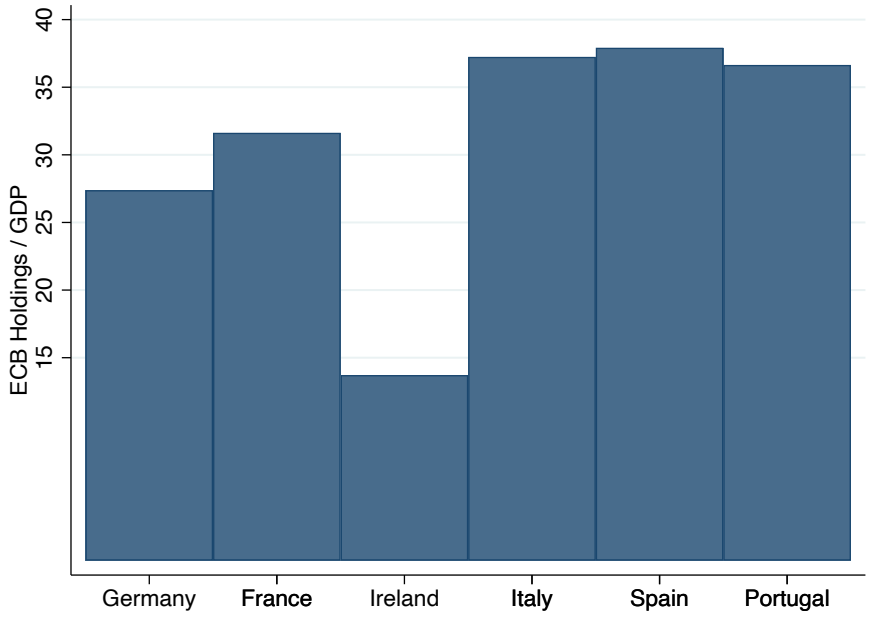


Figure 3: Total Purchases by Country.
We plot total stock of purchases by country as a percent of that countries' GDP.

Our analysis emphasizes that ECB purchase programs largely work by affecting sovereign credit risk premiums. Therefore, it is important to understand how the total supply of sovereign credit risk has evolved and how much of this supply purchases have absorbed. For example, if German debt is seen as risk-free, then increases in German debt supply

[4]Set the purchase weight by country w to depends on population and GDP, $w = aGDP + bPOP$. Then purchases divided by GDP are given by $a + bPOP/GDP$ and are thus inversely related to GDP per capita.

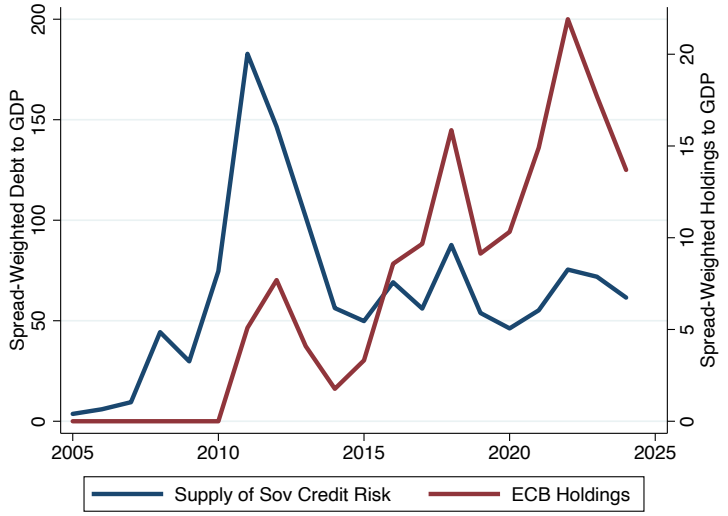
would not contribute to the total supply of credit risk and ECB purchases of German bonds will not affect the supply of credit risk absorbed by the ECB.

We proceed as follows: we take total debt for each Euro area country and multiply by the sovereign spread of that country, measured as the 10-year government bond yield minus the 10-year yield on German bunds. We sum this spread weighted debt across all Euro countries and divide by the sum of GDP across all countries. Note that Germany, as mentioned, gets zero weight by construction here and that low spread countries also get little weight. This is akin to the (Greenwood and Vayanos, 2014) calculation in the US of using maturity-weighted debt to GDP to proxy for the total supply of duration risk, but is applied here to sovereign credit risk. We follow the same approach using the ECB's holdings of each countries' bonds: we weight holdings by each countries' sovereign spread and sum them to proxy for the total sovereign credit risk held by the ECB. This adjusts purchase programs in terms of the supply of sovereign credit risk. For example, the SMP was much smaller overall than the PSPP or PEPP in terms of Euro holdings, but was more skewed towards high risk countries.

Figure 4 plots these two measures. In Panel A, we see the total supply of sovereign credit risk rises substantially starting in 2008 and peaks in 2011. We see another spike in 2018 and again after 2020. ECB holdings show similar patterns: the ECB absorbs a substantial amount of sovereign credit risk during the sovereign debt crisis period (through the SMP), and again during the PSPP and PEPP. The spikes in the red line roughly coincide with spikes in the blue line, so that the ECB absorbs sovereign credit risk when the supply increases. Panel B shows the share of total sovereign credit risk held by the ECB (the ratio of red and blue lines in Panel A). This share rises to around 25% since 2020 with a peak near 30%.

These facts suggest that the ECB dynamically absorbs bond supply in bad economic times. More specifically, it absorbs sovereign credit risk at times when the total supply of sovereign credit risk is large. We now turn to the behavior of sovereign spreads to see

Panel A: Total Supply of Sov Credit Risk & ECB Holdings of Sov Credit Risk



Panel B: Share of Sovereign Credit Risk Held by ECB

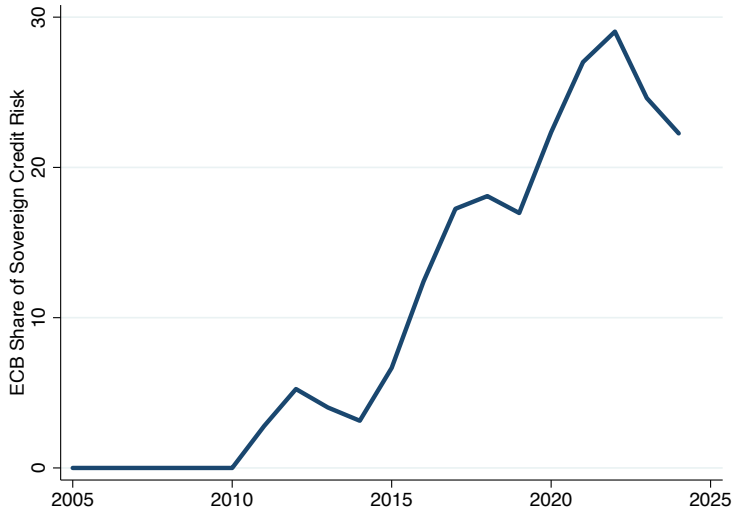


Figure 4: Spread-weighted Debt Supply, Euro Area.
This figure plots government debt weighted by sovereign spreads, normalized by total Euro area GDP as a measure of the total supply of sovereign credit risk. It then constructs the same measure for ECB holdings. Panel B takes the percentage of the ECB holdings to the total.

how purchases affect their dynamics and levels.

2.3 The Evolution of Sovereign Spreads in the Euro area

Figure 5 plots the rise and fall of sovereign bond yields since 2000 for select countries in the Euro area relative to the yield on 10-year German bunds. Spreads for Italy, Spain, Portugal, and Ireland rose substantially starting in 2010 before falling to modest levels since. Spreads have been relatively narrow since 2021, as the second panel shows. Italy has the highest average spread over the past 5 years at around 100 bps followed by Spain at around 50 bps.

What role, if any, have asset purchase policies played for this narrowing of spreads? We explore two pieces of evidence, based on narrow responses of sovereign yields around key asset purchase announcements, as well as low frequency evidence based on country by country fundamentals.

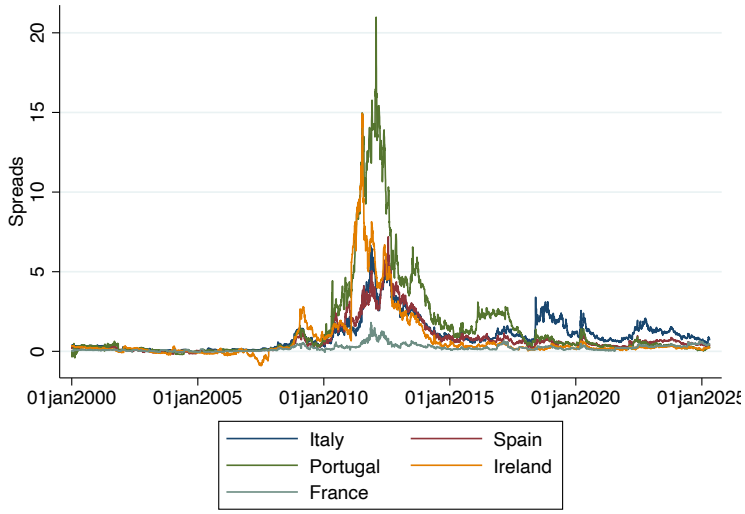
Broad Announcement Effects of Asset Purchase Programs

Figure 6 plots cumulative announcement effects of the SMP, OMT, PSPP, and PEPP programs, respectively, for several Euro area countries. These announcement effects on yields have been studied elsewhere in the literature (for example, Krishnamurthy et al. (2018)). We also note that these programs had different stated goals – the SMP and OMT are targeted specifically at vulnerable countries (Italy, Spain, Portugal, Greece, and Ireland) during the sovereign debt crisis, while the PSPP was seen as broad based across the Euro area. We follow the literature and use May 10th 2010 and August 7th 2011 for the SMP announcements, July 26th, August 2nd, and September 6th of 2012 for the OMT, January 22nd 2015 for the PSPP, and March 18th 2020 for the PEPP. Announcement effects within a program are cumulative. In the appendix, we consider a broader set of ECB announcements about purchases but find cumulative effects primarily come from the main announcement days listed here.[5]

Several important patterns emerge from Figure 6. First, the cumulative announce-

[5]We do not study announcements on quantitative tightening, or reductions in bond holdings by the central bank. See Du et al. (2024).

