

Temi di discussione

(Working Papers)

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THE MARKET STABILIZATION ROLE OF CENTRAL BANK ASSET PURCHASES: HIGH-FREQUENCY EVIDENCE FROM THE COVID-19 CRISIS

by Marco Bernardini* and Annalisa De Nicola**

Abstract

This paper uses confidential high-frequency data to investigate the dynamic effects on the government bond market of the central bank asset purchases carried out in Italy during the COVID-19 pandemic crisis. We find that in response to an outright purchase of long-term bonds: (*i*) long-term yields drop by 4 to 5 basis points per billion euros on impact and tend to remain compressed over the trading day; (*ii*) short- and medium-term bond yields are also strongly affected; (*iii*) the yield curve shifts downwards and flattens owing to a reduction in the credit and liquidity risk premia embedded in sovereign spreads; (*iv*) market liquidity improves steadily. We also show that: (*v*) the yield impact of a purchase is substantially larger in times of heightened market stress; (*vi*) asset purchases operate similarly and effectively in quieter times as well. These results suggest that actual purchases affect market prices over and above purchase announcements, and that adjusting their pace and composition according to market conditions can boost the overall effectiveness of a programme.

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^{*} Bank of Italy, DG Economics, Statistics and Research.

^{**} Bank of Italy, DG Markets and Payment Systems.

1. Introduction¹

In response to the rapid deterioration of the economic outlook and the sharp tightening in financial conditions spurred by the spread of the COVID-19 pandemic, in March 2020 the Governing Council of the European Central Bank (ECB) announced a new series of outright purchases of public and private sector securities. On March 12, it added a temporary envelope of €120 billion to its existing Asset Purchase Programme (APP). On March 18, it announced a new programme – the Pandemic Emergency Purchase Programme (PEPP) – with an initial envelope of €750 billion, increased to €1350 billion on June 4.

The PEPP was designed with the dual role of easing the monetary policy stance and of contributing to the stabilization of financial markets. The "stance role" aims at providing additional monetary policy accommodation in order to offset the negative impact of the pandemic on the inflation outlook, thereby supporting the economic recovery from the crisis and the return of inflation towards the price stability objective. This is pursued mainly through the calibration of the size of the overall envelope and the length of the net purchase and reinvestment phases, which are communicated after a new decision is taken. The "market stabilization role", instead, aims at avoiding or at least reducing financial fragmentation, thereby safeguarding the smooth transmission of monetary policy to all parts of the euro area. This is pursued mainly through a flexible implementation of the programme over time, across asset classes, and among jurisdictions, which implies that the pace and the composition of the purchases under the PEPP are not fixed a priori, but can be adjusted over time as deemed appropriate.²

In this paper, we investigate the dynamic effects on the government bond market of the central bank purchases carried out in Italy during the pandemic crisis. The Italian government bond market provides an ideal case study. At the beginning of March 2020, when fears started to mount over the economic outlook, it was one of the hardest-hit markets in the euro area, suffering from a sharp rise

¹ The views expressed in this paper are those of the authors and do not necessarily reflect those of Banca d'Italia or the Eurosystem. We are indebted to Piergiorgio Alessandri, Martina Cecioni, Gioia Cellai, Paolo Del Giovane, Eugenio Gaiotti, Giuseppe Grande, Alberto Locarno, Salvatore Nasti, Stefano Neri, Simone Pezzini, Alessandro Secchi, Stefano Siviero, and Fabrizio Venditti for useful comments and suggestions. We are also grateful to Onofrio Panzarino and Daniele Sechi for assistance with the data. All remaining errors are ours.

² The overall amount of PEPP holdings is published weekly on the ECB website. A more detailed report is published every two months and refers to the jurisdictional composition of public sector net purchases, the weighted average maturity of public sector holdings, and the share of private assets purchased in primary and secondary markets for private sector asset purchases.



Fig. 1 – Stress in the Italian government bond market during the COVID-19 crisis

Note: The left axis measures the yield spread on 10-year Italian government bonds over their German equivalents, which provides a proxy for sovereign credit and liquidity risks, in basis points. The right axis measures a daily indicator of (il)liquidity in the Italian government bond market, based on prices quoted on MTS Cash, in basis points.

in investors' risk aversion and a marked deterioration in liquidity conditions (Figure 1). Although financial conditions eased considerably with the March announcement of the PEPP – and to a lesser extent also after its (largely anticipated) recalibration in June – for several months they remained significantly tighter than before the pandemic. We take advantage of the substantial variation in purchase flows, investors' risk perceptions, and liquidity conditions that has characterized the Italian government bond market during the COVID-19 crisis to assess to what extent, through which channels, and under what conditions the implementation of a central bank purchase programme is able to compress market yields within the trading day.

