BANCA D'ITALIA
EUROSISTEMA

Questioni di Economia e Finanza

(Occasional Papers)

Credit strikes back: the macroeconomic impact of the 2022-23 ECB monetary tightening and the role of lending rates

by Antonio Maria Conti, Stefano Neri and Alessandro Notarpietro

October 2024

Number 884

BANCA D'ITALIA
EUROSISTEMA

Questioni di Economia e Finanza

(Occasional Papers)

Credit strikes back: the macroeconomic impact of the 2022-23 ECB monetary tightening and the role of lending rates

by Antonio Maria Conti, Stefano Neri and Alessandro Notarpietro

Number 884 – October 2024

The series Occasional Papers *presents studies and documents on issues pertaining to the institutional tasks of the Bank of Italy and the Eurosystem. The* Occasional Papers *appear alongside the* Working Papers *series which are specifically aimed at providing original contributions to economic research.*

The Occasional Papers *include studies conducted within the Bank of Italy, sometimes in cooperation with the Eurosystem or other institutions. The views expressed in the studies are those of the authors and do not involve the responsibility of the institutions to which they belong.*

The series is available online at www.bancaditalia.it .

ISSN 1972-6643 (online)

Designed by the Printing and Publishing Division of the Bank of Italy

CREDIT STRIKES BACK:
THE MACROECONOMIC IMPACT OF THE 2022-23 ECB MONETARY TIGHTENING AND THE ROLE OF LENDING RATES

by Antonio M. Conti*, Stefano Neri** and Alessandro Notarpietro**

Abstract

This paper assesses the transmission of the European Central Bank's (ECB) 2022-23 monetary policy tightening to the euro-area economy, focusing on the cost of credit to non-financial corporations (NFCs). Three results are of particular interest. First, during the 2022-23 tightening cycle, key interest rates increased much more and at an unprecedented pace compared with previous tightening episodes, and the transmission to the credit market was more pronounced. Second, the results of a BVAR model-based analysis show that banks' risk perception is an important factor in explaining the stronger transmission of the 2022-23 monetary policy tightening to the cost of credit compared with previous episodes of monetary policy tightening. Third, simulations based on both BVAR and DSGE models show that the 2022-23 tightening is likely to have a further downward impact on real GDP growth and inflation in 2024. The bank lending channel is identified as a significant contributor to the macroeconomic effects of monetary policy tightening.

JEL Classification: E32, E37, E51, E52, C32.

Keywords: monetary policy, bank lending channel, Bayesian VAR models, DSGE models.

DOI: 10.32057/0.QEF.2024.884

* Banca d'Italia, International Relations and Economics Directorate.

** Banca d'Italia, Economic Outlook and Monetary Policy Directorate.

1. Introduction[1]

In the summer of 2021, euro-area inflation woke up after many years. The large and sustained rise in inflation demanded a strong and exceptionally swift monetary policy response from the ECB (see Neri, 2024). The process of normalizing monetary policy began in December 2021. The Governing Council announced the end of the net asset purchases under the PEPP starting from March 2022 and the gradual reduction of those under the APP from the second quarter of 2023. In July 2022, the ECB began raising the policy rates. By September 2023, the ECB had raised its policy rates by 450 basis points (bps). Over the same period, the composite cost of borrowing on new loans to non-financial corporations (NFCs) increased by more than 350 bps.

The assessment of the macroeconomic impact of a monetary policy tightening is crucial for the calibration of its stance. This is particularly important in the face of significant and prolonged supply-side shocks, such as those that have hit the euro area in 2021 and 2022. In these circumstances, there is a trade-off between stabilizing inflation and preventing the de-anchoring of long-term inflation expectations, and reducing the impact of the shocks on economic activity and employment.

The objective of this paper is threefold. The first objective is to undertake a comparative analysis of the monetary policy tightening cycles of 2005-07 and of 2022-23, with a focus on the behaviour of banks' lending policies. Secondly, the paper analyses the determinants of the increase in lending rates over the latter tightening cycle, distinguishing between the impact of monetary policy and the rise in banks' lending margins. Thirdly, the paper presents a quantitative assessment of the macroeconomic impact of the 2022-23 tightening.

The analyses performed in the paper are based on two different types of models. First, we run counterfactual simulations using a Bayesian Vector Autoregressive (BVAR) model, with the aim of reconstructing the main determinants of the evolution of banks' lending rates over the two monetary tightening episodes of 2005-07 and 2022-23. The methodology is based on conditional forecasting, as in Giannone et al. (2019). We then use an extended BVAR framework similar to the one used in Altavilla et al. (2016) and Crump et al. (2024) and an estimated dynamic stochastic general equilibrium (DSGE) model that incorporates a banking sector (Gerali et al. 2010) to quantify the macroeconomic effects of the most recent tightening, with a focus on the role of the banking sector in the transmission of the monetary impulses.

The results are as follows. Compared to the 2005-07 tightening cycle, in 2022-23 key interest rates increased much more and at unprecedented speed, amidst a very uncertain macroeconomic environment, and the transmission of the policy rate hikes to credit markets was particularly strong.

[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 thank Fabio Busetti, Michele Caivano, Alessio De Vincenzo, Alessandro Secchi, Federico Maria Signoretti, Fabrizio Venditti and Roberta Zizza for useful comments.

Banks' risk perception was a major driver of lending rates in 2022-23 and contributes to explaining the stronger transmission of monetary policy to the cost of credit compared with past historical episodes. According to the BVAR and DSGE model-based simulations, the 2022-23 tightening would have reduced output growth by about 1 percentage point (pp) in 2022, between 3.5 and 5 in 2023, and around 2 in 2024, with a reduction in inflation by 0.5-1.0 pp in 2022, about 3 to 4 pp in 2023, and 2 to 3.5 in 2024. The banking channel exerted a substantial contribution to the macroeconomic effects of the tightening.

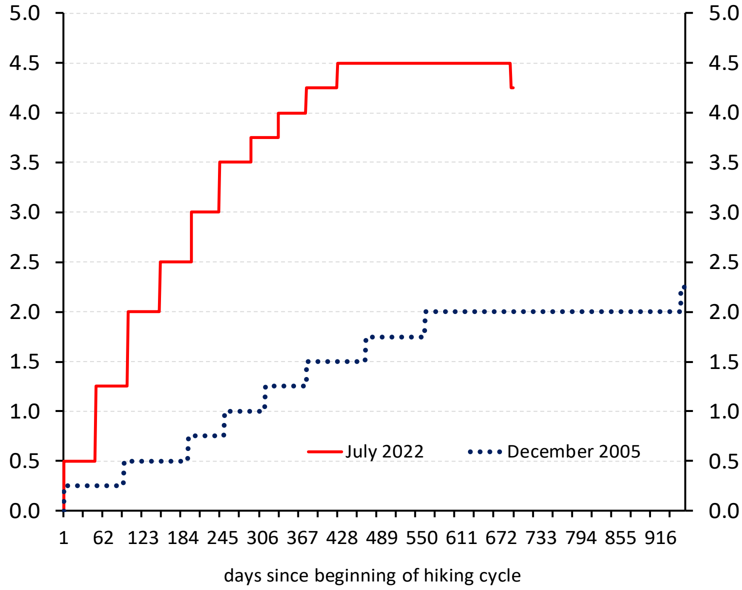
The remainder of the paper is structured as follows. Section 2 compares the 2005-07 and 2022-23 tightening cycles. Section 3 studies the transmission of monetary policy to lending rates to NFCs in 2022 and 2023. Section 4 quantifies the macroeconomic impact of the 2022-23 tightening cycle. Section 5 offers some conclusions. The Appendix presents robustness and further results.

2. The 2005-07 and 2022-23 tightening cycles

The 2005-07 and 2022-23 tightening cycles were different in terms of pace and magnitude of the increases in the ECB's policy rates (Figure 1). The two hiking cycles also occurred in very different macroeconomic environments in the euro area.

The first hiking cycle started in December 2005. The Main Refinancing Operations (MRO) rate had remained at 2 per cent since June 2003, when the ECB's Governing Council reduced it by 50 bps to counter downside risks to economic growth. Between December 2005 and June 2007, the MRO rate was raised by 200 bps. The last rate hike was decided in July 2008 to prevent broadly based second-round effects and to counter the increasing upside risks to inflation.