Panel A: Sovereign Spreads, 2000-2025



Panel B: Sovereign Spreads, 2021-2025

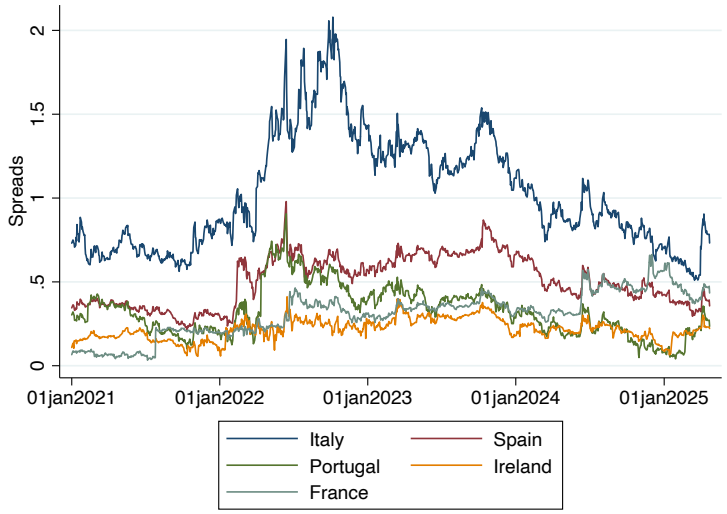


Figure 5: Sovereign Spreads, Euro Area.
This figure plots sovereign spreads by country for bonds of 5-year maturity where spreads are taken relative to the yield on 5-year German bunds. Data are from bloomberg.

ment effects on German yields are negligible across all programs. Germany is typically viewed as the safest country with the lowest yield among the Euro area countries at any

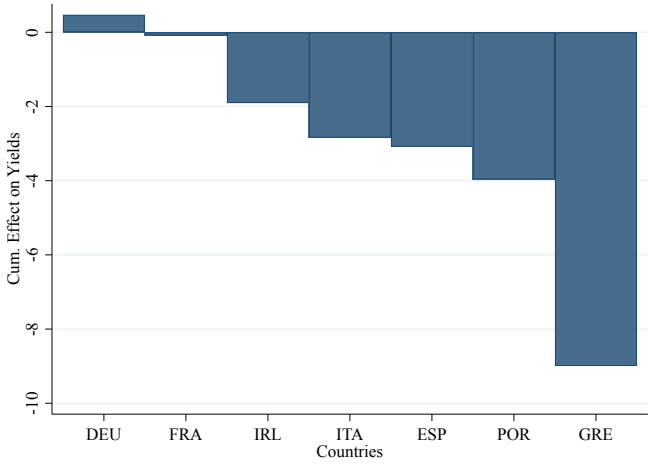
point in time, as captured in Figure 5. This suggests that the effects of the announcements on yields did not work through long-term risk-free rates, but instead worked entirely through reductions in sovereign spreads to Germany. We interpret this as largely affecting sovereign credit risk premiums. This pattern holds more broadly with riskier countries responding more – e.g., the response for Greece is larger than the response for Italy which is larger than the response for France, in line with the ordering of the average yields of each of these countries.

To make this point cleanly, we plot the cumulative announcement effects against the average yield by country in Figure 7 where we use an expanded set of 11 Euro area countries, adding Austria, Finland, Belgium, and the Netherlands to the above list. The average yield by country on the x-axis is computed as the average yield over the past 20 years from 2005-2025 to give an ordering of high and low yield countries. The results are clear that high-yield countries see the largest declines in yields, while low yield countries, like Germany, see no change in yield from the announcements.

The differential pattern is perhaps not surprising for the SMP and OMT programs which were squarely aimed at the sovereign debt crisis affecting higher risk countries. However, the relative pattern continues to hold for the PSPP and PEPP which were broad in terms of sovereign purchases and thus not only aimed at vulnerable countries. Panel B of Figure 7 plots the cumulative announcement effects within each program against the average country yield: across each program all lines are downward sloping, meaning higher-yield countries benefit most in terms of yield declines. Furthermore, Germany – the safest, lowest yield country – does not respond substantially to any announcements. Thus, even these later patterns appear consistent with purchases affecting the credit risk premium, or sovereign spreads, rather than the level of yields through long-term risk-free rates.

Importantly, the magnitude of the announcement effects also decay – they are stronger for the initial programs than for the later ones. This is despite the fact that the later pro-

Panel A: Cumulative Announcement Effects, Select Countries



Panel B: Announcement Effects by Program, Select Countries

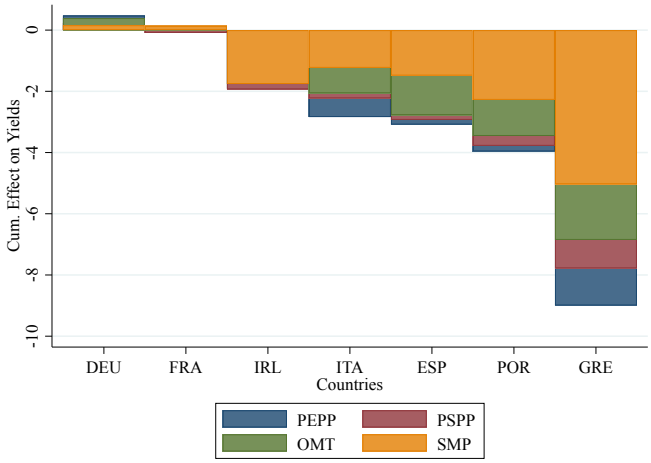
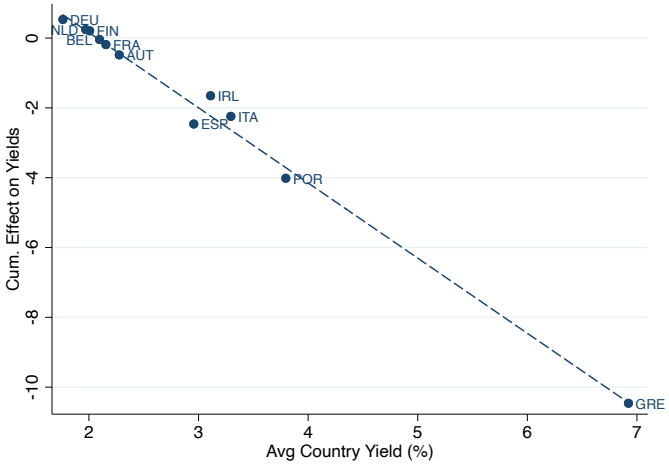


Figure 6: Announcement Effects, Euro Area.
This figure plots cumulative announcement effects to asset purchase policies in the Euro area including the SMP, OMT, PEPP, and PSPP. The top panel gives total cumulative announcement effects. The bottom panel breaks down cumulative announcement effects into contributions by program.

grams were much larger in scope in terms of actual purchases – the SMP was relatively small in total purchases compared to the PSPP or PEPP. Figure 8 makes this point by constructing a "multiplier" as the decrease in yield for several countries by program (coming

Panel A: Cumulative Effects by Country vs Avg Yield by Country



Panel B: Effects by Program and Country vs Avg Yield by Country

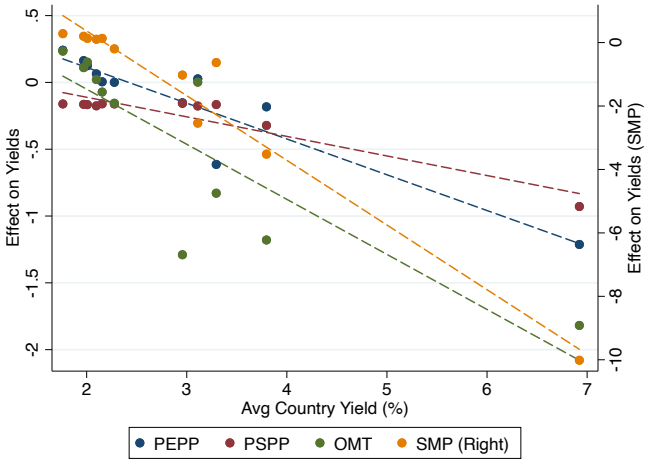


Figure 7: Announcement Effects Against Average Yields.
This figure plots cumulative announcement effects to asset purchase policies in the Euro area by country including the SMP, OMT, PEPP, and PSPP against a 20-year average yield of each country from 2005-2025. The top panel gives total cumulative announcement effects. The bottom panel breaks down cumulative announcement effects into contributions by program. The main result is that across programs the response lines up with the average yield of each country.

from the announcement responses) divided by how much of that countries' sovereign bonds were ultimately purchased as part of the program. The latter is measured as a frac-

tion of country GDP. A value of 20 implies that purchasing Italian bonds equal to 1% of the GDP of Italy would lower 10-year Italian bond yields by 20 basis points. We focus on a set of higher risk countries because they were included in all programs and because low risk countries show little to no yield response to the programs.