To this end, we abstract from "announcement effects", which are highly persistent and reflect changes in market expectations driven by news on the size and length of the programme, and focus on "flow effects", which are mostly temporary in nature and reflect the outcome of actual purchases. Our empirical investigation aims at providing useful insights to both scholars and policymakers. From an economic perspective, we shed light on the size, persistence, propagation, and state-dependent nature of flow effects. According to economic theory, these effects could reflect portfolio rebalancing activities as well as the presence of imperfect substitutability between different securities or some degree of illiquidity in the market (D'Amico and King, 2013). Despite some recent work on the topic, the empirical literature is still scarce, mostly due to confidentiality constraints on the data. From a policy perspective, it informs policymakers about the capability of actual purchases to mitigate – over the trading day – the effects of adverse shocks hitting the government bond market. This is of key importance for the market stabilization role of central banks: market tensions could in fact give rise to self-fulfilling flight-to-safety dynamics that would impair the smooth transmission of monetary policy to the real economy (Lane, 2020).

The empirical analysis is characterized by the use of confidential high-frequency data on purchase flows and local projection methods. The use of high-frequency data allows us to pin down the causal relationship running from purchases to yields, avoiding the simultaneity bias that typically affects the estimation of flow effects (Ghysels *et al*, 2017; De Santis and Holm-Hadulla, 2020). In particular, we follow Ghysels *et al*. (2017) and identify a central bank purchase shock by exploiting the fact that, prior to the execution of a trade, central bank's portfolio managers need to perform a set of due diligence activities that likely delay their potential reaction to external shocks for few minutes. The use of local projection methods (Jordà, 2005) allows us to directly compute a set of impulse responses from these data without the need of specifying the unknown underlying multivariate dynamic system at intraday frequencies. This avoids imposing implicit dynamic restrictions and allows accommodating panel structures and non-linear specifications in a very flexible way.

We first study the average dynamic effects over the period characterized by the Eurosystem's response to the COVID-19 pandemic crisis. We document five main findings. First, an outright purchase of long-term bonds by the central bank leads to a decrease in the corresponding bond yields by 4 to 5 bp per bn on impact, reaching a peak effect of 7 bp per bn within the first 20 minutes. Second, the yield impact of an outright purchase tends to be persistent, remaining economically significant also at longer horizons (i.e. 1-2 hours after an intervention). Third, these effects reverberate to shorter-maturity bond yields, although to a lesser extent, inducing a downward shift and a flattening of the yield curve. Fourth, the downward movement in the yield curve is driven by a compression of the credit and liquidity risk premia embedded in sovereign spreads. Fifth, the purchase leads to a steady improvement in market liquidity as well.

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We also investigate the presence of time-variation in the estimated effects. According to economic theory, flow effects should be larger in times of distressed financial markets, as outright purchases by the central bank improve risk sentiment and support better market functioning (Cúrdia and Woodford, 2011; Vayanos and Vila, 2020). To investigate this hypothesis we take full advantage of the richness of our high-frequency data and re-estimate the model using 21-day centred rolling windows over the full sample starting in January 2020, which includes the onset of the COVID-19 pandemic. Our results confirm that the yield impact of actual purchases is considerably larger during periods of heightened risk aversion and low market liquidity. At the peak of the pandemic crisis, we find that an outright purchase of long-term government bonds by the central bank reduced corresponding yields by around 10 bp per bn on impact. To explore further the indications coming from the time-varying analysis, we then estimate the dynamic effects of a purchase shock inside and outside stressed periods by means of a state-dependent version of our model. The results confirm that they operate similarly and effectively in quieter times as well.

Our findings have important policy implications for central banks implementing an asset purchase programme. First, they indicate that actual purchases exert meaningful effects on market prices – over and above purchase announcements – and thus can help to guarantee the smooth transmission of monetary policy. Second, they suggest that operational flexibility in the conduct of asset purchases strengthens the effectiveness of a purchase programme. Flexibility, in fact, allows tailoring the pace of asset purchases to financial market conditions, stepping it up when they are more needed but also more likely to be effective.

The rest of the paper proceeds as follows. Section 2 describes the adopted high-frequency identification, the data sources, and the econometric methodology. Section 3 presents the baseline results. Section 4 explores the presence of time-variation and state-dependence in the estimated dynamic effects. Finally, Section 5 concludes.

