Monetary policy transmission in the euro area: is this time different? Chapter I: lags and strength

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Motivation

"Monetary actions affect economic conditions only after a lag that is both long and variable"

Friedman (1961)

- Despite decades of research and policymaking, monetary policy (MP) transmission to the economy still subject to considerable uncertainty:

"At the same time, the past rate increases are being transmitted forcefully to euro area financing and monetary conditions, while the lags and strength of transmission to the real economy remain uncertain."

ECB Monetary policy statement, 4 May 2023

Motivation (2)

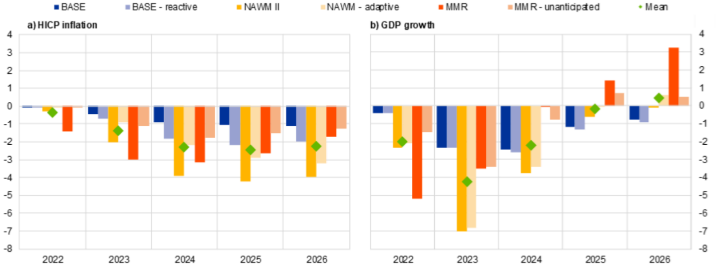
- However, recent research has documented that monetary policy can affect the real economy already within months
- Carvalho et al. (2023) employ daily series on real economic activity in Spain and state-of-the-art high frequency MP shocks
  - They show that consumption and sales react strongly already one quarter after the shock, while the employment is more inertial $\Rightarrow$ Lags are variable!
  - Also argue that the typical use of quarterly data mask the short lags to economic activity $\Rightarrow$ Temporal aggregation matters?
- Allayioti et al. (2024) on the other hand focus on the MP transmission to prices by disaggregating the core HICP basket into interest rate-sensitive and non-sensitive items
  - Their estimates suggest that pass-through to highly sensitive items requires $\sim$ 18 months with the effect being up to 3x stronger than for non-sensitive items
  - Find evidence for stronger and faster MP transmission to prices in the current tightening cycle

Motivation (3)

- More persistent response of prices to MP shocks also in line with the predictions of most (semi-)structural models used at the ECB:

Chart 37: Impact of monetary policy tightening according to a suite of models

(percentage points)



Source: ECB calculations based on the NAWM II model (see Coenen, G. et al., op. cit.), the MMR model (see Mazelis, F. et al., op. cit.) and the ECB-BASE model (see Angelini, E. et al., op. cit.).
Notes: This chart reports the results of a simulation involving changes to short-term rate expectations between December 2021 and March 2024 and changes to expectations regarding the ECB's balance sheet between October 2021 (to account for anticipation) and May 2023. The reported values refer to year-on-year growth rates. "Mean" denotes the average across the six model variants.

Source: Lane (2024)

Motivation (4)

- However, the euro area economy has experienced a spell of large adverse shocks in the post-pandemic period, forcing an abrupt shift to high-inflation regime after nearly a decade of below-target inflation
- Recent literature has highlighted that such shift gives rise to a state-dependent Phillips curve due to price setting decisions (Cavallo et al. (2023)) and hence a stronger transmission of shocks in high-inflation regimes (De Santis and Tornese (2023))

Executive summary

- This project:
  - Documents the transmission lags of MP shocks over two decades of the euro area existence
  - Determines whether the transmission has changed in the current tightening cycle, both with respect to lags & strength
  - And if so, identifies the key factors affecting the stabilization properties of monetary policy in the post-pandemic environment
- Main findings:
  - Empirical estimates suggest that it takes $12-18$ months for the MP shock to fully transmit to both output and headline inflation
  - The response of inflation to policy rate hikes has been both stronger & more persistent in the current tightening cycle
  - Structural investigation indicates that forceful central bank response and more flexible price setting have contributed to the stabilization properties of monetary policy at the current juncture

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Empirical framework

- As the baseline model, I employ a linear Bayesian structural vector autoregression (SVAR)
  - For robustness, also local projections to address the bias in IRFs related to potential VAR mis-specification (Ramey (2016), Nakamura and Steinsson (2018))
- In order to pin down potential changes in the monetary transmission mechanism, I extend the SVAR to allow for time variation both in the parameter space and shock volatilities (TVP-SVAR-SV)
  - Estimated using the sparse matrix approach of Chan and Jeliazkov (2009)
  - See ▸ Econometric framework for more details)

Data

- The benchmark model consists of five variables, but I also include a larger set of macro indicators to control for the omitted variable bias:

Benchmark	Extended	
	Real economy & prices	Financial
Real GDP	Unemployment	Lending to NFCs & HHs
HICP inflation	Economic sentiment indicator	NFC deposits
3-month EURIBOR	Core HICP inflation	HH deposits
Euro Stoxx 50	Services HICP inflation	NFC deposit rate
EUR/USD		HH deposit rate
		CISS

- Models are estimated with data sample from January 2002 to October 2023 (Q1 2002 to Q3 2023 when quarterly data are used) $\Rightarrow$ Dictated by the availability of shock series (noisy intra-day OIS data prior to 2002)

Identification

- Identification of MP shock is done via mixture of high frequency information with narrative sign restrictions as in Zlobins (2022) (see HFI + NSR for details on the identification strategy)
  - For robustness, also Target factor of Altavilla et al. (2019)
- The obtained shock series is then plugged directly into the SVARs, following the "internal instrument" VAR literature (Romer and Romer (2004), Ramey (2011), Barakchian and Crowe (2013), Plagborg-Møller and Wolf (2021))
  - IRFs to the policy shock are then generated via Cholesky decomposition by ordering the shock series first as suggested by Plagborg-Møller and Wolf (2021)
- On top of that, two alternative identification approaches are considered to pin down MP shock
- First, a simple recursive Cholesky decomposition with the same ordering as stated in the previous slide

Identification (2)

- Second, sign and zero restrictions of Arias et al. (2018) are utilized, using the following scheme:

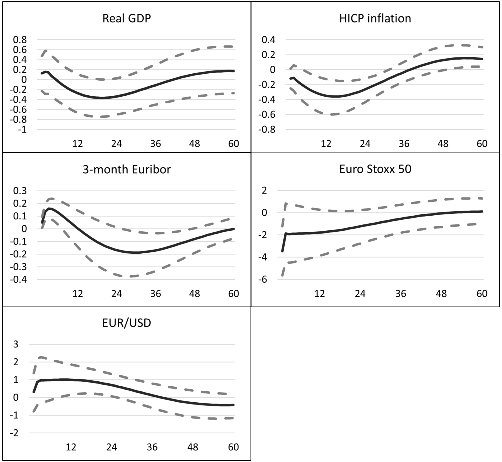
Shock	Real GDP	HICP inflation	3-month EURIBOR	Euro Stoxx 50	EUR/USD
Aggregate demand	-	-	0		
Aggregate supply	-	+	0		
Monetary policy			+	-	+

- All restrictions are imposed to hold on impact only

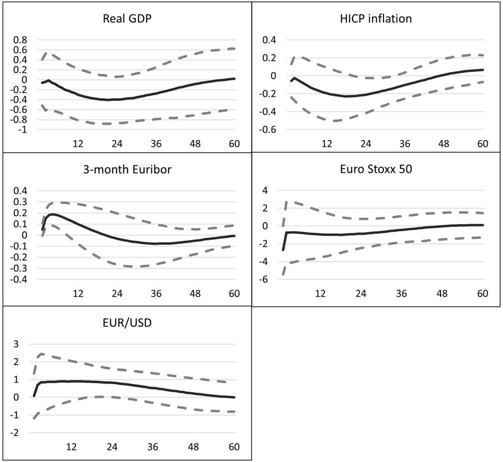
Contents

Monetary policy requires $\sim$ 12 – 18 months to fully transmit to output & prices

(a) $p = 12$ lags



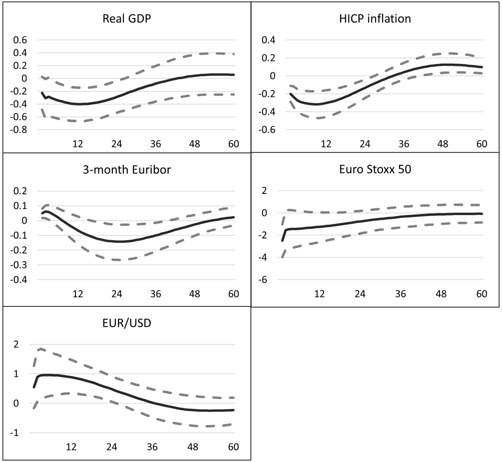
(b) $p = 6$ lags



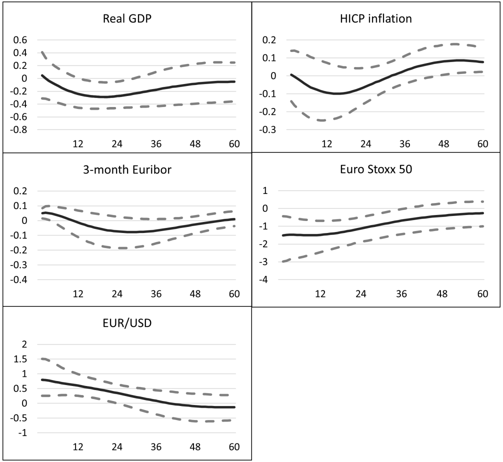
Note: Figures show impulse response functions from a Bayesian SVAR to the CMP shock, normalized to generate a 5 bps increase in the 3-month EURIBOR. The solid line shows the median response while the dashed region denotes the 68% credible sets.

Estimates are broadly robust across various identification strategies

(a) Target factor of Altavilla et al. (2019)



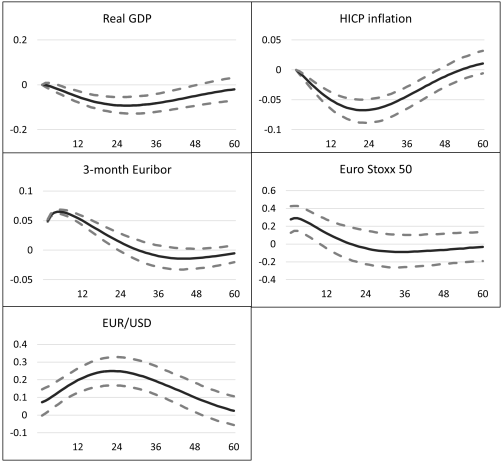
(b) Sign and zero restrictions



Note: Figures show impulse response functions from a Bayesian SVAR to the MP shock, normalized to generate a 5 bps increase in the 3-month EURIBOR. The solid line shows the median response while the dashed region denotes the 68% credible sets.

Estimates are broadly robust across various identification strategies (2)

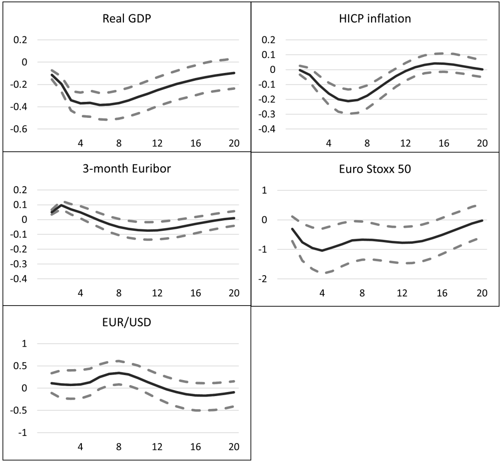
(a) Cholesky decomposition



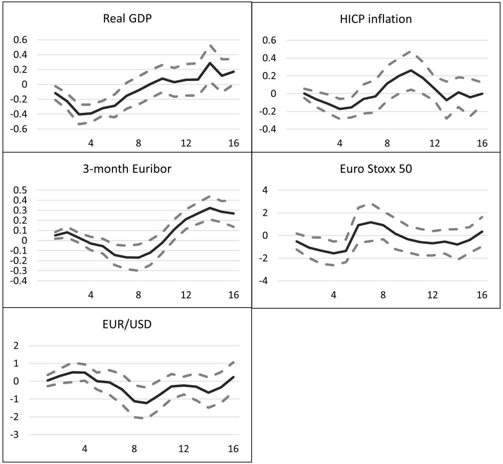
Note: Figures show impulse response functions from a Bayesian SVAR to the MP shock, normalized to generate a 5 bps increase in the 3-month EURIBOR. The solid line shows the median response while the dashed region denotes the 68% credible sets.