First, we note that these multipliers are relatively comparable within a program – the announcement responses by country to the SMP are similar relative to how much was purchased in that country through the SMP program. However, the multipliers are far larger for the SMP as a whole than for either the PSPP or PEPP. This highlights both that the raw yield responses in the SMP are much larger, and also that the PSPP was much larger in scope.

We argue that the initial announcements are much more powerful because they convey a purchase rule by the ECB that goes beyond the scope of the initial program. That is, they convey that the ECB is willing to step in to bond markets in future bad states of the world, and this provides a powerful channel through which yields respond to initial announcements.

Low frequency moves in spreads.

To assess the impact of asset purchases on spreads in low frequency data outside of narrow event studies, we need a measure of what sovereign yields in the Euro area would look like absent this policy. Our approach is to run a regression of sovereign spreads on country fundamentals before purchase policy became important. Using the evolution of fundamentals going forward provides a predicted path of spreads absent intervention. This analysis is admittedly rough for two reasons. One is that we have a relatively short sample of data to construct the relation between spreads and fundamentals. A second is that extrapolating based on past fundamentals will be incorrect if the true relationship is non-linear. The analysis will miss any feedback of the policies on fundamentals and our assumption is the effect on fundamentals is smaller than that for spreads, though to the extent the policies improve fundamentals in a country we will understate the counterfac-

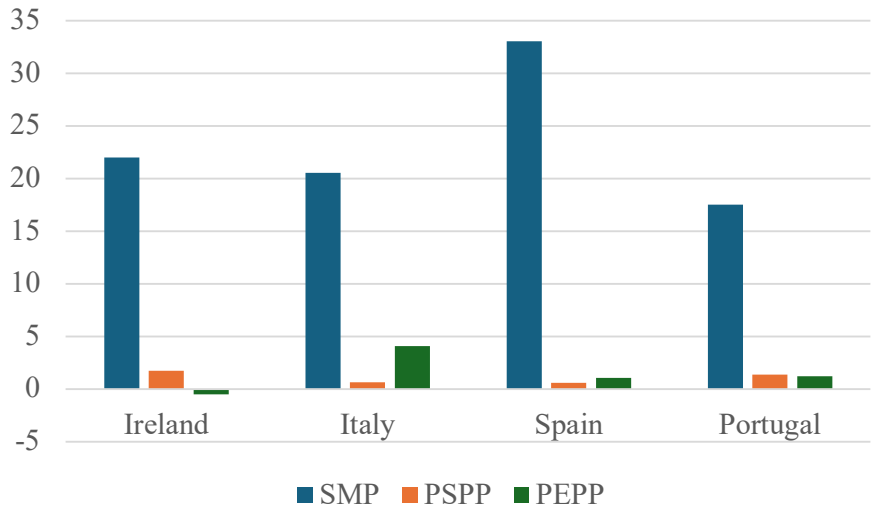


Figure 8: Yield Response divided by Purchase Amounts across countries and programs. We take $-\Delta y_i$ as the decrease in 10-year bond yields for each country i using event studies responses to each purchase facility. We then divide this response by the total ultimate purchases of country i's sovereign bond in a given program as a share of country i's GDP.

tual spread. Last, the analysis is imperfect because factors other than fundamentals can drive spread variation.

Table 1 runs a panel regression of sovereign spreads in the Euro area for 10 countries on country characteristics using annual data.[6] Spreads are 10-year government bond yields minus the 10-year yield on German bunds. We regress spreads on each countries debt to GDP ratio, deficit to GDP, unemployment rate, and 5-year GDP growth. The regression includes country fixed effects and uses annual data. We break the regression into two periods: 2000-2011, largely the period before significant interventions in bond markets (in accordance with Figure 1), and 2012-2025, which is the post period after interventions have taken place. We do note as a caveat the importance of including the 2008-2011 period in the early sample because spread variation in the Euro area was mini-

[6]France, Spain, Italy, Portugal, Austria, Belgium, the Netherlands, Finland, and Ireland. Spreads are taken with respect to Germany.

Table 1: Sovereign Spreads and Country Fundamentals

We regress sovereign yields on country fundamentals including debt to GDP, unemployment, deficit to GDP, trailing 5-year GDP growth, and country fixed effects. Data are annual. Driscoll Kraay standard errors in parentheses using 5 annual lags.

VARIABLES	(1) 2000-2011	(2) 2012-2025
$ln(Debt/GDP)$	0.09***	-0.01*
	(0.03)	(0.01)
Government Deficit as % of GDP	0.07	-0.07
	(0.05)	(0.06)
GDP Growth	-0.03	-0.02**
	(0.02)	(0.01)
Unemp	0.13**	0.13***
	(0.06)	(0.03)
Observations	110	130
R-squared	0.56	0.65
Number of groups	10	10

mal before this (as shown earlier in Figure 5). The relative coefficients help us understand whether the patterns in spreads differ in terms of loadings on fundamentals during the period of large asset purchases.

Most notably, the coefficient on debt to GDP switches from a strongly significant positive value of 0.09 to a slight negative value. That is, increased debt supply in a country previously raised its bond yield but now has virtually no effect. Our story fits with the patterns in Figure 2 that purchases have leaned against such supply increases: despite large increases in debt levels, private investors have not had to hold more bonds because the ECB has largely absorbed new issuance. The R^2 in both regressions is high – these variables explain 56% and 65% of spread variation, respectively.

How much has this decreased loading on debt supply and other fundamentals affected yields? We answer this by taking the coefficients in the pre-period in this regression and then assessing the implied path of sovereign spreads based on the evolution of the right hand side variables. We refer to this as the "predicted spread." The regression provides this for each country individually. To keep things simple and keep the focus

on a few countries, we take the predicted values for four countries that faced large concerns from bond investors: Italy, Spain, Portugal, and Ireland. The predicted spread is most influenced by Italy and Spain where debt levels have increased the most. We plot an equal-weighted average of these predicted spreads in Figure 9 against the same equal-weighted average of the actual path of spreads.

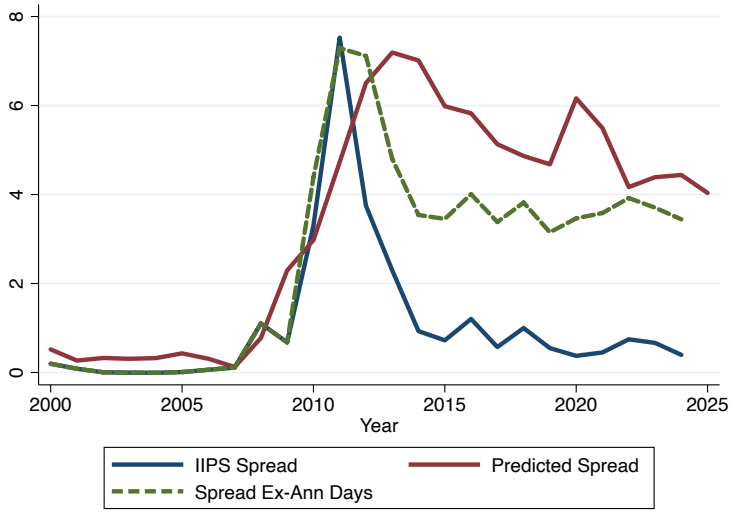


Figure 9: Spreads, Predicted Spreads, and Spreads Excluding Purchase Announcements.
The blue line plots the actual spread for an equal-weighted average of Italy, Spain, Portugal, and Ireland. The red line plots a predicted spread based on country fundamentals using data up until 2010 and projected forward. The green line plots the actual spread omitting spread changes that occur in a 2-day window around purchase announcements.

As Figure 9 makes clear, actual spreads are much lower than those predicted using the pre-period regression and the evolution of country fundamentals. Notably, we also plot the actual spreads when we exclude spread changes on asset purchase announcement days used in Figure 6. The ex-announcement day implied spreads are quantitatively close to the predicted spreads but around 350 bps above the actual spreads.

A consistent explanation for these facts is that the announcements conveyed a pur-

chase rule, that purchases would be state-contingent. Purchases would be higher in periods where debt supply for a country expands and where the country spreads would normally rise. By purchasing in these bad states of the world, and compressing yields in these states, yields co-vary less with debt supply. This helps lower yields ex-ante (e.g., when the policies are first announced) through an insurance channel: bond investors expect purchases in bad states which makes holding bonds safer ex-ante.

Figure 10 takes another approach to make these points that does not aggregate predicted spreads across countries. Instead, it uses the predicted spreads for our initial regression and scatter plots them against actual spreads for each country and year in our sample. The different colors run this analysis in different periods and sub-periods. The slope in the pre-period between predicted and actual spreads is 1 by definition, but the slope flattens substantially later in the sample. The main result is that in the last 10 years, the slope of predicted vs actual spreads is far below 1. However, we emphasize that the predicted spreads still do a good job explaining actual spreads – the points still lie close to the line despite the slope being slower. Actual spreads are more so a "muted version" of predicted spreads but still line up with fundamentals in the same way. Put differently, the ranking across countries of sovereign yields still appears to reflect country fundamentals (e.g., yields in Italy are higher than in France), but the relative magnitudes are muted relative to the difference in fundamentals and the prior relationship between fundamentals and spreads. This is consistent with the policies acting primarily on credit risk premiums.

