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# Empirical analysis of the pass-through of upstream financing conditions in the euro area

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This short analytical note assesses the pass-through from upstream to downstream financing conditions in the euro area. Upstream financing conditions include the long-term interest rates and yields that are perceived most susceptible to economic policy decisions and market expectations. By contrast, downstream financing conditions should closely reflect borrowing costs faced by households and businesses and therefore have a direct impact on consumption and investment decisions. Understanding the pass-through along the chain of financing conditions is at the core of effective monetary policy transmission.

Contrary to common assumptions of the co-movement of upstream and downstream financing conditions, our findings highlight the complexity of this transmission. Our analysis distinguishes among movements in the upstream financing conditions that are respectively caused by shifts in market inflation expectations, sovereign spreads and monetary policy surprises. More specifically, we find that the sign, timing, persistency and intensity of the pass-through vary depending on the nature of the original shock.

We find that, while the pass-through is only partial and sluggish in the case of inflation expectations shocks, the transmission exceeds fullness in the presence of monetary policy surprises. Additionally, in the case of heightened sovereign stress, the downstream conditions react with the opposite sign, reflecting an active role of the ECB in preventing market fragmentation and safeguarding financial transmission against this type of shock.

# 1 Introduction

Financial intermediation plays a crucial role in the transmission of monetary policy. Central banks, pursuing price stability, adjust policy rates to influence lending conditions set by financial institutions in order to affect borrowing costs for consumers and businesses. In the context of unconventional measures, financial intermediation has not only acted as a monetary policy tool but has also represented its end. For instance, and following Lane (2021), in the post-COVID recovery period, the ECB's monetary policy compass shifted towards preserving favourable financing conditions, thereby contributing to the sustained support of economic recovery. The shift in focus at that time was motivated by the understanding that spikes in euro area sovereign yields would inevitably and invariably transmit to bank lending rates regardless of the specific shock driving the movements in upstream financing conditions.

The focus on preserving favourable financing conditions stayed in place until a rapid acceleration of inflation in the second half of 2021, which prompted the ECB to initiate a tightening cycle, beginning with the withdrawal of unconventional stimulus and followed by a series of successive rate hikes. The current tightening measures have been accompanied by the Transmission Protection Instrument (TPI) to safeguard against cross-market and cross-country financial fragmentations as consequence of rapidly rising interest rates.

Regardless of the policy objective, effective monetary policy transmission relies on a smooth pass-through from **upstream financing conditions**, closely aligned with policy rates, to **downstream financing conditions**, directly impacting investment and spending decisions. While a long-term co-moving relation is a reasonable assumption based on the expectations hypothesis, which sees lending rates as a composite of current and expected future short-term interest rates and term and credit premia, the short-run dynamics may differ (Gürkaynak & Wright, 2012). Indeed, in the short run, the pass-through to downstream financing conditions may vary in timing and significance due to the nature of the initial shock, uncertainty in the financial system and available liquidity.

This brief policy note assesses the empirical robustness of the pass-through from upstream to downstream financing conditions in the euro area, considering shock dependency. To this end, we implement a VARX model incorporating a set of rates that represent both upstream and downstream financing conditions. Furthermore, we employ an IV-identification strategy to isolate movements in the upstream financing conditions and estimate causal relationships among these rates.

# 2 A daily VARX and stylized shock-invariant pass-throughs

Our analysis focuses on a quantitative assessment of the pass-through from upstream to downstream financing conditions. To achieve this objective we first provide the selection of suitable indicators for their representation in our model (herewith financial condition indicators are abbreviated as FCIs).

On the one hand, the upstream FCIs refer to the prevailing long-term interest rates, sovereign yields and market expectations set in financial markets, which are most responsive to monetary policy decisions. In the light of this definition, we can use the 10-year overnight index swaps (OIS10Y) and the 10-year EA GDP-weighted yield (EMU10Y) as proxy indicators for upstream FCIs.

On the other hand, downstream FCIs refer to end-users' funding and borrowing costs and encompass the prevailing interest rates and borrowing costs faced by households and corporations. These conditions are conventionally assumed to be directly influenced, among other factors, by the upstream financing conditions. The downstream FCIs encompass variables typically acknowledged to represent the external-financing premium for firms (see for example Angelini et al., 2019). To approximate external financing costs on a daily frequency, we can use the senior bank bond (SBR) rate as a proxy for bank lending rate, non-financial corporate bond (NFC) rate and a cost-of-equity (COE) index.[1] In the past decade, the non-bank related component of external financing for small and medium-sized enterprises (SMEs) on average represented roughly 55% (Lane, 2021).

[1] The cost of equity is sourced from Bloomberg and represents a synthetic measure of the average cost the market incurs to raise funds through issuing equity (stocks). It is calculated using a dividend discount model.

Therefore, the selected measures of financing conditions can be perceived to represent different layers of financial transmission, while their dynamic relationship is modelled via a daily Vector Autoregressive Model.

