

The Conditional Path of Central Bank Asset Purchases

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ABSTRACT

We investigate the financial market effects of central bank asset purchases by exploiting the unique setting provided by ECB's PSPP and PEPP policies. These programs consist in purchases of identical assets. The PSPP aimed to reduce deflationary risks, while the PEPP was announced to alleviate sovereign risks. We assess the effects of both policies on these two intermediate objectives. We find that the PSPP positively affects inflation swaps whereas the PEPP negatively impacts sovereign spreads. We explore the reasons for these differentiated effects. Making the rationale of a policy clear and credible influences its transmission to asset prices.

Keywords: Monetary Policy, Asset Prices, Central Bank Communication, Central Bank Reaction Function, Intermediate Objectives.

JEL Classification: G12, E52, E58.

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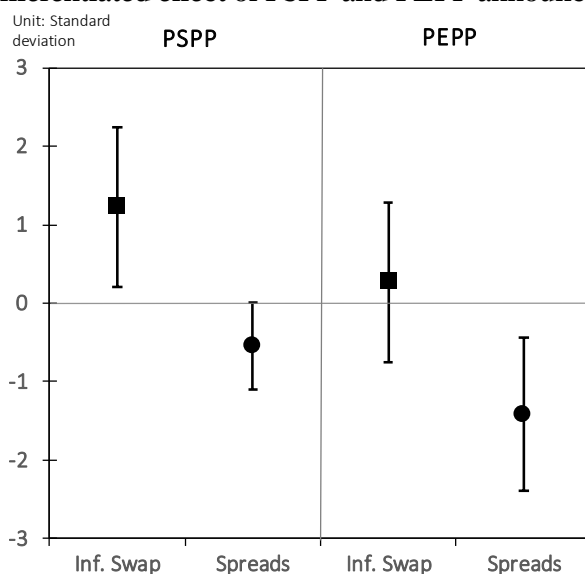
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NON-TECHNICAL SUMMARY

This paper documents a novel pattern of monetary policy by exploring whether central bank asset purchases can produce differentiated effects on the economy. Two of the asset purchase programs of the European Central Bank (ECB) provide a unique setting to explore this question. During the pandemic, the ECB increased the monthly pace of its asset purchases within the Public Securities Purchase Programme (PSPP) initiated in 2015. It also launched another asset purchase program called the Pandemic Emergency Purchase Programme (PEPP). Both programs purchase essentially identical assets (euro area sovereign bonds). However, they have been motivated by different rationales or intermediate objectives. In January 2015, the ECB worried about deflation risks as both inflation and inflation expectations were falling, with the ECB President Mario Draghi putting inflation swaps in the spotlight. On 18 March 2020, the PEPP was announced in response to the pandemic-driven financial and economic crisis as the Eurozone was facing a sharp increase in financial stress on sovereign debt markets.

The differentiated effect of PSPP and PEPP announcements



Note: This figure shows the estimated effects of PSPP and PEPP announcements on 5-year 5-year-forward inflation swaps and sovereign spreads in the euro area. The sovereign spread measure is the first principal component of 10 euro area sovereign spreads relative to Germany (Eurozone12 minus Luxemburg). These variables are normalized to 1 unit standard deviation. Boxplots show 90% confidence intervals.

This paper explores why the ECB considered having two separate programs by comparing their respective financial market effects. Using an event-study methodology, we assess the effects of the two asset purchase programs on the two asset prices that capture the respective intermediate objective of the programs: 5-year in 5-year-forward inflation swaps and euro area sovereign spreads. The main result of this paper is that the PSPP and PEPP are not substitutes. We find that ECB announcements of purchases of the same assets do not produce the same effects according to whether they relate to the PSPP or PEPP. PSPP announcements have a positive impact on inflation swaps and only a slight negative impact on euro area sovereign spreads. At the opposite, PEPP announcements have no impact on inflation swaps, but a strong negative effect on sovereign spreads. This effect of PEPP announcements is more than twice larger than the one of PSPP announcements.

We explore the potential sources of these differentiated effects. Although the same assets are purchased, the characteristics of the programs differ. We investigate seven alternative hypotheses. The first hypothesis is that our estimates would reflect differences in operational characteristics like the size, length and purchase pace. A second hypothesis is that the PEPP announcement was not as clear as the PSPP announcement (specifically linked to inflation). A third hypothesis relates to the fact that the PSPP announcement was largely anticipated by ECB watchers compared to the PEPP. A fourth hypothesis is that our estimates reflect that different variables were under stress when the programs were implemented. A fifth hypothesis is that the financial and economic context evolved. A sixth hypothesis relates to PEPP capital key deviations while the PSPP has to comply with ECB capital key shares. We find that these factors do not explain the differentiated effects. Finally, a seventh hypothesis is that communicating different intermediate objectives for each program suggests that the PSPP and PEPP policies follow different reaction functions and triggers different asset price reactions. The empirical and narrative evidence presented in this paper is consistent with the hypothesis that the rationale for both policies were interpreted as different.

A key policy implication of our main result relates to the potential benefit of central bank asset purchases as a monetary policy instrument. Two asset purchase programs can be implemented in parallel with different effects and help reach distinct intermediate objectives. Our results suggest that central banks could make use of this additional flexibility to achieve their objectives. More generally, what central banks choose to communicate (the stated purpose or structure of a given policy) can affect how financial market participants react.

Le rôle de la conditionnalité des achats d'actifs des banques centrales

RÉSUMÉ

Nous étudions les effets des achats d'actifs par les banques centrales sur les marchés financiers en exploitant le cadre fourni par les politiques PSPP et PEPP de la BCE. Ces programmes consistent en des achats d'actifs identiques. Le PSPP visait à réduire les risques déflationnistes, tandis que le PEPP a été annoncé pour atténuer les risques souverains. Nous évaluons les effets des deux politiques sur ces deux objectifs intermédiaires. Nous trouvons que le PSPP affecte positivement les swaps d'inflation alors que le PEPP a un impact négatif sur les spreads souverains. Nous explorons les raisons de ces effets différenciés. Rendre l'objectif d'une politique claire et crédible influence sa transmission aux prix d'actifs.

Mots-clés : politique monétaire, prix d'actifs, communication de la banque centrale, fonction de réaction de la banque centrale, objectifs intermédiaires.

Les Documents de travail reflètent les idées personnelles de leurs auteurs et n'expriment pas nécessairement la position de la Banque de France. Ils sont disponibles sur publications.banque-france.fr

1. Introduction

This paper documents an original pattern of monetary policy by exploring whether central bank asset purchases can produce differentiated effects. Consider a central bank purchasing the same class of asset (say, 10-year French bonds), for the same quantity (say, 1.000€) and to the same counterparty (say, a given commercial bank) but using two separate programs to do so. This paper investigates the impact of these two asset purchase programs on asset prices.

Two of the asset purchase programs of the European Central Bank (ECB) provide a unique setting to explore this question. During the pandemic, the ECB has increased the monthly pace of its asset purchases within the Public Securities Purchase Programme (PSPP) initiated in 2015. It also launched another asset purchase program called the Pandemic Emergency Purchase Programme (PEPP). Both programs purchase essentially identical assets (euro area sovereign bonds). However, they have been motivated by different rationales or intermediate objectives.¹ In January 2015, the ECB worried about deflation risks as both inflation and inflation expectations were falling, with the ECB President Mario Draghi putting inflation swaps in the spotlight. On 18 March 2020, the PEPP was announced in response to the pandemic-driven financial and economic crisis as the Eurozone was facing a sharp increase in financial stress on sovereign debt markets. In a Financial Times column published on 19 March 2020, the ECB President Christine Lagarde linked the PEPP with the fact that sovereign bond yields had increased and become more dispersed.² A key feature of the PEPP is the flexibility option in the country breakdown of purchases.³ It signals the ECB willingness to deviate from capital key if needed and that it will be technically able to reduce sovereign spreads. It makes clear that the rationale of the PEPP is about sovereign risks.

This paper explores why the ECB considered having two separate programs by comparing their respective financial market effects. Using an event-study methodology, we assess the effects of the two asset purchase programs on the two asset prices that capture the respective intermediate objective of the programs: 5-year in 5-year-forward inflation swaps and euro area sovereign spreads.⁴ This question has become even more topical since the ECB announced at the 16 December 2021 meeting that it would stop net purchase flows for one program (the PEPP) and increase net purchase flows for the other (the PSPP). The implicit assumption behind this decision is that both programs are substitutes and produce similar effects (see the press conference on that day).⁵ This paper documents whether this is the case.

While there is an abundant empirical literature that highlights the effects of central bank communication above and beyond policy actions, its main focus is on communication about the future likely policy path (see Gürkaynak et al., 2005, and Hansen and McMahon, 2016), on announcements that could convey information about the macroeconomic outlook (Campbell et al., 2012, and Nakamura and Steinsson, 2018), and on the role central banks play in the characterization of macroeconomic shocks (Bauer and Swanson, 2022). In contrast, this paper focuses on the role of communication about the objectives of different policy instruments.

¹ Both programs share the same final objective, and the ECB always asserted that these asset purchases contribute to supporting economic activity in order to maintain price stability over the medium term.

² See the original extract of the Financial Times article in Section A of the Appendix.

³ For the PSPP, the country breakdown of asset purchases has to reflect the share of each euro area member in the ECB capital. The aim is to avoid creating market distortions among EMU countries.

⁴ The event-study can also reveal how the policy and its objective were interpreted by financial market participants.

⁵ "We have decided that we will discontinue the Pandemic Emergency Purchase Programme (PEPP) on the due date (...). We did not want to have a transition that would be hurting (...) which is the reason why we decided to increase the volume of purchases under the APP", Christine Lagarde, 16 December 2021 press conference.

While this work is also related to the literature on the empirical assessment of the impact of asset purchases, our contribution is to compare the effects of the two programs on the two different intermediate policy objectives. An important aspect of the monetary transmission mechanism is the role of institutional policy design and central bank communication in influencing private beliefs about the effects of monetary policy. The features of these two ECB asset purchases offer a relevant setting to properly identify whether the conditional path of a policy instrument matters for its transmission to asset prices.

The main result of this paper is that the PSPP and PEPP are not substitutes. We find that ECB announcements of purchases of the same assets do not produce the same effects according to whether they relate to the PSPP or PEPP. PSPP announcements have a positive impact on inflation swaps and only a slight negative impact on euro area sovereign spreads.⁶ At the opposite, PEPP announcements have no impact on inflation swaps, but a strong negative effect on sovereign spreads. This effect of PEPP announcements is more than twice larger than the one of PSPP announcements.⁷ The reversal of the effects on inflation swaps and sovereign spreads between the two programs holds across various specifications and robustness tests.