2. Empirical framework

2.1. High-frequency identification

Quantitative analyses of asset purchase programmes featuring a market stabilization function, such as the Eurosystem's Securities Markets Programme (SMP) and the Pandemic Emergency

Purchase Programme (PEPP), are exposed to endogeneity problems (Ghysels *et al.*, 2017). If Eurosystem's interventions are triggered by sudden and strong price deteriorations, regressions of changes in yields on the amount of purchase flows may give null or even positive coefficients, suggesting that the interventions have been ineffective or counterproductive even if they actually contributed to stabilizing bond yields in spite of unceasing upward pressures. Simultaneity bias between bond yields and purchase flows can arise even in the absence of an explicit market stabilization purpose, as central bank's portfolio managers tend to account for the relative values of bonds when they allocate purchases towards individual securities or maturity sectors (De Santis and Holm-Hadulla, 2020).

To address the simultaneity issue, we use confidential high-frequency data sampled at 5-minute intervals on purchases of Italian government bonds made by Banca d'Italia. In particular, we follow Ghysels *et al.* (2017) and identify central bank purchase shocks by assuming that, while they might have a contemporaneous impact on changes in yields, shocks to yields (and possibly other financial variables) might impact monetary policy purchases only with a one-period lag. Hence, the key identifying assumption is that it takes at least 5 minutes for a central bank's portfolio manager to react to external shocks that put upward pressure on bond yields. This conjecture, also formed on the basis of informal enquiries, is justified by the need of the trading desk to perform a set of due diligence procedures prior to the execution of the trade.

2.2. The data

Our dataset comprises intraday observations of Italian and German bond yields, an indicator of the degree of liquidity in the Italian sovereign market, and outright purchases of Italian government bonds by Banca d'Italia. Data are observed at 5-minute intervals from 9:00 a.m. to 5:30 p.m. over the period 2 January 2020 – 30 September 2020. Data on bond yields are collected from Bloomberg and refer to the mid-yield on the 2-, 5-, and 10-year benchmark bonds.³

As a proxy for the degree of liquidity in the Italian government bond market, we use an internal Banca d'Italia indicator that keeps track of all available information coming from MTS Cash, a quotedriven regulated market that represents the main interdealer platform in which Italian government

³ In the few cases in which an observation is not available (11 in total), we replace the missing values with previous values. This allows us to work with a balanced dataset. The results reported in this paper are entirely unaffected by this treatment.

bonds are traded.⁴ The indicator is computed as the simple average of the bid-ask price spreads for all the Italian government bonds quoted on MTS Cash. An increase in the indicator thus signals higher transaction costs and lower liquidity conditions.

Confidential data on the outright purchases of Italian government bonds made by Banca d'Italia are retrieved from the market platform where trades are conducted. We consider purchase flows in the 2-, 5-, and 10-year maturity buckets (i.e. each observation measures the total amount of the purchases that took place between the previous and the current yield observation).⁵ Until March 15, the data refers to the purchases conducted under the APP; from March 16 onwards, they also include the "emergency" purchases implemented under the temporary additional APP envelope and, from the end of March, the PEPP. We do not disentangle between the purchases conducted under the APP, its temporary envelope, and the PEPP because they all run in parallel and are implemented in a similar way (thus implying that market participants are unable to distinguish among them). Finally notice that, differently from previous studies, our proprietary data on outright purchases do not suffer from any recording lag, thus guaranteeing the match with the yield observations also at very high frequencies.⁶

2.3. The model

Equipped with the described high-frequency identification strategy, we use Jordà's (2005) local projections (LPs) to compute the dynamic effects of an outright purchase on the government bond market. This method allows us to directly estimate an impulse response function (IRF) without specifying the unknown underlying multivariate dynamic system, as it is the case in Vector AutoRegressions (VARs).⁷ This avoids imposing implicit dynamic restrictions and allows

⁴ Banca d'Italia has access to MTS data under its market supervisory activity. It is responsible for supervising wholesale trading venues for government securities to ensure the overall efficiency and orderly conduct of trading.

⁵ The 10-, 5-, and 2-year buckets include, respectively, outright purchases of Italian public sector securities with residual maturity from 9 to 11 years; 4 to 6 years; and 1 to 3 years.

⁶ For instance, one drawback of the Eurosystem confidential dataset on outright purchases used by Ghysels *et al.* (2017) is related to the presence of a recording lag that is likely to introduce a measurement error at frequencies higher than 15 minutes.

⁷ An impulse response can be defined as the difference between two forecasts at increasingly distant horizons. With LPs this object is estimated directly, while with VARs the *k*-period ahead forecasts (with k > 1) are extrapolated from the underlying dynamics of the model (i.e. from the first few autocorrelations of the data). As stressed in Jordà (2005), Ramey (2016), and Stock and Watson (2018), the difference between LPs and VARs in the impulse response literature is analogous to the difference between direct and iterated multi-step forecasts in the forecasting literature. However, while the goal of direct multi-step forecast, the goal of LPs is to obtain a consistent estimate of an impulse response.

accommodating in a very simple and flexible way panel structures and, as we do later in the paper, state-dependent specifications.

