Quantifying Financial Stability Trade-offs for Monetary Policy*

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Introduction I

- Financial stability considerations have always played an important role in monetary policy given that financial and price/macroeconomic stability are complementarity policy objectives in general. In specific circumstances, however, both objectives can also come into conflict ("financial stability-monetary policy trade-offs").
- Potential roles of monetary policy in addressing financial stability risks and trade-offs
  - Crisis management: little dispute about central bank as lender of last resort to avert bank runs and systemic liquidity squeezes, despite moral hazard ("cleaning").
  - Crisis prevention: ongoing disagreement as to whether central bank should counteract a financial boom to contain systemic risk ("leaning against the wind" (LAW)).
  - Monetary policy as potential source of financial instability (e.g., risk-taking view, policy transmission through financial-market sentiment (Kashyap and Stein, 2023).

Introduction II

- GFC and subsequent related phenomena raised pertinent questions which intensified the academic and policy debate as to whether, to which extent and how monetary policy should take financial stability considerations into account.
  - Would preemptive monetary policy tightening early in the credit boom have lessened the dramatic macroeconomic and social costs of the GFC?
  - Now that macroprudential policy has been widely established as the first line of defense: is there a complementary role for monetary policy in crisis prevention by leaning against the wind?
  - Did conventional and unconventional monetary-policy easing after the crisis produce excessive financial stability risks as unintended consequences?
  - How to withdraw monetary policy stimulus and tighten standard and quantitative policy given the risks arising from such side effects (e.g., taper tantrum, UK gilt crisis)?
  - Monetary framework or strategy reviews by major central banks (Fed, ECB) revealed need for models to better understand and quantify potential trade-offs between financial stability and monetary policy. (Goldberg et al., 2020, European Central Bank, 2021)

What do we do in the paper?

- We estimate the dynamic interactions between two measures of ex-*ante* and ex-*post* financial stability risks, inflation, real GDP growth and monetary policy rates in the euro area using a structural quantile VAR model (QVAR).
  - QVAR (Chavleishvili and Manganelli, 2023) estimates nonlinear conditional forecast distributions over short- to medium-term horizons
  - Including summary indicators of ex-ante and ex-post systemic risk enables us to integrate a wide range of relevant financial stability constellations into monetary policy analysis.
- We use scenario analysis to quantify the implications of specific financial stability risks for monetary policy and the dynamic costs and benefits of different policy responses to such risks. We distinguish between two potential trade-offs:
  - The *inter*-temporal trade-off or "credit-bites-back" case (Schularick and Taylor, 2012): by tightening during the boom phase (LAW), monetary policy can limit the risks of a financial crisis and the associated downside risks to the economy in the medium term, at the expense of reducing growth and inflation today.
  - The *intra*-temporal trade-off: relates to the short-term trade-off between containing financial turmoil and achieving macroeconomic stability when deciding on the speed of monetary policy tightening (front-loading versus gradualism).
- This overall framework enables us to address all questions related to the role of financial stability consideration for monetary policy mentioned on the previous slide.

Outline

Related literature and contribution I

- Two quotes from the literature:
  - *"Acceptance that monetary policy deliberations should take account of the consequences of the policy decision for financial stability will require a sustained research effort, to develop the quantitative models that will be needed as a basis for such a discussion."* (Woodford, 2012, p. 5)
  - *"How might central banks adapt their monetary-policy processes to take account explicitly of the intertemporal tradeoff we have identified? One suggestion is that policymakers should seek to develop summary measures of financial conditions that are most useful for capturing the kind of credit-bites-back risk we have highlighted."*(Kashyap and Stein, 2023, p. 68)

Related literature and contribution II

- Macro-at-risk, QVAR and counterfactual policy scenarios: Adrian et al. (2019), Adrian et al. (2022), Chavleishvili and Manganelli (2023), Chavleishvili et al. (2021)
    - We blend standard macro-at-risk and dynamic monetary-policy modelling frameworks
    - We apply scenario analysis to address financial stability trade-offs for monetary policy
- Cost-benefit analysis of leaning-against-the-wind policy: Filardo and Rungcharoenkitkul (2016), Svensson (2014), Svensson (2017), Gourio et al. (2018), Brandao-Marques et al. (2020), Richter et al. (2021), Chen and Phelan (2023)
    - Through scenario analysis, we estimate the short- to medium-term costs and benefits of certain LAW policies in terms of paths of the entire conditional forecast densities of all variables of interest
    - We feed the forecast densities into an asymmetric policy loss function to adopt a risk management perspective (Kilian and Manganelli, 2008) which we compare to a standard squared policy loss function.
- Financial stability risks and gradualism in monetary policy: Stein and Sunderam (2018), Cavallino et al. (2022), Kashyap and Stein (2023), Jiang et al. (2023)
    - We introduce the short-run or *intra*-temporal financial stability trade-off
    - We apply our cost-benefit framework to inform monetary policy about the adequate speed of monetary tightening in the face of inflationary pressures and heightened risks of financial distress
    - Empirical counterpart to the theoretical model of Stein and Sunderam (2018)