We explore the potential sources of these differentiated effects. Although the same assets are purchased, the characteristics of the programs differ. The first hypothesis is that our estimates would reflect differences in operational characteristics like the size, length and purchase pace. We document that these differences are minor in practice and cannot explain the differentiated effects. A second hypothesis is that the PEPP announcement was not as clear as the PSPP announcement. The PSPP statement was specifically linked to inflation asserting that asset purchases would be implemented until “a sustained adjustment in the path of inflation” is observed. Conversely, being enacted in response to the financial and economic crisis caused by the pandemic, the PEPP statement was general. However, based on narrative evidence from newspapers, we show that the PEPP was clearly interpreted as being about sovereign risks. A third hypothesis relates to the fact that the PSPP announcement was largely anticipated by ECB watchers and financial markets from Fall 2014 while it was less the case for the PEPP.⁸ Under the assumption that these anticipation effects were incorporated in asset prices, the event-study methodology circumvents that issue by focusing on changes in asset prices on the days of announcements. Therefore, even if the PSPP had been less of a surprise than the PEPP, it would not explain why the effects on inflation swaps and sovereign spreads are different.

Another set of explanations relates to the different economic and financial environments when both programs were introduced. A fourth hypothesis is that our estimates reflect that different variables were under stress at the time when the programs were decided and thus required specific intervention. We test whether the level, the variation and volatility over 40 business days of both dependent variables matter for the differentiated effects. The main result holds when controlling for the dynamics of inflation swaps and sovereign spreads. A fifth hypothesis is that the different financial and economic contexts explain the differentiated effects.⁹ We pay attention to controlling for the financial context and to how liquidity and volatility evolved over time.

⁶ Those results hold above and beyond other announcement effects on these days: monetary surprises (identified by Altavilla et al., 2019), other program announcements and daily changes in financial stress.

⁷ We also estimate these effects for each of the 10 individual sovereign spreads separately and confirm this result.

⁸ The Covid-19 pandemic was not anticipated. When it started to spread in Europe in January 2020 and because of the asymmetric spread across countries, the ECB reaction to the pandemic was not anticipated before March 2020.

⁹ We also discuss how the role of fiscal policy effects as a potential confounding factor could lead to an under-estimation of the “true” impact of PEPP on inflation swaps and sovereign spreads.

A sixth hypothesis relates to PEPP capital key deviations. The PSPP has to comply with ECB capital key shares but PEPP purchases can deviate and entail potential differences in the country allocation of asset purchases. Based on ECB data, we show that the difference between both programs in terms of purchase deviations is actually limited. We nevertheless use the fact that PEPP Italian and French purchases deviate in opposite directions to test whether our main result is driven by a mechanical effect of over- or under-purchasing some sovereign bonds. We find no evidence of this, and we also show that our main result holds for the 17 out of 19 countries for which PEPP purchases do not deviate from the capital key.

Finally, a seventh hypothesis is that the rationale for the two programs influences investors' beliefs and decisions triggering different asset price reactions. Communicating different intermediate objectives for each program suggests that the PSPP and PEPP policies follow different reaction functions. In addition, while the PSPP rationale appeared credible because it was directly in line with the ECB mandate, the flexibility option embedded in the PEPP design conveys a strong signal to investors that the ECB will be able to effectively reduce sovereign spreads and makes the rationale about sovereign spreads credible. The empirical and narrative evidence presented in this paper is consistent with the hypothesis that the rationale for both policies were interpreted as different.

Our interpretation of the mechanism that drives the differentiated effects is the following. Assume that a central bank announces it will use a given policy – for instance, asset purchases – until a particular goal is achieved – say, for instance, lower term premia or an exchange rate depreciation. The effects of these purchases on financial markets then differ across the two cases because the central bank has effectively announced two different conditional paths of purchases. In the first case, purchases will not stop until term premia lowers, whereas in the second case, purchases will not stop until the exchange rate depreciates. Even though the central bank purchases identical assets, the differences in conditionality create two different policies and lead to two different sets of effects on financial markets. By communicating on its intermediate objectives at policy announcements, the central bank provides information to private agents on the variables entering the reaction function for a given asset purchase program. This in turn affects investors' beliefs and decisions as observed via asset prices. Making the rationale of a given policy clear and credible influences the transmission of this policy. There is a direct analogy with state-contingent forward guidance policies which clarify the reaction function that guides how the central bank sets the policy rate.

A key policy implication of our main result relates to the potential benefit of central bank asset purchases as a monetary policy instrument. Two asset purchase programs can be implemented in parallel with different effects and help reach distinct intermediate objectives. Our results suggest that central banks could make use of this additional flexibility to achieve their objectives. More generally, what central banks choose to communicate (the stated purpose or structure of a given policy) can affect how financial market participants react.

This paper relates to the existing literature in several respects. First, it links to numerous empirical studies on the effects of asset purchase announcements on asset prices. Guidolin and Neely (2010), Hofmann and Zhu (2010), Krishnamurthy and Vissing-Jorgensen (2011), Gagnon et al. (2011), Joyce et al. (2011), Wright (2012), Glick and Leduc (2012), Bauer and Rudebusch (2014), Rogers et al. (2014), Szczerbowicz (2015), Altavilla et al. (2016), Haitsma et al. (2016), Ghysels et al. (2017), Afonso et al. (2018) De Pooter et al. (2018), Krishnamurthy et al. (2018), Moessner (2018), Altavilla et al. (2019), Lewis and Roth (2019), De Santis (2020), De Santis and Holm-Hadulla (2020), Pagliari (2020), Altavilla et al. (2021), Bernardini and Conti (2021), Lhuissier and Nguyen (2021), Costain et al. (2021) and Swanson (2021) all investigate the

effects of different asset purchase programs in different countries. We differ from these contributions by differentiating the effects of both asset purchase programs on both asset prices identified as the rationale of each program. Second, this paper analyses the role of communication in conveying information on policymakers' preferences (Blinder et al., 2008). Communication strategies may produce a benchmark for assessing central bank performance (see Woodford, 2005, Eusepi and Preston, 2010, Gürkaynak et al., 2010, Schmidt and Nautz, 2012, Davig and Foerster, 2021, and Leombroni et al., 2021). Finally, the closest paper to ours is Lunsford (2020) who shows that the nature of the language used in forward guidance announcements in the United States (US) influences investors' responses to monetary policy statements. Variations in the expected path of policy rates have differentiated effects on financial and macroeconomic variables depending on the forward guidance language. Our paper aims to shed light on a similar pattern, but through the credible communication of a rationale for asset purchase programs.

2. The financial market effects of asset purchases

The PSPP was announced on 22 January 2015 and purchases started in March 2015.¹⁰ It was introduced to counter deflationary risks as both inflation and inflation expectations were falling. Figure 1 shows the evolution of inflation swaps in the years around the PSPP implementation. PSPP consists in purchases of government bonds which could include nominal and inflation-indexed assets, with a monthly pace of purchases of €60 billion up to September 2016. A key dimension of this asset purchase policy relates to the cross-country allocation: purchases are realized according to the ECB capital key, so in proportion to the respective size of Eurosystem countries. The monthly target for the purchase flows has been adjusted on several occasions thereafter, upward or downward, and the program end has been postponed regularly. Since September 2019, there is no announced deadline for these purchases which are now conducted "as long as necessary". In December 2021, the ECB decided to increase the monthly flow of net purchases from €20 to €40 billion, and then reduce this pace back to €20 billion from October 2022.

The PEPP was announced on 18 March 2020 to counter sovereign and fragmentation risks raised by the asymmetric nature of the Covid-19 shock as the Eurozone was facing a sharp increase in financial stress on sovereign debt markets. Figure 1 shows the evolution of sovereign spreads around the PEPP enactment. The list of eligible assets is similar to the APP.¹¹ Initially, purchases were expected to be conducted until the end of 2020 with a first envelope of €750 billion. The PEPP has then been expanded (until 2022 for a total amount of €1850 billion). Finally, PEPP purchases may be implemented in "a flexible manner" in terms of both their monthly pace and their geographical breakdown share. This meant that purchases could deviate from the capital key across time. The ECB also announced at the same time that PEPP purchases have to comply with the ECB capital key eventually. In December 2021, the ECB announced that net purchases under the PEPP will stop in March 2022 while repayments will be reinvested until the end of 2024.

¹⁰ The PSPP is part of a broader Asset Purchase Programme (APP) that includes the CBPP3 (Covered-Bond Purchase Programme), ABSPP (Asset-Backed Securities Purchase Programme) and CSPP (Corporate Securities Purchase Programme). PSPP purchases represent more than 80% of all APP purchases. CBPP3 and ABSPP purchases started in October and November 2014 respectively. The CSPP was launched later, and purchases started in June 2016.

¹¹ The bulk of PEPP purchases involves public securities. One key difference with the PSPP is the eligibility waiver for Greek sovereign bonds.

2.1. The signaling effect of policy announcements

We investigate the effects of both asset purchase programs on market-based inflation expectations and sovereign spreads with an event-study. As these policy decisions have been communicated through press releases at specific dates, this approach is well suited to measure the reaction of asset prices on days of policy announcements. The event-study methodology consists in estimating the effect of policy decisions on changes in asset prices within a short window around the relevant event. Considering that no other event occurred in the same window, the high-frequency change in asset prices can be attributed to the policy announcement. The key assumption is that, since asset prices adjust in real-time, the latest price before the start of the window reflects all information and expectations before the event, so movements during the window only reflect the effect of the policy announcement and are not driven by potential confounding factors (see Lucca and Moench, 2015, de Jong and Naumovska, 2016, and Cieslak et al., 2019). This is crucial for identification since it strips out the endogenous variation in asset prices associated with other shocks.¹²

The effects of PSPP and PEPP announcements are assessed using the following two equations:

$$\Delta\pi_t^e = \alpha + \beta_{pspp}I_t^{PSPP} + \beta_{pepp}I_t^{PEPP} + \phi X_t + \mu_t \quad (1)$$

$$\Delta spread_t = \alpha' + \gamma_{pspp}I_t^{PSPP} + \gamma_{pepp}I_t^{PEPP} + \phi' X_t + \mu_t' \quad (2)$$

where $\Delta\pi_t^e$ is the daily change in market-based inflation expectations and $\Delta spread_t$ is an indicator of the daily change in sovereign spreads. The dummy variables I_t^{PSPP} and I_t^{PEPP} capture the PSPP and PEPP announcements. X_t is a vector of control variables that capture other ECB announcements and their direct and indirect – via financial stress – effects on the dependent variables. Equations (1) and (2) are estimated with OLS using Huber-White heteroskedasticity-robust standard errors, from 1 January 2009 until 16 December 2021 and for announcement days only. We thus assess whether PSPP and PEPP announcements provide relevant information to investors above and beyond the other information conveyed by the ECB throughout these 129 meetings. Our sample starts in 2009 to control for all other asset purchase programs announcements (that started with the CBPP1 on 7 May 2009). Table A in the Appendix describes the variables and their sources.

We consider all dates at which the flow of purchases has been modified. The dummy variables take the value 1 (resp. -1) when the size of the program increases (resp. decreases). All announcements, but the launch of PEPP on 18 March 2020, happened on Governing Council meeting days. PSPP purchases began in March 2015, but the announcement was made on 22 January 2015, so our dummy takes the value one on this date. The PEPP launch was announced through a press release at 23.53 CET time in the evening of 18 March 2020, so the effects on European financial markets can only be observed on 19 March 2020. Hence, the dummy variable I_t^{PEPP} takes the value 1 on this date. Figure 2 reports all dates for PSPP and PEPP announcements.