These results suggest that state-contingent purchases play a key role in explaining sovereign bond yields in Europe. We've shown that purchases help stabilize debt supply by making net supply (net of ECB holdings) more stable than actual debt supply and that purchases absorb a substantial fraction of sovereign credit risk. This manifests in yield dynamics: yields appear less sensitive to debt supply in the period since purchases began. Finally, the evidence is consistent with the idea that this reduced risk for bond investors has led to a compression in sovereign yields despite varying country fundamentals. The

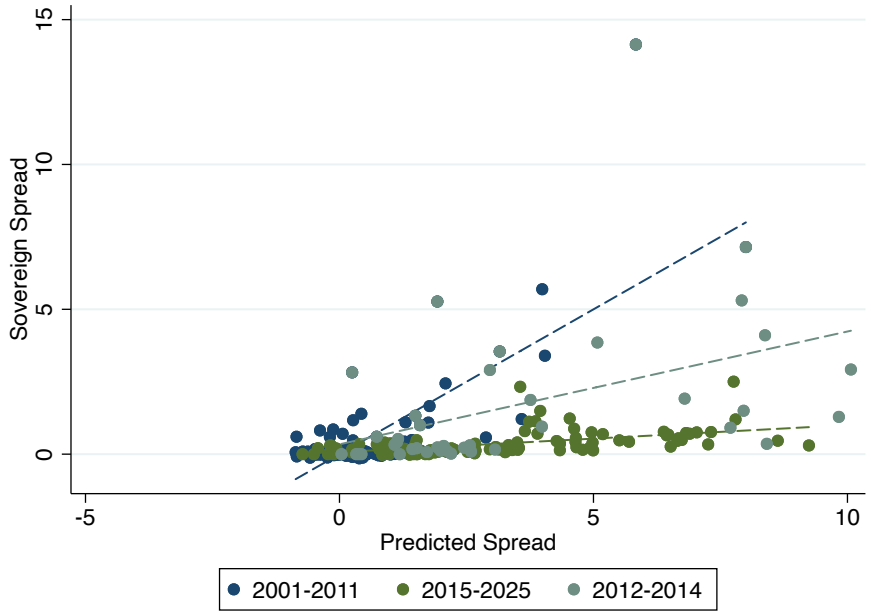


Figure 10: Spreads vs Predicted Spreads.
This figure scatter plots spreads in the Euro area against predicted spreads, fitted using a panel regression from 2000-2010. The green period shows that the slope between predicted spreads and actual spreads flattens substantially post 2015.

next section explores this state-contingent behavior around ECB announcements more cleanly by using option price data around announcements.

3. State Contingency

We follow the method developed in Haddad et al. (2025) which uses option prices to assess the state-contingent nature of policy announcements. Specifically, option prices reveal the risk-neutral distribution of the underlying asset over the horizon equal to the option maturity. The method uses the shift in this entire distribution before and after the announcement using an event-study approach. By understanding how the entire distribution changes, the method infers the amount of "price support" added to each possible

state of the world to arrive at the new distribution. That is, denote the future price of the asset by p and the risk-neutral cumulative distribution function (CDF) before the announcement is made as $F_p()$. We can construct this CDF using option prices on the asset across strike prices (Breeden and Litzenberger, 1978). Denote the CDF after the announcement is made as $F_{p'}()$ where we use $'$ to denote post announcement. Define the price support function $g()$ such that $p' = p(1 + g(p))$ – that is, g maps the future prices before the announcement p to the future prices after the announcement p'. Then we can recover this price support as $g(p) = \frac{F_{p'}^{-1}(F_p(p)) - p}{p}$. The function $g(p)$ tells us (in percentage terms), how much we would need to raise or lower the price in each future state of the world p in order to arrive at the new distribution, or how much the announcement changes prices in different future states of the world. Importantly, option prices measure states of the world as the future price of the asset absent the announcement. A useful example in Haddad et al. (2025) is that if asset purchases are a constant (i.e., not state-contingent) and the price impact of purchases is constant, then $g()$ will be constant so that price support is flat. In contrast, if purchases are expected to be larger when asset prices are low, a form of backstop or policy put, then $g(p)$ will be downward sloping meaning there is more price support from the central bank in low price states and vice versa.

March 12th, 2020 Statement: "Not here to close spreads"

During the ECB Press Conference on March 12th, 2020, President Lagarde stated "My point number two has to do with more debt issuance coming down the road depending on the fiscal expansion that will be determined by policymakers. Well, we will be there, as I said earlier on, using full flexibility, but we are not here to close spreads. This is not the function or the mission of the ECB."[7] This statement is particularly useful for our arguments because it directly discusses state-contingency (or lack there of) and appeared to provide an update on the beliefs of the market under what conditions the ECB would

[7]For the full statement and press conference, see *link here*.

intervene. The state-contingency is exactly about states where sovereign spreads would rise and whether the ECB would act to close them. We thus view this as taking away perceived support through asset purchases in future states where sovereign spreads were to rise.

The statement had a large effect on sovereign bond yields – the 10-year yield on Italian government bonds rose 60 bps from one day before to one day after the press conference. The 10-year yields on Spain and Portugal rose roughly 40 bps, while France and German yields rose by 30 and 20 bps, respectively. Thus, the yield response was significant and larger exactly for the countries with relatively higher spreads and who had been viewed as risky by bond investors.

A natural explanation for this response is that the statement represented a feared removal of a policy put – that the bond market believed prior actions indicated that the ECB would in fact respond to both spreads and debt issuance due to fiscal expansions in response to the COVID shock. To assess this, we use option price data from Bloomberg on 10-year Italian, French, and German bonds and follow the methodology in Haddad et al. (2025) to assess the state-contingent impact of the press conference. Our data is limited to only these three countries.

Figure 11 plots the price support function $g()$ using options data on 10-year bond futures in Italy, France, and Germany. The options have a maturity of 2 months but the results are robust to using different option maturities between 1 and 6 months. The x-axis normalizes the current price of the bonds to be 100, and the y-axis plots price support as a function of the future price absent the news (coming from the pre-announcement distribution). We see substantially different responses for Italy, France, and Germany. Note that the plot is entirely in price space, but roughly speaking we can convert to yields easily given we use 10-year bonds because a 6% price drop on a 10-year bond is equivalent to a 60 bps rise in bond yield.

For Italy, the statement appeared consistent with removing a put option based on

yields spiking. For example, the left portion of the graph, a future state of the world where Italian bond prices would fall and yields would rise, sees a strongly negative price support reaching -8% for an underlying price change of -6%. A consistent interpretation is that following a bad shock, which would raise Italian yields by 60 bps, the lack of support by the ECB to "close spreads" meant that yields would in fact rise by an additional 80 bps, for a total of nearly 140 bps. We see far less effect in the right tail – in good states where Italian bond yields were to *fall* by 60 bps (e.g., bond prices rise 6%), the effect is only a reduction of 20 bps. Thus, the statement partly removed the perceived backstop from the ECB of keeping a lid on Italian bond yields. The loss in value of this partial removal lead Italian bond yields to rise 60 bps on the impact on the news.

This same effect is not present for Germany (green line), which shows a flat price support function at -2%, consistent with the overall increase in yield for German bonds of 20 bps. Interestingly, France, which was not viewed as safe as Germany but not as risky as Italy, responds in between. All three countries see the same price support in good states of the world (the right part of their distributions) and only differ in terms of the effects in the left tail.

These responses show up more broadly in risky securities in Italy and the Euro area. We conduct the same exercise for the Euro Stoxx index and UniCredit, a large Italian bank. Euro Stoxx is a broad index that captures the stock market in Europe, but is broader than only the Euro area. The response of UniCredit helps us understand the effects on the financial sector in a more exposed country like Italy. Unlike options on bond futures, we have a much longer data history for option prices on both series where we can study additional announcements in our sample. Figure 12 plots the effect of the news on the price as a function of the state and finds results similar to those for Italian bond futures. The scale is magnified because equities are riskier than bonds, but the overall pattern is similar.

Announcements of the SMP, OMT, PSPP, and PEPP

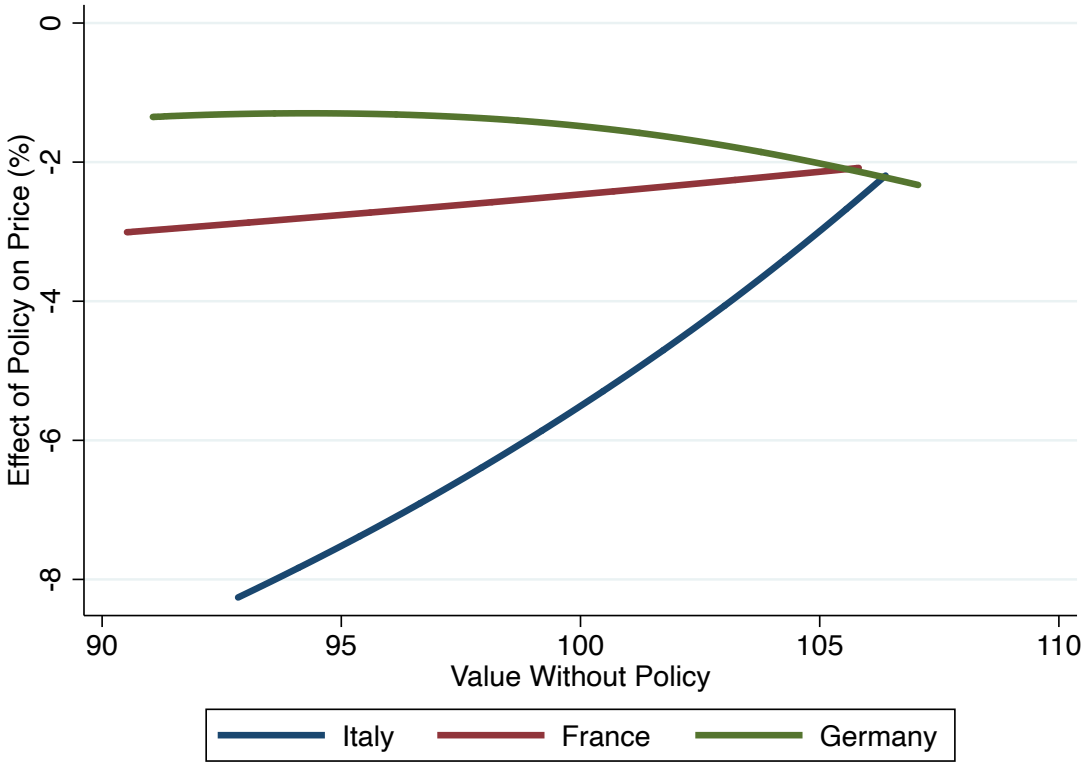


Figure 11: Price Support Function, Response to March 12 ECB Statement.
Lagarde "we are not here to close spreads" (ECB Press Conference, March 12, 2020). Options on 10-year sovereign bond futures for Germany, France, and Italy.