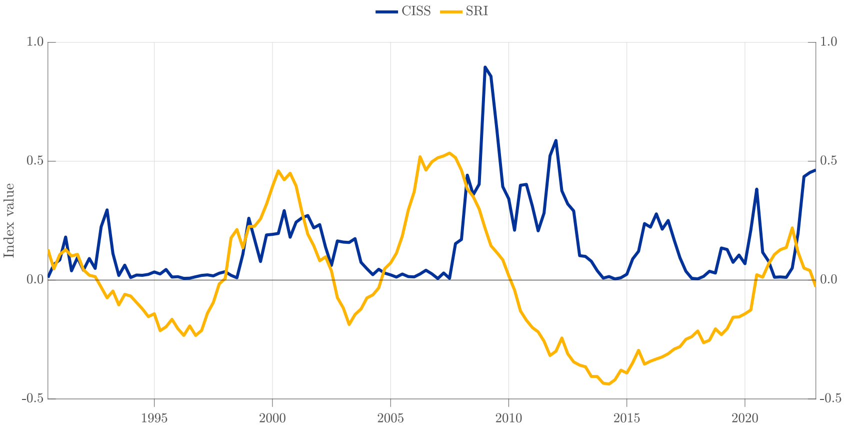
Operationalising financial stability

Financial stability risks ex-ante and ex-post

- Distinguish between two dimensions of financial stability:
  - (i) Systemic risk ex-*ante*, i.e. the risk of a future financial crisis.
  - (ii) Systemic risk ex-*post*, i.e. the severity of a realised financial crisis.
- We capture these dimensions through the ECB's systemic risk indicator (SRI) and the composite indicator of systemic stress (CISS).
  - The SRI (Lang et al. (2019)) gauges trends in system-wide financial imbalances by combining several sub-indicators, most notably linked to 2 to 3-year changes in real asset prices and credit volumes.
  - The CISS (Holló et al. (2012) and Chavleishvili and Kremer (2023)) quantifies the level of systemic stress in the financial system by looking at individual stress indicators (like risk spreads and asset volatilities) covering a broad set of financial markets and financial intermediaries as well as their cross-correlations.
- Dividing financial stability into dormant and realised risks permits us to independently analyse the interactions with monetary policy over medium-term and short-term horizons.

Financial stability in the euro area

Figure 1: Time series of the euro area CISS and SRI, 1990Q2:2022Q4



Source: ECB.
Note: he CISS is constructed to take values between [0; 1] while the SRI is a weighted-average of the following components: two-year change in the bank credit-to-GDP ratio; two-year growth rate of real total credit; two-year change in the debt-service-ratio; three-year change in the residential-real-estate price-to-income ratio; three-year growth rate of real equity prices; current account-to-GDP ratio, see also Holló et al. (2012) and Lang et al. (2019).

Quantile VAR

QVAR model

- Using the quantile regression framework of Koenker and Bassett Jr. (1978), Chavleishvili and Manganelli (2023) formalise the QVAR as

$$Y_t = C^j D_t + A_0^j Y_t + \sum_{p=1}^{P} A_p^j Y_{t-p} + \sum_{s=0}^{S} B_s^j X_{t-s} + \varepsilon_t^j \tag{1}$$

$$F\left(\varepsilon_{i,t}^j < 0 | \Psi_{i,t-1}\right) = j \; \forall \; i = 1, 2, \ldots, K \tag{2}$$

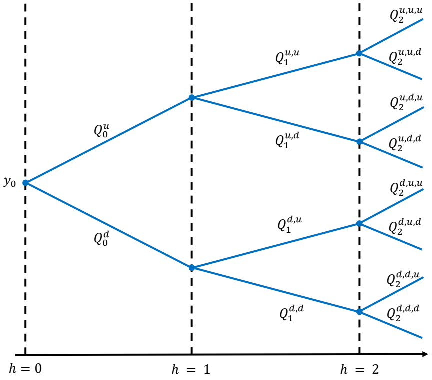
  letting $j \in (0;1)$ be the index of quantiles to be estimated, and where Y_t is a $K \times 1$ vector of endogenous variables, X_t an $M \times 1$ vector of exogenous variables, D_t an $R \times 1$ vector of deterministic terms, ε_t^j the error term at quantile j, and $F(\cdot)$ an unspecified CDF conditioned on information $\Psi_{i,t-1}$.

- For a sufficiently granular set of estimated quantiles, $j \in \eta$, equations (1)-(2) specify the entire joint conditional distribution of the system.

Conditional quantile projection in the QVAR

- To simulate forward, pick a random quantile from η for each variable and each forecast period and use the associated parameter estimates to govern the forward paths.
- Repeat the exercise a sufficiently large number of times until enough of the probability space has been explored (Chavleishvili and Manganelli (2023)).
- Scenario analysis can be done through appropriate restrictions on the quantile paths. Background

Figure 2: Illustration of forward simulation in the QVAR



Source: Own illustration.