The VARX model used in this analysis can be formally represented as:

$$Y_t = \alpha X_t + \sum_{j=1}^{p} \beta_j Y_{\{t-j\}} + A\nu_t$$

where $Y_t$ is a $5 \times 1$ vector containing the endogenous variables $[OIS10Y, EMU10Y, SBR, NFC, COE]$ at time $t$ and $X_t$ is a $3 \times 1$ vector comprising the following exogenous variables: a constant term, a linear trend and a dummy variable.[2] $\beta_j$ is a $5 \times 5$ matrix representing coefficients for the $j^{th}$ lag of the endogenous variables, and α is a $5 \times 3$ matrix representing coefficients for the exogenous variables in $X_t$. $\nu_t$ is a $5 \times 1$ vector and represents the structural innovations, and $A$ is a $5 \times 5$ matrix capturing contemporaneous structural relations, forming a $5 \times 1$ matrix of reduced-form residuals $u_t$, with $u_t = A\nu_t$. Different assumptions related to the matrix $A$ allow us to investigate how the pass-through is contingent on various types of shocks influencing the movement of financing conditions.

The starting point of the analysis lays in evaluating the stylized empirical relationship between upstream and downstream financing conditions. We estimate a 2-lag VARX model using a sample that contains weekdays spanning the period from 1 June 2017 to 31 August 2023 – the number of observations, $T$, amounts to 1631.[3]

The assessment of the reduced-form pass-through involves assuming non-identified contemporaneous structural relationships, $A = I_5$, whereby the dynamic responses of endogenous variables depend entirely on the reduced-form lagged coefficients $\beta_j$. To allow various potential sources influencing financing conditions, the pass-through from upstream to downstream FCIs is examined in response to an increase in the 10-year sovereign yield. In particular, this increase can be driven by two elements, the risk-free component and a credit spread, i.e. following the understanding the 10-year sovereign yield, EMU10Y, as a sum $EMU10Y = OIS10Y + spread$. In the first scenario, the increase is indirectly applied through the riskless component, OIS10Y, reflecting changes in expected policy rates, for example. In the second scenario, a direct (autonomous) increase of the EMU10Y variable is considered, encompassing various possible shocks, including heightened uncertainty and credit risk.

## 2.1 The pass-through of the 10-year OIS:

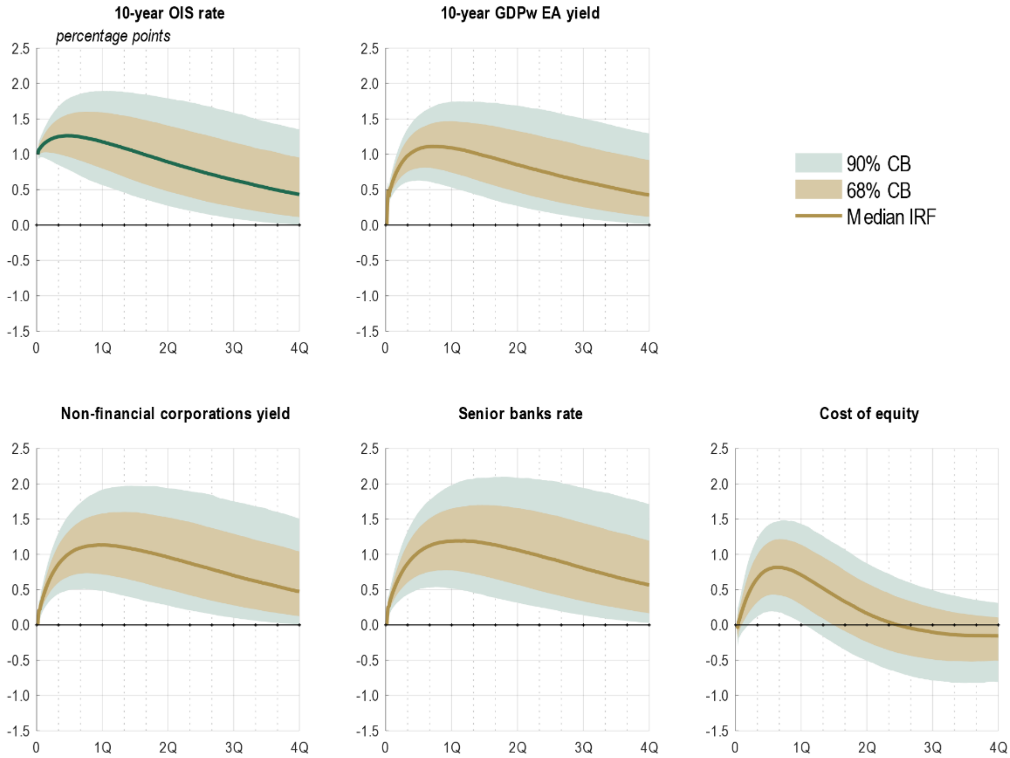
***After an OIS10Y shock, the pass-through to downstream indicators unfolds with a delay: it takes about a month for both NFC and SBR to show a 50% transmission of the initial shock, and with 65% after a quarter in COE.***

[2] The dummy variable is binary, taking a value of 1 for standardized residuals exceeding three standard deviations in a preliminary VAR estimation and 0 otherwise. We include this variable to mitigate the effects of large outliers, aiming to derive reliable confidence intervals essential for assessing the significance of the pass-through.