In earlier work (Haddad et al., 2025) we studied several additional purchase announcements.

Figure 13 looks at announcements of asset purchases by the European Central Bank. We use five announcement dates for the OMT and SMP found by Krishnamurthy et al. (2018) to have substantial asset price effects and we add announcements of the PSPP and PEPP discussed earlier. Ideally, for each of these announcements, we would like to have options on sovereign bonds for high risk countries in the Eurozone (e.g. Italy) as we use for the statement on closing spreads in the last subsection. This is most directly where the asset purchase announcements were aimed. However, this data is not available until later

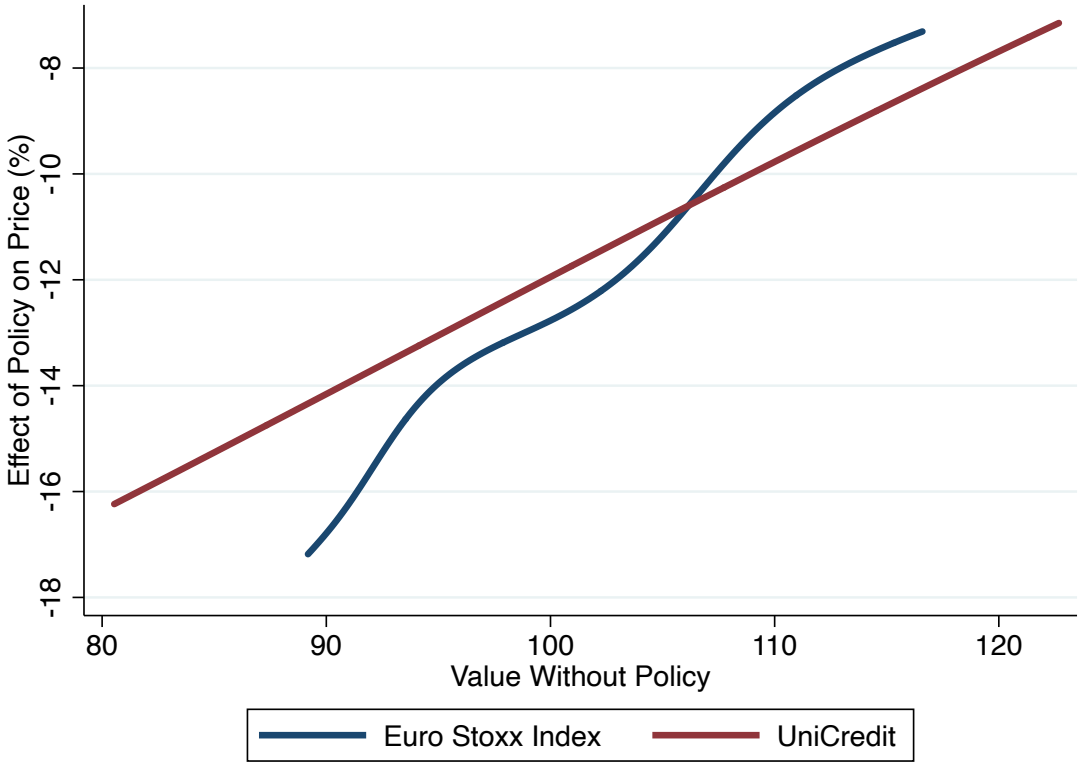


Figure 12: Price Support Function, Response to March 12 ECB Statement.
Lagarde "we are not here to close spreads" (ECB Press Conference, March 12, 2020). Options on Euro Stoxx index and UniCredit, a large Italian bank.

in our sample, so we are not able to use it for the SMP, OMT, or PSPP announcements.

Despite this, Krishnamurthy et al. (2018) show a very broad asset price response to the announcements. In fact, they estimate most of the increase in total value from these announcements came from the reaction of stock markets. Our analysis of the March 12th press conference is in keeping with this pattern, where stock markets reacted substantially. One interpretation is a feared "doom loop" that sovereigns would be unable to pay creditors or roll over debt and this would lead to substantial declines in economic activity. This could be coming from higher taxation, strong fiscal adjustments, or losses born by holders of sovereign bonds which included a large portion of the banking sector in Eu-

rope. These losses could lead to a substantial credit crunch that would result in a decline in economic activity. The fact that the asset price effects were broad also means we can use options on the Euro Stoxx index to assess conditional purchases. This assumes that any conditional purchases will be correlated with the stock index value and that the stock index will respond to purchases in those states.

Figure 13 shows strong effects of conditional policy from these announcements. Across the announcements, the extra support in the left tail explains about 20% of the overall reaction on average. This is likely not surprising as part of the goal of the early announcements of the SMP and OMT was to promise to do "whatever it takes." Thus, the intention of a backstop by the ECB in this case was explicit. We find relatively weaker effects of the PSPP and PEPP announcements in January 2015 and March 2020, respectively. These weaker results are in keeping with the weaker overall reaction to later announcements of asset purchases. We note that the x-axis coverage across announcements depends on the range of option strikes available at each announcement date.

The gray line plots a fitted polynomial across all these announcements as a reference for the typical shape of the response. It implies that the ECB purchase policy would raise stock prices by over 15% if they were to fall 25% (to a value of 75 on the x-axis) in the case of no intervention, removing a substantial amount of downside rise. In contrast, the price support function is 2% if stock prices increase by 25% (to a value of 125). The pattern highlights the increased left tail support in these policies.

Appendix Figure 15 repeats this exercise using options on UniCredit, a large Italian bank. The patterns are similar to those in the Euro Stoxx index.

3.1 Additional evidence

We have shown how ECB purchase announcement effects depend on countries credit risk and argued that the evidence thus far supports the view of a dynamic policy for asset

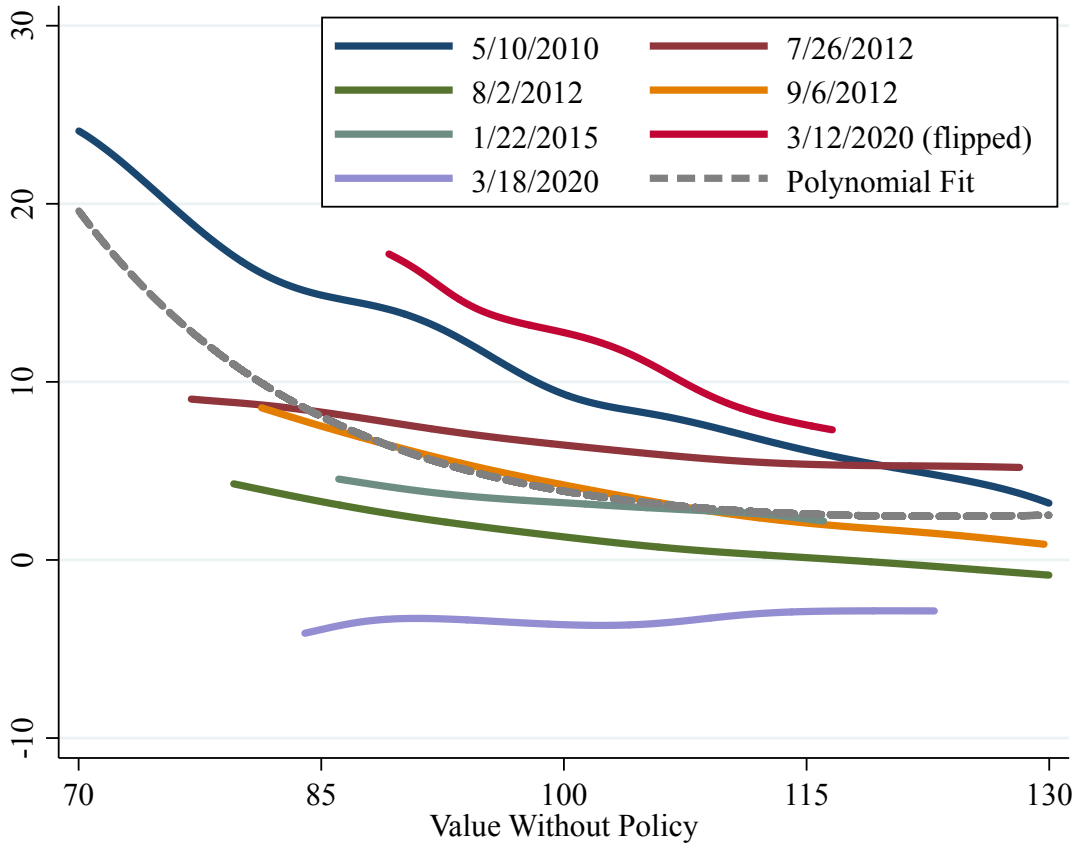


Figure 13: Price Support Function, asset purchases announcements for Euro Stoxx.
ECB Asset Purchase announcements. Figure adds additional dates to the figure in Haddad et al. (2025) that include the PSPP and PEPP announcements (in addition to the SMP and OMT announcement dates). We include the Lagarde press conference from the last subsection (3/12/2020) with the sign flipped to compare the pattern to other announcements which provided left tail support (rather than removing it).

purchases.