In particular, for each variable of interest we estimate a set of H + 1 separate regressions based on the following specification:

$$\tilde{y}_{d,t+h} = \sum_{i=0}^{p} \beta_{i}^{(h)} p_{d,t-i}^{m} + \sum_{i=1}^{p} \Gamma_{i}^{(h)} C_{d,t-i} + \alpha_{d}^{(h)} + \alpha_{t}^{(h)} + \Theta_{d,t}^{(h)} + u_{d,t+h}^{(h)}$$
(1)

for h = 0, ..., H. On the left-hand-side of model (1), $y_{d,t+h}$ is a generic variable of interest in the 5minute interval t + h of day d. We consider 12 variables: purchase flows of Italian government bonds in the 2-, 5-, and 10-year maturity buckets, the corresponding bond yields, German bond yields at the same three maturities, the term spread between the 10- and 5-year Italian bond yields, the sovereign spread between 10-year Italian and German yields, as well as an indicator of (il)liquidity in the Italian government bond market. Following Ghysels *et al.* (2017), purchase flows are specified in levels while financial variables are specified in differences. To report all the IRFs in levels, we specify $\tilde{y}_{d,t+h} = y_{d,t+h}$ in the former case and $\tilde{y}_{d,t+h} = y_{d,t+h} - y_{d,t-1}$ in the latter.⁸

On the right-hand-side of model (1), $p_{d,t}^m$ measures the outright purchases of *m*-maturity Italian government bonds in the intraday interval *t* of day *d*, $C_{d,t}$ is a vector of control variables that includes all the analysed variables $\tilde{y}_{d,t}$ other than $p_{d,t}^m$, $\alpha_d^{(h)}$ and $\alpha_t^{(h)}$ are day and intraday fixed effects that absorb day-fixed characteristics and intraday seasonal patterns, and $\Theta_{d,t}^{(h)}$ denotes a set of dummy variables that control for monetary policy announcement effects.⁹ The high-frequency identifying assumption discussed in Section 2.1 is implemented by including contemporaneous and lagged values of $p_{d,t}^m$ but only lagged values of $C_{d,t}$: this is equivalent to applying a Cholesky-type recursive identification scheme in which the purchase flow variable $p_{d,t}^m$ is ordered first (Ramey, 2016). In all the

⁸ The cumulative IRF of a variable specified in differences $(\Delta y_{d,t})$ at horizon *h* is obtained directly by cumulating the variable from horizon 0 to horizon *h* before the estimation: $\tilde{y}_{d,t+h} = \sum_{j=0}^{h} \Delta y_{d,t+j} = y_{d,t+h} - y_{d,t-1}$. This is equivalent to cumulating the IRF after the estimation (as usually done in VARs) but comes with the advantage of providing direct inference on the coefficients of the cumulative IRF (a key feature of LPs).

⁹ Concerning $C_{d,t}$, we do not include the term and sovereign spreads as they are a linear combination of the other variables (the vector therefore contains 9 variables). Concerning $\Theta_{d,t}$, we include an impulse dummy (i.e. a variable that takes the value unity in correspondence of one observation and zero otherwise) for each ECB Governing Council's press release and for a comment on sovereign spreads made on 12 March 2020 during the ECB press conference. We do not include a dummy to control for the announcement of the PEPP because (*i*) it was made after financial markets closed and (*ii*) the adopted panel structure implies that we abstract from market-opening effects.

estimations we compute Driscoll and Kraay (1998) standard errors, which take into account arbitrary heteroscedasticity, cross-day correlation, and within-day serial correlation among the residuals $u_{d,t+h}^{(h)}$.

The parameter $\beta_0^{(h)}$ measures the impulse response of the variable *y* in the intraday interval *t* + *h* to an outright purchase *p* of *m*-maturity bonds in the intraday interval *t*. The estimated elasticities are presented in basis points per billion euros (bp per bn) for comparability of our results with those in the SMP and APP literatures.¹⁰ In the baseline, we specify three lags for all the variables (*p* = 3) and focus on the purchase of long-term bonds (*m* = 10).¹¹ Since with LPs the number of observations available for estimation decreases with the horizon *h*, we hold the sample constant by using the one implied by the longest horizon, which in our baseline analysis is set to one hour (*H* = 11).

It is important to stress that our empirical framework is not suited to assess the overall longterm impact of the APP and the PEPP on the economy, which would require the elaboration of a fully-fledged structural model and, inevitably, additional restrictive assumptions. Our approach aims, instead, at providing a robust and agnostic set of estimates that can inform policymakers about the capability of actual purchases to affect market prices over the trading day as well as guide more structural research on the topic.