[3] The model fitted meets the stability condition, being its largest eigenvalue 0.9980 and smaller than the unit. The VAR is estimated using 2 lags as suggested by both BI and HQ information criteria. Both information criteria tend to more accurately select the true model or structure of the data, especially as the sample size increases – this is particularly important for inference. Table 1 in the Technical Appendix, p. 15, presents the results of the different information criteria evaluated up to 15 lags, and Table 2 presents the results of VARX estimation with some assumption tests.

In the first scenario, Figure 1 presents the empirical impulse responses derived from a reduced-form analysis following a one-period one percentage point (pp) increase in the 10-year OIS rate. Note that the shock becomes very persistent. The OIS10Y increment quickly translates into a substantial and statistically significant rise in the sovereign yield, exceeding a 50% pass-through within the first week. In contrast, there is a lag effect in the downstream FCIs. Both the NFC and SBR downstream FCIs require approximately one month to achieve a 50% pass-through, while COE needs up to three months. A full pass-through from upstream FCIs to NFC and SB rates is observed after six months, but there is no a complete transmission to the COE, which achieves a 65% transmission at most.

Chart 1: **Impulse responses to a shock-invariant increase in 10-year OIS rate**



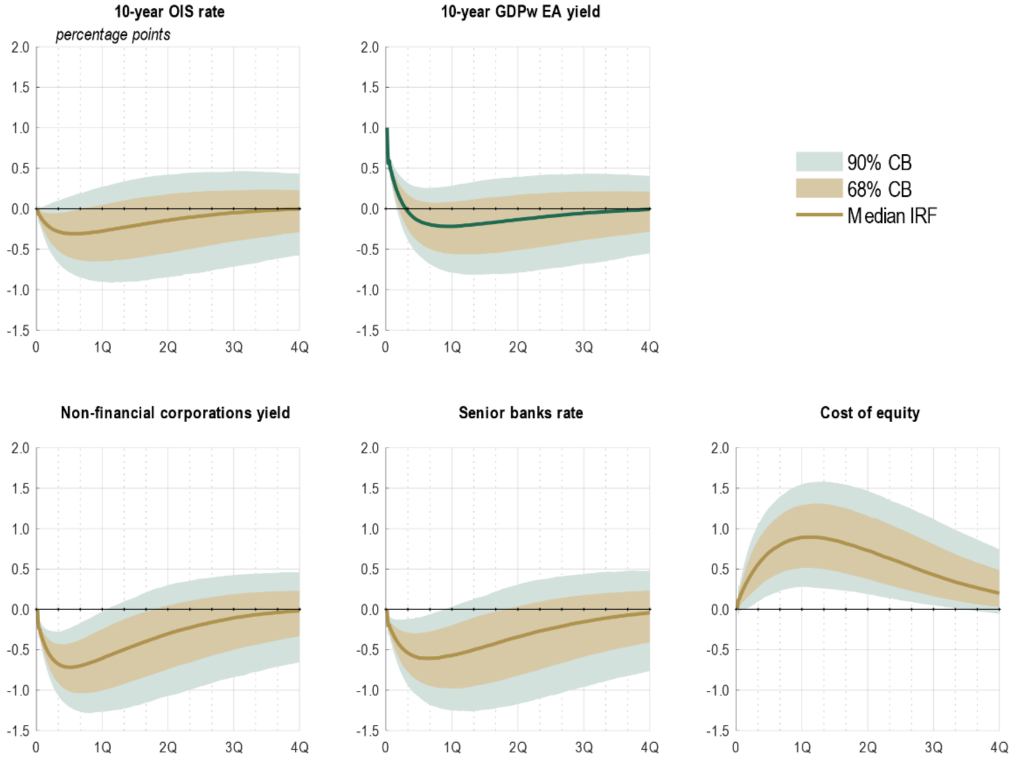

Note: The dark brown lines indicate the median impulse response paths. The dark green line represents the median response of the shocked variable. The confidence bands, generated using wild bootstrapping with 5,000 samples, help address potential issues related to serial correlation.