We assess how this affects the term structure of sovereign spreads. If markets believe this state-contingent policy will be in place indefinitely – that is the ECB will now use such purchases to fight future crises for the forseeable future – then announcements will affect even very long-maturity sovereign bonds.

In this spirit we look at the pass-through of shorter-term bond spread to longer-term

spreads during purchase announcements. Table 2 shows a significant pass-through of shorter-term bond spreads to long-term spreads on announcement dates. Specifically, we use the same set of announcement days of ECB purchases studied earlier and interact these announcements with the change in 5-year sovereign spreads. The interaction coefficient of event dummy times short term spreads in column 1 is 0.6. This implies that the ten-year bond spread decreased by 60 bps given a 100bps reduction in the 5 year bond. We include the change in 5-year spread on its own to control for the normal relationship between spread changes at different maturities. These results imply a significant effect on long-maturity sovereign spreads that are consistent with the rule view. Finally, they are also consistent with the broad sovereign credit risk premium channel for announcements where a change in credit risk premia affects sovereign bonds across maturities.

In table 3 we look at aggregate effects of the policy announcements across Euro area countries. Specifically, we look at GDP-weighted Credit Default Swap spreads and GDP-weighted yields. That is, we aggregate all countries to a single time-series based on their GDP shares. We see that interventions push down the aggregate CDS spread by 66bps and the aggregate yield by about 40bps. This difference can be traced back to the increase in yields on German bonds during the announcements. The increase of roughly 30 bps is surprising in light of the fact that a considerable amount of German bonds were bought through the various announcements. If anything we would have expected reductions german yields. This increase strongly suggests the possibility that the market is pricing some risk transfer from higher risk countries to Germany. However, it again cuts against a broad effect on lowering long-term risk-free rates.

4. A Simple Model with an Asset Purchase Rule

We turn to a quantitative model of the yield curve which incorporates an asset purchase rule. Such a model allows us to investigate the quantitative plausibility of our findings

Table 2: Announcement Effects and Country Spreads

We regress spread changes long-term bonds (10 and 30 years) on announcement dummies and the spread change in the short-term bond (5 years). We include the 11 main Euro area countries. Standard errors are clustered by country and time.

	10-Year Spread Change	30-Year Spread Change
Constant	0.0003	0.0003
	(0.0007)	(0.0005)
Event Dummy	-0.0149	-0.0749
	(0.0263)	(0.0468)
(Event Dummy) $\times \Delta Spread_{5yr,i,t}$	0.6127***	0.1281***
	(0.0703)	(0.0483)
$\Delta Spread_{5yr,i,t}$	0.0869	0.0496
	(0.0694)	(0.0409)
R-squared	0.0955	0.0371
R-squared Adj.	0.0955	0.0370
N	40727	40727

Table 3: Announcement Effects on Aggregate spreads and Yields

We regress GDP-weighted CDS spreads, GDP-weighted yields, and the German yield as a benchmark, on the set of ECB purchase announcements ("Events"). All yields are 5 year maturity to match the 5-year CDS.

	Agg GDP-weighted CDS	Agg GDP-weighted Yield	German Yield
Constant	0.0003	-0.0004	-0.0002
	(0.0012)	(0.0008)	(0.0007)
Event Dummy	-0.6623***	-0.4262***	0.3044***
	(0.2110)	(0.1322)	(0.1164)
R-squared	0.0020	0.0021	0.0014
R-squared Adj.	0.0018	0.0019	0.0012
N	4941	4941	4941

and the importance of various mechanisms. Furthermore, it provides a laboratory to assess the impact of alternative purchase rules.

We follow a structure similar to Greenwood and Vayanos (2014), Haddad and Sraer (2020), Vayanos and Vila (2021), Greenwood et al. (2023), with the addition of an asset purchase rule. Here we present the minimum structure need to motivate our empirical analysis, but we extend this model in many directions.

4.1 Reduced form model

The term structure consists of zero coupon bonds with maturities up to T and face value of one. The short rate r is the yield on the bond with a maturity of one period. Bonds are issued by the government and purchased by investors and the central bank. We model the investment decision of investors and treat the issuance policy of the government as exogenous, and consider alternative purchase rules by the central bank. We also assume that each country i has a probability $1 - exp(-b(i)h_t)$ of default per period where h_t is the common default risk component across countries and $b(i)$ controls the country i specific default risk. Here we assume no recovery.

The price of each bond is then given by

$$P_t^{(n,i)} = \hat{E}\left[e^{-r_t} e^{-b(i)h_t} P_{t+1}^{(n-1,i)}\right] \tag{1}$$

To keep things simple we assume innovations to default risk are priced but default risk itself is not. We assume the dynamics for the risk-free rate, the aggregate default process, and the bond market SDF are fully captured by the state vector Z_t. For example, for the risk-free rate r, the state Z could include the output gap and inflation as in a standard Taylor rule. The state vector Z follows a VAR(1) so that we can write the dynamics of Z and the dynamics for the risk-free rate r_t, the aggregate default process h_t, and the bond

market SDF as follows

$$Z_{t+1} = \mu + \rho Z_t + \Sigma \epsilon_{t+1} \tag{2}$$

$$r_t = \delta_0 + \delta_1 Z_t + \delta_2 \nu_{t+1} \tag{3}$$

$$h_t = \psi_0 + \psi_1 Z_t + \psi_2 \nu_{t+1} \tag{4}$$

$$\lambda_t = \lambda_0 + \lambda_1 Z_t \tag{5}$$

$$\log(SDF_{t+1}) = -r_t - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t'\varepsilon_{t+1}, \tag{6}$$

where λ_t governs the price of risk. Given this structure, we obtain that yields y for country i and maturity n are of the following form

$$y_t^{(n,i)} = a(n,i) + \beta^{rf}(n) Z_t + \beta^{cr}(n) b(i) Z_t \tag{7}$$

$$\beta^r(n) = -\frac{1}{n}(I - (\rho^Q)^n)(I - \rho^Q)^{-1}\delta_1 \tag{8}$$

$$\beta^c(n) = -\frac{1}{n}(I - (\rho^Q)^n)(I - \rho^Q)^{-1}\psi_1 \tag{9}$$

where $\rho^Q = \rho - \sigma\lambda_1$ is the risk-adjusted persistence of the state variable Z, $y_t^{(n,i)}$ is the yield on country i at time t, $cr_t = \beta^c(n) Z_t$ represents the credit risk premium at time t for maturity n, $b(i)$ is country i's loading on credit risk, and $\beta^r(n) Z_t$ denotes the risk-free rate at various horizons. Asset purchases can affect both the long-term risk-free rate and the credit risk premium component.

The equation above means that yields and returns follow a two factor structure and can be represented in terms of the yields of a safe country, and a spread that incorporates a credit risk premium. Let $i = 1$ be the country with zero default risk ($b(1) = 0$). In the context of the Euro area, we can think of $i = 1$ as Germany. Let $n^* > 1$ be a reference maturity, say 10-years. Then the two factor structure allows us to write

$$y_{n,i,t} = \phi^r(n) y_{n^*,1,t} + \phi^c(n) \frac{b(i)}{\bar{b}} \left(\bar{y}_{n^*,t} - y_{n^*,1,t} \right), \tag{10}$$

where $\bar{y}_{n,t} = \sum_i \frac{y_{n,i,t}}{I}$ and $\bar{b} = \sum_i \frac{b(i)}{I}$ are the average yield and average credit exposure across countries, and $\phi^r(n) = \beta^r(n)/\beta^r(n^*)$ and $\phi^c(n) = \beta^c(n)/\beta^c(n)$ are the bond exposures relative to the reference maturity n^*. Thus, the first term in Equation 10 gives the risk-free yield at maturity n based on the risk-free yield ($i = 1$) and reference maturity n^*. The second term gives the yield spread of any country i based on country i's relative risk exposure, $\frac{b(i)}{\bar{b}}$, and the average yield spread relative to the risk-free country $i = 1$. This is useful guide for how asset purchases work in our structural model below. Asset purchases will work though term spreads, by impacting the term structure of risk-free bonds, or credit spreads by impacting the term structure of yield differential across countries.

Analogously we can write bond returns for country i and maturity n as

$$r_{n,i,t} = \frac{n}{n^*} \phi^r(n) r_{n^*,1,t} + \frac{n}{n^*} \phi^c(n) \frac{b(i)}{\bar{b}} \left(\bar{r}_{n^*,t} - r_{n^*,1,t} \right),$$

That is, returns and yields both follow a two factor structure based on a duration component and a credit risk component.

4.2 Structural model of Risk-Premia

To evaluate the effect of asset purchases we follow a structure similar to Greenwood and Vayanos (2014), Haddad and Sraer (2020), Vayanos and Vila (2021), and Greenwood et al. (2023), that endogenizes the dynamics of the stochastic discount factor as a function of the supply of debt that investors must hold. While their setting is quite flexible, here we focus on the simplest setting where there are only arbitrageurs, who are marginal investors in the bond market, and must absorb variation in the supply of bonds. Similarly, by shifting

their portfolios and absorbing risk off their balance sheet, asset purchases impact the term premium and the credit risk-premium.