Model specification

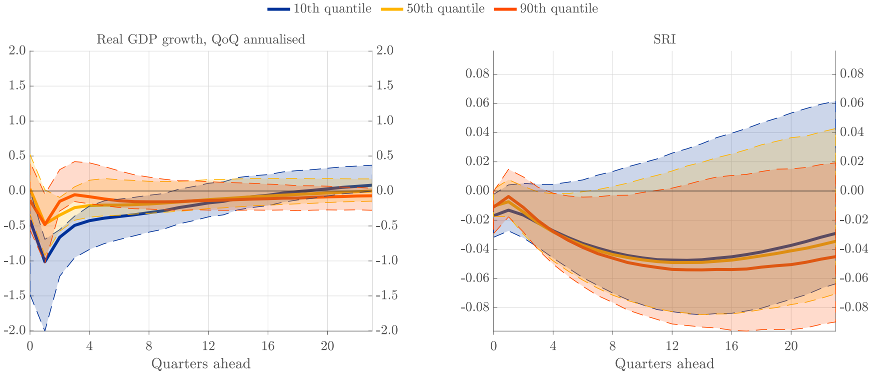
- We estimate the following QVAR:

$$Y = \begin{bmatrix} CISS \\ SRI \\ 400\Delta ln\,(HICP) \\ 400\Delta ln\,(real\ \ GDP) \\ \Delta OIS^{€}_{3M} \end{bmatrix} \qquad X = \begin{bmatrix} 400\Delta ln\,(Cmdt.\ prices) \end{bmatrix}$$

- Estimation over 1990Q1:2022Q4 with $P = S = 2$ lags.
- COVID-dummies for 2020Q1:2020Q4 (Lenza and Primiceri (2022)).
- Zero restrictions on select parameters to:
  (i) ensure that commodity prices reflect supply shocks
  (ii) impose transmission lag of monetary policy
- Recursive identification places the financial block of CISS and the SRI first, followed by the real block of inflation and growth, and the monetary policy block last.

Quantile IRFs: Financial shocks I

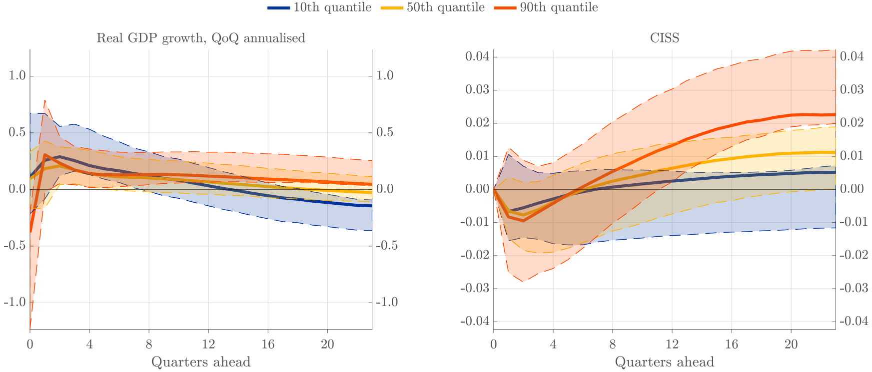
Figure 3: Impact of a CISS-shock on select quantiles of real GDP growth and the SRI



Notes: QIRFs for the SRI (right) and real GDP growth (left) for a CISS shock. Based on 10^6 forward simulations. The shock size equals the standard deviation of the residuals in the CISS equation at the median. Historical median values of the respective time series are used as initial conditions. Shaded areas indicate 95% confidence intervals based on 20,000 forward simulations for each of 20,000 bootstraps for the mean QVAR representation using the residual block bootstrap procedure in Brüggemann et al. (2016) combined with random block length (see Politis and Romano, 1994).
Source: Authors' calculations.

Quantile IRFs: Financial shocks II

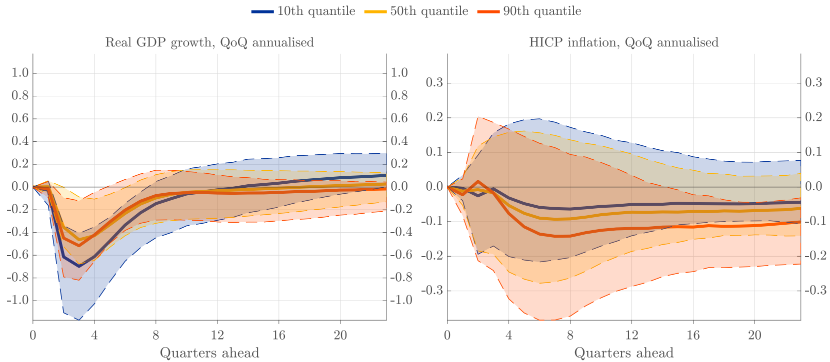
Figure 4: QIRFs for real GDP growth and the CISS following a financial leverage shock



Notes: QIRFs for the CISS (right) and real GDP growth (left) for an SRI shock. Based on 10^6 forward simulations. The shock size equals the standard deviation of the residuals in the SRI equation at the median. Historical median values of the respective time series are used as initial conditions. Shaded areas indicate 95% confidence intervals based on 20,000 forward simulations for each of 20,000 bootstraps for the mean QVAR representation using the residual block bootstrap procedure in Brüggemann et al. (2016) combined with random block length (see Politis and Romano, 1994).
Source: Authors' calculations.