### 2.2 The pass-through of the 10-year EA yield:

***Direct increases in EMU10Y are, in the studied sample, extremely short-lived and are consistent with reduction in the rates related to the downstream indicators.***

Figure 2 illustrates the second instance, where the movement in upstream indicators is directly induced through an increase in the 10-year EA GDP-weighted yield (EMU10Y). The EMU10Y shock dissipates within the first month and is associated with no significant impact on the OIS10Y. Notably different from the previous instance, the increase in the upstream FCIs remains extremely short-lived and is even coupled with an initial decrease in downstream FCIs related to debt financing. The pass-through to both NFC and SBR downstream FCIs occurs rapidly but in a negative direction, resulting in temporary substantial reductions. Conversely, the COE experiences a notable increase, displaying a more prolonged reaction and achieving a full pass-through after a quarter.

Chart 2: **Impulse responses to a shock-invariant increase in 10-year EA GDP-weighted yield**




Note: The dark brown lines indicate the median impulse response paths. The dark green line represents the median response of the shocked variable. The confidence bands, generated using wild bootstrapping with 5,000 samples, help address potential issues related to serial correlation.

***Divergent impulse responses to increases in upstream FCIs highlight the importance of recognizing this variability for effective policymaking.***

The contrasting transmission observed in the two alternative cases, the rise in upstream financing conditions induced via OIS10Y and EMU10Y respectively, may suggest a potential shock-dependency of the pass-through of upstream to downstream financing conditions. Market reactions to changes in risk-free rates and sovereign bond yields can vary due to investors' perceptions of credit and macroeconomic risk, changes in risk preferences, inflation expectations, and expectations about the future policy path. Thus, recognizing the shock-dependency in the pass-through is essential for policymakers to appropriately calibrate their policies, and it is further explored in the following section.

# 3 Shock-dependent pass-through

The previous section analysed the effects of movements in the upstream FCIs without considering the source of the shock. In this section, we look at the transmission from upstream to downstream FCIs in terms of three identified shocks that lead to an increase in the 10-year EA GDP-weighted rate. Specifically, we are interested in capturing movements in upstream FCIs caused by inflation expectations, stress in sovereign markets and monetary policy surprises. All three shocks have importantly characterized the developments in the post-COVID period. We use an instrumental variable approach to impose shock-specific movement in the upstream FCIs and identify the structural relationships, matrix $A$, aligning with the methodology proposed by Gertler and Karadi (2015) and Altavilla et al. (2019). This approach adheres to the following conditions:

$$E(Zu^{EMU10Y}) = \gamma \neq 0 \qquad \text{and} \qquad E(Zu^{0}) = 0$$

where $Z$ represents an instrument, $u^{EMU10Y}$ is the vector of the reduced-form residual in the EMU10Y equation from the previous VARX(2) and $u^0$ are the remaining reduced-form residuals of the other variables contained in $Y$. We apply both relevance, $E(Zu^{EMU10Y}) = \gamma$, and orthogonality, $E(Zu^0) = 0$, conditions to define the matrix of contemporaneous effects $A$ in our baseline VARX(2) model. Considering these conditions, we follow the two-step procedure introduced by Gertler and Karadi (2015) to populate the identifying matrix. The first step isolates the variation in $u^{EMU10Y}$ due to the structural policy shock in $Z$, regressing $u^{EMU10Y}$ on $Z$, yielding a fitted series $\hat{u}^{EMU10Y} = \hat{b}Z$. The second step includes regression of $u^0$ on $\hat{u}^{EMU10Y}$ to populate the loadings in the column related to EMU10Y in $A$.

We use three instrumental variables respectively to simulate a shock-specific increase in EMU10Y: first differences in market-based inflation expectations, proxied as the 10-year inflation linked swap (ILS10Y), first differences in EA sovereign spreads, defined as the difference between EMU10Y and OIS10Y rates, and first differences in OIS10Y changes observed during press release dates linked to the ECB Governing Council's meetings. These instruments help us capture the effects of inflation expectation shocks, stress in sovereign markets and monetary policy surprises, which could cause EMU10Y to rise.[4]

The selection of instruments is driven by key determinants of sovereign yield movements within our examined sample. The inclusion of inflation expectations is directly linked to the prevailing interpretation of the EA sovereign yield increases, notably observed in February 2021, that prompted the re-compassing of monetary policy, focusing on preserving favourable financing conditions. Next, ongoing financial and economic uncertainty in the examined sample has contributed, on several occasions, to movements in sovereign yields based on increased risk of fragmentation, especially during critical events such as the outbreak of the COVID-19 pandemic, the start of the Russian war and uncertainty related to the potential disruptive impact of monetary tightening on financial markets. Lastly, we explore the use of a measure of monetary policy surprises as an instrument for understanding the ability of monetary policy to effectively guide financing conditions in the euro area.