3. Effectiveness and transmission of central bank purchase shocks

3.1. Main results

We start by estimating model (1) over the sub-period characterized by the Eurosystem's flexible implementation of asset purchases in response to the pandemic crisis (i.e. from March 16 onwards).¹² Figure 2 shows the dynamic effects of a central bank purchase of long-term government bonds. The first three rows refer to a specific response variable (purchase flows, Italian bond yields, and German bond yields), while each column refers to a different maturity segment (2-, 5-, and 10-year buckets).

¹⁰ The adopted scaling is not meant to represent the size of a typical purchase conducted in a 5-minute interval, which is much smaller than 1 bn.

¹¹ In the Appendix, we also report the responses to an outright purchase of medium-term bonds (m = 5; see Section 3.2).

¹² Due to the presence of intraday lags and leads, as well as variables specified in differences, the actual size of the intraday dimension in the baseline is equal to 88, observed over 139 trading days (for a total of 12232 observations). The number of estimated parameters in the baseline is equal to 261 (4 β .^(h), 27 Γ .^(h), 226 α .^(h), and 4 Θ ^(h)).

The last row shows the responses of the 10-year/5-year term spread, the 10-year sovereign spread, and the market illiquidity indicator.

We document five main results. First, we find that an outright purchase of 10-year government bonds by the central bank compresses the corresponding yields on impact by 4 to 5 bp per bn. In the following 15 minutes, the yields decrease by further 2 to 3 bp per bn, reaching a peak effect of 7 bp per bn. This finding is difficult to compare with those available in the literature given differences in the frequency of the data, in the scaling of the reported elasticities, and in the time periods under analysis. Taking into account these limitations, our impact elasticities lie in the range of those found by earlier papers using daily data. For instance, for the SMP Casiraghi *et al.* (2016) estimate impact elasticities to be around 2-5 bp per bn for Italy, while Eser and Schwaab (2016) find values in the 1-9 bp per bn range across countries. For the APP, De Santis and Holm-Hadulla (2017) estimate impact elasticities to be around 4 bp per bn.¹³

Second, flow effects tend to be persistent. In response to a brief deviation in purchase flows, the impact on bond yields is found to last in later periods: one hour after a purchase shock, government bond yields remain at a lower level than the one prevailing without it. We also look at longer horizons and found that the estimated effects are still economically relevant 2 hours after the shock (around 3-4 bp per bn; Figure A1 in the Appendix). In interpreting the responses at longer horizons, however, the reader should be aware that our analysis mainly provides a heuristic indication on the persistence of the effects (Ramey, 2016). While the use of high-frequency data maximizes the chances of achieving a clean and reliable identification, it is more likely to limit the statistical power to assess the effects of purchase shocks several hours ahead (Nakamura and Steinsson, 2018). At longer horizons, indeed, more and more shocks tend to affect bond yields, inducing a progressive increase in the width of the confidence bands.¹⁴ Moreover, the analysis of longer horizons also comes at the cost of inducing a substantial reduction in the overall sample size, as we lose *H* observations at the end of each trading day (see Section 2.3). Taking these considerations into account, the results suggest that flow effects can be quite persistent.

¹³ The published version (De Santis and Holm-Hadulla, 2020) focuses on bond prices (i.e. not on bond yields), making comparisons more difficult.

¹⁴ Notice that all the shocks affecting the dependent variable between t and t + h (other than the one of interest hitting in the intraday interval t) are omitted and absorbed by the residual of the LP $(u_{d,t+h}^{(h)})$. This yields consistent but decreasingly efficient IRFs as h increases (Jordà, 2005; Stock and Watson, 2018).



Fig. 2 – Responses to an outright purchase of long-term bonds

Note: The figure shows impulse responses to a central bank purchase of 10-year Italian government bonds. The estimation is based on 12232 observations over the period 16 March 2020 – 30 September 2020. Purchase flows are in € billions and financial variables are in basis points. The horizontal axis measures a 1-hour horizon: 0 indicates the 5-minute interval at which the purchase shock hits and 1–11 the following 5-minute intervals. Gray bands are 68% and 90% confidence intervals.

Third, the yield curve shifts downwards and flattens. On the one hand, we find that the effects are not confined to the maturity segment in which the purchase takes place: in response to an outright purchase of 10-year government bonds by the central bank, short- and medium-term bond yields (i.e. with 2- and 5-year residual maturities) also drop significantly, leading to a downward shift in the yield curve. On the other hand, we find that these indirect effects are smaller in size, with the

10y/5y term spread declining persistently by 1 to 2 bp per bn, leading to a flattening of the yield curve. Overall, the analysis of the responses of shorter-term bond yields unveils the presence of a strong transmission along the term structure, which tends to propagate the local impact of an outright purchase across the maturity spectrum.