As well as with respect to data frequency and choice of IRF estimator

(a) Quarterly data



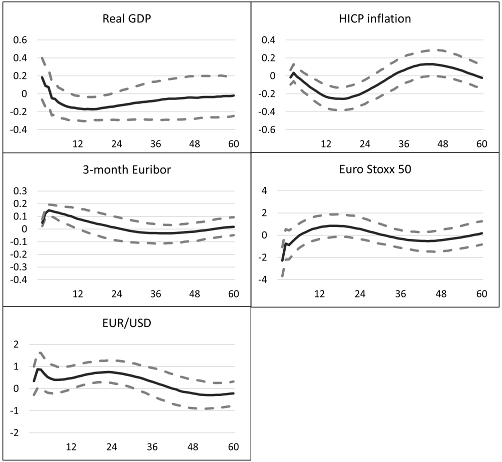
(b) Local projections



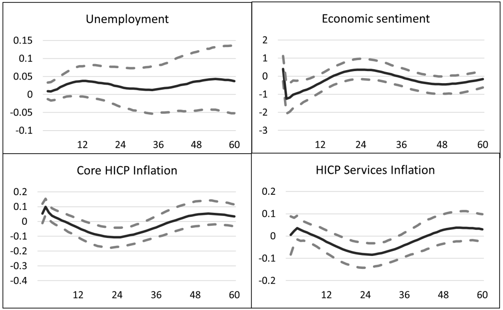
Note: Figures show impulse response functions from a Bayesian SVAR and LPs to the CMP shock, normalized to generate a 5 bps increase in the 3-month EURIBOR. The solid line shows the median response while the dashed region denotes the 68% credible sets (in case of the SVAR) or 90% confidence interval (in case of the LPs).

Baseline estimates also not subject to the omitted variable bias

(a) Benchmark variables



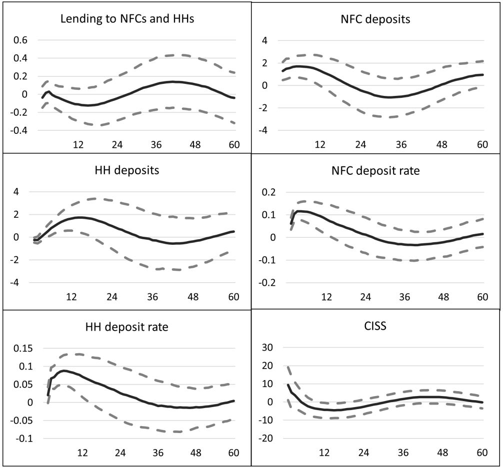
(b) Real economy & prices



Note: Figures show impulse response functions from an extended Bayesian SVAR to the CMP shock, normalized to generate a 5 bps increase in the 3-month EURIBOR. The solid line shows the median response while the dashed region denotes the 68% credible sets.

Baseline estimates also not subject to the omitted variable bias (2)

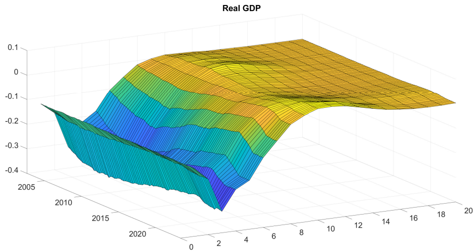
(a) Financial



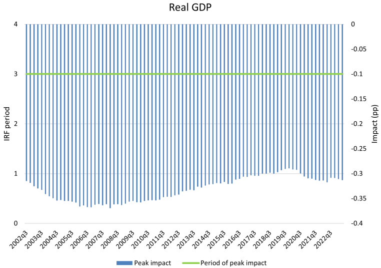
Note: Figures show impulse response functions from an extended Bayesian SVAR to the CMP shock, normalized to generate a 5 bps increase in the 3-month EURIBOR. The solid line shows the median response while the dashed region denotes the 68% credible sets.

Response of output broadly stable over time...

(a) 3D



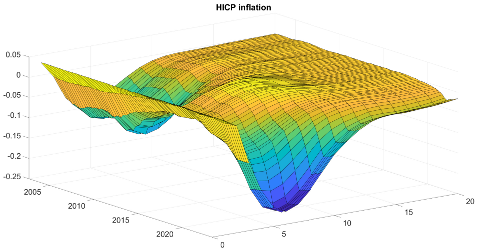
(b) Peak impact & IRF period



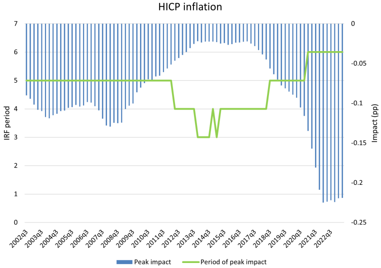
Notes: Figures show impulse response functions from the TVP-SVAR-SV to the CMP shock over period from Q3 2002 to Q3 2023. The shock has been normalized to a 5 bp increase in the 3-month EURIBOR in each period, allowing the estimated elasticities to be comparable over time. All variables are expressed as Y-o-Y growth rates with exception of the 3-month EURIBOR, which enters the model in levels.

... while the reaction of inflation much stronger & more persistent in the current tightening cycle...