Inflation expectations are measured by 5-year in 5-year-forward inflation swaps, which are the most commonly used indicator of market-based long-term expectations.¹³ We also assess

¹² Cook and Hahn (1989), Kuttner (2001) and Cochrane and Piazzesi (2002) have initiated this approach.

¹³ See for instance Gürkaynak et al. (2010) and Wright (2012). Inflation swaps are a measure of compensation for expected inflation and risk premia. We do not aim to disentangle both as one of the transmission mechanisms of asset purchases is arguably to affect risk premia. In any case, including a proxy for volatility risk premia, the VSTOXX, in our regression analysis controls for these dynamics such that the estimated effects of both asset purchase programs on inflation swaps are not driven by a risk premia factor.

whether the result holds with 10-year forward inflation swaps. We compute $\Delta spread_t$ as the change in first principal component of 10 sovereign spreads across 10 euro area countries.¹⁴ Sovereign spreads are computed as the difference between each country's 10-year sovereign yield and the one of Germany.¹⁵ The main advantage of a principal component analysis – which is essentially a weighted average – is to lower the weight for outlier series and therefore maximize the common variance of the 10 series explained by one single metric. The highest correlation between this first principal component and individual country spreads is for French spreads (0.90) and then Italian spreads (0.88). We also assess the robustness of our results with the mean of these 10 sovereign spreads. Dependent variables have been normalized to a unit standard deviation, so the announcement effects are comparable.

The vector of control variables X_t aims to capture the effects of other ECB announcements that could themselves influence inflation swaps and sovereign spreads. It includes dummies for announcements of other asset purchases and long-term refinancing operations. It also includes intraday monetary policy surprises as measured by the change in 2-year OIS rates by Altavilla et al. (2019).¹⁶ For 19 March 2020 and the PEPP launch outside a scheduled Governing Council meeting, we consider the daily change in 2-year OIS rates on that day. These monetary surprises aim to control for all policy announcements or signals disclosed in the press release or during the press conference that could affect our dependent variables. We also include the daily change in the implied stock market volatility (VSTOXX) that captures uncertainty, financial stress and liquidity. Because PSPP and PEPP announcements have been made in response to exceptional developments, this variable aims to control for how ECB policy announcements affect financial stress which daily changes could in turn affect inflation swaps and sovereign spreads (see Blot et al., 2020). Table B in the Appendix shows descriptive statistics for all variables.

Table 1 shows the estimates for both inflation swaps and sovereign spreads. We find that PSPP announcements have a strong positive effect on inflation swaps (column 1) while they only have a slight negative effect on euro area sovereign spreads (column 2). At the opposite, PEPP announcements have no impact on inflation swaps (column 1), but a strong negative effect on sovereign spreads (column 2). Although both PSPP and PEPP announcements have a negative impact on sovereign spreads, the point estimate for the PEPP is more than twice larger than for the PSPP.

These findings document that investors, when pricing inflation swaps and sovereign spreads, have responded differently to the two asset purchase program announcements. Interestingly, the event-study approach, by focusing on financial market participants' reactions, also tells how both policy announcements have been perceived. It provides an indication of the relevance of each dependent variable for each program from the investors' perspective.

In the complementary specifications (columns 3 to 5), the dependent variables are expressed in basis points (bps). These estimates enable us to apprehend the magnitude of the PSPP and

¹⁴ Italy, Spain, Portugal, Greece, Ireland, France, Netherlands, Belgium, Austria and Finland. Table C in the Appendix shows the eigenvalues of the principal component analysis of the 10 daily series. The first principal component explains 72% of the variance of all 10 series.

¹⁵ The reaction of sovereign yields to asset purchases can be decomposed according to their effect on expectations of the policy rate future path, the term premia and the sovereign risk premia. Considering 10-year sovereign rates, we capture the impact of policy announcements on the sovereign risk as the future path of the policy rate and the term premia are common to all euro area countries. Krishnamurthy et al. (2018) decompose the sovereign risk between a default risk, a redenomination risk and a market segmentation effect.

¹⁶ We consider the full monetary event window that goes from the press release to the end of the press conference.

PEPP effects. PSPP announcements increase inflation swaps by almost 2.6 bps, while PEPP ones have no effect. To document the magnitude of the effects on sovereign spreads (and because the unit of principal components is not directly interpretable in economic terms), we use changes in French and Italian spreads that are the best proxies for changes in the first principal component that captures the overall information for the euro area. PSPP announcements have no significant effect on French and Italian spreads but PEPP ones decrease them by 3 and 12 bps respectively.¹⁷

Both PSPP and PEPP announcements should imply an improvement of the euro area economic outlook, so an increase in inflation swaps. In addition, although sovereign risks have not been an explicit objective of the PSPP, there is empirical evidence that PSPP announcements have dragged down sovereign yields (see e.g. Altavilla et al., 2021) and one would expect that PEPP announcements work the same way. Since both programs consist in purchases of the same identical assets, the differentiated effects in Table 1 are puzzling.

2.2. Complementary analysis

We run some complementary tests to ensure the robustness of this pattern. We start by estimating Equation (1) on all days, not policy announcement days only, so we compare the effects of PSPP and PEPP announcements to all other potential events. Column 1 of Table 2 shows the baseline estimates for comparison purposes. Column 2 of Table 2 shows the effects estimated on all days. Point estimates are close to those in Column 1.¹⁸ PSPP announcements have a positive effect on inflation swaps, but no significant effect on sovereign spreads, whereas PEPP announcements have no effect on inflation swaps, but a negative effect on sovereign spreads.

We then limit the sample period that starts in 2015 or in 2019. In the first case, the objective is to focus on the period during which asset purchases were in force while in the second case, the objective is to restrict to a similar period when both programs were reenacted (PSPP net purchases stopped in December 2018 and relaunched in September 2019) or enacted (in March 2020 for the PEPP). The pattern characterized by the differentiated effects of PSPP and PEPP remains the same for both subsamples (see Columns 3 and 4). Over the sample starting in 2019, the point estimates are in line with the previous results – and confirm the differentiated effects –, but because the number of observations is quite limited (25), the standard errors are much larger, so estimates are not statistically significant. This does not invalidate our results as the point estimates are very much similar to the previous estimates over a larger sample.

In addition, we assess the impact of PSPP and PEPP announcements on 10-year inflation swaps and the mean of euro area sovereign spreads. We also include, as an additional control, ECB announcements about the horizons of PSPP purchases. Columns 5 and 6 confirm the differentiated effects. Finally, we estimate the effect of PSPP and PEPP announcements on German and Italian inflation swaps – to check that the evidence provided for euro area inflation swaps holds at the national level – and on German and Italian nominal yields – to ensure that the evidence provided for sovereign spreads is consistent with both terms of the difference. We find that PSPP announcements have a positive effect on inflation swaps in both Germany and Italy (see Columns 7 and 8). In addition, we find no significant effect of these PSPP announcements on German and Italian 10-year nominal yields. We also find that PEPP

¹⁷ We have also estimated Equation (2) for each of the 10 individual spreads. See Figure A in the Appendix for the estimates of PSPP and PEPP effects across individual countries.

¹⁸ The main difference is related to the R^2 that is lower when the specification includes all days.

announcements have no effect on German or Italian inflation swaps, as well as no effect on German nominal yields, but a negative effect on Italian nominal yields. The negative effect on the spread is therefore driven by the decline of Italian yields.

In addition, we explore whether the results only capture short-term announcement effect or persist beyond the announcement day. To that end, we assess the effect of *actual* asset purchases on inflation swaps and sovereign spreads.¹⁹ To do so, we use information released by the ECB on the weekly outstanding amounts of public securities held within the PSPP and PEPP.²⁰ Because purchases are likely to be endogenous to the dynamics of inflation swaps and sovereign stress, we use a two-step identification approach to overcome endogeneity issues and circumvent at best this reverse causality bias. We start by isolating the exogenous component of asset purchases in a given week not explained by the dynamics of inflation swaps and sovereign spreads of the preceding weeks. We then use these residuals as instruments to estimate the causal effect of asset purchases on contemporaneous and future inflation swaps and sovereign spreads.²¹ We find evidence that the differentiated effects persist across the following two weeks (see Table D in the Appendix). PSPP purchases have a positive effect on inflation swaps that increases over time, whereas they have no significant effect on sovereign spreads. At the opposite, we find that PEPP purchases do not affect inflation swaps but have a negative and significant effect on sovereign spreads. These results suggest that these differentiated effects are not only driven by announcement effects and persist beyond the day of the policy meeting. In the next section, we investigate the potential sources of this pattern.

3. Exploring the sources of differentiated PSPP and PEPP effects

In the rest of the paper, we investigate the potential reasons for this puzzling result. To that end, we first set out hypotheses about potential differences in the underlying nature of the two asset purchase programs and in the environment when both programs were implemented that could explain these differentiated effects. We organize these hypotheses around 7 items:

1. Factors related to program announcements
 - Operational characteristics (size, pace, length)
 - Clarity of both announcements: a focused (PSPP) vs. a general statement (PEPP)
 - Anticipation of program implementation (PSPP was more expected than PEPP)
2. Controlling for recent dependent variable dynamics
 - Intermediate objective variables under stress requiring intervention
3. Different financial and economic contexts
4. The role of capital key deviations
5. Different (credible) rationales

In the rest of the paper, we provide insights and complementary analyses in order to shed light on these various hypotheses. Some of the approaches are narrative while some others are assessed empirically.

¹⁹ One criticism against event-studies is that they capture the immediate impact that could be reversed in the following days. However, such a criticism does not account for the fact that other news on these following days might explain the later asset price dynamics.

²⁰ Figure 2 shows PSPP and PEPP net purchase flows.

²¹ See Section C in the Appendix for details. As ECB purchases in a given week could still relate to contemporaneous dynamics in inflation swaps and sovereign spreads, so we use end-of-week values (in contrast to week-average values) to measure asset prices. By doing so, we minimize the possibility that weekly asset purchases respond to contemporaneous inflation swaps and sovereign spreads. This timing feature is similar in spirit to timing restrictions that govern the VAR Cholesky-decomposition.

3.1. Factors related to program announcements

Both programs entail the purchase of identical assets, and the operational characteristics are also very close. First, as often claimed by central banks about their unconventional tools, asset purchases were expected to be temporary and used under exceptional circumstances only, so they should not be seen as a permanent tool of monetary policy. Both PSPP and PEPP were first announced with a finite horizon, i.e. for some months. The PSPP has then been extended multiple times and is still ongoing after 6 years and the PEPP termination date has been postponed twice before being stopped. Second, the size of the two programs can be perceived as different: the ECB announced a monthly pace (€60 billion) of purchases for the PSPP, but a total envelope (€750 billion) for the PEPP. Eventually, there is a strong equivalence between committing to purchase flows over a given period (€60 billion per month over 18 months for the PSPP, so €1080 billion) and a total envelope until a given date (€750 billion initially for the PEPP). In addition, considering that the size of the PSPP was larger than the PEPP, estimates from Table 1 suggest that the effect on sovereign spreads of the PEPP relative to the PSPP was even more powerful. Third and related to the previous point, the ECB communicated on a monthly pace of purchases for the PSPP that appeared strictly pre-determined, but on a total envelope coupled with a “flexible” pace for the PEPP leaving room for maneuver to adjust purchases. This feature introduces a difference in how PSPP and PEPP purchase flows could affect asset prices. However, the actual variability of PSPP and PEPP purchase flows is extremely close. The standard deviation of weekly PSPP and PEPP net flows is €6.41 billion and €6.62 billion, respectively. Overall, it seems that the differences in the operational characteristics of the two programs are negligible in practice.