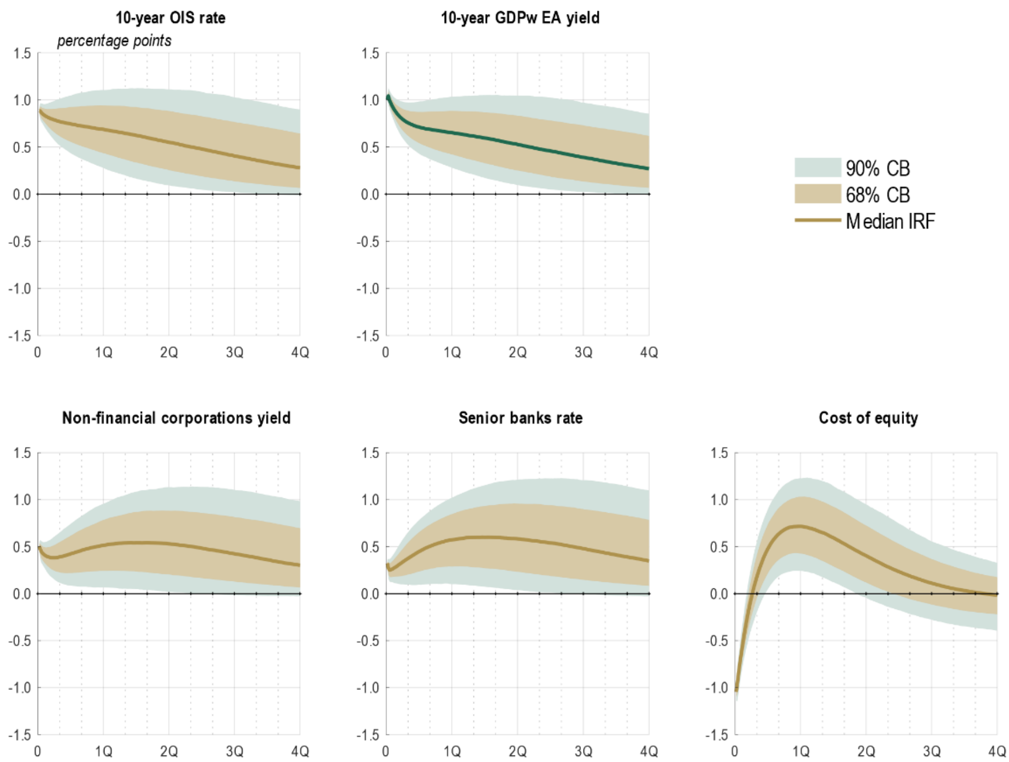
[4] The capture of monetary policy surprises relies on the assumption that first differences, or daily changes, in OIS on the day of the ECB Governing Council meetings are solely a result of monetary policy decisions. In the context of the monetary policy shock, the EMU10Y series is collapsed to dates of the ECB Governing Council to obtain the loading coefficient $\hat{b}$ when regressed to the instrument.

## 3.1 The pass-through of inflation expectations

***An increase in upstream FCIs due to hikes in inflation expectations is only partially transmitted to downstream FCIs.***

Figure 3 illustrates the impulse responses to a one-period 1 pp increase in the 10-year GDP-weighted yield due to the inflation expectation shock. This increase contemporaneously affects the OIS10Y, and both OIS10Y and EMU10Y upstream FCIs show a similar dynamic response to the initial shock in terms of magnitude and persistence.

Chart 3: **Impulse responses to inflation expectations implied increase in EMU10Y**




Note: The dark brown lines indicate the median impulse response paths. The dark green line represents the median response of the shocked variable. The confidence bands, generated using wild bootstrapping with 5,000 samples, help address potential issues related to serial correlation.

In contrast, the contemporaneous response is substantially attenuated in the pass-through to downstream FCIs. Both NFC and SBR exhibit statistically significant positive and persistent responses. In the short run, the effect on SBR is smaller than that on NFC, but in both cases, it is lower than the initial shock, resulting in a roughly 50% pass-through three quarters after the initial shock. This result indicates that, in the case of movements in upstream FCIs due to an inflation expectation shock, there exists an incomplete transmission mechanism, and financial intermediaries may introduce frictions or delays in the transmission process, adjusting their lending rates only partially.

The observed initial negative response in COE may suggest heightened demand for financial equities as investors seek shelter against increased inflation risk. However, this effect subsides after the first month, and the COE begins to increase and achieves a 75% pass-through in the first quarter – a significant pass-through but not complete. Over time, the COE returns to zero after the second quarter, indicating a transient response.