FIGURE 1. Cumulative increase in the ECB policy rate during hiking cycles
(*per cent*)



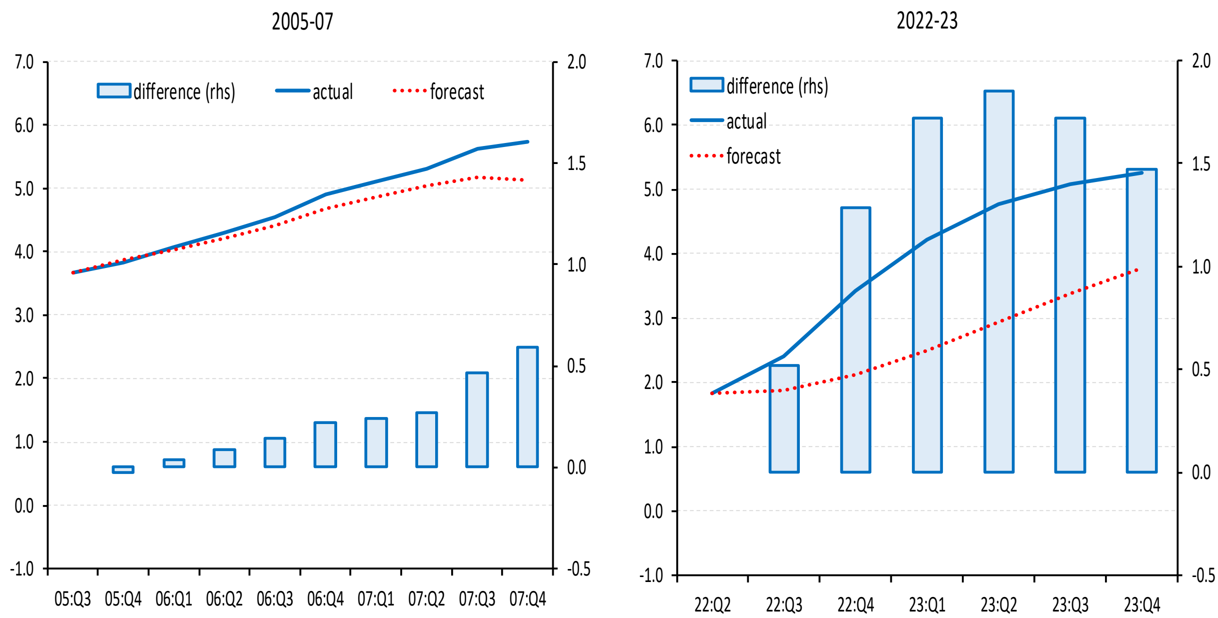
Source: ECB. Latest observation: 14 June 2024.

In the 2022-23 hiking cycle, the normalization of monetary policy began in December 2021, when the Governing Council announced the end of the net asset purchases under the PEPP starting from March 2022, and the gradual reduction of those under the APP from the second quarter of 2023. The ECB began raising the policy rates in July 2022. Since then, the pace and scale of the increases have been unprecedented. The MRO and the other rates (on the Deposit and Marginal Lending facilities, DF and ML, respectively) were raised by a total of 450 bps by September 2023. This cumulative increase is more than twice as large as the one observed during the 2005-07 cycle.

Turning to the euro-area macroeconomic conditions in the two episodes, in the 2005-07 tightening cycle credit supply conditions were protractedly loose and credit demand from both NFCs and households was fuelled by rapid house price growth in some euro-area economies. The 2022-23 cycle was characterized by increasing uncertainty related to the rise in energy prices and the conflict that started after Russia's invasion of Ukraine. As a consequence, the transmission of policy rate hikes to credit markets was markedly different in the two tightening cycles. During the 2005-07 episode, banks only started to tighten lending standards at the end of 2007, after the bursting of the U.S. housing bubble, which had a significant impact on financial markets and banks' risk aversion (see, among many others, Altunbas et al., 2014). By contrast, during the 2022-23 tightening the transmission of the policy hikes to credit markets appeared exceptionally strong from the very beginning, even controlling for the size and speed of rates hikes.

FIGURE 2. LENDING RATES TO NFCS IN THE 2005-07 AND 2022-23 TIGHTENING CYCLES: OUT-OF-SAMPLE FORECASTS

(*per cent and percentage points*) (*per cent and percentage points*)



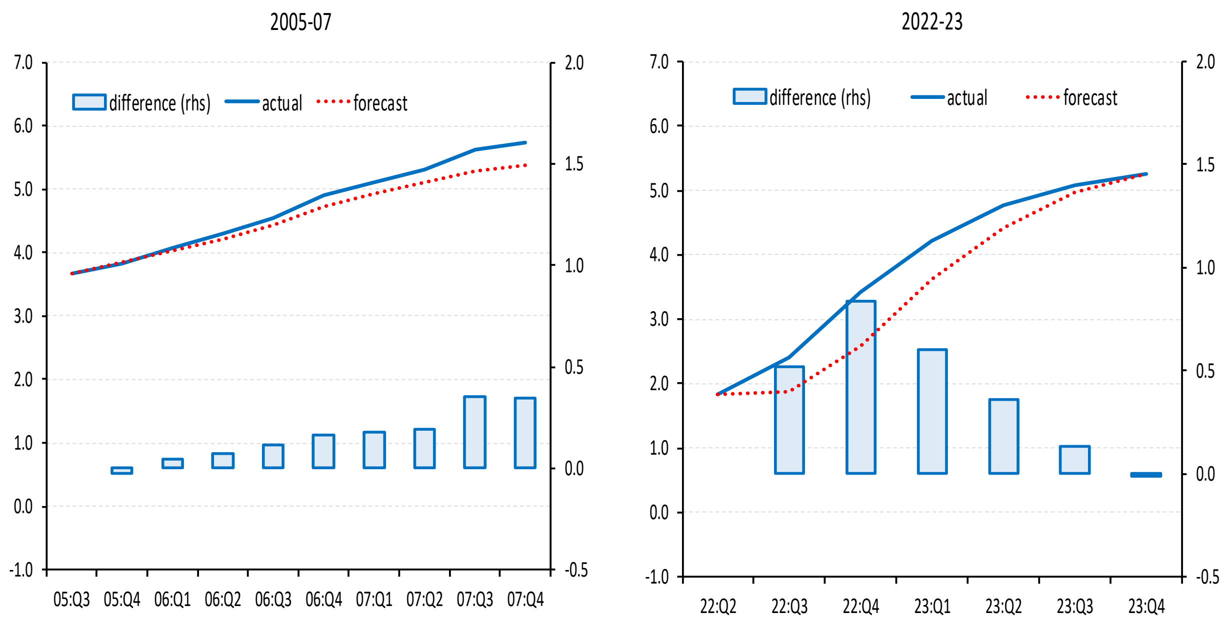
Source: authors' calculations based on ECB data. *Notes*: the sample period goes from 1999:Q2 to 2005:Q3 in the case of the 2005-07 cycle, and from 1999:Q2 to 2022:Q2 in the 2022-23 cycle case. Out-of-sample forecasts are produced starting in the quarter immediately before the first rate hike in each cycle (2005:Q3 and 2022:Q2, respectively).

A simple linear regression of the composite lending cost to NFCs on the overnight rate would produce out-of-sample forecast errors that are very small in the 2005-07 tightening cycle compared to the 2022-23 one (Figure 2).[2] The largest errors in the 2005-07 cycle occur in the last two quarters of 2007, when tensions in financial markets following the burst of the housing bubble in the U.S. and other advanced economies were building up. By contrast, the errors during the 2022-23 tightening cycle are always very large, three times the magnitude of the largest errors in the 2005-07 cycle.

One-step ahead forecasts in the two tightening cycles provide the same message (Figure 3). The absolute value of the errors is, however, smaller than in the previous case, as the model is estimated adding one quarter of data at a time and computing only the one-step ahead forecast. In the case of the 2022-23 cycle, the one-step ahead forecast error for the last quarter of 2023 is almost zero, while it was above 50 bps between 2022:Q3 and 2023:Q1.

FIGURE 3. LENDING RATES TO NFCS IN THE 2005-07 AND 2022-23 TIGHTENING CYCLES: ONE-STEP AHEAD FORECASTS

(*per cent and percentage points*) (*per cent and percentage points*)



Source: authors' calculations based on ECB data. *Notes*: see note to Figure 1.

The unprecedented pace and scale of the increases in the key policy rates in 2022-23 make a comparison with previous tightening cycles particularly difficult. Yet, the differences in out-of-sample forecast errors from a simple linear regression of lending rates over the overnight rate

[2] The estimated equation is: $i_t^L = \alpha + \alpha_{GFC} + \beta i_t^{ON} + \gamma i_{t-1}^L + \varepsilon_t$, where i_t^L is the composite lending cost to NFCs, α_{GFC} is a dummy taking value 1 in 2008:Q4 and 2009:Q1, and i_t^{ON} is the overnight rate. The error term ε_t is assumed to be i.i.d. and normally distributed. Including the 10-year IRS in the equation does not qualitatively alter the comparison between the two tightening cycles. Adding the lagged value of the overnight rate to the equation improves the forecasting performance of the model in the 2022-23 case, but the errors are still significantly larger than in the 2005-07 case.

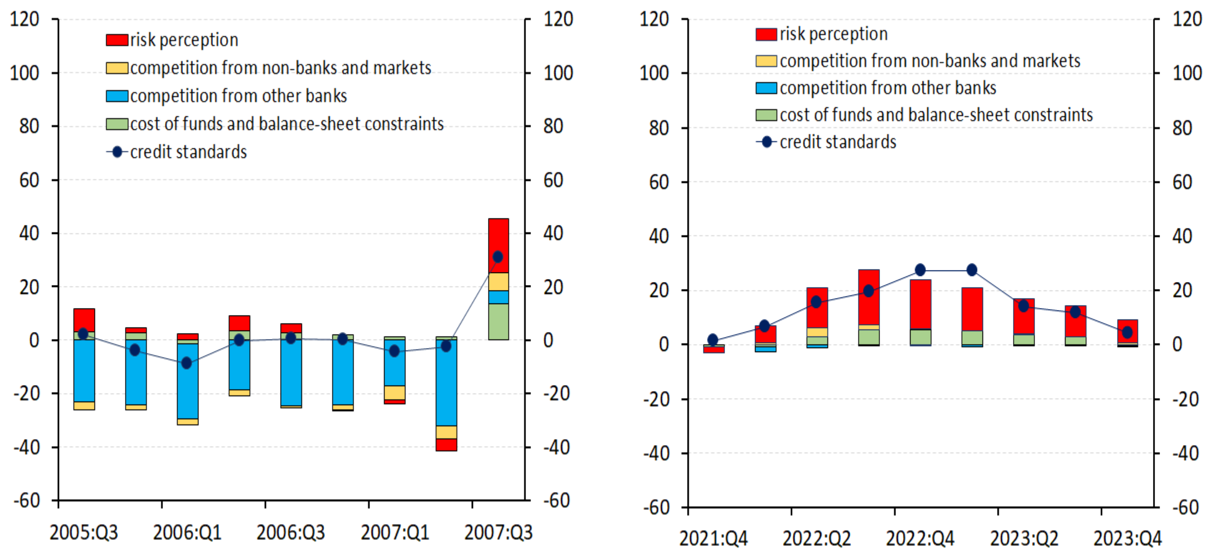
suggest that additional factors beyond monetary policy may have been at play during the 2022-23 tightening cycle.