Investors buy and sell bonds of any maturity and any country with the objective of maximizing their mean-variance objective as follows:

$$\max_{X_t} E_t[W_{t+1}] - \frac{\gamma}{2}\text{Var}_t[W_{t+1}] \tag{11}$$

the vector X are the portfolio weights in every bond for every country i and maturity n.

The arbitrageurs wealth W evolves according to their portfolio choice X_t and the returns R_{t+1} of the different bonds for every i and n:

$$W_{t+1} = (W_t - 1'X_t)(1 + rf_t) + X_t(1 + R_{t+1}). \tag{12}$$

Following Greenwood et al. (2023), we log-linearize returns $r_{n,i,t+1} = \log(1 + R_{n,i,t+1})$:

$$R_{n,i,t+1} \approx r_{n,i,t+1} + \frac{1}{2}\text{Var}_t(r_{n,i,t+1}).$$

This allows us to write the arbitrageur's problem as:

$$\max_X W_t(1 + rf_t) + \sum X(n,i)E_t\left[r_{n,i,t+1} + \frac{1}{2}\text{Var}_t(r_{n,i,t+1}) - rf_t\right] - \frac{\gamma}{2}\text{Var}_t\left[\sum X(n,i)r_{n,i,t+1}\right].$$

Equilibrium yield curve. In equilibrium, the arbitrageur must hold the entire net supply of bonds at each maturity and the first-order condition of the arbitrageur's problem is then

$$E_t[r_{n,i,t+1}] + \frac{1}{2}\text{Var}_t(r_{n,i,t+1}) = rf_t + \gamma\text{Cov}_t\left(r_{n,i,t+1}, X_t R_{t+1}\right), \tag{13}$$

which states that each bond should earn the risk-free rate plus a premium that depends on the arbitrageur's risk aversion γ and the covariance of the bond with the arbitrageur's portfolio $X'R$. Supply shocks or credit shocks will feed into risk-premia as they change the composition of the arbitrageur portfolio. Using the two factor structure from Equation 10 we can write the arbitrageur portfolio returns as

$$r_t^p = x_{t+1}^r r_{n^*,1,t+1} + x_{t+1}^c(\bar{r}_{n^*,t+1} - r_{n^*,1,t+1})$$

where $x_{t+1}^r = \sum_i \sum_n x_{i,n,t} \frac{n}{n^*} \phi^r(n)$ can be thought of as the duration-weighted arbitrageur holdings of risk-free debt and $x_{t+1}^c = \sum_i x_{i,t} b(i)/\bar{b} \frac{n}{n^*} \phi^c(n)$ is the credit-risk weighted arbitrageur holdings of debt. The term $\bar{r}_{n^*,t+1} - r_{n^*,1,t+1}$ is the excess return from credit risk, and to save notation we will write this excess return as $r^e_{n^*,t} = \bar{r}_{n^*,t+1} - r_{n^*,1,t+1}$. This allows us to write date-t risk-premiums of a bond of country i with maturity n as

$$\gamma \frac{n}{n^*} \phi^r(n) x_t^r \text{Var}_t\left(r_{n^*,t+1}\right) + \gamma \frac{n}{n^*} \frac{b(i)}{\bar{b}} \phi^c(n) x_t^c \text{Var}_t\left(r^e_{n^*,t+1}\right) + \gamma \frac{n}{n^*} \left(\frac{b(i)}{\bar{b}} \phi^c(n) x_t^r + \phi^r(n) x_t^r\right) \text{Cov}_t\left(r^e_{n^*,t+1}, r_{n^*,t+1}\right)$$

We can see that policies that change arbitrageurs exposures x^r and x^c or that change returns volatilities will impact risk premiums, which ultimately impact yields. Below we represent yields as deviations to the expectations hypothesis benchmark:

$$y_{n,i,t} - y_{n,i,t}^{x^r=x^c=0} = \gamma E_t \left[\sum_{j=0}^{n} \frac{n-j}{n^*} \phi^r(n-j) x_{t+j}^r \text{Var}_{t+j}\left(r_{n^*,t+j+1}\right) + \sum_{j=0}^{n} \frac{n-j}{n^*} \frac{b(i)}{\bar{b}} \phi^c(n-j) x_{t+j}^c \text{Var}_{t+j}\left(r^e_{n^*,t+j+1}\right) + \sum_{j=0}^{n} \frac{n-j}{n^*} \left(\frac{b(i)}{\bar{b}} \phi^c(n-j) x_{t+j}^c + \phi^r(n-j) x_{t+j}^r\right) \text{Cov}_{t+j}\left(r^e_{n^*,t+j+1}, r_{n^*,t+j+1}\right) \right].$$

4.3 Debt supply and Asset purchase rules

We model the net supply of government debt as summarized by two state variables (which are part of aggregate state Z_t)

$$s_t^r = \sum_i \sum_n \frac{n}{n^*} \phi^r(n) s_{i,n,t} \tag{14}$$

$$s_t^c = \sum_i \sum_n \frac{b(i)}{\bar{b}} \frac{n}{n^*} \phi^c(n) x_{i,t} \tag{15}$$

An asset purchase rule specifies that the central bank holds qe_t bonds given the state Z_t at date-t, which we can also represent in terms of two factors

$$qe_t^r = \sum_i \sum_n \frac{n}{n^*} \phi^r(n) qe_{n,i,t} = a^r + b^r Z_t \tag{16}$$

$$qe_t^c = \sum_i \sum_n \frac{b(i)}{\bar{b}} \frac{n}{n^*} \phi^c(n) qe_{n,i,t} b(i) = a^c + b^c Z_t, \tag{17}$$

the duration risk component and the sovereign credit risk component. To see the effect of an asset purchase rule lets define the co-variances with these two factors. Let $\Omega_{t+j,\phi}^{r,(n-j,i,n^*)} = Cov_{t+j}\left(r_{n-j,i,t+j+1}, r_{n^*,1,t+j+1}\right)$ be the date $t+j$ covariance between $n-j$ risk-free bonds and n^* risk-free bonds in regime $\phi \in \{qe = 0, qe\}$ and let $\Omega_{t+j,\phi}^{r,(n-j,i,n^*)} = Cov_{t+j}\left(r^e_{n-j,i,t+j+1}, r^e_{n^*,,t+j+1}\right)$ be the date $t+j$ covariance between the excess bond returns (relative to the safe yield of the same maturity) in country i with maturity $n-j$ and country i^* and maturity n . The regimes $\phi \in \{qe = 0, qe\}$ are with no asset purchase rule, and with the asset purchase rule. We can then write the effect of the QE regime ϕ on the

term-structure of yields as

$$y^{qe}_{n,i,t} - y^{qe=0}_{n,i,t} = -\gamma \left(E_t \left[\sum_{j=0}^{n} qe^{r}_{t+j} \Omega^{r,(n-j,i,n^*)}_{t+j,qe} \right] + E_t \left[\sum_{j=0}^{n} s^{r}_{t+j} \left(\Omega^{r,(n-j,i,n^*)}_{t+j,0} - \Omega^{r,(n-j,i,n^*)}_{t+j,qe} \right) \right] + \right. \quad (18)$$

$$\left. E_t \left[\sum_{j=0}^{n} qe^{c}_{t+j} \Omega^{c,(n-j,i,n^*)}_{t+j,qe} \right] + E_t \left[\sum_{j=0}^{n} s^{c}_{t+j} \left(\Omega^{c,(n-j,i,n^*)}_{t+j,0} - \Omega^{c,(n-j,i,n^*)}_{t+j,qe} \right) \right] \right) \quad (19)$$

This expression shows how bond purchase rules by the central bank impact bond yields by impacting the duration risk component and the sovereign credit risk component. Within a regime, this will depend on the covariance of bond returns in that regime, i.e. the terms $-\gamma E_t \left[\sum_{j=0}^{\tau} qe^{rf}_{t+j} \Omega^{r,(n-j,i,n^*)}_{t+j,qe} \right]$ for the term-premium and $-\gamma E_t \left[\sum_{j=0}^{\tau} qe^{c}_{t+j} \Omega^{cr,(n-j,i,n^*)}_{t+j,\phi} \right]$ for the credit-risk premium. We see the quantities qe^{rf}_{t+j} and qe^{cr}_{t+j} which measure the maturity-weighted amount of safe-bond equivalents purchased by central banks and the default-risk-weighted amount of purchases.

Effectively, this strips the portfolio of the central bank into the two important risk components: duration and sovereign credit risk, and says the ultimately only the amount of each of these two components matters.

Much of the empirical work in the QE literature can be thought as trying to measure the constant terms in these equations a^r and a^c. The thought experiment in this case is that the econometrician is able to isolate one-off changes in the total bonds held by the central bank. Such policies do not change the future dynamics of bond prices and therefore do not change the covariance of bond returns, so the second-terms in (18) drop out.

Equation (18) makes clear that in general a QE policy will affect yields indirectly through a change in the *dynamics* of bond yields. By changing dynamics of yields, the risk of bonds changes, which affects both unconditional and conditional risk premiums. Our empirical work is based on the assumption that we can identify these terms from the excess movement in yields around asset purchase announcements, and the change in dynamics observed in the data. The idea is that during these announcements, bond markets

learn about the policy rule pursued by the central bank, while in the later announcements, expectation revisions about bond purchases are mostly about about the evolution of state of the economy Z_t rather than the coefficients in the rule.