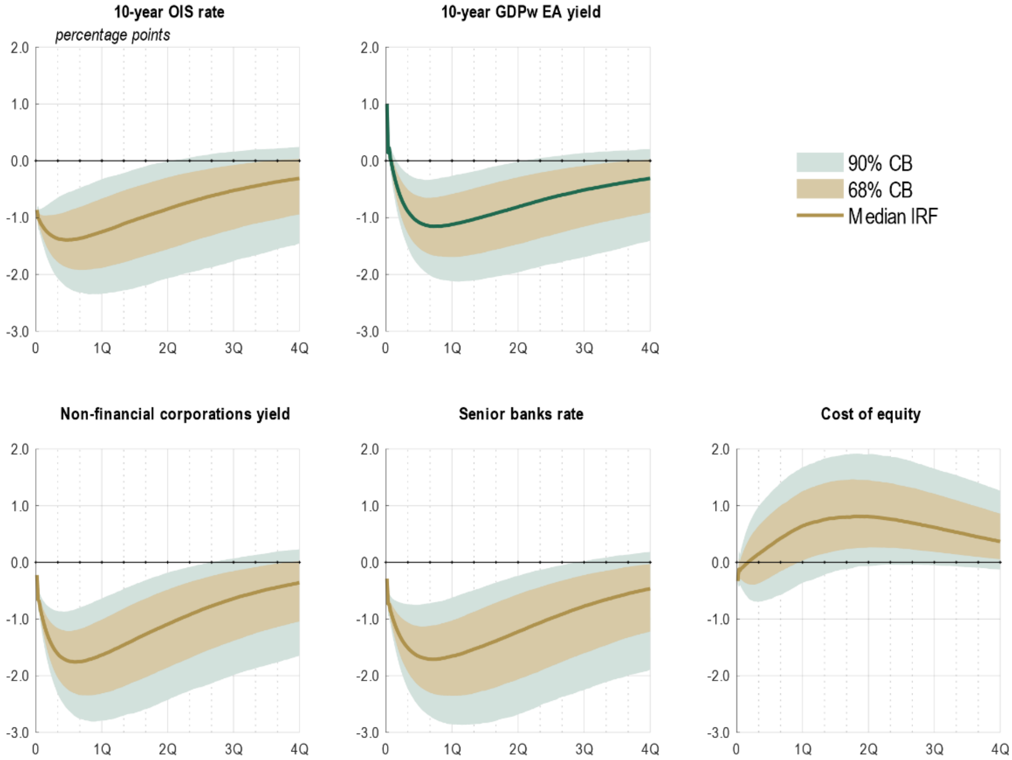
### 3.2 The pass-through of sovereign spreads

***A sovereign spread shock triggers a rapid negative response of OIS10Y, showing the ECB's commitment to mitigate sovereign stress and its ability to stabilize financial markets during high-risk times.***

In contrast to the synchronized movement of upstream FCIs in response to inflation expectation shocks, Figure 4 points towards a contemporaneous and significant reduction of OIS10Y to a 1 pp rise in EMU10Y as consequence of sovereign stress. OIS10Y falls by the same amount, which in the studied sample points to the effect of ECB's unconventional interventions and communication aimed at compressing sovereign yields and mitigating sovereign stress and fragmentation. This interpretation is supported by the rapid decline in EMU10Y, which turns negative within a week. This result reflects sample-specific correlations, influenced particularly by the presence of APP-PSPP until March 2020, both APP-PSPP and PEPP-PSPP in the post-COVID recovery period, and TPI that has accompanied monetary tightening initiated in 2022.

Considering downstream FCIs, a significant and negative pass-through is observed in both NFC and SBR, indicating the dominance of the ECB's intervention effects over the nature of the initial shock. This highlights the effectiveness of unconventional monetary policy tools in reassuring and stabilizing financial markets. The effect on downstream FCIs results in a -150% pass-through within the first two months, becoming insignificant after three quarters. Furthermore, when comparing with the responses to EMU10Y shocks in Figure 2, we observe that the COE response becomes insignificant due to the swift intervention. The result suggests that market participants have become accustomed to the ECB's interventions in response to market stress.

Chart 4: **Impulse responses to increase in EMU10Y implied by the spread shock**




Note: The dark brown lines indicate the median impulse response paths. The dark green line represents the median response of the shocked variable. The confidence bands, generated using wild bootstrapping with 5,000 samples, help address potential issues related to serial correlation.