Another difference could be that the PSPP announcement was much more precise than the PEPP announcement. It explicitly stated that purchases would continue until there is “a sustained adjustment in the path of inflation”. In contrast, implemented during the financial and economic crisis caused by the pandemic, PEPP objectives do not seem as clear. The PEPP statement is general and states that purchases would continue until the “Covid-19 crisis phase is over”. In practice, however, press articles from the Financial Times, Wall Street Journal or Reuters, on 19 March 2020, show that the PEPP was clearly interpreted by ECB watchers as being about sovereign risks (see Section A of the Appendix). Christine Lagarde’s column in the Financial Times on 19 March 2020 confirmed that the PEPP was linked to sovereign risks (see also Section A of the Appendix).

The third potential source of differences relates to the fact that the PSPP announcement was discussed by many ECB watchers in 2013 and 2014 and anticipated by financial markets since the launch of the CBPP3 on 20 October 2014 and the ABSPP on 21 November 2014, whereas the PEPP announcement was not (or at least, less) anticipated (see De Santis, 2020). The event-study methodology is well-suited to tackle the potential issue that one of the two programs might have been more anticipated than the other. With this methodology, the identification of the causal effect of asset purchases relies on a small-enough window to mitigate potential confounding factor bias and on the fact that asset prices at the start of the window should incorporate these anticipation effects. Thus, the change in asset prices on the announcement day would only capture the revision of private agents’ information set after the ECB disclosed the program details. Even with some information frictions among financial market participants, it seems reasonable to assume that anticipation effects were already priced in inflation swaps and sovereign spreads, so our estimates do not reflect that difference.

3.2. Controlling for recent dependent variable dynamics

We now investigate the role of the recent dynamics of the dependent variables when both programs were implemented. The decision to launch the PSPP was taken in reaction to a sustained decrease in inflation swaps and the inflation rate. Likewise, sovereign spreads were much higher during the Covid-19 crisis while they were falling in early 2015. An explanation for the differentiated effects could be that one variable, but not the other, was under stress and required intervention when each program was implemented.²² Thus, our baseline result might be driven by the fact that the volatility of our two dependent variables varied over time. To explore this issue, we normalize the daily change in the dependent variables by their recent volatility (their standard deviation over the preceding 40 business days) such that the PSPP and PEPP estimated effects are conditional on whether these asset prices were under stress and required intervention. We estimate Equations (1) and (2) with these alternative dependent variables. Column (1) of Table 3 shows that our main result is robust to this new specification.

Another way to explore this issue is to control for the level and recent dynamics of the dependent variables at the time of the program implementation. According to this view, PSPP may have affected inflation swaps because they were at low levels in 2015. In addition, PEPP would have had no effect on them if investors had considered that the treatment for inflation swaps was already embedded in the PSPP. The fact that inflation swaps were at a lower level in 2020 than in 2015 downplays these explanations (see Figure 1). We test more formally this hypothesis by augmenting Equations (1) and (2) with a second vector of controls. The effects of PSPP and PEPP announcements are assessed using the following two equations:

$$\Delta\pi_t^e = \alpha + \beta_{pspp} I_t^{PSPP} + \beta_{pepp} I_t^{PEPP} + \phi X_t + \theta Z_t + \mu_t \quad (3)$$

$$\Delta spread_t = \alpha' + \gamma_{pspp} I_t^{PSPP} + \gamma_{pepp} I_t^{PEPP} + \phi' X_t + \theta' Z_t + \mu_t' \quad (4)$$

Equations (3) and (4) are estimated with OLS using Huber-White heteroskedasticity-robust standard errors, from 1 January 2009 until 16 December 2021 and for announcement days only. In this specification, the vector of control variables Z_t includes the level and the change over 40 business days in the dependent variable. Column (2) of Table 3 shows the estimates of these specifications of Equations (3) and (4). PSPP announcements have a positive effect on inflation swaps, but PEPP ones have no significant effect. Conversely, the negative effect of PEPP on sovereign spreads is more than two-times larger than the PSPP effect. The differentiated effect does not appear to be driven by the recent dynamics of the two intermediate objectives.²³

3.3. Controlling for the financial and economic context

Our baseline result might also be driven by the fact that financial and economic conditions were different when both programs were implemented. We therefore include as controls the level of and 50-day change in the VSTOXX (Column 3 of Table 3) to check for potentially different market conditions across time – in terms of financial stress and liquidity (see Bernardini and De Nicola, 2020). While X_t controls for changes that happen on the

²² It can be argued that the effect of PSPP on spreads was “muted” in 2015 because they were on a downward trend since 2012 and could not fall further. At the time of the PEPP implementation, sovereign stress was increasing rapidly but inflation swaps were also decreasing, and at a lower level than in 2015. According to this reasoning, PEPP should have a positive effect on inflation swaps. However, our estimates show that this is not the case and suggest that the differentiated effects does not stem from the different dynamics of the variables.

²³ The fact that PSPP and PEPP effects on sovereign spreads are relatively homogeneous across individual countries (see Figure A in the Appendix) although individual spreads exhibit large cross-sectional dispersion in their levels suggests that the effect of both programs is not driven by the pre-existing conditions on these variables.

announcement days, Z_t aims to capture the overall environment in Equations (3) and (4). As a complementary analysis, we test another specification with the level of and 50-day change in the VIX (Column 4 of Table 3) to control for the global financial environment. We then include the level of and 50-day change in Eurostoxx50 stock prices (Column 5) to capture a potential central bank put – the response of central banks to stock market dynamics (see Cieslak and Vissing-Jorgensen, 2021). We also control for Scotti (2016)’s macroeconomic news surprises (column 6). All these tests confirm the differentiated effects of the two programs.

Another potential issue relates to the fact that the analysis abstracts from fiscal policy and from the fiscal context in which both programs were designed. The fiscal policy stance was much more expansionary in 2020 than in 2015. We may expect that the 2020 massive fiscal stimulus has had a positive effect on inflation and inflation expectations (demand effect) and on sovereign spreads (related to differentiated country debt sustainability issues). Fiscal policy might therefore be a confounding factor driving our results. In the event-study, we check that no fiscal policy announcements happened on days of PSPP or PEPP announcements. More conceptually, considering the estimated effects of PEPP on inflation swaps and on sovereign spreads, the role of fiscal policy effects – if fiscal policy is a confounding factor – would lead to an under-estimation of the “true” impact of PEPP on inflation swaps and sovereign spreads. It suggests that this potential confounding factor does not drive our differentiated results.

3.4. Capital key deviations

One fundamental difference that held attention is the flexibility of the allocation by country of PEPP asset purchases whereas the PSPP purchase shares comply with the ECB capital key. The fact that the capital key constraint is different for both programs could explain their differentiated effects: purchases of given countries’ sovereign bonds at the expense of other countries could thus mechanically affect sovereign spreads.²⁴

In practice, the capital key constraint difference between PSPP and PEPP programs is very limited. Deviations were already a concern with the PSPP, despite the apparent constraint embedded in its operational design. For instance, in September 2017, the issue of capital key deviations was raised for the PSPP, as the ECB had purchased a higher share of Italian and French bonds. Mario Draghi recognized that “there have always been temporary deviations from the capital key” (Press conference, 07/09/2017) because of market liquidity conditions. At the opposite, despite the flexibility announcement, PEPP purchases have been well aligned with the capital key for most countries, except for French and Italian bonds during the first months of the program. Figure 3 shows deviations from the capital key for both programs.²⁵ PSPP deviations are small but not negligible while PEPP deviations only apply to French and Italian bonds. Overall, the difference in capital key deviations appears relatively weak. Another common feature of both programs is that the capital key has to be respected at the end date of each program. Consequently, even in the event of actual capital key deviations, market participants might anticipate subsequent opposite flows to offset initial deviations.

Yet, we explore whether our differentiated results would be – at least partly – driven by this fundamental difference between programs. To that end, we make use of the fact that PEPP asset purchases did not deviate from the capital key for most countries but did so for purchases

²⁴ Conceptually, the case for why PEPP flexibility would affect inflation swaps differently than the PSPP is unclear.

²⁵ Country breakdowns of bonds’ holdings for PSPP and PEPP are available on the ECB website, but not at the weekly frequency. PEPP purchase breakdown is only available for irregular spans of 2 or 3 months, while PSPP purchase breakdown is available at the monthly frequency.

of French and Italian sovereign bonds in the first months and in opposite directions. More specifically, we estimate, based on Equation (2), the PSPP and PEPP announcement effects on a measure of the first principal component of sovereign spreads that exclude these two countries. We also estimate the PSPP and PEPP effects on the spread, relative to German bonds, of Italian bonds (that are over-purchased) and French bonds (that are under-purchased). If the difference between PSPP and PEPP effects is driven by the “mechanical” effect of PEPP capital key deviations, spreads of countries in line with the capital key should not react to the PEPP while French (resp. Italian) spreads should increase (resp. decrease). Table 4 shows estimates of these tests. We find that the differentiated effects of PSPP and PEPP on spreads is at work even after excluding French and Italian bonds (so when the capital key is enforced). In addition, the differentiated effects of PSPP and PEPP also hold for the two individual countries, so they are not a mechanical consequence of buying relatively more Italian bonds or less French bonds. These estimates suggest that the main result is not driven by capital key deviations.

It may be argued that the Securities Market Programme (SMP), launched in May 2010, is close to the PEPP since it consists in purchases of the same assets (i.e. sovereign bonds) and its objective was explicitly to deal with fragmentation risks in euro area sovereign debt markets. However, it would not be relevant to consider this program in our empirical exercise. A key operational feature of the SMP is to purchase sovereign bonds only from countries under stress.²⁶ In that case, the effect on sovereign yields and therefore on spreads is – at least partly – mechanical. In the case of the comparison between the PSPP and PEPP, when the Eurosystem purchases sovereign bonds from countries under stress, it also purchases German bonds – and even more than from countries under stress through the capital key constraint. So the effect on spreads does not boil down to a standard market effect of ECB excess demand for sovereign bonds from one specific country.

3.5. Different (credible) rationales

Another difference between PSPP and PEPP relies on their communicated rationales. As stated in the Introductory Statement released on 22 January 2015, the PSPP was initiated to counter deflationary pressures (“inflation dynamics have continued to be weaker than expected”, “further fall in market-based measures of inflation expectations”, “most indicators of actual or expected inflation stand at, or close to, their historical lows”). Figure 1 shows the evolution of inflation swaps in the years around the PSPP implementation. The ECB explicitly stated that purchases were conditional to “a sustained adjustment in the path of inflation”. The later changes in the pace of purchases also relates to deflation risks. For instance, on 10 March 2016, Mario Draghi motivated the expansion of monthly purchases to €80 billion by “heightened risks to the ECB’s price stability objective” and the 12 September 2019 decision to restart purchases was “taken in response to the continued shortfall of inflation”. Conversely, all decreases in the pace of purchases intervened when the inflation outlook improved.²⁷ Most PSPP statements refer to inflation and inflation expectations at their lowest levels.