(a) 3D



(b) Peak impact & IRF period



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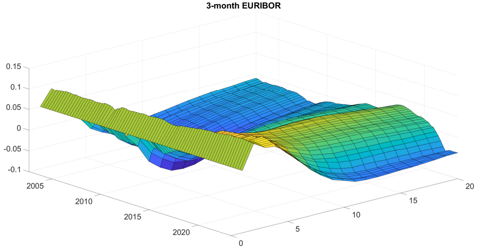
▸ Sub-sample analysis with linear SVAR ▸ Controllling for the cost-push shocks ▸ Results for the core and services inflation

Part of the story - forceful monetary policy response

(a) 3D



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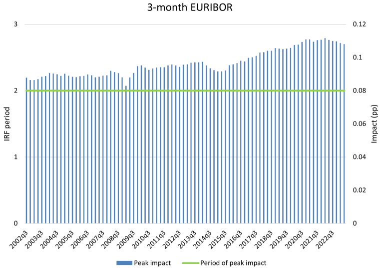

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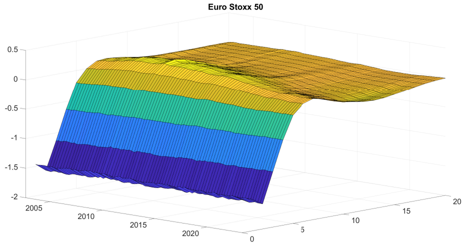
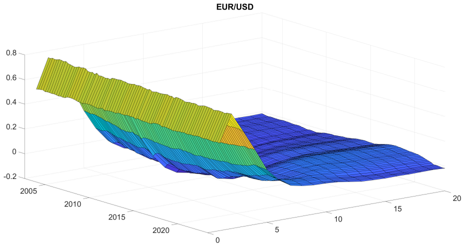
While responses of financial variables largely unchanged over time





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Structural framework

- I rationalize the empirical findings in a medium-scale New Keynesian DSGE model of Sims and Wu (2021), calibrated to the euro area as in Grüning and Zlobins (2023)
- Well suited to pin down potential factors affecting the strength of monetary policy transmission as it features most of the relevant nominal and real rigidities
  - Retail firms set prices according to a variant of **Calvo (1983) price contracts**
  - Wages are also determined via staggered, **Calvo-style wage contracts**
  - Representative household obtains utility from consumption, subject to **habit formation**, and dis-utility from supplying labour
  - Final output is produced by representative wholesale firm, using capital and labor, subject to **utilization adjustment costs** and loan-in-advance constraint
  - Capital production subject to **investment adjustment costs**

The role of MP response

- Conventional monetary policy is implemented via standard Taylor rule with interest rate smoothing:

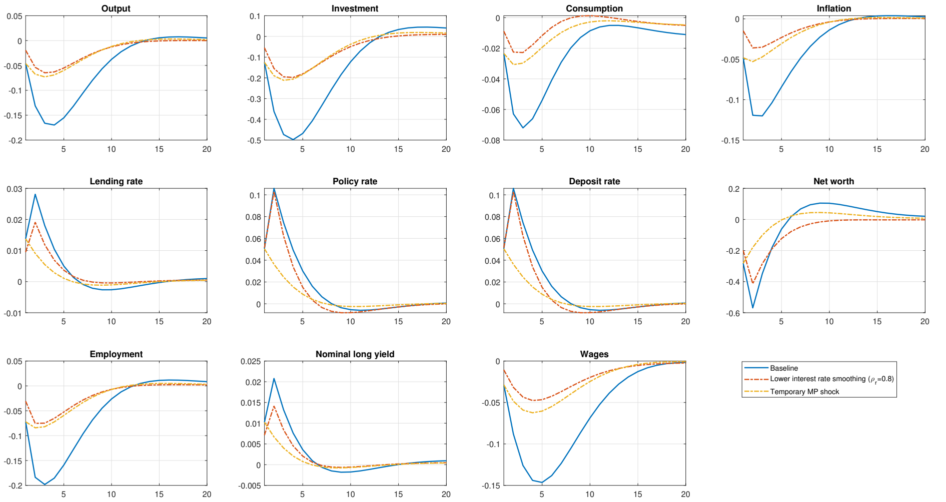
$$lnR_t^{TR} = (1-\rho_r)lnR^{TR} + \rho_r lnR_{t-1}^{TR} + (1-\rho_r)[\phi_\pi(ln\Pi_t - ln\Pi) + \phi_y(lnY_t - lnY_{t-1})] + s_r\varepsilon_{r,t} \quad (1)$$

  where:
  - ρ_r is the parameter governing interest rate inertia
  - ϕ_π and ϕ_y are parameters relating the policy rate's response to inflation and output growth deviation respectively
- In the baseline calibration, these parameters are set to match the values from an estimated, large-scale NAWM II model (Coenen et al. (2018)):
  - $\rho_r = 0.93$
  - $\phi_\pi = 2.74$
  - $\phi_y = 0.1$

The role of MP response (2)

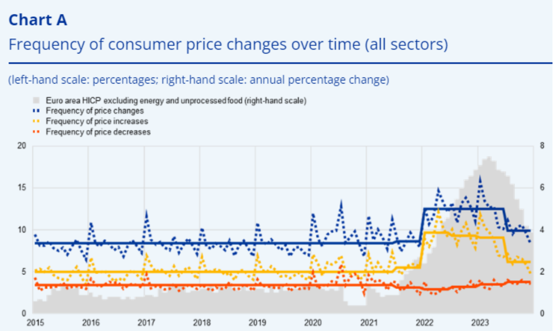
- I then run a simulation with MP shocks to roughly match the profile of empirical IRFs
- In particular, I shock the policy rate in the first two quarters to yield an increase in the interest rate by 5 bps on impact, rising to $\sim$ 10 bps in the second quarter
- In order to examine the role of the MP shock persistence, I create two alternative simulations:
  - Assuming temporary, one-off MP shock (the policy rate is restricted to increase only in the first quarter)
  - Setting $\rho_r = 0.8$ (standard value in the literature)
- The model is solved via a linear approximation about the non-stochastic steady state
  - Following Sims and Wu (2021), exogenous MP shocks are turned off in the steady state, so that it only includes shocks to productivity, liquidity and government spending
  - Thus, the IRFs only reflect the impact of the MP shocks as described above since they are expressed relative to the scenario without any MP shocks

Persistence of the shock - a key determinant of the subsequent outcomes



The role of nominal rigidities: price stickiness

- Post-pandemic inflation surge has been characterized by a substantial increase in the frequency of price changes



Source: Dedola et al. (2024)

- An increase in the frequency of price changes has implications for the price-setting modelling since the Calvo-style contracts assume constant frequency and, *inter alia*, also for the transmission of monetary policy as it implies a steeper Phillips curve (slope of the Phillips curve $\uparrow \Rightarrow$ Sacrifice ratio $\downarrow$)