At least two important differences emerge when comparing the economy at the onset of the 2005-07 and the 2022-23 tightening episodes: risk perceptions and liquidity levels in the system. During the latter tightening cycle, risk perception evolved dramatically as policy rates hikes unfolded, rapidly becoming the main driver of banks' lending decisions. Liquidity holdings of both banks and the private sector were exceptionally large at the onset of the tightening. These resulted in part from the ECB asset purchase programs, in part from the generous fiscal support to the private sector during the pandemic, which households and NFCs stored predominantly as banks deposits. Both features are in stark contrast with the 2005-07 tightening cycle.

The different evolution of banks' risk perception in the two tightening cycles has been suggested as a possible explanatory factor for the differences in banks' lending behaviour (Lane, 2023). In the 2005-07 cycle, banks were competing for granting loans to NFCs and households in a context of limited perception of borrowers' riskiness, as shown by Bank Lending Survey (BLS) data (Figure 4, left-hand panel). By contrast, in the 2022-23 tightening cycle, the perception of borrowers' riskiness led to a progressive tightening of credit standards right after the beginning of the normalization of the ECB's monetary policy at the end of 2021 (Figure 4, right-hand panel).

FIGURE 4. DRIVERS OF LENDING STANDARDS IN THE 2005-07 AND 2022-23 TIGHTENING CYCLES

(*net percentages*)

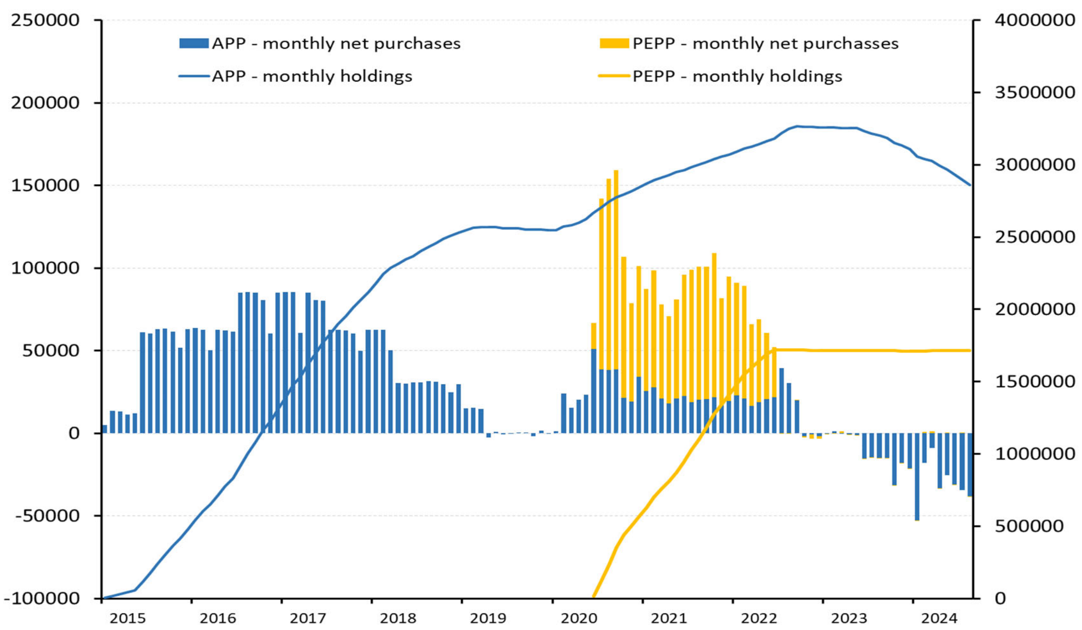


Source: ECB Bank Lending Survey data. *Notes*: The two panels plot credit standards applied to NFCs and the corresponding contributing factors since 2005:Q3 (left-hand panel) and since 2021:Q4 (right-hand panel). Credit standards are defined as the difference between the share of banks reporting a tightening and the share of banks reporting an easing. Thus, positive values denote a tightening, while negative values denote an easing. The net percentages for responses to questions related to contributing factors are defined as the difference between the percentage of banks reporting that the given factor contributed to a tightening and the percentage reporting that it contributed to an easing.

Turning to the availability of central bank liquidity and credit conditions, there is little evidence in the literature on their relationship. Lane (2024) shows that banks' liquidity plays a role in the transmission of monetary policy to bank lending conditions. Banks with lower excess liquidity are more likely to reduce their supply of credit in response to policy rate hikes, and the increase in their lending rates is likely to be larger.

In addition, a third factor may characterize the 2022-23 cycle. The ECB started reducing the Eurosystem's balance sheet in July 2022, when the APP holdings stood at €3,260 billion, halting the reinvestment of maturing securities within APP (Figure 5). On 14 December 2023, the Governing Council announced the intention to continue to fully reinvest the principal payments from maturing securities purchased under PEPP in the first half of 2024, to reduce the portfolio by €7.5 billion per month, on average, over the second half of the year, and then to discontinue the reinvestments at the end of 2024.

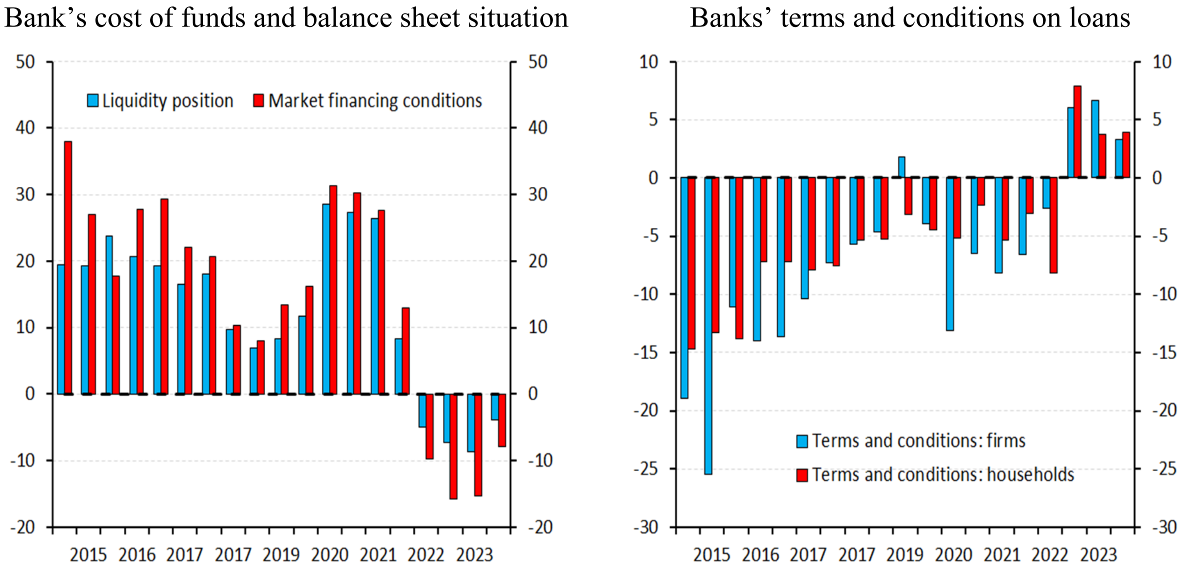
FIGURE 5. EUROSYSTEMS' MONETARY POLICY PORTFOLIOS
(*million euro*)



Source: ECB. *Notes*: monthly net purchases: left-hand scale; monthly holdings: right-hand scale.

As quantitative tightening continues, the transmission of the restrictive monetary policy stance to loan quantities and prices may strengthen. Indeed, the responses to the BLS suggest that, just as asset purchases provided a positive boost to credit and the macroeconomy until 2022, the reduction in the Eurosystem's balance sheet may have exerted a negative impact on banks' liquidity position and an upward pressure on lending rates (Figure 6). This points to a potential drag on aggregate demand.

FIGURE 6. IMPACT OF ECB'S MONETARY PORTFOLIOS ON BANKS



Source: ECB Bank Lending Survey.

Overall, a comparison of the 2005-07 and 2022-23 tightening cycles reveals that during the latter, key interest rates increased much more and at unprecedented speed, amidst a very uncertain macroeconomic environment. Even controlling for such factors, during the latter tightening the transmission of the policy rate hikes to credit markets was particularly strong.

The next section further investigates the possible drivers of the large forecast errors for lending rates to NFCs produced by the simple linear equation in the 2022-23 tightening cycle, by examining the role of banks' risk perceptions and by relying on multivariate models.