The PEPP announcement occurred in the context of the financial and economic crisis caused by the pandemic. The PEPP statement was more general than the PSPP one and stated that purchases would continue until the “Covid-19 crisis phase is over”, so PEPP objectives might

²⁶ Szczerbowicz (2015) finds significant effects of SMP announcements on Greek, Italian, Spanish, Portuguese and Irish sovereign yields but not on the French sovereign yield. De Pooter et al. (2018) find significant and long-lasting effects of SMP purchases on sovereign bond liquidity premia of Ireland, Italy, Portugal and Spain.

²⁷ The reduction of the monthly pace of purchases announced on 26 October 2017 reflected “growing confidence in the gradual convergence of inflation towards our inflation aim”.

not seem as clear as PSPP ones. However, the PEPP was clearly interpreted as a response to the financial effects of the Covid-19 crisis, which triggered an asymmetric increase in sovereign stress, directly related to the spread of the virus in euro area countries. Financial markets feared that fiscal responses would undermine public debt sustainability, especially for a couple of fragile countries. The PEPP announcement followed Christine Lagarde's comment that the ECB was "not here to close spreads" on 12 March 2020 - that amplified sovereign stress - and made clear that the PEPP aimed to respond to sovereign risks ("fully committed to avoid any fragmentation", "high spreads impair the transmission of monetary policy", "the ECB will not tolerate any risks (...) in all jurisdictions of the euro area"). Figure 1 plots the evolution of sovereign spreads around the PEPP enactment. While justifying the PEPP on 4 June 2020, Christine Lagarde reiterated that the PEPP is expected "to address the risk of market segmentation" in the euro area.²⁸ As an anecdotal evidence, ECB watchers seem to confirm this interpretation (see for instance the tweet from Frederik Ducrozet at Pictet Wealth Management on 17 May 2021 : "Like it or not, markets will continue to focus on weekly PEPP purchases as peripheral bond yields move higher").

While the PSPP rationale appeared credible because directly in line with the ECB mandate, the PEPP *flexibility option* is a crucial element of the PEPP different rationale - although the actual capital key deviations were limited. First, the possibility for capital key deviations reinforced that the rationale of the PEPP was about sovereign risks, and second, it signaled that the ECB will be technically able to reduce sovereign spreads. The possibility for capital key deviations therefore makes the overall policy announcement credible. This feature is important since, contrary to the PSPP for which there is no need to convince financial markets that this program is fully consistent with the ECB mandate of maintaining price stability, the intermediate objective of the PEPP is related to the ECB mandate only through the argument of the smooth transmission of monetary policy in all jurisdictions of the euro area. In order to affirm this novelty, the ECB needed a distinct program with a flexibility option regarding the country breakdown of purchases to make this new rationale credible. The flexibility option embedded in the policy design aims to convince financial market participants that the PEPP can achieve its purpose. From an anecdotal perspective, in response to the case with the German constitutional court, the ECB highlighted that the PSPP was consistent with the ECB mandate and that capital key shares were respected. For the PEPP to be credible, the ECB had to alter beliefs on that latter issue.

On this matter, one can draw a parallel with the sequence combining the "Whatever it takes" and OMT (Outright Monetary Transaction) program announcements in July and September 2012. The ex-ante perspective of announcing a program that could deviate from the established principles of market neutrality and capital key allocation can exert an impact even if ex-post the program does not make use of the "built-in flexibility". The credibility of the announcement could in fact be enough to affect market participants' beliefs. A prominent example of this sort of credibility is the July 2012 "Whatever it takes" speech. The announcement was credible enough to influence financial markets even though the ECB never conducted any asset purchase under the OMT program. The differentiated design and the different rationales between PSPP and PEPP could then affect market participants' beliefs differently and generate these different impacts on asset prices.

²⁸ On 10 December 2020, the ECB updated its language towards a more general phrasing and the idea of preserving favorable "financing conditions". This change aimed to refer to household and corporate interest rates in jurisdictions where they may be tightening and not focus exclusively on the divergence in sovereign interest rates.

Besides, the dichotomy between inflation swaps and sovereign spreads can be interpreted in a different but closely related fashion. The PSPP set-up can be linked to the reassertion of the ECB mandate and its inflation target. This policy was introduced when inflation swaps were at historical lows and the ECB needed to reaffirm its capacity to reach its inflation target. At the opposite, the PEPP set-up can be linked to a cyclical shock (in contrast to a low-frequency shock to investors' beliefs about the inflation target) hitting the euro area asymmetrically and generating sovereign and fragmentation risks. These alternative rationales also provide information related to the ECB asset purchase reaction functions and how policymakers react to deviations from the inflation target and to an asymmetric shock.

4. Discussion and Conclusion

This paper documents an original pattern in the transmission of ECB asset purchases. We investigate whether asset purchases from two different programs produce different financial market effects. To answer this question, we exploit the unique setting of ECB asset purchases: the PSPP was introduced in 2015 to counter deflationary risks, while the PEPP was introduced in 2020 to counter sovereign risks. The main result of this paper is that the PSPP and PEPP are not substitutes. We find that the PSPP positively affects inflation swaps but has only a slight negative impact on sovereign spreads, whereas the PEPP has a strong negative effects on sovereign spreads but no effect on inflation swaps.

Our analysis suggests that the key difference between the two ECB programs relies on their rationale and the operational design that makes these announcements credible. Our favored explanation of the mechanism at work is the following. The different rationales create different reaction functions. The information conveyed by the announcement – communicating the rationale for a policy and the operational features that make it credible – signals to investors which variable enters policymakers' asset purchase reaction function. The two programs, by shaping investors' beliefs about policymakers' preferences, affect their own intermediate objective: inflation swaps or sovereign spreads. As a consequence, the effects of the initial announcements – when the first signals about which variables enter the asset purchase reaction function are disclosed – should be larger since investors update their beliefs about the reaction function. This is consistent with our finding that the first announcement for each program (22 January 2015 for the PSPP and 18 March 2020 for the PEPP) has larger impact than later ones. The main policy implication of this paper is that communicating explicitly a credible rationale for a given policy is crucial in determining the effects of that policy on its intermediate objectives.

This mechanism may be related to the frameworks of Eusepi and Preston (2010) and Davig and Foerster (2021). Both papers discuss the extent to which central bank communication may be central in driving private expectations. Eusepi and Preston (2010) show that communicating the precise details of the monetary strategy or the variables on which central bank decisions are conditioned help anchor private expectations. Davig and Foerster (2021) show that central banks that communicate a tolerance band around their inflation target and communicate their inflation forecasts provide the same information as a rule-based policy without having to express explicitly their policy rule. Those theoretical models show that agents extract information about policymakers' reaction function from central bank communication. In this paper, thanks to the unique setting of ECB asset purchases, we provide evidence that similar mechanisms can be empirically observed.

Another related implication refers to the benefit of using asset purchases as an instrument of monetary policy. Two different programs of asset purchases can be implemented in parallel with different objectives whereas this is not directly the case for the interest rate instrument. Policymakers could adjust the reaction function for the policy interest rate but could not have two different interest rates and reaction functions at the same time. Our results suggest that central banks could make use of this additional flexibility from asset purchases to achieve different objectives (say, for instance, increasing inflation swaps, reducing sovereign spreads, lowering term premia, or depreciating the exchange rate). More generally, what central banks choose to communicate (the stated purpose or structure of a given policy) can affect how financial market participants react.

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Table 1 - The effects of PSPP and PEPP announcements

	Normalised to 1 SD		In basis points		
	(1)	(2)	(3)	(4)	(5)
	Swap5y5y	PCA_spd	Swap5y5y	Spd_FR	Spd_IT
PSPP	1.227**	-0.550*	2.623**	-0.786	-3.839
	[2.04]	[-1.68]	[2.04]	[-0.67]	[-1.43]
PEPP	0.265	-1.418**	0.567	-3.009***	-12.239**
	[0.44]	[-2.46]	[0.44]	[-2.91]	[-2.21]
X_t	Yes	Yes	Yes	Yes	Yes
N	129	129	129	129	129
R2	0.14	0.39	0.14	0.33	0.51

Note: t-statistics in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Parameters are estimated from Equation (1) for inflation swaps and Equation (2) for sovereign spreads with OLS using Huber-White heteroskedasticity-robust standard errors. The dependent variable is the daily change in 5-year 5-year forward inflation swaps in columns (1) and (3), in the first principal component of 10-year sovereign spreads with Germany for 10 euro area countries (Italy, Spain, Portugal, Greece, Ireland, France, Netherlands, Belgium, Austria and Finland) in column (2) and in the French and Italian spread with Germany in columns (4) and (5). The constant being null has been removed from the table. The parameters for the control variables have also been removed for parsimony and are available from the authors upon request.

Table 2 - Exploring further the announcement effects

Inflation swaps								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline	All days	Post 2015	Post 2019	Swap10y	PSPP_Ext	DE	IT
	Swap5y5y	Swap5y5y	Swap5y5y	Swap5y5y	Swap10y	Swap5y5y	Swap10y	Swap10y
PSPP	1.227**	1.240**	1.279*	1.729	1.142*	1.617**	0.784*	0.910*
	[2.04]	[2.16]	[1.86]	[1.44]	[1.84]	[2.15]	[1.91]	[1.66]
PEPP	0.265	0.256	0.418	0.407	-0.028	0.364	-0.025	-0.001
	[0.44]	[0.41]	[0.66]	[0.41]	[-0.04]	[0.57]	[-0.05]	[-0.00]
X _t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	129	2713	57	25	129	129	123	129
R2	0.14	0.05	0.23	0.32	0.18	0.15	0.19	0.12
Sovereign spreads								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline	All days	Post 2015	Post 2019	Mean	PSPP_Ext	DE	IT
	PCA_spd	PCA_spd	PCA_spd	PCA_spd	Mean_spd	PCA_spd	Nom IR	Nom IR
PSPP	-0.550*	-0.277	-0.541	-0.194	-0.698***	-0.556	0.194	-0.438
	[-1.68]	[-0.77]	[-1.51]	[-0.29]	[-2.73]	[-1.37]	[0.47]	[-0.93]
PEPP	-1.418**	-1.785**	-1.459**	-1.306*	-1.261*	-1.419**	0.486	-1.468*
	[-2.46]	[-2.10]	[-2.41]	[-1.90]	[-1.81]	[-2.41]	[1.34]	[-1.80]
X _t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	129	2713	57	25	129	129	129	129
R2	0.39	0.09	0.69	0.82	0.34	0.39	0.35	0.47

Note: t-statistics in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Parameters are estimated from Equation (1) for inflation swaps and Equation (2) for sovereign spreads with OLS using Huber-White heteroskedasticity-robust standard errors. The dependent variable is the daily change in 5-year 5-year forward inflation swaps in the upper panel and the first principal component of 10-year sovereign spreads with Germany for 10 euro area countries (Italy, Spain, Portugal, Greece, Ireland, France, Netherlands, Belgium, Austria and Finland) in the bottom panel. The constant being null has been removed from the table. The parameters for the control variables have also been removed for parsimony and are available from the authors upon request. Column (1) shows the baseline estimates. In column (2), equations (1) and (2) are estimated on all days, not announcement days only. In columns (3) and (4), the sample period starts in January 2015 and 2019, respectively. In column (5), the dependent variable is replaced with 10-year inflation swaps (upper panel) and the mean of the 10 sovereign spreads (bottom panel). In column (6), we control for announcements of the extension of the period during which asset purchases will be conducted. In the upper panel, columns (7) and (8) show estimates for German and Italian 10-year inflation swaps, while in the bottom panel, columns (7) and (8) show estimates for the German and Italian 10-year nominal interest rates.