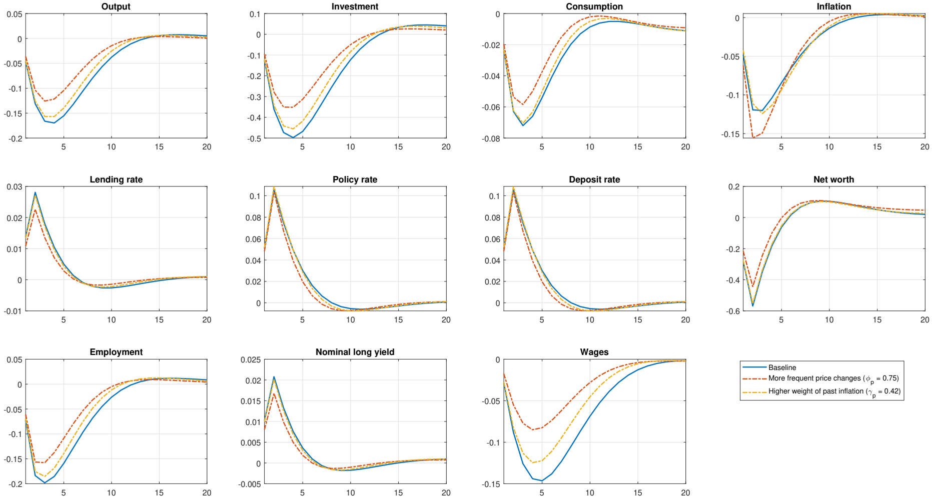
The role of nominal rigidities: price stickiness (2)

- Recall the Calvo setup:
  - In each period, a firm faces a constant probability $1-\phi_p$ to reset its nominal price $\Rightarrow \phi_p$ governs the aggregate price rigidity ($\phi_p \downarrow \Rightarrow$ frequency $\uparrow$)
  - Firms that cannot set their prices optimally simply index to lagged inflation: $\phi_p \, \Pi_{t-1}^{\gamma_p(1-\epsilon_p)} P_{t-1}^{1-\epsilon_p}$ $\Rightarrow \gamma_p$ governs the degree of price indexation ($\gamma_p \uparrow \Rightarrow$ weight of past inflation $\uparrow$)
  - Thus, the aggregate prices evolves as a weighted sum of reset and lagged prices:

$$P_t^{1-\epsilon_p} = (1-\phi_p)(P_t^*)^{1-\epsilon_p} + \phi_p \Pi_{t-1}^{\gamma_p(1-\epsilon_p)} P_{t-1}^{1-\epsilon_p} \tag{2}$$

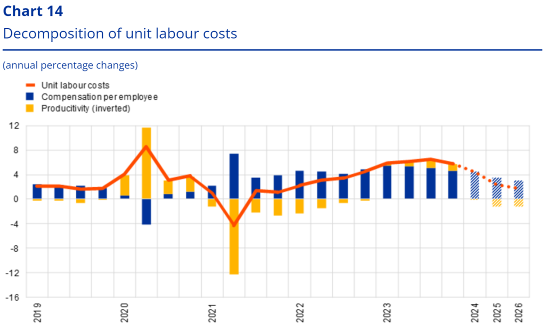
- In the benchmark calibration, $\phi_p = 0.82$ which implies that price contracts are reset every $1/(1-0.82) \sim 5.5$ quarters and $\gamma_p = 0.23$ (as in the NAWM II)
- I run two alternative simulations to pin down the role of price rigidities in the MP transmission:
  - Set $\phi_p = 0.75$, a standard value in the literature, implying average duration of price contracts equal to 4 quarters
  - Set $\gamma_p = 0.42$ as in Warne et al. (2008) (original NAWM)

Increase in price flexibility gives rise to a favourable trade-off for MP stabilization in the current tightening cycle



The role of nominal rigidities: wage stickiness

- Given the strength of the labour market, the recent inflation surge has led to concerns about the emergence of wage-price spiral (see e.g. Lorenzoni and Werning (2023))
- Strong wage growth also often mentioned in recent policy discussions as a risk for sustaining inflation higher-for-longer (see Cipollone (2024) among others)

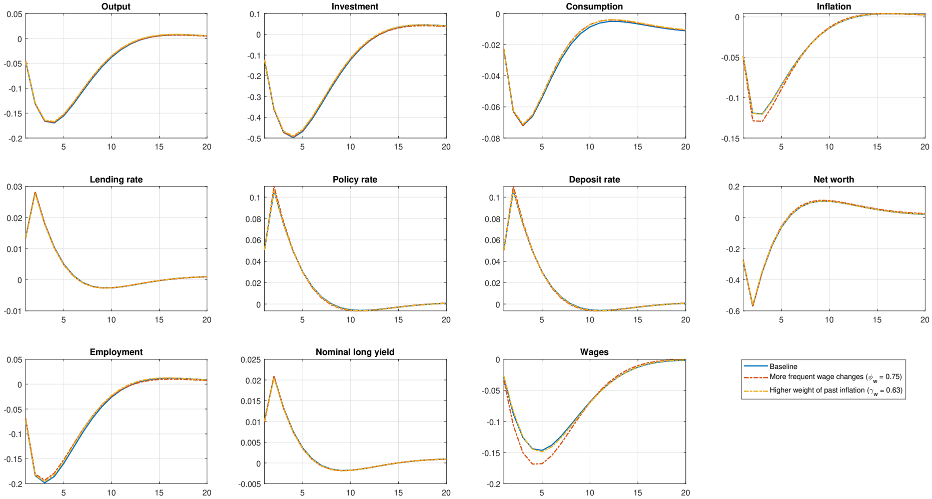


Source: Cipollone (2024)

The role of nominal rigidities: wage stickiness (2)