Quantile IRFs: Monetary policy I

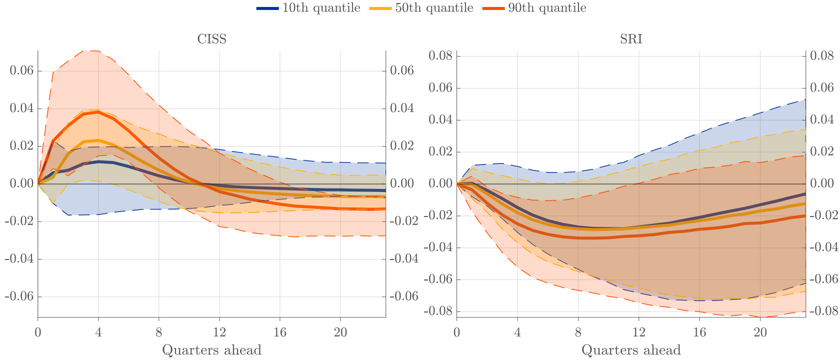
Figure 5: QIRFs of real GDP growth and HICP inflation following a monetary policy shock



Notes: QIRFs for real GDP growth (left) and HICP inflation (right), QoQ annualised values for a monetary policy shock. Based on 10^6 forward simulations. The shock size equals the standard deviation of the residuals in the interest rate equation at median. Historical median values of the respective time series are used as initial conditions. Shaded areas indicate 95% confidence intervals based on 20,000 forward simulations for each of 20,000 bootstraps for the mean QVAR representation using the residual block bootstrap procedure in Brüggemann et al. (2016) combined with random block length (see Politis and Romano, 1994).
Source: Authors' calculations.

Quantile IRFs: Monetary policy II

Figure 6: QIRFs of the CISS and SRI following a monetary policy shock



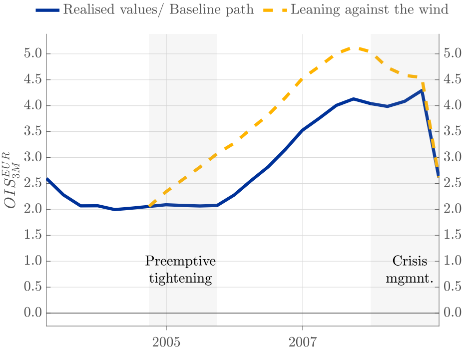
Notes: QIRFs for the CISS (left) and SRI (right), QoQ annualised values for a monetary policy shock. Based on 10^6 forward simulations. The shock size equals the standard deviation of the residuals in the interest rate equation at median. Historical median values of the respective time series are used as initial conditions. Shaded areas indicate 95% confidence intervals based on 20,000 forward simulations for each of 20,000 bootstraps for the mean QVAR representation using the residual block bootstrap procedure in Brüggemann et al. (2016) combined with random block length (see Politis and Romano, 1994).
Source: Authors' calculations.

Scenario analysis: Leaning against the financial cycle

Monetary policy before and during the GFC I

- The GFC scenarios restrict the paths of the SRI and the CISS from 2004 to 2010 with the aim to replicate the historical financial boom-bust pattern.
- Baseline scenario fixes policy rate to its realised path over the projection horizon.
- Counterfactual LAW scenario assumes that interest rate increases by 25 bps each quarter (= +1 pp. in total) during the boom (2004Q4–2005Q3) and decreases by 25 bps each quarter (= -1 pp. in total) during the crisis (2008Q1–2008Q4).

Figure 7: Path of the 3-month EUR OIS rate before and during the GFC in the baseline and counterfactual scenario



Source: ECB, LSEG and authors' calculations.