Table 3 – Announcement effects beyond the financial context

Inflation swaps						
	(1)	(2)	(3)	(4)	(5)	(6)
	Normaliz.	DepVarDyn	VstoxxDyn	VixDyn	StoxxDyn	MacroSurp.
	Swap5y5y _N	Swap5y5y	Swap5y5y	Swap5y5y	Swap5y5y	Swap5y5y
PSPP	1.035**	1.472**	1.407**	1.361**	1.467**	1.408**
	[2.11]	[2.42]	[2.05]	[2.02]	[2.30]	[2.13]
PEPP	0.354	0.423	0.282	0.218	0.26	-0.272
	[0.51]	[0.77]	[0.61]	[0.49]	[0.51]	[-0.38]
X _t	Yes	Yes	Yes	Yes	Yes	Yes
Z _t	No	Yes	Yes	Yes	Yes	Yes
N	129	127	127	127	127	124
R2	0.11	0.18	0.22	0.21	0.21	0.18
Sovereign spreads						
	(1)	(2)	(3)	(4)	(5)	(6)
	Normaliz.	DepVarDyn	VstoxxDyn	VixDyn	StoxxDyn	MacroSurp.
	PCA_spd _N	PCA_spd	PCA_spd	PCA_spd	PCA_spd	PCA_spd
PSPP	-0.553	-0.562	-0.379	-0.423	-0.433	-0.704**
	[-1.50]	[-1.65]	[-1.11]	[-1.28]	[-1.36]	[-2.09]
PEPP	-1.155***	-1.402**	-1.266***	-1.280***	-1.364***	-1.564*
	[-3.12]	[-2.26]	[-2.95]	[-2.85]	[-2.90]	[-1.92]
X _t	Yes	Yes	Yes	Yes	Yes	Yes
Z _t	No	Yes	Yes	Yes	Yes	Yes
N	129	127	127	127	127	124
R2	0.29	0.41	0.40	0.40	0.40	0.40

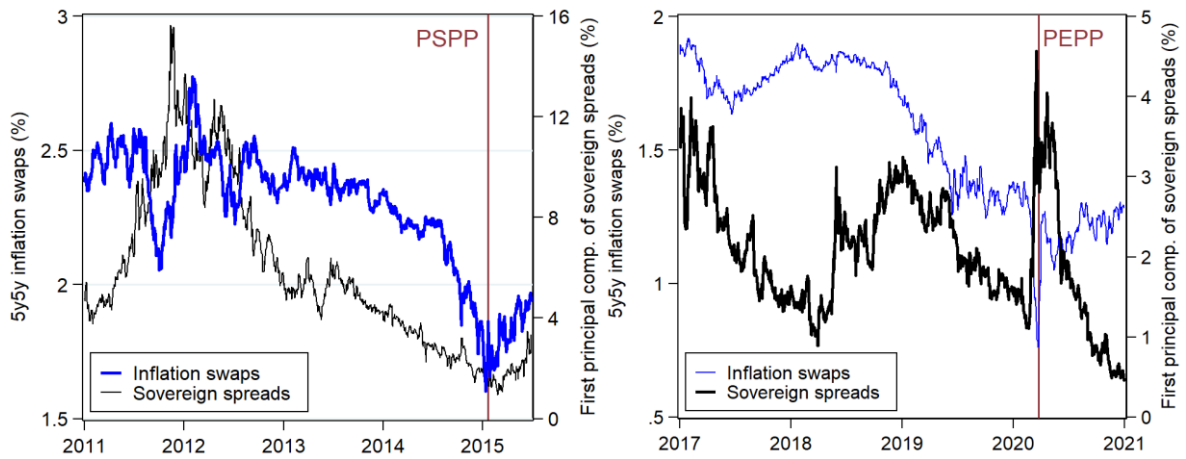
Note: t-statistics in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Parameters are estimated from Equation (1) for inflation swaps and Equation (2) for sovereign spreads with OLS using Huber-White heteroskedasticity-robust standard errors in columns (1), and from Equation (3) for inflation swaps and (4) for sovereign spreads for the remaining columns. The dependent variable is the daily change in 5-year 5-year forward inflation swaps in the upper panel and the first principal component of 10-year sovereign spreads with Germany for 10 euro area countries (Italy, Spain, Portugal, Greece, Ireland, France, Netherlands, Belgium, Austria and Finland) in the bottom panel. The constant being null has been removed from the table. The parameters for the control variables have also been removed for parsimony and are available from the authors upon request. In column (1), we normalize the daily change in inflation swaps and sovereign spreads by the standard deviation (SD) of its daily changes over a rolling-window of 40 business days. In columns (2) to (5), we control for the level and change over 40 business days in the dependent variable, VSTOXX, VIX and Eurostoxx50 respectively. In column (6), we include Scotti (2016)'s macroeconomic surprises as an additional control.

Table 4 – Exploring the role of capital key deviations

	(1)	(2)	(3)
	PCA ex. FR/IT	Spd_IT	Spd_FR
PSPP	-0.570* [-1.80]	-0.519 [-1.43]	-0.291 [-0.67]
PEPP	-1.308** [-2.37]	-1.655** [-2.21]	-1.115*** [-2.91]
X _t	Yes	Yes	Yes
N	129	129	129
R2	0.33	0.51	0.33

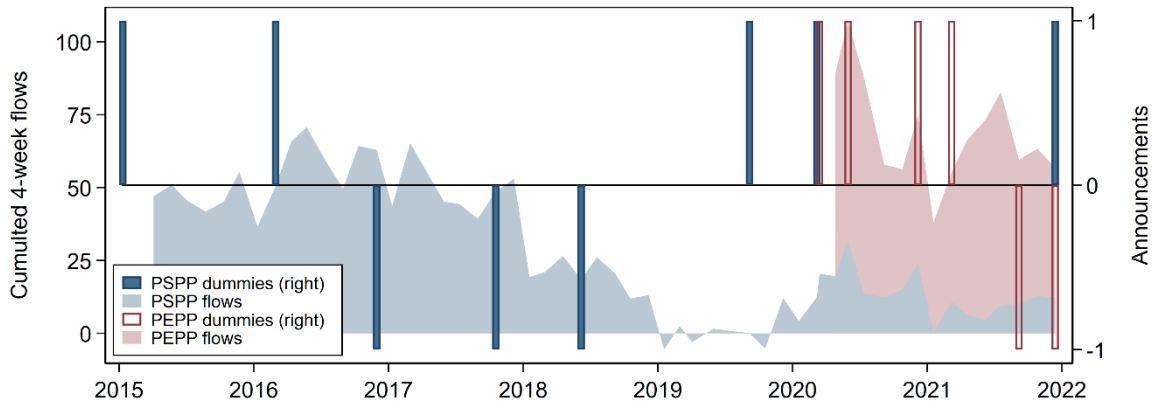
Note: t-statistics in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. Parameters are estimated from Equation (2). The dependent variable is the first principal component of 10-year sovereign spreads with Germany excluding France and Italy, so for 8 euro area countries (Spain, Portugal, Greece, Ireland, Netherlands, Belgium, Austria and Finland) in column (1), the Italian 10-year sovereign spread in column (2) and the French 10-year sovereign spread in column (3). The constant and parameters for the control variables have been removed for parsimony and are available from the authors upon request.

Figure 1 - Inflation swaps and sovereign spreads around policy implementations



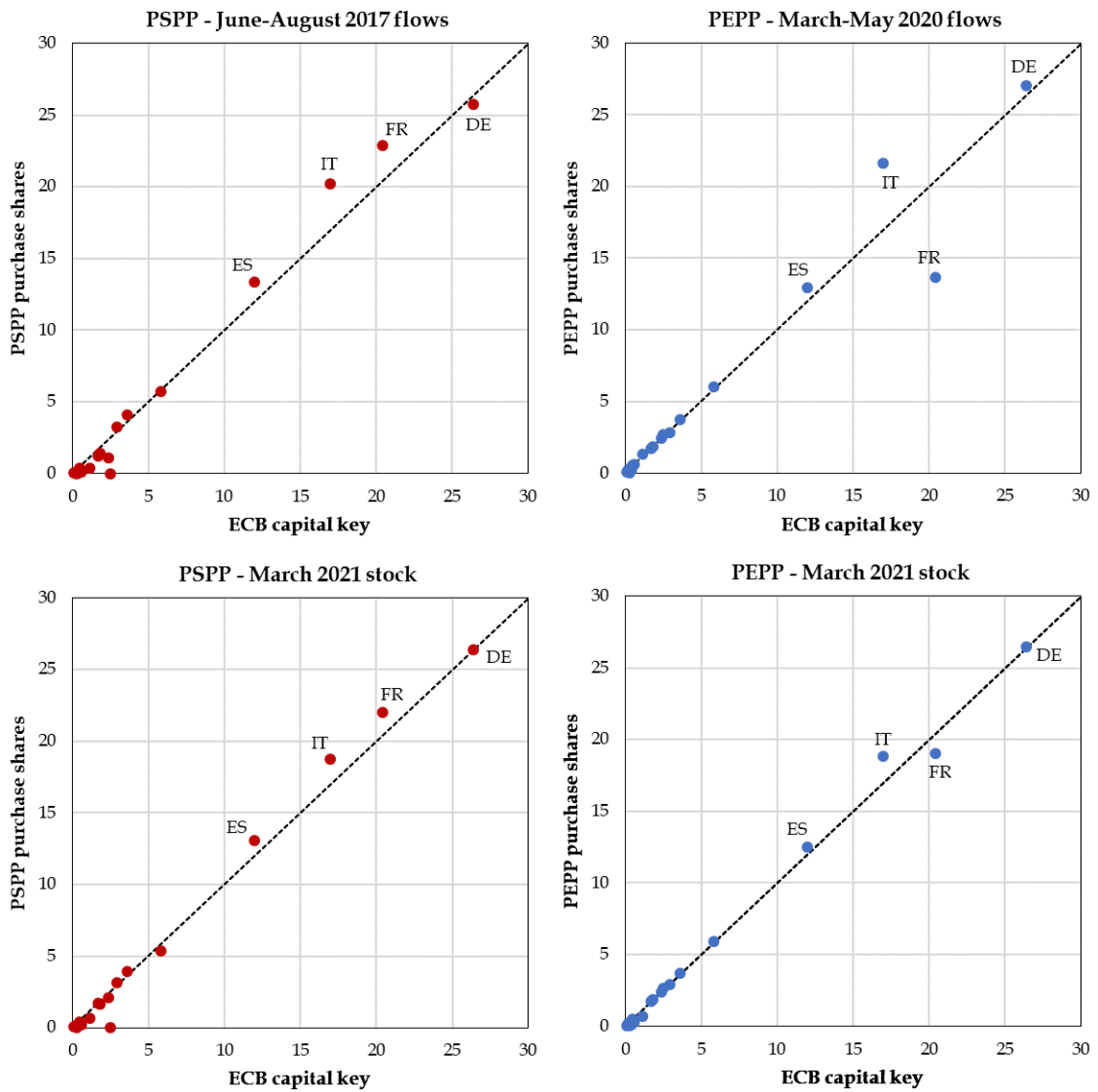
Note: Both panels show the evolution of 5-year 5-year-forward inflation swaps (blue line) and the first principal component of 10 euro area sovereign spreads relative to Germany (black line) in the years around the PSPP implementation (left panel) and around the PEPP implementation (right panel). The first principal component is rescaled to the interest rate space for sake of simplicity. Source: Datastream.