Fourth, the downward movement in the yield curve is largely driven by a compression of the credit and liquidity risk premia embedded in sovereign spreads. Indeed, we find that the purchase of Italian government bonds is not associated with any discernible impact on short-, medium-, and long-term German government bond yields. These results suggest that targeted interventions can be used as a tool for countering financial fragmentation that may arise in specific market segments.

Fifth, the purchase of long-term bonds leads to an improvement in market liquidity. In this respect, notice that a purchase can impact market liquidity through a combination of direct and indirect effects. On impact, it might momentarily increase the bid-ask spreads of the acquired securities by absorbing supply from the market, possibly exerting a very small but negative effect on market liquidity. In later periods, however, an outright purchase by the central bank might indirectly reduce market bid-ask spreads by improving confidence and stimulating investors' demand of government securities. The finding that the market (il)liquidity indicator decreases steadily in response to an outright purchase by the central bank provides empirical support for the view that policy interventions "crowd in" other investors through a confidence channel (Lane, 2020).

These findings bring interesting policy implications. They suggest that by implementing outright purchases central banks can mitigate the effects of adverse shocks hitting the government bond market. This helps to counteract the negative consequences of market volatility and flight-to-safety dynamics, thereby supporting the smooth transmission of monetary policy by reducing fragmentation risks and improving market liquidity.

3.2. Robustness

The baseline results in Figure 2 are not specific to the analysed horizon or the maturity of the purchased securities. First, we find that the effects are still economically relevant two hours after the initial shock (Figure A1 in the Appendix). This despite the fact that by selecting H = 23 we lose, for each day in our sample, almost two hours of potential trades that take place at the end of the day. Second, we obtain very similar results for the effects of medium-term bonds purchases (Figure A2 in the Appendix).

The results also hold across alternative model specifications. First, we find that they are robust to the selection of higher order lags, despite the fact that by selecting a higher *p* we lose, for each day in our sample, several trades that take place at the start of the day. Second, the inclusion of day and intraday fixed effects is not found to drive the results, although it slightly increases the size and precision of the estimated elasticities at longer horizons. Third, the use of two-way clustered standard errors, instead of the ones based on Driscoll and Kraay, only leads to a very small decrease (increase) in the width of the confidence bands at shorter (longer) horizons.

4. Are the effects different in times of market stress?

Flow effects are thought to be larger in times of stressed market conditions, as outright purchases by the central bank improve risk sentiment and support better market functioning (Cúrdia and Woodford, 2011; Vayanos and Vila, 2020). In this respect, the results in Figure 2 only show the average flow effects over the period 16 March 2020 – 30 September 2020 and, as such, may mask the presence of temporal heterogeneity.

4.1. Time-variation in flow effects

To shed light on the degree of time-variation in the effectiveness of actual purchases, we take advantage of the richness of our proprietary high-frequency data and, for each day in the period 2 January 2020 – 30 September 2020, we re-estimate model (1) using 21-day centred rolling windows.¹⁵ The use of the full sample allows us to unveil the presence of heterogeneity within the baseline period marked by the Eurosystem's flexible implementation of asset purchases as well as to track the yield impact of asset purchases at the onset of the COVID-19 crisis.

We find that the estimated impact elasticities have been considerably larger during phases of heightened risk aversion and low liquidity conditions (Figure 3). In mid-March, when at the height of the COVID-19 pandemic crisis the yield spreads on Italian government bonds over their German equivalents increased abruptly and liquidity conditions deteriorated rapidly, a purchase of long-term bonds reduced corresponding yields on impact by around 10 bp per bn. In May, when the 10-year sovereign spread reached a new peak whereas the market liquidity proved to be more resilient, the

¹⁵ Point estimates and confidence bands are now estimated on (drastically) smaller samples as we lose many observations from the daily dimension (i.e. we use only 21 trading days instead of 139, for a total of 1848 observations).



Fig. 3 – Time-varying yield impact of an outright purchase of long-term bonds

Note: The left axis measures the time-varying impact response of the 10-year bond yield to a central bank purchase of 10-year Italian government bonds (bp per bn). The estimation is repeated for each day in the period 2 January 2020 – 30 September 2020 and is based on 21-day centred rolling windows of 1848 observations each. Gray bands are 68% and 90% confidence intervals. The right axis in the top panel measures the yield spread on 10-year Italian government bonds over their German equivalents, which provides a proxy for sovereign credit and liqudity risks, in basis points. The right axis in the bottom panel measures an indicator of (il)liquidity in the Italian government bond market, based on prices quoted on MTS Cash, in basis points.

yield impact has been on average at around 4-5 bp per bn. Finally, from June onward, when financial conditions eased considerably, the yield impact has been on average at around 2-3 bp per bn.