3. The transmission of monetary policy to lending rates in the 2022-23 tightening cycle

Simple univariate models have a hard time predicting the evolution of lending rates to NFCs during the 2022-23 tightening cycle, as shown in Section 2. This section shows that adding among the explanatory variables banks' risk perception as measured by the BLS largely improves the forecasting accuracy, suggesting that banks' risk perception was a major driver of the surge in lending rates in 2022-23, and that this additional channel can account for the stronger transmission of monetary policy to the cost of credit to NFCs compared to the 2005-07 tightening cycle.

3.1. The role of risk perception

Multivariate models (VAR and Vector Error Correction) relying solely on the relation between market and lending rates tend to underestimate the cost of credit to NFCs when not appropriately taking into account the sharp increase in banks' risk perception (Bottero and Conti, 2023).

In order to gauge the possible drivers of the overtightening of lending rates in 2022-23 with respect to historical regularities, in this section we carry out two counterfactual exercises using BVAR models. We use the following specification:

$$\boldsymbol{Y}_t = \boldsymbol{c} + \boldsymbol{B}(L)\boldsymbol{Y}_{t-1} + \boldsymbol{u}_t \tag{1}$$

where $\boldsymbol{Y}$ is a vector of endogenous variables, $\boldsymbol{c}$ is a vector of constant terms, $\boldsymbol{u}$ is a vector of normally distributed residuals $\boldsymbol{u}_t \sim N(\boldsymbol{0}, \boldsymbol{\Sigma})$ with variance/covariance matrix $\boldsymbol{\Sigma}$, $\boldsymbol{B}(L)$ is a matrix polynomial in the lag operator L, and t denotes the (quarterly) time frequency.[3]

In the first exercise, we estimate the BVAR including the cost of credit to NFCs, short- and long-term reference rates (the composite cost of borrowing to NFCs; the 3-month Euribor; the 10-year IRS, respectively) over the sample 2003:Q1-2021:Q4. We then feed the model with the realized path of market rates from 2022:Q1 to 2023:Q4 and compute the conditional forecast of lending rates over the same period. The exercise highlights a significant under-prediction of the cost of borrowing for NFCs (Figure 7, panel a; blue line); the forecast error gradually increases to up to about 90 bps (Figure 7, panel b; blue bars). Such under-prediction is consistent with the results reported in panel b of Figure 2 and Figure 3, obtained in a simpler univariate framework.

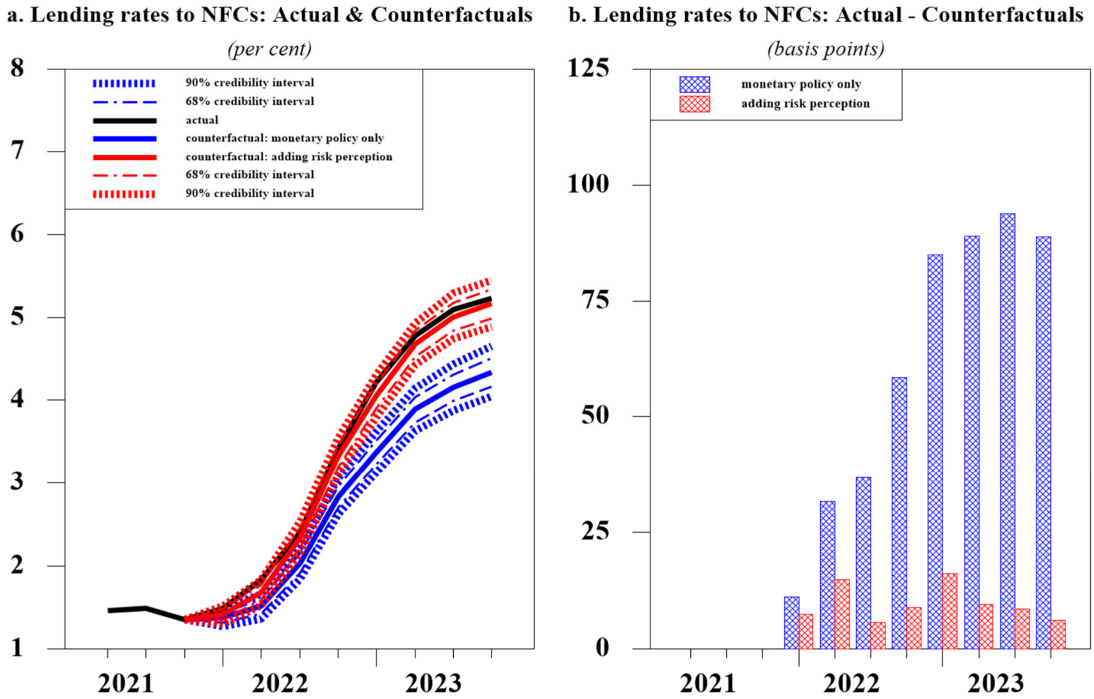
In the second exercise, we repeat the estimation extending the BVAR with the BLS risk perception factor, i.e., banks' evaluation of firms' riskiness as borrowers. Analogously to what done in the first exercise, we then add the actual path of risk perception to those of short- and long-term market rates, and compute the conditional forecast of the cost of credit to NFCs. The results show an almost perfect fit of the realized pattern of lending rates (Figure 7, panel a; cyan line) and, accordingly, much smaller forecast errors (14 bps at the peak; Figure 7, panel b; cyan bars), compared with the baseline VAR specification. The additional increase in the cost of credit with respect to the one implied by the pass-through from short and long-term rates amounts to about 30 and 85 bps, on average, in 2022 and in 2023. The results suggest that banks' risk perception was indeed a major driver of lending rates in 2022-23 and that this channel can rationalize the stronger transmission of monetary policy to the cost of credit to NFCs compared with past historical episodes (see Lane, 2023).

Some remarks are in order. The exercise shows that omitting risk perception from the modelling of monetary policy pass-through to the cost of credit leads to sizeable forecast errors. The exercise is purely reduced-form, as it is silent on the possible drivers of the increase in banks' risk perceptions, which may reflect monetary policy itself or the deterioration in the economic outlook.

[3] The BVAR is a simplified version of the model developed by Conti et al. (2023) for the Italian economy but – similarly to the one used by Auer and Conti (2024) for the euro area – it is augmented with the BLS indicator of banks' risk perception. The availability of the latter constrains the start of the sample to 2003:Q1, while 2023:Q4 was the last quarter available at the start of this project. The model is estimated in levels, as is standard in the literature for interest rates and survey data. The number of lags is p=4. The prior is assumed to be Minnesota, with values for the coefficients related to the overall tightness, the other lags and the decay.

It is likely that both of these factors, possibly interacting with each other, contributed to the heightened risk perception (Hernandez De Cos, 2024).

FIGURE 7. THE ROLE OF RISK PERCEPTION IN DRIVING LENDING RATES DURING THE 2022-23 TIGHTENING CYCLE



Source: authors' calculation based on ECB and LSEG quarterly data. *Notes*: Panel a: Black line: actual evolution of composite indicator of cost of borrowing to euro-area NFCs. Blue straight line: counterfactual obtained from a BVAR including lending rates, short-and long-term reference rates. Blue dashed (dotted) lines: 0.68 (0.90) credible intervals of the counterfactual based on monetary policy only. Red straight line: counterfactual obtained adding to the BVAR banks' risk perception factor from the BLS. Red dashed (dotted) lines: 0.68 (0.90) credible intervals of the counterfactual obtained adding risk perception. Panel b: Blue (red) bars: forecast errors from the corresponding counterfactuals. The estimation sample period goes from 2003:Q1 to 2021:Q4.

3.2. Robustness

The robustness of the findings reported in Section 3.1 is assessed by considering alternative specifications of the BVAR model, including the drivers of tightening in credit supply, prior settings, the importance of Covid-19 data for the conditional forecasts (Lenza and Primiceri, 2022) and a disaggregated look at the short- and long-term component of the composite cost of borrowing. In this subsection we show the results of these robustness checks.

Drivers of credit supply tightening. Figure 7 documents the effects of including risk perception, which behaves in a remarkably different way during the 2005-07 and 2022-23 tightening cycles, according to the replies by financial intermediaries included in the BLS. Alternative or complementary explanations for the different behaviour of lending rates in the two tightening cycles may include a reduced bank competition in 2022-23 compared to 2005-07 and/or a different behaviour of banks in pricing riskier loans (which, however, could be triggered by heightened risk perception). To account for these factors, we repeat the analysis conducted in Section 3.1 by alternatively replacing risk perception with (*i*) a measure of bank competition or (*ii*) margins on riskier loans, and (*iii*) we also extend the BVAR to simultaneously account for both risk perception and bank competition. The results are shown in Figure B2 in the Appendix and can be summarized as follows. First, replacing risk perception with margins on riskier loans and bank competition increases the distance between the realized and the counterfactual lending rates dynamics (Figure B1.a and B1.b). Second, simultaneously accounting for risk perception and bank competition provides an almost identical picture with respect to the baseline (Figure B1.c). All in all, this evidence strengthens the conclusion on the importance of risk perception as a major driver of the cost of credit to NFCs during the 2022-23 tightening cycle.

Priors set-up. In the baseline, we use a simple Minnesota prior with standard settings. As a robustness check, we repeat the analysis with the sum-of-coefficients prior, which allows to better underpin cointegration relations (see Giannone et al., 2015, Aastveit et al., 2017, and references therein). With respect to the use of the Minnesota prior, the distance between observed lending rates and counterfactual ones based on monetary policy only shrinks a bit in 2022. However, results on the role of banks' risk perception are largely confirmed, as its inclusion implies an additional increase in the cost of credit of about 15 bps, on average, in 2022 and over 70 bps in 2023.