- Since the wages are set in a similar Calvo-like fashion, a potential implications of more flexible wage-setting for MP transmission can be determined by altering the parameters governing the duration of wage contracts and their indexation to inflation
- In the baseline calibration, $\phi_w = 0.78$, implying and average duration of wage contracts equal to $\sim$ 4.5 quarters and $\gamma_w = 0.37$ (as in the NAWM II)
- I run two alternative scenarios:
  - Set $\phi_w = 0.75$, a standard value in the literature, yielding an average duration of wage contracts equal to 4 quarters
  - Set $\gamma_W = 0.63$ as in Warne et al. (2008)

However, peculiarities related to wage-setting entail little implications for the effectiveness of monetary policy



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Summary

- Overall, the empirical estimates suggest that it takes approximately 12 – 18 months for the MP shock to fully transmit to both output and headline inflation
- While the transmission lags to core and services inflation are longer as full pass-through requires more than 2 years
- In addition, non-linear results show that the effect of monetary policy on output has been broadly stable over two decades of the euro area existence
- However, the response of inflation to policy rate hikes has been much stronger and more persistent in the current tightening cycle
- Structural investigation points out two factors which have contributed to the stabilization properties of monetary policy at the current juncture:
  - forceful central bank response to the post-pandemic inflation surge
  - more flexible price setting, allowing the central bank to engineer a disinflation with smaller output losses

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Econometric framework

- As the baseline model, I employ a structural vector autoregression (SVAR):

$$y_t = C_t + A_1 y_{t-1} + ... + A_p y_{t-p} + \epsilon_t \quad (3)$$

  where C_t is an $n \times 1$ vector of constants, A_j ($j = 1, \ldots, p$) is an $n \times n$ array of coefficients related to the *j-th* lag and ϵ_t is an $n \times 1$ structural error vector with zero mean and variance-covariance matrix Σ
- The model is estimated with standard Bayesian techniques by specifying an independent Normal-Wishart prior
  - The AR coefficient of the prior is set to 0.8, overall tightness $\lambda_1 = 0.1$, cross-variable weighting $\lambda_2 = 0.5$, lag decay $\lambda_3 = 2$, exogenous variable tightness $\lambda_4 = 100$

Econometric framework (2)

- In order to adress the bias in IRFs related to potential VAR mis-specification (Ramey (2016), Nakamura and Steinsson (2018)), I also deploy local projections estimator of Jordà (2005):

$$X_{i,t+h} = \alpha_{i,h} + \theta_h MP_t + \phi_h(L) Z_{i,t-1} + u_{i,t+h} \quad (4)$$

where $X_{i,t+h}$ is the variable of interest, MP_t is an exogenous monetary policy shock, $Z_{i,t-1}$ is a vector of control variables (including lagged values of the variable of interest), $\phi_h(L)$ is a polynomial in the lag operator and $u_{i,t+h}$ is an error term

Econometric framework (3)

- Finally, I extend the SVAR as in equation 3 to allow for time variation both in the parameter space and shock volatilities to pin down potential changes in the transmission mechanism
- For convenience, matrices of SVAR coefficients are stacked into vector:

$$\theta_t = (C_t', vec(A_{1,t})', ..., vec(A_{p,t})') \tag{5}$$

- The time variation of coefficients is then assumed to evolve according to a random walk process:

$$\theta_t = \theta_{t-1} + \upsilon_t \quad \upsilon_t \sim N(0, \Omega) \tag{6}$$

where υ_t is a white noise vector with block-diagonal covariance matrix Ω

Econometric framework (4)

- Additionally, the error covariance matrix is rendered to be period-specific as follows:

$$\Sigma_t = F_t \Lambda_t F_t' \tag{7}$$

where F_t is a lower triangular matrix with a unit diagonal and Λ_t is a diagonal matrix with elements denoted by $\exp(\lambda_{i,t})$ and the log-volatilities $\lambda_{i,t}$ following the AR(1) process:

$$\lambda_{i,t} = \gamma \lambda_{i,t-1} + \nu_{i,t} \quad \nu_{i,t} \sim N(0, \phi_i\ ) \tag{8}$$

where γ is a persistence parameter set to 0.8 for all volatilities and $\nu_{i,t}$ is a white noise error with variance ϕ_i.

Back

Identification via HFI + narrative sign restrictions

- First, we gather high frequency reactions of interest rates and stock prices around the policy announcements from the EA Monetary policy Event Study Database (EA-MPD) of Altavilla et al. (2019)
  - We use both the press release (for conventional policy shocks) and press conference window (for all unconventional policy innovations)
- Then, we include high frequency surprises into the VAR and ensure that they do not depend on their own lags:

$$m_t = a_0 + \sum_{j=1}^{p} 0 \; m_{t-j} + \epsilon_t \tag{9}$$

- The VAR is estimated on a monthly basis with standard Bayesian techniques by specifying an independent Normal Wishart prior
  - We include data since January 2002 to October 2023
  - If several announcements take place during month t, the surprises are summed up as in Andrade and Ferroni (2021), Kerssenfischer (2019)

Identification via HFI + narrative sign restrictions (2)

- In the second step, we apply the following identifying restrictions:

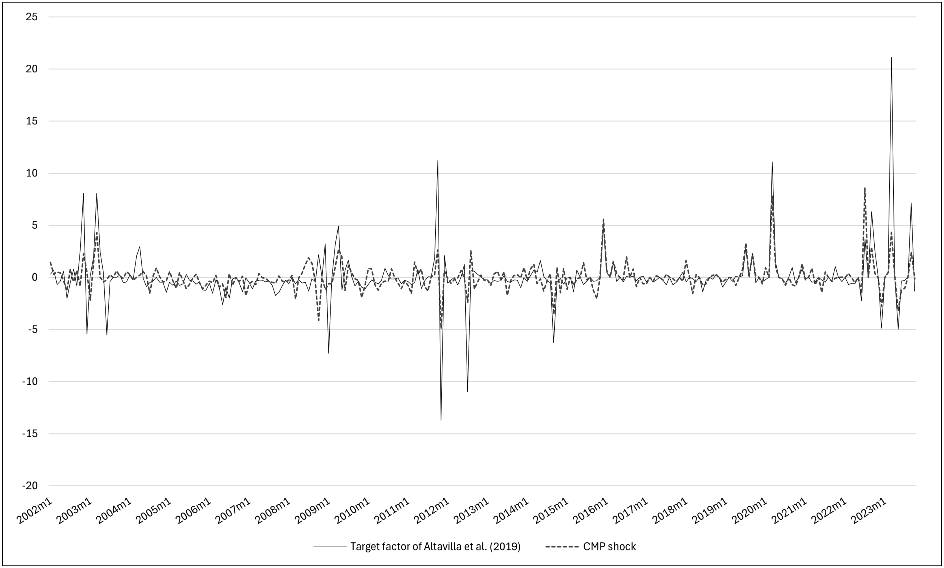
Shock	3-month OIS (press release)	3-month OIS (press conference)	1-year OIS	10-year OIS	10-year IT	Euro Stoxx 50
CMP	-					+
NIRP		-				+
FG			-			+
QE				-	-	+
MS-QE				+	-	+
Information		-	-	-		-