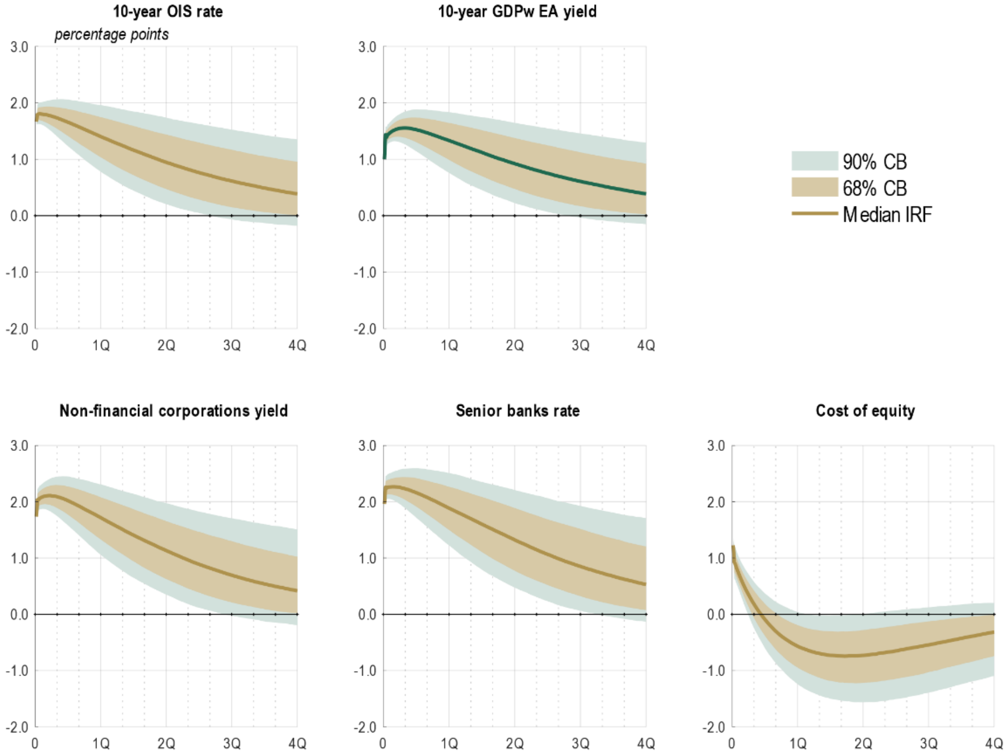
## 3.3 The pass-through of monetary policy surprises

***Monetary policy surprises show a rapid and pronounced response of downstream FCIs. This heightened sensitivity in downstream FCIs suggests that market participants swiftly adjust to the central bank's signalled path, reflecting their expectations immediately in borrowing costs for consumers and businesses.***

The transmission from upstream to downstream FCIs in response to a monetary policy shock is shown in Figure 5. The increase in EMU10Y should be interpreted as a move by the central bank to tighten financing conditions. The OIS curve, being highly responsive to monetary policy, demonstrates a strong co-movement with EMU10Y, in terms of both magnitude and persistence. There is a slight overshooting observed in OIS10Y within the first month, implying that a 100 b.p. move in GDP-weighted sovereign yields is consistent with a relatively stronger movement in OIS curve. In the context of monetary policy tightening, this could point towards a relatively greater sensitivity of sovereign yields to reduced inflation expectations, while the OIS curve would to a greater extent reflect the altered expected short-rate path.

Moreover, the rise in EMU10Y induced by monetary policy triggers positive and notable responses in downstream indicators, persisting for approximately 50 days after the initial shock. In particular, there is a significant over-reaction in both NFC and SBR, reaching about 200% at the peak. The results suggest an in-sample hyper-sensitivity of market participants to changes in the policy rate and their perception of a strong signal of the ECB's intention to alter financing conditions. On the other hand, the monetary policy movements implied in the upstream FCIs in the studied sample are consistent with only short-lived effect on the costs of raising equity, with the dynamics becoming insignificant within the month of the shock.

Chart 5: **Impulse responses to increase in EMU10Y implied by monetary policy surprises**




Note: The dark brown lines indicate the median impulse response paths. The dark green line represents the median response of the shocked variable. The confidence bands, generated using wild bootstrapping with 5,000 samples, help address potential issues related to serial correlation.

# 4 Conclusions

Understanding the dynamics of the monetary policy transmission mechanism is pivotal to effective policymaking. In this analysis, we assessed the pass-through from upstream to downstream financing conditions in the euro area, considering shock-dependency.

***The study highlights the complexity of financial transmission, urging policymakers to design customized and measured responses to different types of shocks.***

Our findings shed light on distinct pass-through patterns in response to different identified shocks. When examining inflation expectation shocks, we noted only a partial pass-through to downstream financing conditions. Moreover, in the case of sovereign stress, the impact in the studied sample is immediately reduced and favourability of downstream financing conditions is broadly preserved. In both cases – the inflation expectations shock and the heightened sovereign stress – the responses could imply market participants' familiarity with ECB interventions and unconventional measures that reflected commitment to adhere to the price stability objective and to protect the financial transmission from becoming fragmented.

Finally, in response to monetary policy surprises, we saw a strong market reaction, highlighting the significant role of central bank signalling. This underscores the importance of clear communication by central banks to guide market expectations and stabilize financial conditions.

In conclusion, understanding the complexity of the pass-through of downstream financing conditions to diverse shocks is crucial for effectively designing monetary policy strategies. Policymakers should, considering effectiveness and efficiency, remain vigilant to these dynamics, employing targeted and measured responses to different types of shocks affecting financing conditions.