Monetary policy before and during the GFC II

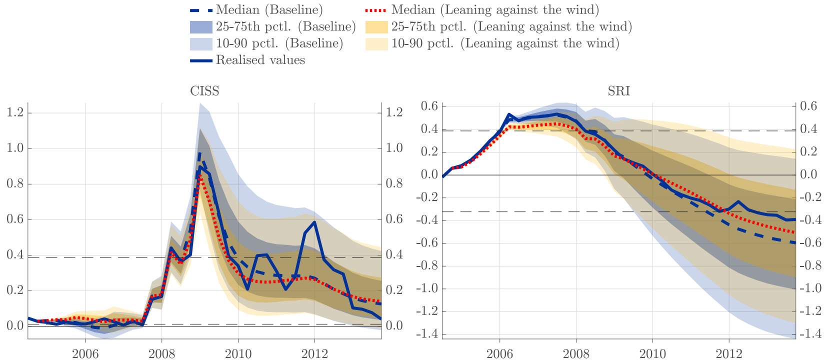
- Counterfactual designed as "modest policy intervention" (Leeper and Zha, 2003) to address the Lucas critique (Lucas, 1976). Policy intervention is neither large nor persistent.
- GFC replicated through appropriate quantile restrictions on the SRI and the CISS (Table 1). Background

Table 1: Conditional quantile realisations for the CISS and SRI

	2004	2005				2006				2007				2008			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
CISS	30	30	35	45	40	30	30	30	20	20	20	85	45	95	30	90	95
SRI	45	80	90	90	90	90	30	60	60	60	60	50	25	25	-	-	-

The financial boom-bust: Leaning against the wind I

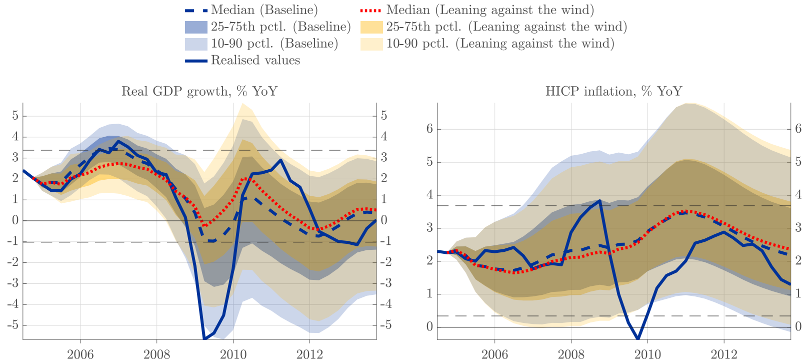
Figure 8: Conditional quantile forecasts of the CISS and SRI over the financial boom and bust in the baseline and counterfactual scenarios



Notes: Based on 10^6 forward simulations using 2004Q3 as forecast origin. Horizontal dashed lines indicate the 10th and 90th uncondtional percentiles, respectively.
Source: ECB, Eurostat and authors' calculations.

The financial boom-bust: Leaning against the wind II

Figure 9: Conditional quantile forecasts of real GDP growth and HICP inflation over the financial boom and bust in the baseline and counterfactual scenarios



Notes: Based on 10^6 forward simulations using 2004Q3 as forecast origin. Horizontal dashed lines indicate the 10th and 90th uncondtional percentiles, respectively.
Source: ECB, Eurostat and authors' calculations.

What drives macro-at-risk? I

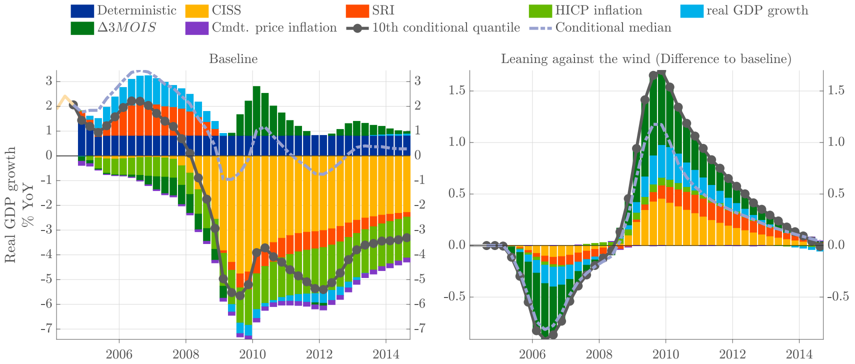
- The QVAR is a non-linear model, and many standard VAR tools such as forecast error variance and historical decompositions can not be immediately applied.
- Use Shapley values (Lundberg and Lee (2017)) as a model agnostic, additive measure to assess, which system variables explain the quantile projections.
- Effectively, we are decomposing the j'th quantile projection of variable i at forecast horizon, h, $Q^j_{i,h}$ into loadings from each feature $f \in \mathcal{F}$

$$Q^j_{i,h} = \sum_{f \in \mathcal{F}} \mathcal{S}^j_{i,h,f} \tag{3}$$

- The Shapley values, $\mathcal{S}^j_{i,h,f}$, are the weighted average contributions of each model feature (variables) in all possible model permutations.
    - Should not be equated to historical decompositions or forecast error variance decompositions from the linear SVAR.