We also see that an important aspect of policy is not only what the central bank buys, but *when* it buys. This is captured in the covariance of the purchases qe_t with the amount of risk Ω. For example, even if the policy is not targeted to high $b(i)$ or high default risk countries and buys all the bonds proportionally to country size, the equation shows that the sovereign credit risk premium channel will be particular powerful if the policy happens in periods when credit-risk premiums are high.

A way to make the expression above more transparent is to consider a rule that is duration neutral $qe_t^r = 0$, but is net long/short credit risk. For visualization lets also assume that the risk-free rate and the default intensity are orthogonal to each other. The two assumptions together allow us to write

$$y_{n,i,t}^{qe} - y_{n,i,t}^{qe=0} = -\gamma E_t \sum_{j=0}^{n} qe_{t+j}^{c} \frac{n-j}{n^*} \frac{b(i)}{\bar{b}} \phi^{c,qe}(n-j) \mathrm{Var}_{t+j}^{qe} \left(r_{n^*,t+j+1}^{e} \right) +$$

$$\gamma E_t \sum_{j=0}^{n} s_{t+j}^{c} \frac{n-j}{n^*} \frac{b(i)}{\bar{b}} \left(\phi^{c,qe}(n-j) \mathrm{Var}_{t+j}^{qe} \left(r_{n^*,t+j+1}^{e} \right) - \phi^{c}(n-j) \mathrm{Var}_{t+j} \left(r_{n^*,t+j+1}^{e} \right) \right),$$

where we see that such credit-based QE policy will impact yields through the co-movement it has with the variance of the credit risk-factor and also by changing the variance or the credit risk-factor itself. A rule that leans against spreads – that is increases holdings when spreads widen – will make the variance of spreads lower by lowering $\mathrm{Var}_{t+j}^{qe} \left(r_{n^*,t+j+1}^{e} \right)$. This has the effect of lowering yield spreads unconditionally.

5. Conclusion

Asset purchase policies are a dynamic state-contingent plan instead of a succession of independent interventions. We apply this view to the experience of asset purchase programs in the Euro area. Our evidence suggests that the market expects interventions in large part based on high sovereign spreads and the total supply of sovereign credit risk. In turn, this provides a powerful mechanism to lower spreads in the Euro area: because interventions typically occur when spreads, debt issuance, and dislocations are high, purchases provide ex-ante insurance to investors which increases demand and lowers credit risk premiums on sovereign bonds. We illustrate this channel is both low frequency data and event study analysis, including using option prices to assess the state-contingent impact of interventions.

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A. Data Appendix

We outline our main data sources here.

Data on Sovereign Yields and CDS: All data on sovereign yields and sovereign CDS for Euro area countries (at all maturities) are from Bloomberg.

Macro Data: Data on government debt, GDP, population, deficit, and unemployment come from the global macro data base https://www.globalmacrodata.com/. See Müller et al. (2025).

Central Bank Balance Sheets: Data on the total size of central bank balance sheets for the ECB, Federal Reserve, Bank of Japan, and Bank of England come from Fred. We supplement this with direct data from central bank websites if needed to fill in recent years.

ECB Holdings: Data on sovereign bond holdings by the ECB come from the ECB website. We use data from the SMP, PSPP, and PEPP and use these programs holdings of sovereign bonds in the Euro area.

Option Price Data: All data on option prices of stock indices or bond futures are from Bloomberg.

B. Additional Empirical Results

Figure 14 plots the yield spreads for Italy and France through the March 2020 experience, with vertical lines marking the March 12th and March 18th statements. We see the rise in spreads for both countries on the March 12th statement, although with much larger magnitude for Italy. March 18th provides a near reversal in spreads.

Figure 15 repeats our analysis constructing the price support function using options on UniCredit, a large Italian bank.

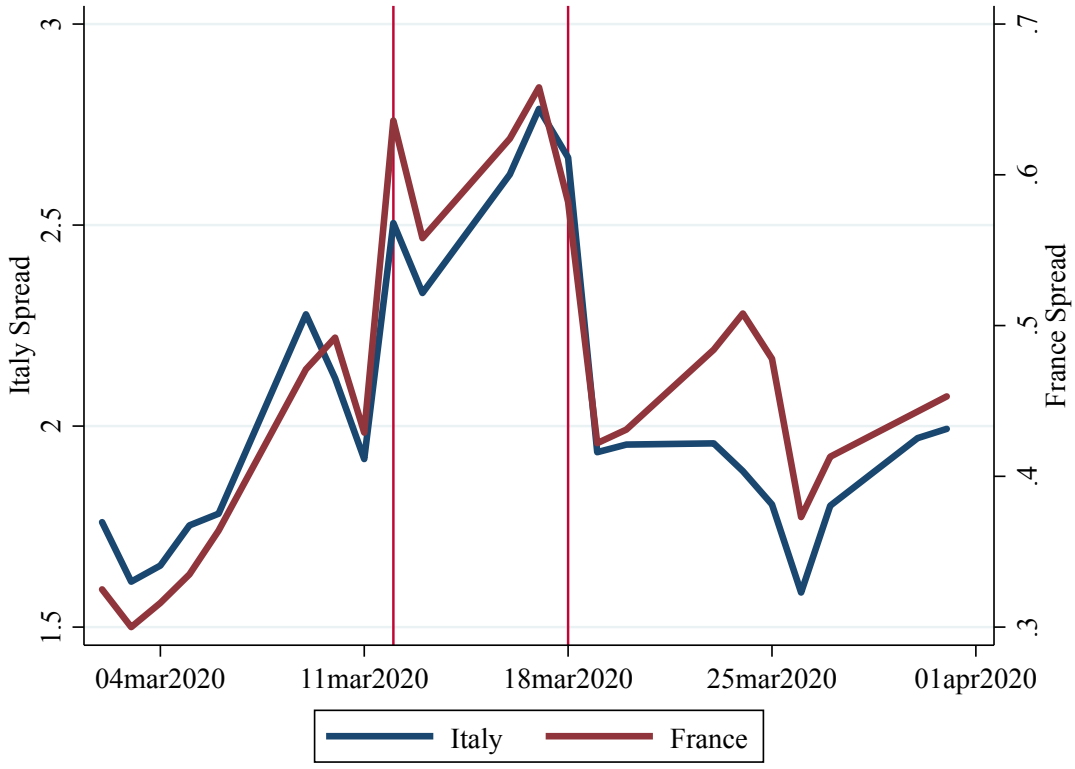


Figure 14: Spreads during March of 2020.
Vertical lines mark March 12th and March 18th, which denote the "we are not here to close spreads" press conference and the announcement of the PEPP, respectively.

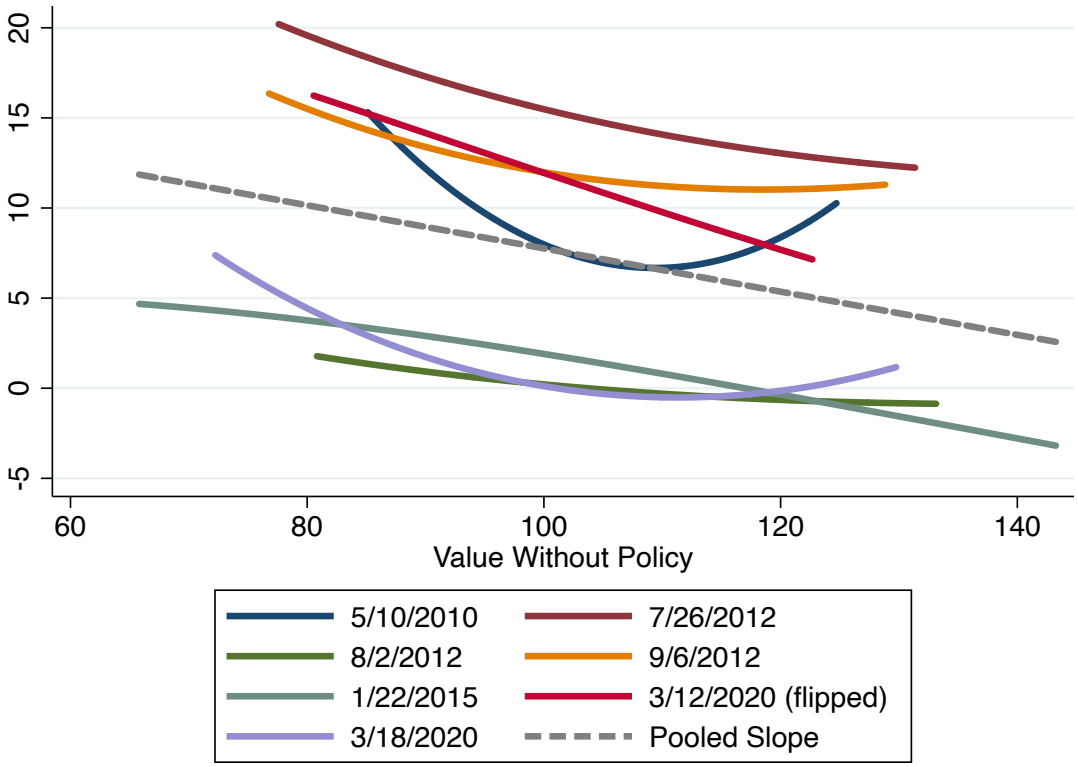


Figure 15: Price Support Function, asset purchases announcements: UniCredit.
ECB Asset Purchase announcements. We use option price data on UniCredit, a large Italian bank, to construct the price support function around ECB announcement dates. Dates include the SMP, OMT, PSPP, and PEPP announcements. We include the March 12, 2020 Lagarde press conference with the sign flipped to compare the pattern to other announcements which provided left tail support (rather than removing it).