- All restrictions are imposed to hold on impact only
- Additionally, we augment traditional sign restrictions with narrative information about the respective shocks, using the approach of Antolín-Díaz and Rubio-Ramírez (2018)
- In essence, this information is implemented by placing restrictions on the structural disturbances and historical decompositions for key historical events, sharpening the inference

Identification via HFI + narrative sign restrictions (3)

- We use the following narrative restrictions to tell apart the effects of different monetary policy measures:
  - **Narrative Sign Restriction I.** *An expansionary CMP shock took place in November 2011.*
  - **Narrative Sign Restriction II.** *For November 2011, the CMP shock was the overwhelming driver of the unexpected movement in 3-month OIS (press release window).*
  - **Narrative Sign Restriction III.** *An expansionary NIRP shock took place in June 2014.*
  - **Narrative Sign Restriction IV.** *For June 2014, the NIRP shock was the overwhelming driver of the unexpected movement in 3-month OIS (press conference window).*
  - **Narrative Sign Restriction V.** *An expansionary FG shock took place in July 2013.*
  - **Narrative Sign Restriction VI.** *For July 2013, the FG shock was the overwhelming driver of the unexpected movement in 1-year OIS.*
  - **Narrative Sign Restriction VII.** *An expansionary QE shock took place in January 2015.*
  - **Narrative Sign Restriction VIII.** *For January 2015, the QE shock was the overwhelming driver of the unexpected movement in 10-year OIS.*
  - **Narrative Sign Restriction IX.** *An expansionary market-stabilization QE shock took place in September 2012.*
  - **Narrative Sign Restriction X.** *For September 2012, the market-stabilization QE shock was the overwhelming driver of the unexpected movement in 10-year Italian yield.*

Comparison of shock series



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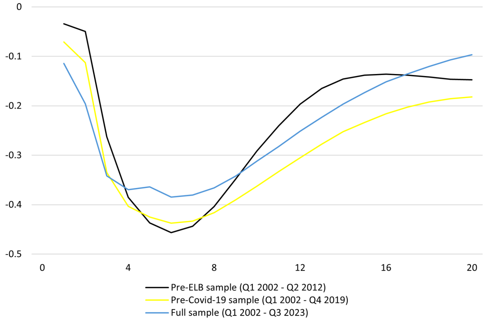
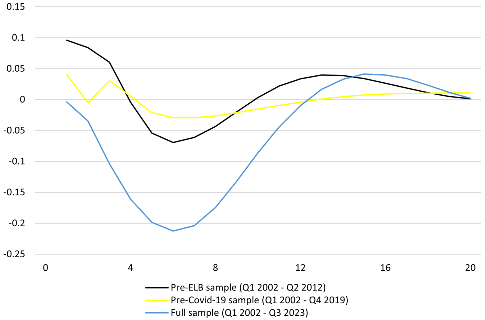
Sub-sample analysis with linear SVAR confirm the results from TVP-SVAR-SV

(a) Real GDP



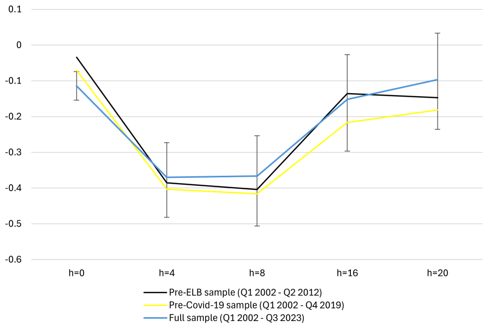
(b) HICP inflation



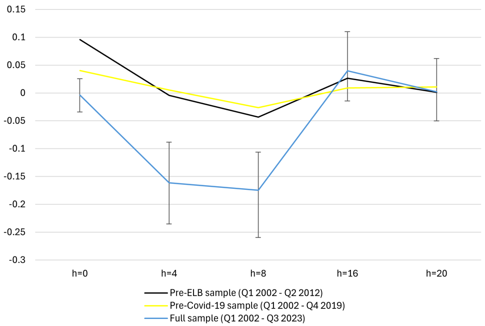
Note: Figures show impulse response functions from a linear Bayesian SVAR, estimated over different sub-samples. IRFs to the CMP shock have been normalized to generate a 5 bps increase in the 3-month EURIBOR, with solid lines showing the median responses.

Sub-sample analysis with linear SVAR confirm the results from TVP-SVAR-SV (2)

(a) Real GDP



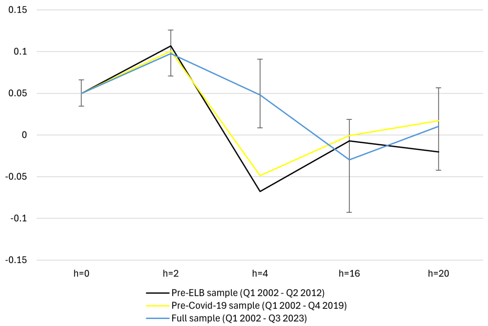
(b) HICP inflation



Note: Figures show impulse response functions from a linear Bayesian SVAR, estimated over different sub-samples. IRFs to the conventional monetary policy shock, obtained via mixture of high frequency information with narrative sign restrictions as in Zlobins (2022), have been normalized to generate a 5 bps increase in the 3-month EURIBOR. Solid lines show the median responses at selected horizons while whiskers denote the 68% credible sets from estimation using the full sample.