What drives macro-at-risk? II

Figure 10: Shapley value decomposition of the 10th conditional quantile forecast for real GDP growth in the baseline and counterfactual scenario

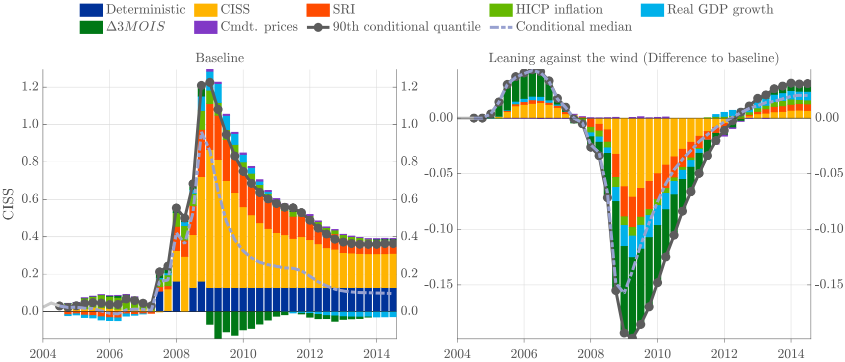


Source: ECB and authors' calculations.

Note: Shapley values are computed jointly for all lags of a given variable. All $K \cdot 2^{K+M}$ model evaluations are based on 50.000 forward simulations and employ the estimated parameters from the full model specification. Parameters are fixed at their full model estimates. 'Deterministic' covers constant terms and, to the extent relevant, exogenous shocks and historical values from conversion of quarterly to annual growth rates.

What drives macro-at-risk? III

Figure 11: Shapley value decomposition of the 90th conditional quantile forecast for the CISS in the baseline and counterfactual scenario



Source: ECB and authors' calculations.

Note: Shapley values are computed jointly for all lags of a given variable. All $K \cdot 2^{K+M}$ model evaluations are based on 50.000 forward simulations and employ the estimated parameters from the full model specification. Parameters are fixed at their full model estimates. 'Deterministic' covers constant terms and, to the extent relevant, exogenous shocks and historical values from conversion of quarterly to annual growth rates.

Gains and losses of leaning against the wind I

- The assessment of tail risks in the QVAR lends itself to the notion of the central banker as a macroeconomic risk manager (Kilian and Manganelli (2008)).
- Consider a monetary policy maker faced with the problem:

$$\min_{\Omega_t} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \rho^t \left[\begin{array}{c} a\mathcal{L}^- \left(\pi_t, \pi^-, \alpha\right) + (1-a)\,\mathcal{L}^+ \left(\pi_t, \pi^+, \beta\right) \\ +w_y b \mathcal{L}^- \left(y_t, y^\bullet, \zeta\right) \\ +w_y (1-b)\,\mathcal{I}\left(y_t > y^\bullet\right)\left(c\mathcal{L}^- \left(y_t, y^-, \gamma\right) + (1-c)\,\mathcal{L}^+ \left(y_t, y^+, \delta\right)\right) \end{array} \right] \right]$$

$$s.t.$$

$$\pi_t = \pi\left(\Omega_t\right),\; y_t = y\left(\Omega_t\right) \tag{4}$$

where ρ is the usual discount factor, $\mathcal{I}(\cdot)$ the indicator function and w_y a relative weight and defining

$$\mathcal{L}^- \left(x, x^*, \varphi\right) = \mathcal{I}\left(x < x^*\right)\left(x^* - x\right)^{\varphi}$$

$$\mathcal{L}^+ \left(x, x^*, \varphi\right) = \mathcal{I}\left(x > x^*\right)\left(x - x^*\right)^{\varphi}$$

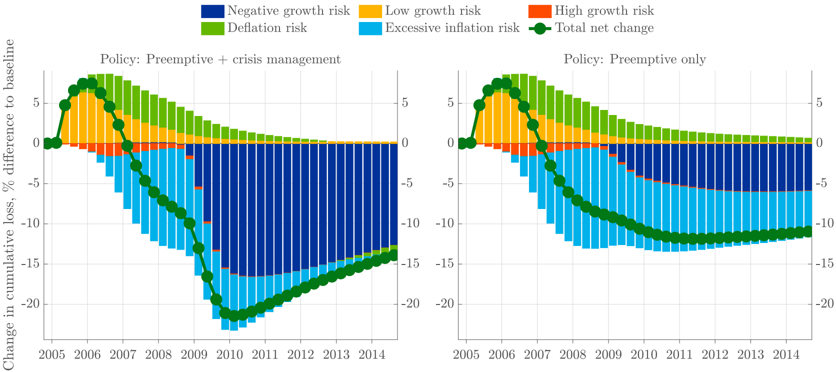
for some stochastic process, x with target x^*.