Dealing with the exceptional volatility triggered by Covid-19. We repeat all the exercises by estimating the BVAR until 2019:Q4 to address the exceptional volatility triggered by the Covid-19 pandemic. The results are broadly unaffected.

Short and long-term components of the composite cost of borrowing. We repeat all the exercises by using either the short-term or the long-term component of the cost of borrowing. The results show an almost perfect fit for the short-term component and also a significant improvement for the long-term component compared to the model based on market rates only.

After demonstrating the importance of banks' risk perception for the evolution of the cost of credit, in the next section we provide a quantitative assessment of the macroeconomic impact of the monetary policy tightening.

4. The macroeconomic impact of the 2022-23 tightening cycle

The calibration of the monetary policy stance crucially hinges upon the quantitative evaluation of its macroeconomic impact, especially in times of prevailing large and persistent supply-side shocks, such as those that hit the euro area in 2021 and 2022, which lead to a trade-off between the stabilization of inflation and economic activity and raise the risk of a de-anchoring of long-term inflation expectations. An excessive duration of a restrictive phase may cause monetary policy to excessively weaken aggregate demand and bring inflation below its target (Panetta, 2024a).

In this section, we provide a quantitative assessment of the 2022-23 tightening by u economic activity and consumer prices to the BVAR and using a framework analogous to that of Banbura et al. (2015) for the euro area and Crump et al. (2024) for the U.S. We also use an estimated fully-fledged DSGE model with a banking sector (Gerali et al., 2010).

4.1. The BVAR

Conditional forecasts, as those used in Section 3, represent an important connection between the scenario analysis methodology widely employed by central banks and the purely structural approach based on the identification of policy and macroeconomic shocks and computation of impulse responses (Banbura et al. 2015; Crump et al. 2024). In fact, the difference between conditional and unconditional forecasts – or between two alternative conditional forecasts – obtained in the BVAR can be (loosely) interpreted as an impulse response function (IRF).

Even without resorting to a fully-fledged structural scenario *à la* Antolìn-Diaz et al. (2021), the literature has shown how to carefully design such scenarios to narrow down the combination of shocks driving conditional forecasts (Altavilla et al. 2016; Crump et al. 2024).[4]

When interested in evaluating the effects of alternative monetary policies, the researcher can first simulate the model conditional on the realized policy (*tightening scenario*) and then repeat the simulation using a different policy path (*no-tightening scenario*). The difference between the two simulations delivers an estimate of the impact of monetary policy, providing a loose definition of IRFs (see Altavilla et al. 2016 and Crump et al. 2024; for more details, see Appendix B.2).

We apply this methodology to assess the macroeconomic effects of the 2022-23 ECB's monetary policy tightening. In order to quantify the macroeconomic impact of the tightening, we need to rely on a larger BVAR than the one used in Section 3. Specifically, we use an 8-variables model that includes real GDP, the Harmonized Index of Consumer Prices (HICP), short and long-term interest rates (respectively, the 3-month €-STR and the 10-year IRS rate), lending rates to NFCs (the composite indicator of the cost of borrowing, as in Section 3), stock prices (the EURO STOXX, to control for financial conditions and expectations on economic activity, more below), banks' risk perception from the BLS and, lastly, oil prices to take global price pressures into account.[5]

[4] Altavilla et al. (2016) use a multi-country model of the larger euro-area countries to quantify the impact of the Outright Monetary Transactions shock. Crump et al. (2024) develop a comprehensive modelling framework based on a large BVAR of the U.S. economy, in which they design several scenario analyses on monetary and fiscal policy.

[5] The model is again estimated in log-levels, except for interest rates and banks' risk perception which are considered in levels, as usual. The number of lags is p=4. Due to the larger size of the model, we also add a sum-of-coefficient prior as recommended by Giannone et al. (2015). The lending rate to NFCs is the composite indicator of the cost of borrowing, as in Section 3, while the stock prices are given by the Dow Jones €-STOXX.

The estimation sample is 2003:Q1 – 2022:Q2, the last quarter before the first policy hike. The counterfactual analysis is therefore performed starting from 2022:Q3 (i.e., the first period in which the ECB increased the policy rate) with a projection horizon of two and a half years, until 2024:Q4.

As stated above, the evaluation of the 2022-23 ECB monetary tightening is achieved by comparing two scenarios, defined as the tightening and the no-tightening scenarios. The no-tightening scenario is given by financial markets' expectations over, respectively, short- and long-term rates and stock prices available at the end of 2021, before the ECB announcement of discontinuing the PEPP.[6] The tightening scenario, instead, has the features summarized in Table 1. Compared to the no-tightening scenario, there is a shift in the path of short-term market rates by about 400 bps, which broadly reflects the observed overall increase in the policy rate between December 2021 and September 2023 (Assumption A). In other words, the counterfactual no-tightening simulation imposes the path of the short-term rate that financial markets expected at the end of 2021.[7] Moreover, we assume that the rise in the short-term rate is only driven by monetary policy shocks and not by central bank information shocks (Assumption B). The latter could in fact imply a positive co-movement of policy rates with inflation and economic activity (see Jarocinski and Karadi, 2020), which would be at odds with the evidence in the case of a tightening. In order to exclude central bank information shocks, in the no-tightening scenario we impose that future stock prices follow the path implied by financial market expectations as of end-2021, by using synthetic futures prices for the EURO STOXX index.[8]

To further isolate the change in short-term interest rates driven by the ECB policy rate decisions, in the tightening scenario we also impose that real GDP and consumer prices do not respond at the time of the monetary policy shock compared with the no-tightening scenario, although they are allowed to move subsequently. The same assumption is made for banks' risk perception (Assumption C). This is done by assuming that real GDP, the HICP and risk perception share the same impact under both scenarios.

Finally, in order to exclude that the differences between the tightening and the no-tightening scenarios are related to global factors (such as oil prices), we assume that the latter share the same evolution in both scenarios.[9]

[6] The results presented in this subsection are robust to (*i*) estimating the model until 2021:Q4 and (*ii*) using the unconditional forecasts of short-term rates and stock prices obtained from the BVAR model as no-tightening scenario.
[7] We use the technical assumptions on short-term interest rates included in the Eurosystem and ECB staff macroeconomic projections for the euro area of December 2021 and September 2023 in the no-tightening and tightening scenarios, respectively. We do not condition on a specific path of long-term interest rates.
[8] We use the technical assumptions of the Eurosystem and ECB staff macroeconomic projections.
[9] The results are robust to relaxing assumption D by assuming that global factors do not move on impact only.

TABLE 1. ASSUMPTIONS FOR THE TIGHTENING AND NO-TIGHTENING SCENARIOS

Assumption A*: *Shift in the path of short-term market rates   The 3-month rate increases by about 400 bps over the three-year projection horizon under the tightening scenario relative to the no-tightening scenario.
Assumption B: Monetary policy shocks – not central bank information shocks – drive the shift in the path of short-term market rates   Stock prices diminish by about 18% on impact and remain in negative territory over the first two years under the tightening scenario relative to the no-tightening scenario.
Assumption C*: *No other domestic drivers of the tightening beyond monetary policy   Other domestic variables are not allowed to change at the time of the first policy rate hike. Changes in real GDP, consumer prices and banks' risk perception are set to zero on impact, i.e. they are the same under the tightening and the no-tightening scenario.
Assumption D*: *Same path of global factors over the two scenarios   Global factors share the same path in the tightening and the no-tightening scenario.

Notes: the impacts reported for short-term market rates (400 bps) and stock prices (-18%) are obtained comparing their actual paths with those expected by financial markets expected at the end of 2021

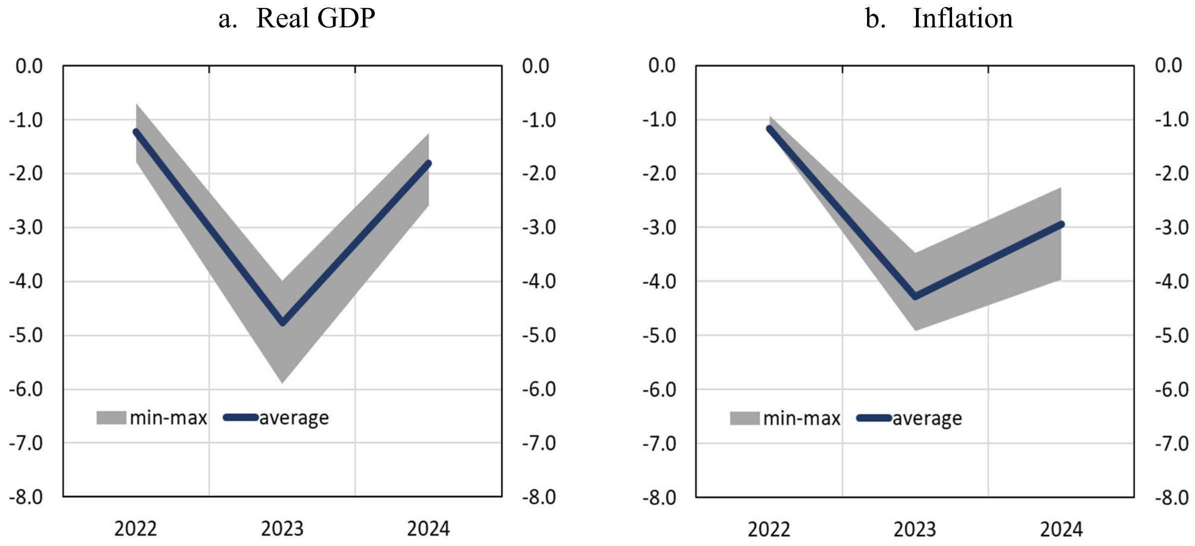
In Figure B2, for each variable we plot the posterior median difference between the tightening and the no-tightening scenario together with the 0.68 and 0.90 credible intervals. The IRFs are well behaved and consistent with our *a priori*. In particular, the size of monetary transmission amounts to about 400 bps, triggers upward pressures on long-term rates and passes-through smoothly to lending rates to NFCs, significantly lowering stock prices and raising banks' risk perception, consistently with the activation of the bank lending channel of monetary policy, particularly strong during the 2022-23 tightening cycle (Lane, 2023; Bottero and Conti, 2023; Hernandez De Cos, 2024; Auer and Conti, 2024). The response of real GDP and consumer prices is sizable and persistent, with their levels remaining below the baseline for about 10 quarters.