Sub-sample analysis with linear SVAR confirm the results from TVP-SVAR-SV (3)

(a) 3-month EURIBOR



Note: Figures show impulse response functions from a linear Bayesian SVAR, estimated over different sub-samples. IRFs to the conventional monetary policy shock, obtained via mixture of high frequency information with narrative sign restrictions as in Zlobins (2022), have been normalized to generate a 5 bps increase in the 3-month EURIBOR. Solid lines show the median responses at selected horizons while whiskers denote the 68% credible sets from estimation using the full sample.

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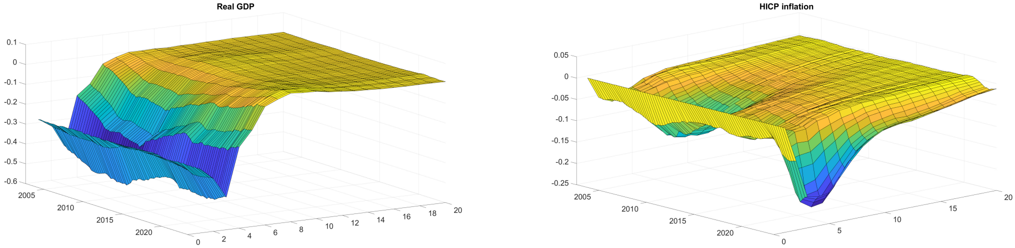
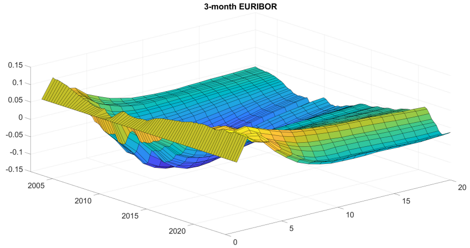
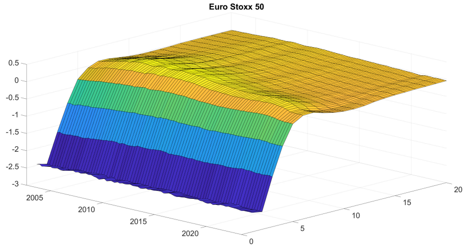
Results remain robust after controlling for the role of cost-push shocks



Notes: Figures show impulse response functions from the TVP-SVAR-SV to the CMP shock over period from Q3 2002 to Q3 2023. The shock has been normalized to a 5 bp increase in the 3-month EURIBOR in each period, allowing the estimated elasticities to be comparable over time. All variables are expressed as Y-o-Y growth rates with exception of the 3-month EURIBOR, which enters the model in levels. Cost-push shocks are captured by including the Brent oil price as endogenous variable in the model.

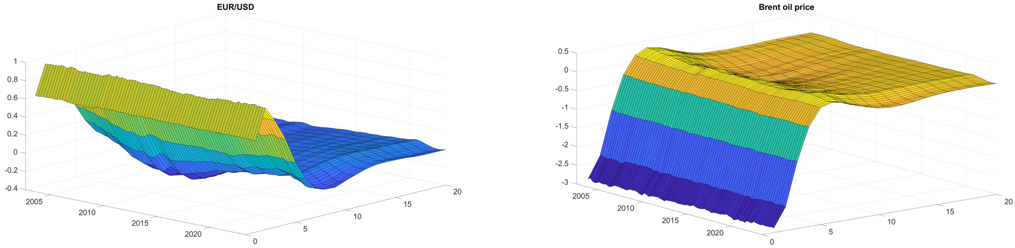
Results remain robust after controlling for the role of cost-push shocks (2)





Notes: Figures show impulse response functions from the TVP-SVAR-SV to the CMP shock over period from Q3 2002 to Q3 2023. The shock has been normalized to a 5 bp increase in the 3-month EURIBOR in each period, allowing the estimated elasticities to be comparable over time. All variables are expressed as Y-o-Y growth rates with exception of the 3-month EURIBOR, which enters the model in levels. Cost-push shocks are captured by including the Brent oil price as endogenous variable in the model.

Results remain robust after controlling for the role of cost-push shocks (3)



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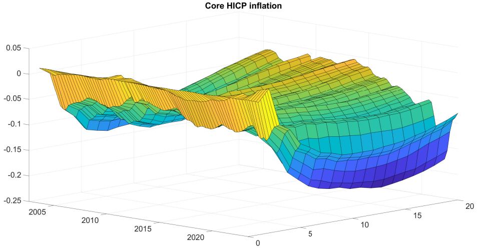
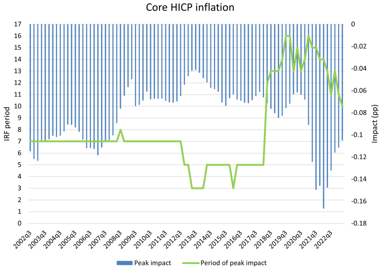
The results hold true also for the core...

(a) 3D



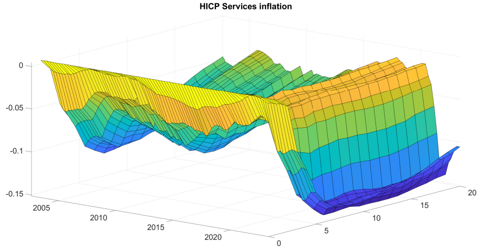
(b) Peak impact & IRF period



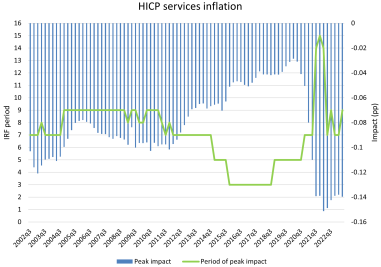
Notes: Figures show impulse response functions from the TVP-SVAR-SV to the CMP shock over period from Q3 2002 to Q3 2023. The shock has been normalized to a 5 bp increase in the 3-month EURIBOR in each period, allowing the estimated elasticities to be comparable over time. All variables are expressed as Y-o-Y growth rates with exception of the 3-month EURIBOR, which enters the model in levels.

... and services inflation

(a) 3D



(b) Peak impact & IRF period



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