Figure 2 - PSPP and PEPP announcement dummies and purchase flows



Note: This graph shows the dummy variables for PSPP announcements (blue filled bars) and for PEPP announcements (red empty bars). The dummy variable takes the value 1 when the ECB announces an increase in net purchase flows and the value -1 for a decrease in net purchase flows (right scale). The graph also shows in the background the evolution of actual net purchase flows under the PSPP (blue area) and the PEPP (red area) (left scale in €bn). Source: Datastream and ECB's Weekly Financial Statements.

Figure 3 – PSPP and PEPP capital key deviations



Note: Left-hand side panels show how actual PSPP purchase shares compare to the ECB capital key, while right-hand side panels show how actual PEPP purchase shares compare to the ECB capital key. On the upper row, 3-month flows are considered while the bottom row plots purchase stocks as of March 2021. Source: <https://www.ecb.europa.eu/mopo/implement/pepp> for the history of 3-month PEPP purchase breakdowns and <https://www.ecb.europa.eu/mopo/implement/app> for the history of monthly PSPP purchase breakdowns.

APPENDIX

A. Press articles

The ECB will do everything necessary to counter the virus

Christine Lagarde, ECB President

Financial Times - 19 March 2020

<https://www.ft.com/content/281d600c-69f8-11ea-a6ac-9122541af204>

“Risk-free rates have moved up and government bond yields – benchmarks that are key to the pricing of all assets – have increased everywhere and become more dispersed. These developments impair the smooth transmission of our monetary policy across the euro area and put price stability at risk.”

“As a result, the European Central Bank’s governing council has created a new Pandemic Emergency Purchase Programme of up to €750bn until the end of the year on top of the €120b in extra purchases announced on March 12.”

ECB to launch €750bn bond-buying programme

Financial Times - 19 March 2020

<https://www.ft.com/content/711c5df2-695e-11ea-800d-da70cff6e4d3>

“The move brought an instant rebound in European debt markets, boosting the price of sovereign bonds from Italy to Germany, which had been under pressure from investors selling assets in response to fears about the pandemic.”

“The yield on Italian 10-year bonds dropped 106 basis points to 1.37 per cent – almost halving the Italian government’s financing costs, and soothing fears that investors could test the ECB’s ability to backstop the debts of peripheral nations.”

“Economists have been calling for the ECB to increase its bond-buying programme, which has already collected €2.6tn of assets, particularly since the borrowing costs of southern eurozone countries – including Italy and Greece – began rising sharply to levels not seen for more than a year.”

“Ms Lagarde was also forced to beat a hasty retreat and to issue an apology to the rest of the council last week after she said it was not the ECB’s role to “close the spread” in sovereign debt markets – referring to the gap between Italian and German bond yields that is a key risk indicator for Italy. That triggered a bond market sell-off, pushing up Italian government bond yields.”

ECB to Buy Bonds to Combat Economic Slowdown From Coronavirus

Wall Street Journal - 19 March 2020

<https://www.wsj.com/articles/ecb-seeks-to-mend-rifts-as-economic-clouds-gather-11584523534>

“The European Central Bank unveiled a new €750 billion (\$818.7 billion) bond-buying program aimed at shielding the eurozone economy from the spreading coronavirus, casting aside longstanding taboos to send a determined signal to investors that the bank will stand behind the region’s embattled governments.”

“The decision came during an unscheduled late-night conference call among top ECB officials, on a day when borrowing costs for governments like Italy and Spain jumped as the virus roiled and shuttered the region.”

“Last Thursday, ECB President Christine Lagarde stressed at a news conference that the bank was “not here to close spreads,” suggesting it wouldn’t intervene to narrow the difference in borrowing costs between Germany and Italy.”

ECB to print 1 trillion euro this year to stem coronavirus rout

Reuters - 19 March 2020

<https://www.reuters.com/article/us-health-coronavirus-ecb-idUSKBN21543D>

“The European Central Bank launched 750 billion euro emergency bond purchase scheme in a bid to stop a pandemic-induced financial rout from shredding the euro zone’s economy and raising fresh concerns about the currency bloc’s viability.”

“Although global stocks continued to fall after the ECB’s move, the euro held broadly steady and bond yields in the bloc’s periphery tumbled, with Italy leading the way with a 90 basis point drop on its 10-year benchmark.”

“Although it will still buy government bonds according to each country’s shareholding in the bank, the so-called capital key, the ECB said it would be flexible and may deviate from this rule.”

“This was seen as a clear indication that it will not tolerate the surge in yield spreads between euro zone members seen in Italy and Greece in recent days.”

B. Complementary information

Table A – Data description and sources

Event-study analysis		
PSPP	Dummy variable that equals +1 when the ECB announces an increase in PSPP purchase flows and -1 for a decrease in purchase flows, and 0 otherwise.	ECB
PEPP	Dummy variable that equals +1 when the ECB announces an increase in PEPP purchase flows and 0 otherwise.	ECB
LTRO	Dummy variable that equals 1 when LTRO or TLTRO programs or extensions are announced, and 0 otherwise.	ECB
PELTRO	Dummy variable that equals 1 when PELTRO programs or extensions are announced, and 0 otherwise.	ECB
OTHER_PURCH	Dummy variable that equals 1 when other asset purchases are announced (CBPP1, SMP, CBPP2, OMT, ABSPP, CBPP3 and CSPP), and 0 otherwise.	ECB
PSPP_Ext	Dummy variable that equals 1 when the length of PSPP purchases are announced, and 0 otherwise.	ECB
Swap5y5y	5-year in 5-year-forward inflation swaps	Datastream Thomson Reuters
Swap10y	10-year forward inflation swaps	Datastream Thomson Reuters
Spd_*	Difference between the 10-year sovereign interest rate for country * and the 10-year sovereign interest rate for Germany (* Italy, Spain, Portugal, Greece, Ireland, France, Netherlands, Belgium, Austria or Finland)	Datastream Thomson Reuters
PCA_spd	First principal component of the 10 Spd_*	Authors' computation
Mean_spd	Mean of the 10 Spd_*	Authors' computation
OIS2y	Intraday changes in 2-year OIS rates	Altavilla et al. (2019)
VSTOXX	Eurostoxx50 implied volatility index	Datastream Thomson Reuters
VIX	CBOE's SP500 implied volatility index	Datastream Thomson Reuters
Eurostoxx50	Stock price index of Eurozone stocks	Datastream Thomson Reuters
Scotti_macro	Real-time surprise index summarizing economic data surprises.	Scotti (2016)
Flow analysis		
PSPP	Weekly net PSPP purchase flows	ECB
PEPP	Weekly net PEPP purchase flows	ECB
Swap5y5y	End-of-week 5-year in 5-year-forward inflation swaps	Datastream Thomson Reuters
Spd_*	End-of-week 10-year sovereign spread for country * computed as above	Datastream Thomson Reuters
HICP	Growth rate of the Harmonised Index of Consumer Prices (month-over-month growth rate). Last available	Datastream Thomson Reuters
Dsvnf02	Treasury nominal interest rates at the 2-year maturity	Federal Reserve Board

Note: If not specified in the bottom panel, the daily series presented in the upper panel that are used for the flow analysis are the week-average of the daily observations.

Table B - Descriptive statistics

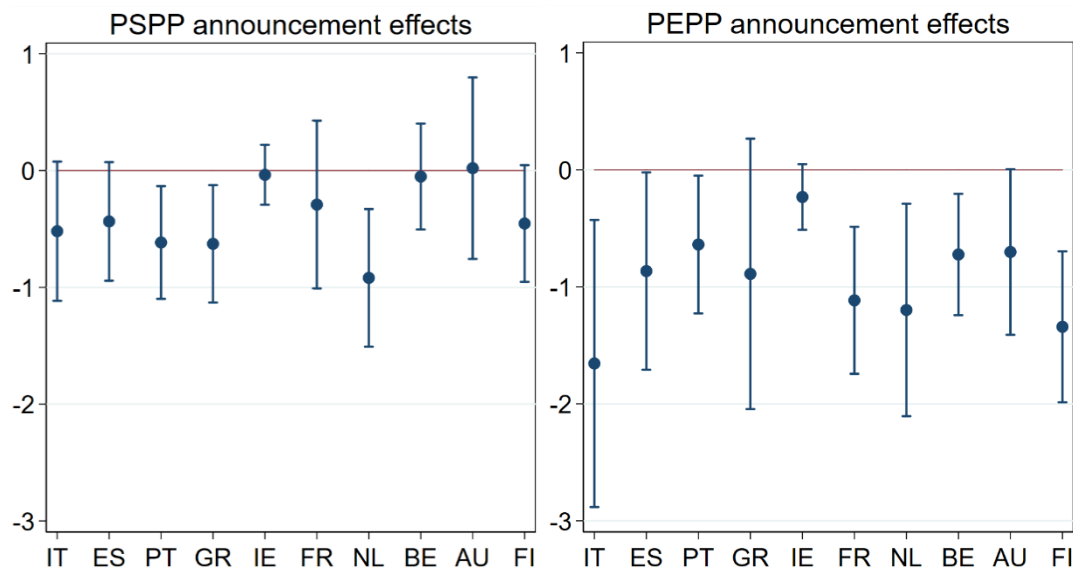
Variable	Obs	Mean	Std. Dev.	Min	Max
Swap5y5y	129	2.07	0.48	0.79	2.93
Swap10y	129	1.75	0.45	0.47	2.46
pca_spd	129	0.31	2.79	-2.98	9.57
mean_spd	129	1.88	1.48	0.43	7.44
Spd_IT	129	1.92	0.99	0.64	4.98
Spd_ES	129	1.72	1.19	0.49	5.71
Spd_PT	129	3.23	2.87	0.49	11.89
Spd_GR	129	8.03	7.78	1.16	46.80
Spd_IE	129	1.93	2.12	-0.11	9.45
Spd_FR	129	0.45	0.25	0.12	1.39
Spd_NL	129	0.23	0.15	-0.03	0.71
Spd_BE	129	0.67	0.50	0.18	2.63
Spd_AU	129	0.37	0.25	0.04	1.24
Spd_FI	129	0.25	0.13	0.00	0.77
OIS2y	129	-0.10	3.96	-17.17	15.18
VSTOXX	129	24.21	8.44	13.30	61.80
VIX	129	19.26	10.06	9.22	74.24
Eurostoxx50	129	312.7	65.7	173.1	471.8
Swap10yDE	123	1.9	0.4	0.8	2.6
Swap10yIT	129	1.5	0.4	0.2	2.3
NomIR DE	129	1.2	1.3	-0.7	3.6
NomIR IT	129	3.2	1.6	0.5	6.6
Scotti_macro	124	0.00	0.03	-0.13	0.19