To assess the robustness of the results, we consider five alternative specifications that modify our benchmark over several dimensions (replacing the €-STR rate with the 3-month Euribor; replacing the 10-year IRS with either the 10-year German Bund or the 10-year sovereign spread between the German Bund and the Italian BTP; replacing oil prices with a synthetic indicator of energy, which accounts for gas and electricity; using real instead of nominal energy prices). Figure 8 shows the average impact of the monetary policy tightening on year-on-year real GDP growth and inflation together with the minimum and maximum across the various specifications.

According to the BVAR, the ECB tightening would have reduced output growth by about 1 pp in 2022, 5 in 2023, and around 2 in 2024, triggering a reduction in inflation by 1.0 pp in 2022, about 4 pp in 2023, and 2 in 2024.[10]

It is not easy to put these estimates into context, as the debate on the macroeconomic impact of the 2022-23 tightening is still open, and the evidence based on (B)VAR models is sparse at best. D'Amico and King (2023b) report estimates of the effects on the U.S. economy of the tightening operated by the Federal Reserve in 2022-23, based on a VAR model. They show that the total increase in short-term interest rates of more than 500 bps since February 2022 would have lowered real GDP growth by about 1.5 pp in 2022, and about 3 pp in both 2023 and 2024. As for CPI inflation, these figures would be around 1.5 pp in 2022, over 3.5 pp in 2023 and about 3 pp in 2024. Despite the difference in both data and empirical approach, their estimates are in line with our quantitative assessment.[11]

FIGURE 8. MACROECONOMIC EFFECTS OF THE 2022-23 TIGHTENING IN THE BVAR MODEL
(*year-on-year changes; per cent*)



Source: authors' calculations based on the BVAR model. *Notes*: Simulations based on the posterior mean of the distribution of the parameters. The blue line refers to the average impact across six simulations the baseline and the five alternative specifications); the grey shaded areas represent the intervals defined by the minimum and maximum across simulations.

Quantifying the role of risk perception. Using the same framework, we also evaluate the specific role of lending rates in driving the macroeconomic impact of the 2022-23 tightening. In order to assess the contribution of the banking sector, we compare two simulations: (*i*) the tightening

[10] When we repeat the whole set of exercises by estimating the BVAR model until 2019:Q4 to avoid the exceptional volatility triggered by the outbreak of the Covid-19 pandemic, we find a more sluggish and less sizeable response of real GDP growth and inflation. This may possibly reflect changes in the structure of the economy during the most recent period, as suggested in the literature (Cavallo et al., 2024). The latter may have resulted in a faster transmission of the tightening to inflation. We leave the investigation of this point for future research.
[11] D'Amico and King (2023b) run policy counterfactuals based on a structural VAR model that includes measures of both anticipated and unanticipated monetary policy developed by the same authors (D'Amico and King, 2023a).

scenario described above, and (*ii*) the same tightening scenario, in which we additionally impose the path of lending rates that would have been observed absent the activation of banks' risk perception. This counterfactual path of lending rates is lower than the historically observed path by about 30 and 85 bps, on average, in 2022 and 2023, in line with the results of the analysis illustrated in Section 3.1 (see Figure 7b). The results of this exercise are shown in Figure 9.

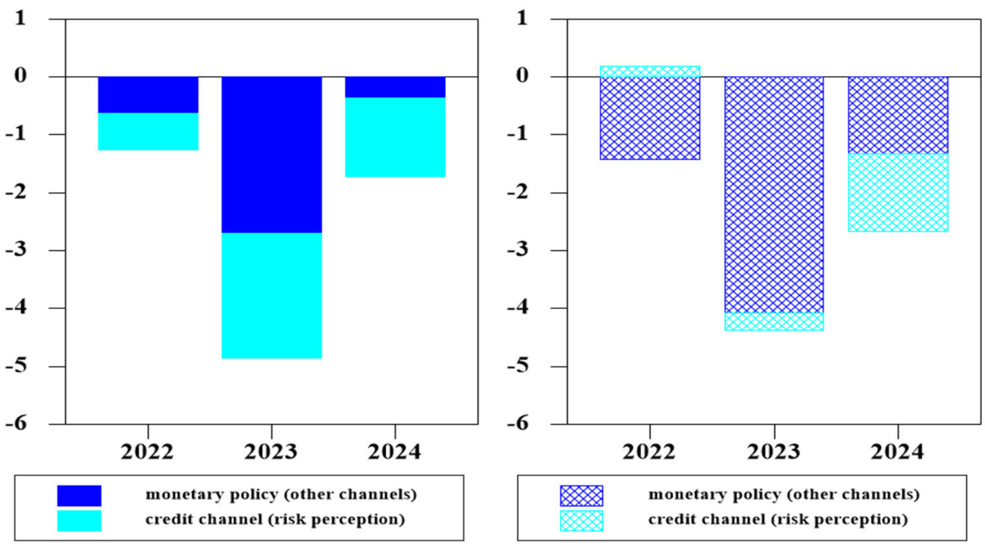
The risk perception channel would have contributed to over 0.5 pp of the reduction in real GDP growth in 2022, almost 2 pp in 2023, and 1.5 pp in 2024 (Figure 9a), while it would have contributed to almost 0.4 pp of the reduction in inflation on average in 2023 and 1.5 pp in 2024 (Figure 9b). Overall, the credit channel exerted a significant contribution to the macroeconomic effects of the 2022-23 monetary policy tightening.

These estimates are broadly in line with the evidence usually reported in VAR models, where the impact of credit shocks on inflation is lagging with respect to the effect on output growth *via* a Phillips curve (see, for example, Altavilla et al. 2019; Bottero and Conti, 2023, where the peak impact on inflation is equivalent to about one fourth of the overall impact on real GDP growth).

FIGURE 9. MACROECONOMIC EFFECTS OF THE 2022-23 TIGHTENING: THE ROLE OF THE CREDIT CHANNEL IN THE BVAR MODEL

(*year-on-year changes; per cent*)

a. Real GDP   b. Inflation



Source: authors' calculations based on ECB and LSEG quarterly data. *Notes*: simulations based on the posterior mean of the distribution of the parameters according the baseline model described in Section 4.1. The cyan bar refers to the average impact of the credit channel (i.e. the effect obtained by assuming that risk perception), while the blue bar refers to the impact of other channels of monetary policy.

4.2. *The DSGE model*

We provide a further quantification of the impact of the 2022-23 tightening based on the model developed in Gerali et al. (2010) (GNSS henceforth). The model features financial frictions and an imperfectly competitive banking sector. Banks issue collateralized loans to both households and firms, obtain funding via deposits, and accumulate capital out of retained earnings. Lending rates depend on the banks' capital-to-assets ratio and on the degree of interest rate stickiness. We update the estimation of the model, adding total hours worked as an additional observable to improve the estimation of the labor market related parameters.

The model is estimated with Bayesian methods using data for the euro area from 1998:Q1 to, alternatively, 2019:Q4 and 2023:Q4. Considering the two alternative sample periods allows us to assess potential instabilities in the posterior distribution of the parameters, likely related to the Covid-19 pandemic and the 2021-22 energy shocks, which may affect the quantification of the effects of monetary policy.

We employ three different detrending methods to extract the business cycle components of the time series with trends. As in GNSS, we use the two-sided Hodrick-Prescott filter (HP-2s) with a smoothing parameter equal to 1600. A well-known drawback of this filter is that, by its two-sided nature, it imposes patterns that are not a feature of the data-generating process and could not be recognized in real time (Hamilton, 2018). A possible remedy is the use of the one-sided HP filter (HP-1s), which would remove by construction the artificial ability to predict the future realizations of a time series. However, one problem with HP-1s is the fact that filtered values at the end of the sample are very different from those in the middle (Hamilton, 2018). This is especially problematic for our analysis, since our sample includes, at its very end, the Covid-19 pandemic and the energy shocks. The last method that we employ is the revised Beveridge-Nelson decomposition (BN henceforth; see Kamber, Morley and Wong, 2018). The proposed filter uses a BN decomposition imposing a low signal-to-noise ratio on an AR(1) model. Figures A1 and A2 in the Appendix show the detrended time series (consumption, investment, hours worked, deposits, loans to households, loans to firms, house prices).[12]

A few remarks are in order. HP-1s provides, by construction, the same results over the sample 1998:Q1-2019:Q4 if applied up until 2019:Q4 or, alternatively 2023:Q4. This is instead not the case for HP-2s, which extracts different cyclical components depending on the sample length, due to the above-mentioned role of "future" realizations in real time. The BN filter instead always extracts different cyclical components if applied to the full sample or, alternatively, up until 2019:Q4. In terms of qualitative behavior of the series, the BN-filtered cyclical variables are rather similar to the HP-1s -filtered, while those extracted by HP-2s tend to overemphasize an expansionary phase in the first part of the sample.