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# Technical Appendix

Table 1: **Lag-selection Information Criteria**

| Lags | loglik | p(LR) | AIC | BIC | HQC |
|---|---|---|---|---|---|
| 1 | 16474.1 | | -20.3393 | -20.2059 | -20.2898 |
| 2 | 16698.8 | 0.0000 | -20.5864 | **-20.3697*** ** | **-20.5059*** ** |
| 3 | 16747.0 | 0.0000 | -20.6151 | -20.3150 | -20.5037 |
| 4 | 16787.3 | 0.0000 | -20.6340 | -20.2506 | -20.4917 |
| 5 | 16822.3 | 0.0000 | -20.6464 | -20.1796 | -20.4731 |
| 6 | 16859.9 | 0.0000 | -20.6620 | -20.1119 | -20.4579 |
| 7 | 16901.1 | 0.0000 | -20.6820 | -20.0486 | -20.4469 |
| 8 | 16946.2 | 0.0000 | -20.7069 | -19.9901 | -20.4408 |
| 9 | 16977.6 | 0.0000 | -20.7149 | -19.9147 | -20.4179 |
| 10 | 17010.2 | 0.0000 | **-20.7243*** ** | -19.8408 | -20.3964 |
| 11 | 17028.5 | 0.0625 | -20.7160 | -19.7491 | -20.3572 |
| 12 | 17058.8 | 0.0001 | -20.7225 | -19.6723 | -20.3328 |
| 13 | 17079.7 | 0.0187 | -20.7175 | -19.5839 | -20.2968 |
| 14 | 17098.5 | 0.0523 | -20.7097 | -19.4928 | -20.2581 |
| 15 | 17118.0 | 0.0358 | -20.7030 | -19.4028 | -20.2204 |

Table 2: **OLS VAR(2) Model Estimation**

| | OIS10Y | EMU10Y | NFC | SBR | COE |
|---|---|---|---|---|---|
| Constant | 0.0041 | 0.0220 | 0.0145 | 0.0179 | 0.2411*** |
| | (0.01) | (0.01) | (0.02) | (0.02) | (0.05) |
| Trend | 0.0000 | 0.0000** | 0.0000 | 0.0000 | 0.0001*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Dummy | 0.0210 | 0.0340 | 0.0973*** | 0.1169*** | 0.3024*** |
| | (0.02) | (0.03) | (0.03) | (0.04) | (0.10) |
| OIS10Y (t-1) | 1.0745*** | 0.4774*** | 0.1967** | 0.2405*** | -0.046 |
| | (0.08) | (0.08) | (0.09) | (0.09) | (0.15) |
| OIS10Y (t-2) | -0.0382 | -0.3841*** | -0.1096 | -0.1579* | 0.1050 |
| | (0.08) | (0.08) | (0.09) | (0.09) | (0.15) |
| EMU10Y (t-1) | -0.0652 | 0.5745*** | -0.2293*** | -0.2014*** | 0.1050 |
| | (0.06) | (0.06) | (0.07) | (0.07) | (0.11) |
| EMU10Y (t-2) | 0.0311 | 0.3301*** | 0.1507** | 0.1337* | -0.0704 |
| | (0.06) | (0.07) | (0.07) | (0.07) | (0.11) |
| NFC (t-1) | -0.0865 | 0.1213 | 0.9760*** | -0.3919** | -0.0832 |
| | (0.15) | (0.15) | (0.16) | (0.17) | (0.29) |
| NFC (t-2) | 0.0817 | -0.1426 | 0.0025 | 0.3840** | 0.0676 |
| | (0.15) | (0.15) | (0.16) | (0.17) | (0.29) |

| | | | | | |
|---|---|---|---|---|---|
| SBR (t-1) | 0.1261 | -0.0590 | 0.1335 | 1.4119*** | -0.0476 |
| | (0.15) | (0.13) | (0.15) | (0.16) | (0.25) |
| SBR (t-2) | -0.1262 | 0.0750 | -0.1256 | -0.4210*** | -0.0191 |
| | (0.14) | (0.13) | (0.14) | (0.16) | (0.25) |
| COE (t-1) | -0.0114 | -0.0144 | 0.0002 | -0.0029 | 0.9369*** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.04) |
| COE (t-2) | 0.0116 | 0.0149 | 0.0009 | 0.0025 | 0.0396 |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.04) |
| Adjusted R-squared | 0.9986 | 0.9982 | 0.9988 | 0.9991 | 0.9911 |
| Ljung–Box test NSC (t-1) | 0.9397* | 0.5034 | 0.5751 | 0.4212 | 0.4959 |
| Ljung–Box test NSC (t-2) | 0.8797 | 0.4974 | 0.2270 | 0.0885 | 0.5874 |
| KS test Normality | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |

Notes: The coefficients are based on the VARX(2) model, with standard deviations presented within parentheses. * denotes significance at 90%, ** denotes significance at 95% and *** denotes significance at 99%. The 'NSC' in the Ljung–Box test represents the p-value for a Ljung–Box test on the null hypothesis of randomness of the residuals. We consider 1 and 2 lags, and * denotes rejection of randomness (i.e. serial correlation) at 90%, ** at 95% and *** at 99%. The 'KS test Normality' represents the Kolmogorov–Smirnov test for the null hypothesis of normality of the residuals, and * denotes rejection of normality at 90%, ** at 95% and *** at 99%.