This simple yet insightful evidence is remarkable for two reasons. First, it captures a general pattern in the data. We find in fact very similar indications when looking at the time-variation in the

yield impact of an outright purchase of medium-term government bonds (Figure A3 in the Appendix). This indicates that the uncovered time-variation is not linked to a specific intervention. Second, it might even provide a conservative estimate of the yield impact in bad times. It could be argued, in fact, that our high-frequency identifying assumption becomes stronger in times of market turmoil since central banks' portfolio managers tend to be more responsive to external shocks (i.e. react in less than 5 minutes); if true, this would attenuate the yield impact estimated in periods of market stress.

These results bring relevant implications for both scholars and policymakers. From an economic perspective, they provide empirical support for the prediction that central bank purchases are more effective in reducing risk premia and improving market confidence in bad times (Cúrdia and Woodford, 2011; Vayanos and Vila, 2020). From a policy perspective, they suggest that operational flexibility in the conduct of asset purchases can strengthen the effectiveness of a purchase programme: for a given envelope, flexibility allows reallocating purchase flows over time, stepping up their pace when they are needed but also more likely to be effective.

4.2. Flow effects inside and outside stressed periods

To explore further the indications coming from the time-varying analysis as well as to offer useful benchmarks for theorists and policymakers, we estimate a state-dependent version of model (1) in which we summarize the dynamic effects of a long-term purchase shock in stressed and quieter periods. In particular, for each variable of interest we estimate a set of H + 1 separate regressions based on the following specification:

$$\begin{split} \tilde{y}_{d,t+h} &= \left[\sum_{i=0}^{p} \beta_{i}^{(Sh)} p_{d,t-i}^{m} + \sum_{i=1}^{p} \Gamma_{i}^{(Sh)} C_{d,t-i} + \alpha^{(Sh)} \right] I_{d,t-1} \\ &+ \left[\sum_{i=0}^{p} \beta_{i}^{(NSh)} p_{d,t-i}^{m} + \sum_{i=1}^{p} \Gamma_{i}^{(NSh)} C_{d,t-i} + \alpha^{(NSh)} \right] (1 - I_{d,t-1}) \\ &+ \alpha_{d}^{(h)} + \alpha_{t}^{(h)} + \Theta_{d,t}^{(h)} + u_{d,t+h}^{(h)} \end{split}$$
(2)

for h = 0, ..., H, where $I_{d,t}$ is a dummy indicator that takes the value unity if the market is in a stressed state. We define the latter as a period in which both our intraday proxies of sovereign risk and market



Fig. 4 – Responses to an outright purchase of long-term bonds in/out stressed periods

Note: The figure shows impulse responses to a central bank purchase of 10-year Italian government bonds inside and outside stressed periods. The estimation is based on 16808 observations over the period 2 January 2020 – 30 September 2020. Purchase flows are in € billions and financial variables are in basis points. The horizontal axis measures a 1-hour horizon: 0 indicates the 5-minute interval at which the purchase shock hits and 1–11 the following 5-minute intervals. Gray bands are 68% and 90% confidence intervals.

(il)liquidity are above their 75th percentile (approximated to 190 and 20 bp, respectively). This approach strikes a balance between the need of defining a relatively high threshold and that of having a sufficient number of observations in the stressed state. The main difference from model (1) is that now all the regressors (with the exception of the dummy variables) are interacted with $I_{d,t-1}$

and $(1 - I_{d,t-1})$.¹⁶ Accordingly, the $\beta_0^{(Sh)}$ and $\beta_0^{(NSh)}$ coefficients provide directly the dynamic effects of an outright purchase inside and outside stressed periods.

Figure 4 shows the dynamic effects of a central bank purchase of long-term government bonds inside and outside stressed periods obtained by estimating model (2) over the full sample 2 January 2020 – 30 September 2020. We highlight two main results. First, all the analysed variables respond more strongly to purchases under stressed market conditions. For instance, in stressed periods the 10-year sovereign spread is compressed by around 8 bp per bn and market liquidity improves notably after a monetary policy intervention. The responses are however less persistent at longer horizons. Second, the results indicate that the implementation of asset purchases by the central bank exerts economically meaningful effects also in quieter times: we find that outside stressed periods the 10-year sovereign spread is persistently compressed by 4 bp per bn and market liquidity tends to slowly improve after a purchase shock.¹⁷

These results bring a last interesting insight. While actual purchases are found to exert larger financial effects in periods of heightened market stress, their transmission through the government bond market is operating and effective in quieter times as well. Regardless of market conditions, in fact, actual purchases are found to compress sovereign spreads across the entire maturity spectrum and help to improve the liquidity of the market.