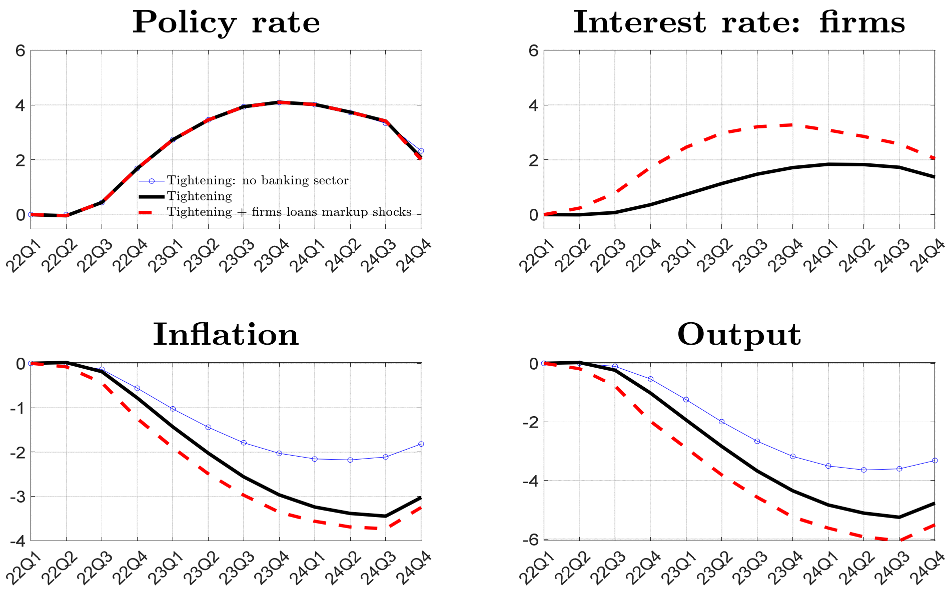
Based on the pros and cons of the different detrending methods, and taking into account the potential implications of the Covid-19 pandemic and the energy shocks for the behavior of the

[12] Figures A5, A6 and A7 provide additional information by reporting the contribution of monetary policy shocks to the historical dynamics of interest rates, output and inflation.

macroeconomic time series used in the estimation exercise, we perform model-based simulations using all six combinations of the three detrending methods and two sample periods.

The simulations allow us to assess the role of the banking sector in the transmission of the 2022-23 monetary policy tightening. We set monetary policy shocks to reproduce the difference between market expectations over the path of the overnight rate as of September 2023 (when the last interest rate increase occurred) and those of December 2021 (when the tightening started, with the announcement by the Governing Council of the end of the net asset purchases). Figure 10 reports the responses of the policy and of the lending rates, output and inflation.

FIGURE 10. MACROECONOMIC EFFECTS OF THE 2022-23 TIGHTENING
(*deviations from the baseline*)



Source: authors' calculations based on the model in Gerali et al. (2010). *Notes*: Each line corresponds to the average effect across six different model parameterizations, each corresponding to an alternative combination of detrending methods and sample periods. In each case, simulations are performed based on the posterior mean of the distribution of the parameters. The policy rate, interest rate on loans to firms, and inflation are in annualized percentage point deviations from the baseline. Output is in percent deviations from the baseline.

The model implies an imperfect pass-through of the monetary policy impulse on banks' lending rates (black solid line in the upper right panel). To allow the model to reproduce the actual path of the lending rates to NFCs, the simulations also include shocks to banks' markup on the rate on loans (red-dashed lines). Such shocks may help capture, among other drivers of the cost of credit, the swift increase in banks' risk perception documented in the previous section, which is not explicitly accounted for by the model. These shocks are added to the simulation of the model with monetary policy shocks. The impact on output and inflation associated with higher lending rates due to the increase in banks' markups is non-negligible. Adding the forecast errors reported in

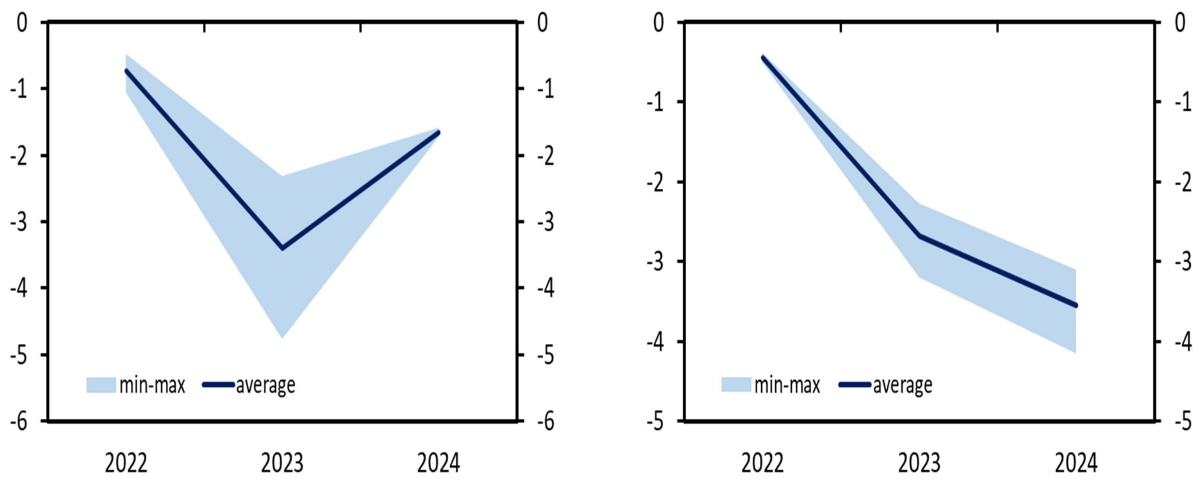
Figure 3 to the path of the lending rates implied by the model (black solid lines) would only cover half of the difference with respect to the observed lending rates.

FIGURE 11. MACROECONOMIC EFFECTS OF THE 2022-23 TIGHTENING

(*year-on-year changes; per cent*)

a. Real GDP growth

b. Inflation



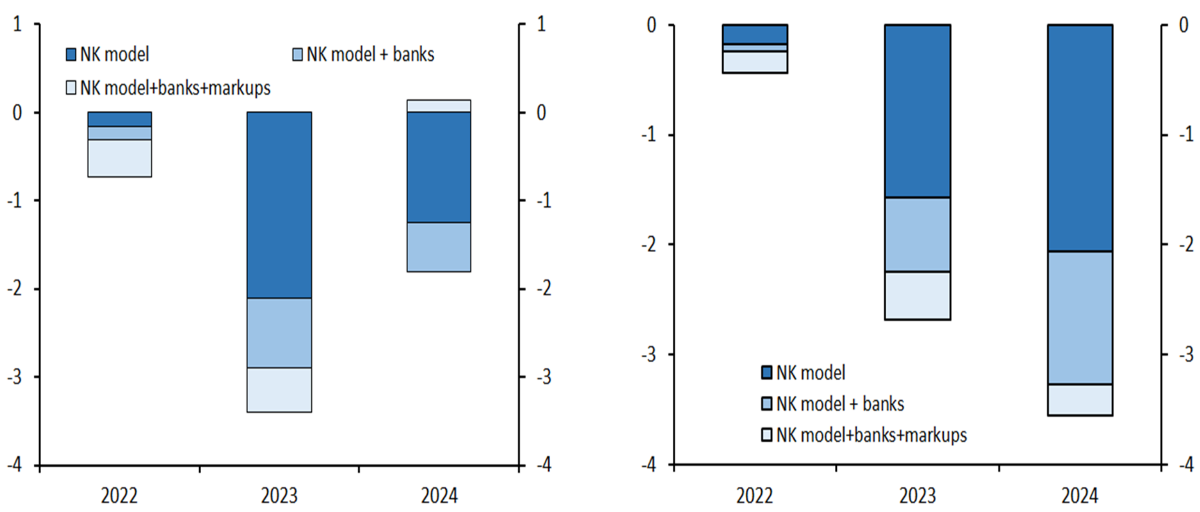
Source: authors' calculations based on the model in Gerali et al. (2010). *Notes*: Simulations based on the posterior mean of the distribution of the parameters. The blue line refers to the average impact across the six simulations; the light blue shaded areas to the intervals defined by the minimum and maximum across the simulation.

FIGURE 12. MACROECONOMIC EFFECTS OF THE 2022-23 TIGHTENING: THE ROLE OF THE BANKING SECTOR

(*percentage point*)

a. Real GDP growth

b. Inflation



Source: authors' calculations based on the model in Gerali et al. (2010). *Notes*: each bar measures the average effects of shocks to the monetary policy and lending rates in the three versions of the model that are considered.