Gains and losses of leaning against the wind II

- π^-, π^+, y^- and y^+ are a set of thresholds for inflation and output growth, respectively, $y^\bullet \geq y^-$ a level below which output deviations are particularly costly, and $0 \leq a, b, c, \leq 1$ the balance of risks.
- To fix ideas, assume that tolerable inflation lies in the band $[1.75\%; 2.25\%]$, that the central banker cares about avoiding negative, i.e. $y^\bullet = 0$, while the growth target equals the 7-year moving average annual growth rate, $y^- = y^+ = 2.28\%$.
- We assume the central bank cares equally about over- and undershooting inflation, $a = 0.5$, a lot about negative growth, $b = 0.75$, as well as below target, but positive growth, $c = 0.9$. Finally, we set $\rho = 0.98^{\frac{1}{4}}$, $w_y = 0.5$ and $\alpha = \beta = \gamma = \delta = \zeta = 2$.

Gains and losses of leaning against the wind III

Figure 12: Change in expected loss by leaning against the wind



Notes: The figure displays the quarterly differences in the central bank loss function, between a leaning-against-the-wind policy scenario in the context of the GFC, and the baseline scenario. Calculations are based on 10^6 forward simulations using 2004Q3 as the forecast origin.
Source: Authors' calculations.

Scenario analysis on the short-run financial stability trade-off

Short-run trade-off: front-loading vs gradualism I

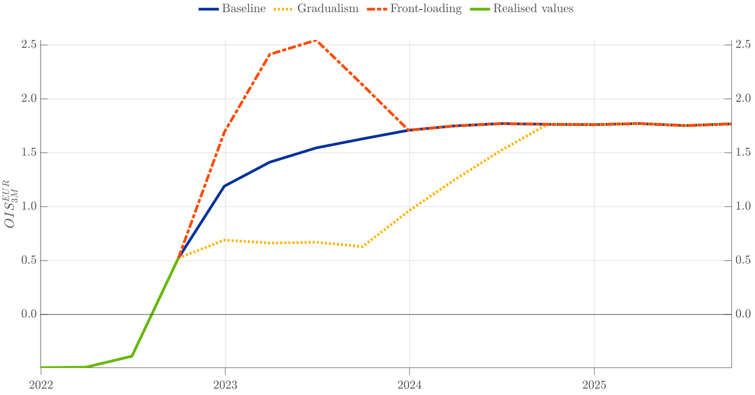
- 2022 saw a global monetary tightening to counteract the partly supply-driven surge in inflation.
- Start of tightening cycle and volatility in commodity markets sparked an increase in financial stress. After years of ultra-low interest rates and quantitative easing, elevated asset valuations and bank profitability may deteriorate disorderly as monetary policy tightening proceeds.
- Short-run trade-off for monetary policy: front-loading policy helps prevent inflation from becoming entrenched but also risks triggering or amplifying stress in the financial system; gradual approach supports financial stability and economic activity growth, albeit at the risk of inflation staying persistently high.
- Large downside risks to growth from elevated financial stress amplifies the usual Phillips-curve trade-off.

Short-run trade-off: front-loading vs gradualism II

- Scenario replicates the macroeconomic outlook at the end of 2022Q3 that the ECB was facing at the time when deciding on the speed and extent of further policy tightening.
- Baseline scenario (2022Q4 to 2026Q4) conditions on continued upward pressure on commodity prices and further interest rate hikes as anticipated by the market.
    - Projections about commodity prices taken from the ECB's publicly available Macroeconomic Projection Exercise (MPE).
    - Interest rate path from ECB's Survey of Monetary Analysts (SMA).
- We also set quantile restrictions on the future paths of inflation and real GDP growth so that they are broadly consistent with the ECB's projections from the MPE at the time.
- Counterfactual scenarios assume 4 consecutive quarters of additional 25 bps increases (front-loading) or decreases (gradualism) in interest rates compared to the market-expected path. This should again ensure a "modest policy intervention".

Short-run trade-off: front-loading vs gradualism III

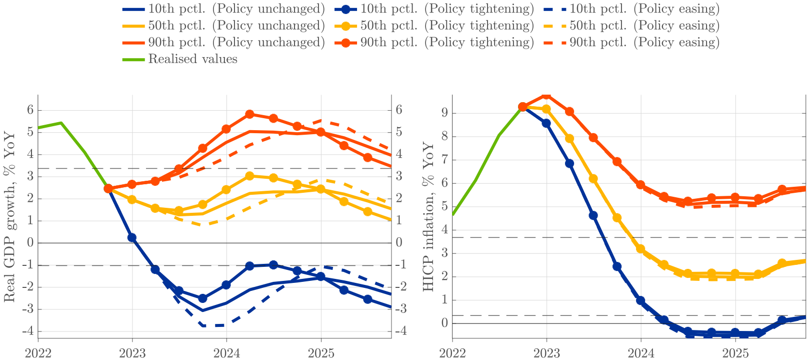
Figure 13: Expected 3-month EUR OIS rates in the baseline, front loading and gradualism scenarios



Source: ECB, LSEG and authors' calculations.