5. Conclusions

We used confidential high-frequency data to investigate the dynamic effects on the government bond market of the central bank asset purchases carried out in Italy during the COVID-19 pandemic crisis. We find that actual purchases of government bonds compress corresponding yields over and above purchase announcements. These effects tend to be persistent over the trading day and are not confined to the maturity segment in which the purchase takes place. They induce a downward shift and a flattening of the yield curve by compressing the credit and liquidity risk premia embedded in sovereign spreads and help to improve market liquidity by supporting market confidence. We also

¹⁶ We specify a predetermined indicator to avoid the possible contemporaneous influence of the purchase shock on the state of the market. The actual size of the intraday dimension is still equal to 88, but now is observed over 191 trading days (for a total of 16808 observations). The number of estimated parameters is now equal to 348 (8 β .^(*i*), 54 Γ .^(*i*), 279 α .^(*i*), and 7 Θ ^(*i*)).

¹⁷ Similar results are obtained when looking at the purchase of medium-term bonds (Figure A4 in the Appendix).

document that, while actual purchases exert larger financial effects in periods of heightened market stress, they operate similarly and effectively in quieter times as well.

Our findings have two relevant policy implications for central banks implementing an asset purchase programme. First, they indicate that actual purchases can help to guarantee the smooth transmission of monetary policy by counteracting the negative consequences of market volatility and flight-to-safety dynamics, in particular avoiding self-fulfilling movements. Second, they suggest that a flexible implementation of outright purchases – which allows stepping-up their pace where and when they are more needed – can boost the overall effectiveness of a purchase programme.

An interesting avenue for future research would be to disentangle the sources of the timevariation in the yield impact of actual purchases. While we have shown that they exerted a larger impact in times of heightened risk aversion – especially when market liquidity was extremely low – more episodes are needed to attempt a precise identification of the underlying drivers. Is it credit or liquidity risk that matters for the size of flow effects? Are there other driving forces? In this respect, the comparison of different crises over time and across markets may offer relevant insights to both scholars and policymakers.

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Appendix



Fig. A1 – Responses to an outright purchase of long-term bonds at longer horizons

Note: The figure shows impulse responses to a central bank purchase of 10-year Italian government bonds. The estimation is based on 10564 observations over the period 16 March 2020 – 30 September 2020. Purchase flows are in \notin billions and financial variables are in basis points. The horizontal axis measures a 2-hour horizon: 0 indicates the 5-minute interval at which the purchase shock hits and 1–23 the following 5-minute intervals. Gray bands are 68% and 90% confidence intervals. Dashed lines are the baseline estimates in Figure 2. The differences between the solid and the dashed lines are driven by the selection of a two-hour horizon (H = 23 instead of H = 11), which reduces the size of the intraday dimension.



Fig. A2 – Responses to an outright purchase of medium-term bonds

Note: The figure shows impulse responses to a central bank purchase of 5-year Italian government bonds. The estimation is based on 12232 observations over the period 16 March 2020 – 30 September 2020. Purchase flows are in \notin billions and financial variables are in basis points. The horizontal axis measures a 1-hour horizon: 0 indicates the 5-minute interval at which the purchase shock hits and 1–11 the following 5-minute intervals. Gray bands are 68% and 90% confidence intervals.



Fig. A3 – Time-varying yield impact of an outright purchase of medium-term bonds

Note: The left axis measures the time-varying impact response of the 5-year bond yield to a central bank purchase of 5-year Italian government bonds (bp per bn). The estimation is repeated for each day in the period 2 January 2020 – 30 September 2020 and is based on 21-day centred rolling windows of 1848 observations each. Gray bands are 68% and 90% confidence intervals. The right axis in the top panel measures the yield spread on 10-year Italian government bonds over their German equivalents, which provides a proxy for sovereign credit and liqudity risks, in basis points. The right axis in the bottom panel measures an indicator of (il)liquidity in the Italian government bond market, based on prices quoted on MTS Cash, in basis points.



Fig. A4 – Responses to an outright purchase of medium-term bonds in/out stressed periods

Note: The figure shows impulse responses to a central bank purchase of 5-year Italian government bonds inside and outside stressed periods. The estimation is based on 16808 observations over the period 2 January 2020 – 30 September 2020. Purchase flows are in € billions and financial variables are in basis points. The horizontal axis measures a 1-hour horizon: 0 indicates the 5-minute interval at which the purchase shock hits and 1–11 the following 5-minute intervals. Gray bands are 68% and 90% confidence intervals.

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