Table C - Principal Component Analysis

Event-study analysis			
N	3,392	Variables	10
	Eigenvalue	Proportion	Cumulative
Comp1	7.26	0.73	0.73
Comp2	1.31	0.13	0.86
Comp3	0.5	0.05	0.91

Correlation table			
	Mean_spd	Spd_FR	Spd_IT
PCA_spd	0.95	0.9	0.88

Figure A - Announcement effects on individual sovereign spreads



Note: The left panel shows the estimated effect -using equation (2)- of PSPP announcements on each country's sovereign spread with Germany, while the left panel shows the estimated effect -using equation (2)- of PEPP announcements on each country's sovereign spread with Germany. Bars represent a 90% confidence interval.

C. The implementation effect of asset purchases

We explore whether the former results only capture the role of communication – announcement effects – or persist beyond the announcement day. To that end, we assess the effect of *actual* asset purchases on inflation swaps and sovereign spreads. To do so, we use information released by the ECB on the weekly outstanding amounts of public securities held within the PSPP and PEPP. Figure 2 shows PSPP and PEPP net purchase flows.

Because the ECB may adjust weekly purchases to the dynamics of inflation swaps and sovereign spreads, there is a potential endogeneity issue such that we cannot directly test the effect of weekly purchases on these two variables. To circumvent this reverse causality, we follow a two-step approach. We first estimate the relationship between weekly purchases and *lagged* inflation swaps and sovereign stress, up to the last day of the previous week.²⁹ We then use the residuals from this first-stage equation in a second-stage equation to assess the impact of exogenous variations in purchases on contemporaneous and future inflation swaps and sovereign spreads. Because ECB purchases could still relate to *contemporaneous* dynamics in inflation swaps and sovereign spreads, we use some timing features of the data to circumvent this issue. ECB purchases are the sum of all purchases during a given week, whereas asset prices are end-of-week values (in contrast to week-average values).³⁰ Therefore, within a given period (i.e. week), we minimize by construction the possibility that weekly asset purchases respond to contemporaneous inflation swaps and sovereign spreads.

The first-stage equation consists in purging the endogenous response of PEPP and PSPP purchases for their main potential determinants. We estimate the following two equations:

$$pspp_t = \alpha + \sum_i \rho_i pspp_{t-i} + \sum_i \delta_{1i} pca1_{t-i} + \sum_i \delta_{2i} pca2_{t-i} + \sum_j \phi_j \pi_{t-i}^e + \theta Z_{1,t} + \epsilon_t^{pspp} \quad (A1)$$

$$pepp_t = \alpha' + \sum_i \rho'_i pepp_{t-i} + \sum_i \delta'_{1i} pca1_{t-i} + \sum_i \delta'_{2i} pca2_{t-i} + \sum_j \phi'_j \pi_{t-i}^e + \theta' Z_{1,t} + \epsilon_t^{pepp} \quad (A2)$$

where $pspp_t$ and $pepp_t$ are weekly outstanding amounts for both programs, regressed on their own lagged values. We compute the first ($pca1$) and second ($pca2$) principal components of 10 euro area sovereign spreads.³¹ We also include lagged 5-year in 5-year-forward inflation swaps (π_t^e). We consider purchases during a week t against inflation expectations and sovereign spreads in the previous two weeks (so $i = 2$). Inflation swaps and sovereign spreads are considered at their end-of-week values. The vector $Z_{1,t}$ include financial market volatility (VSTOXX) to control for changing market conditions, Scotti (2016)'s macroeconomic news surprise index and the (month-over-month) inflation rate to control for the endogenous policy response of a standard central bank reaction function.³² Equation (A1) for PSPP purchases is estimated from March 2015 (week 14) to December 2021 (week 52), while Equation (A2) for PEPP purchases is estimated from April 2020 (week 15) to December 2021 (week 52). Residuals of both equations, shown in Figure B, represent our exogenous variations in PSPP and PEPP weekly purchases.

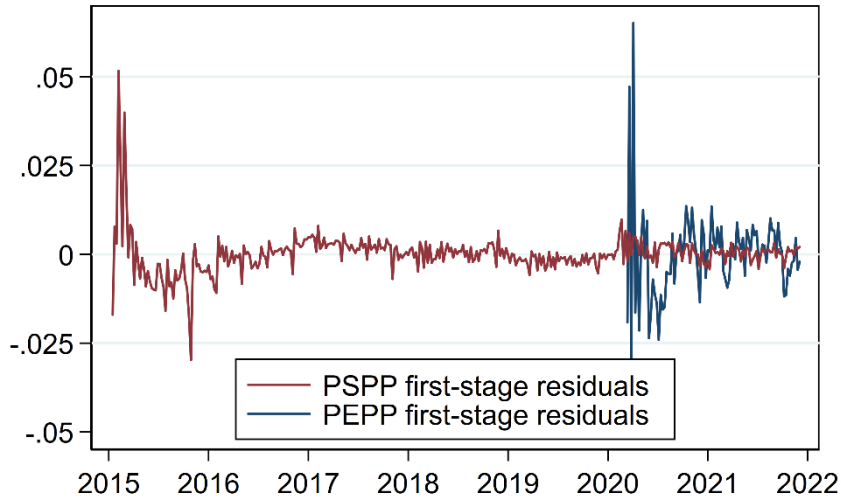
²⁹ See Blot et al. (2020) for a similar procedure.

³⁰ This timing feature is similar in spirit to timing restrictions that govern the VAR Cholesky-decomposition.

³¹ The first two principal components have eigenvalues above one. They explain 75% of the variance (51% and 24%).

³² Alternative specifications (including the ECB's sovereign CISS, excluding the set of macroeconomic controls or considering these controls with a lag) provide similar results in the 2nd-stage equation (see Table E in the Appendix).

Figure B – First-stage residuals



Note: The figure plots the residuals of equation (A1) in red for PSPP purchases and the residuals of equation (A2) in blue for PEPP purchases.

In the second-stage equation, we estimate the effects of the first-stage residuals on inflation swaps and sovereign spreads. Equation (A3) for PSPP purchases is estimated from March 2015 to March 2021, while Equation (A4) for PEPP is estimated from April 2020 to December 2021:

$$Y_{t+h} = \alpha + \rho Y_{t-1} + \beta_{pspp} \epsilon_t^{pspp} + \theta Z_{2,t} + \mu_t \quad (A3)$$

$$Y_{t+h} = \alpha' + \rho' Y_{t-1} + \gamma_{pepp} \epsilon_t^{pepp} + \theta' Z_{2,t} + \mu_t' \quad (A4)$$

where Y_{t+h} is either 5-year in 5-year-forward inflation swaps or the first principal component of euro area sovereign spreads with Germany. To capture the dynamic effects of PEPP and PSPP, both equations are estimated for $h = \{0, \dots, 2\}$. The vector $Z_{2,t}$ includes raw net purchase flows of the considered program, a dummy for ECB policy announcements – to control for the effects evidenced in the event-study –, the change in financial market volatility (VSTOXX), and monetary surprises as measured by Altavilla et al. (2019). In the PEPP equation (6), because PSPP and PEPP purchases happen side-by-side, we also include PSPP residuals as an additional control in the vector $Z_{2,t}$. We estimate both equations with OLS and compute heteroskedasticity and autocorrelation robust Newey-West standard errors. Both dependent variables and PSPP and PEPP residuals have been normalized to a unit standard deviation so the effects can be compared.

We find evidence that the differentiated effects are persistent. Table D provides evidence of the same pattern as in the event-study. PSPP purchases have a positive effect on inflation swaps, whereas they have no significant effect on sovereign spreads. The PSPP effect on inflation swaps increases with time: a 1-standard-deviation (SD) increase in PSPP purchases generates an increase of 0.023 SD in inflation swaps during the contemporaneous week up to 0.045 SD after 2 weeks. At the opposite, we find that PEPP purchases do not affect inflation swaps (the point estimate of the contemporaneous effect is 0.007) but have a negative and significant effect on sovereign spreads. A 1-SD increase in PEPP purchases reduces the first principal component of euro area spreads by 0.041 SD in the contemporaneous week and by 0.069 SD two weeks after.

Table D - Implementation effects

	Swap5y5y			PCA_spd		
	t	t+1	t+2	t	t+1	t+2
PSPP flows over 2015 - 2021						
	(1)	(2)	(3)	(4)	(5)	(6)
ϵ_{PSPP}	0.023*** [3.49]	0.032*** [3.60]	0.045*** [3.21]	-0.007 [-0.61]	-0.030* [-1.92]	-0.017 [-0.77]
$Z_{2,t}$	Yes	Yes	Yes	Yes	Yes	Yes
N	352	351	350	352	351	350
R2	0.97	0.95	0.92	0.93	0.87	0.81
PEPP flows over 2020 - 2021						
	(1)	(2)	(3)	(4)	(5)	(6)
ϵ_{PEPP}	0.007 [0.42]	0.008 [0.25]	0.033 [1.04]	-0.041*** [-2.80]	-0.036* [-1.70]	-0.069*** [-2.95]
$Z_{2,t}$	Yes	Yes	Yes	Yes	Yes	Yes
N	89	88	87	89	88	87
R2	0.98	0.96	0.95	0.96	0.94	0.91

Note: t-statistics in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Parameters are estimated from Equation (A3) for the effect of PSPP flows (upper panel) and Equation (A4) for the effect of PEPP flows (bottom panel) with OLS using Huber-White heteroskedasticity-robust standard errors. The dependent variable is 5-year 5-year forward inflation swaps in columns (1) to (3) and the first principal component of 10-year sovereign spreads with Germany for 10 euro area countries (Italy, Spain, Portugal, Greece, Ireland, France, Netherlands, Belgium, Austria and Finland) in columns (4) to (6). PSPP residuals are estimated from Equation (A1) while PEPP residuals are estimated from Equation (A2). The constant and parameters for the control variables have also been removed for parsimony and are available from the authors upon request. The effect of PSPP (or PEPP) is estimated contemporaneously and over the following 2 weeks. The sample for the upper panel starts in March 2015 (week 14) and the one for the bottom panel starts in April 2020 (week 15). They both end in December 2021 (week 52).