The intratemporal trade-off between price and financial stability

Figure 14: Conditional quantile forecasts of real variables with and without additional monetary policy measures

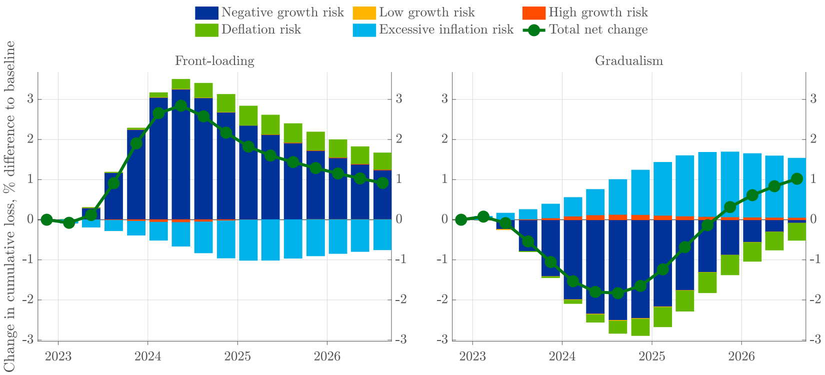


Notes: Based on 10^6 forward simulations using 2022Q3 as forecast origin. Horizontal dashed lines indicate the 10th and 90th unconditional percentiles, respectively.

Source: ECB, Eurostat and authors' calculations.

Expected losses of monetary policy

Figure 15: Change in expected loss by tightening and easing monetary policy



Notes: The figure displays the quarterly differences in the central bank loss function, as defined in equation 4, between a front-loaded (left-hand panel) or a more gradual (right-hand panel) monetary-policy tightening scenario and the baseline tightening scenario in the context of the 2022 inflation bout. Calculations are based on 10^6 forward simulations using 2004Q3 as the forecast origin.
Source: Authors' calculations.

Conclusion

Conclusions

- We present a flexible empirical framework for the consistent integration of financial stability considerations into standard monetary policy analysis.
- By assessing financial stability risks in terms of their potential first-order effects on output and inflation, considering such risks does not require an explicit financial stability objective, nor are they relegated to a mere side show.
- Our focus on tail risks supports the adoption of a risk management approach when monetary policy is confronted with immediate or more distant financial stability risks.
- In scenario analyses, we address the standard intertemporal financial stability trade-off and identify a novel intratemporal trade-off (the underlying financial stability risks are not new, though). We illustrate how our framework can be used to quantify realistic financial stability risks around the baseline macroeconomic projections produced by central banks.
- The framework is general enough to support alternative modelling choices (e.g., econometric model, measurement of financial stability dimensions, monetary policy instruments).

Thank you!

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Background

A: Scenario analysis in the QVAR

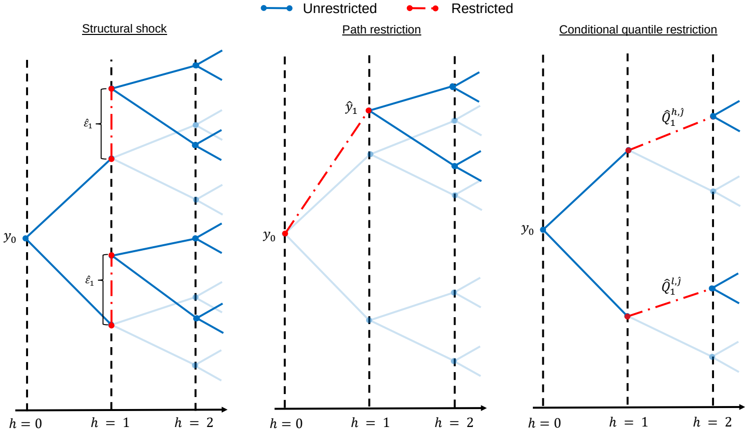
Scenario analysis in the QVAR I

- Knowing how to simulate the model forward, scenario analysis can then be undertaken by either, or through a combination, of:
  (i) A sequence of structural quantile shocks, $\{\tilde{\hat{\varepsilon}}^{j}_{\tau+h}\}_{h=1}^{H}$.
  (ii) Imposing fixed paths for one or more variables, $\{\hat{y}^{j}_{i,\tau+h}\}_{h=\underline{h_i}}^{\overline{H_i}}$.
  (iii) Choosing a quantile path, and consequently the estimation coefficients governing the dynamic properties, for one or more variables, $\{\hat{j}_{i,\tau+h}\}_{h=\underline{h_i}}^{\overline{H_i}}$ where $j_{i,\tau+h}$ is the quantile realisation of variable i.
- Methods 1 and 2 are similar to the linear case of conditional forecasting (e.g. Waggoner and Zha (1999) and Leeper and Zha (2003)), while method 3 is unique to the QVAR.

Back: QVAR Back: Scenario analysis

Scenario analysis in the QVAR II

Figure A.1: Illustration of scenario analysis in the QVAR



Source: Own illustration.
Notes: The illustration for scenario analysis through structural shocks and path restrictions assumes that the restrictions are applied equally across quantiles.

Back: QVAR Back: Scenario analysis