The transmission of monetary policy involves an increase in the cost of credit and a sharp decline of firms' credit demand and investment (not reported). Shutting down the bank lending channel would imply an underestimation of the magnitude of the recessionary effects induced by the policy tightening (blue-circled lines). Figure 11 reports the results of the simulations including the shocks to both the monetary policy rate and banks' markup in terms of year-on-year percentage changes with respect to a baseline scenario.

The tightening would have reduced output growth by almost 1 pp in 2022, 3.5 in 2023, and about 2 in 2024. The corresponding reduction in inflation would amount to 0.5 pp in 2022, about 3 pp in 2023, and 3.5 in 2024. This range of results is broadly in line with the one reported by the ECB using similarly constructed model-based simulations (ECB, 2023). As shown in Figure 12, the banking channel would contribute to about 0.5 pp of the reduction in output growth in 2022, 1 pp in 2023, and almost 0.5 pp in 2024, and to about 1 pp of the reduction in inflation on average in 2023 and 2024. Overall, the banking channel exerted a substantial contribution to the macroeconomic effects of the tightening.

4.3. Discussion

Some caveats are in order. A number of confounding factors may be at play, which render the assessment of the impact of the 2022-23 tightening particularly complicated.

Specific features characterizing the 2022-23 tightening cycle include the ample liquidity available to firms and a relatively high level of households' savings accumulated during the Covid-19 period, as noted in Section 2. The large availability of accumulated liquidity to firms and households could possibly contribute to a reduction in the recourse to bank credit, all other things being equal. While this may point to a lower-than-usual strength of the banking channel, the magnitude of such an effect is difficult to quantify.

Moreover, recent evidence points to an increased frequency of price adjustments in the face of the exceptionally large energy price shocks of 2021 and 2022, which may still have been at play, at least in the early stages of the tightening (Cavallo et al., 2024). With a relatively higher frequency of price adjustment, the impact of the tightening on price inflation would likely be more frontloaded, while the output decline would correspondingly be more muted. Nonetheless, the relative contribution of the banking channel would arguably remain unaltered, to the extent that nominal price rigidities do not directly affect banks' lending decisions.

Last but not least, the resilience shown by the labour market to a slowing economy may cushion the impact of the 2022-23 tightening on economic activity and inflation.

These limitations suggest that the estimates of the macroeconomic effects of the 2022-23 monetary policy tightening should be treated with caution, although, as noted above, they are within the range of those obtained by ECB and Federal Reserve staff in similar exercises based on DSGE and VAR models.

5. Concluding remarks

Since the beginning of 2023, inflation has started to decline after a period of sustained growth, reaching double-digit levels in October and November 2022. Despite the unprecedented rise in consumer prices, long-term inflation expectations have remained anchored at the 2% target, largely due to the ECB's monetary policy response.

In order to avoid unnecessary damage to the economy and to ensure that inflation remains on target, it is essential to assess the macroeconomic impact of monetary tightening in order to calibrate the future stance of monetary policy.

The paper has shown that the increases in the key ECB interest rates by the Governing Council between July 2022 and September 2023 had a significant downward impact on real GDP growth and inflation, partly due to the response of bank credit supply. These macroeconomic effects are still being felt throughout the economy (Panetta, 2024b).

References

Aastveit, K.A., A. Carriero, T. Clark and M. Marcellino (2016). "Have Standard VARs Remained Stable Since the Crisis?", *Journal of Applied Econometrics*, vol. 32(5), 931–951.

Altavilla, C., D. Giannone and M. Lenza (2016). "The Financial and Macroeconomic Effects of the OMT Announcements", *International Journal of Central Banking*, vol. 12(3), pp. 29-57.

Altavilla, C., M. Darracq Pariès and G. Nicoletti (2019). "Loan supply, credit markets and the euro area financial crisis", *Journal of Banking and Finance*, vol. 109(C).

Altunbas, Y., L. Gambacorta and D. Marques-Ibanez (2014). "Does Monetary Policy Affect Bank Risk?", *International Journal of Central Banking*, vol. 10(1), pp. 95-136.

Antolín-Díaz, J., I. Petrella and J. F. Rubio-Ramírez (2021). "Structural scenario analysis with SVARs", *Journal of Monetary Economics*, 117, 798-815.

Auer, S., and A. M. Conti (2024). "*Bank lending in an unprecedented monetary tightening cycle: evidence from the euro area*", Banca d'Italia, Occasional Paper 856.

Bańbura, M., D. Giannone and M. Lenza (2015). "Conditional forecasts and scenario analysis with vector autoregressions for large cross-sections", *International Journal of Forecasting*, vol. 31(3), pp. 739-756.

Bottero, M., and A. M. Conti (2023). "*In the thick of it: an interim assessment of monetary policy transmission to credit conditions*", Banca d'Italia, Occasional Paper 810.

Cavallo, A., F. Lippi and K. Miyahara (2024) "Large shocks travel fast", *American Economic Review Insights*, forthcoming.

Conti, A. M., A. Nobili and F. M. Signoretti (2023). "Bank capital requirements, lending supply and economic activity: A narrative perspective", *European Economic Review*, 151, January.

Crump, R. K., S. Eusepi, D. Giannone,E. Qian and A. Sbordone (2024). "A Large Bayesian VAR of the United States economy". *International Journal of Central Banking*, forthcoming.

D'Amico, S. and T. B. King (2023a). "What does anticipated monetary policy do?", *Journal of Monetary Economics*, vol.138, pp. 123-139.

D'Amico, S. and T. B. King (2023b). "Past and future effects of the recent monetary policy tightening", *Chicago Fed Letter*, 483.

ECB (2023). "*A model-based assessment of the macroeconomic impact of the ECB's monetary policy tightening since December 2021*", ECB Economic Bulletin 3/2023.

Gerali, A., S. Neri, L. Sessa and F. M. Signoretti (2010). "Credit and Banking in a DSGE Model of the Euro Area", *Journal of Money, Credit and Banking* 42, 107-141.

Giannone, D., M. Lenza and G. E. Primiceri (2015). "Prior Selection for Vector Autoregressions", *The Review of Economics and Statistics*, vol. 97(2), 436-451.

Giannone, D., M. Lenza and L. Reichlin (2019). "Money, Credit, Monetary Policy, and the Business Cycle in the Euro Area: What Has Changed Since the Crisis?", *International Journal of Central Banking*, vol. 15(5), 137-173.

Hernandez De Cos, P. (2024). "*Monetary Policy Transmission and the Banking System*", Speech at the Conference "The ECB and its Watchers", Frankfurt am Main.

Jarociński, M. and P. Karadi (2020). "Deconstructing Monetary Policy Surprises—The Role of Information Shocks", *American Economic Journal: Macroeconomics*, vol. 12(2), 1-43.

Lane, P. (2023). "*The banking channel of monetary policy tightening in the euro area*", Remarks at the Panel Discussion on Banking Solvency and Monetary Policy, NBER Summer Institute 2023 Macro, Money and Financial Frictions Workshop, Cambridge, 12 July.

Lane, P. (2024). "*The analytics of the monetary policy tightening cycle*", Guest lecture at Stanford Graduate School of Business, Stanford, 2 May.

Neri, S. (2024). "*'There has been an awakening'. The rise (and fall) of inflation in the euro area*", Banca d'Italia, Occasional Paper 834.

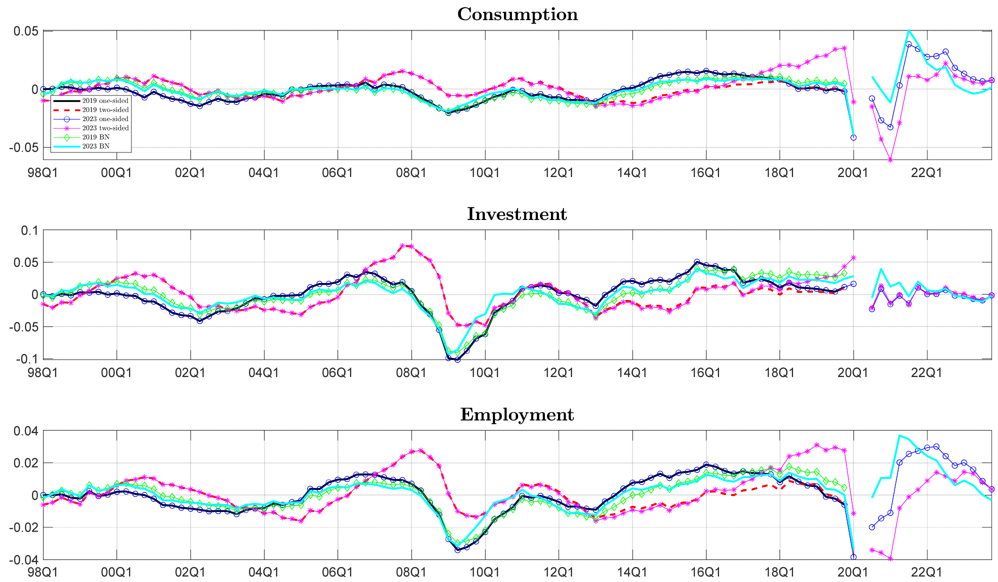
Panetta, F. (2024a). "Monetary policy in a shifting landscape", *Speech* at the Inaugural conference of the ChaMP Research Network, Frankfurt am Main, 25 April.

Panetta, F. (2024b). "Monetary policy after a perfect storm: *festina lente*", *Speech* at the 3rd Bank of Finland International Monetary Policy Conference on 'Monetary Policy in Low and High Inflation Environments', Helsinki, 26 June.

Appendix

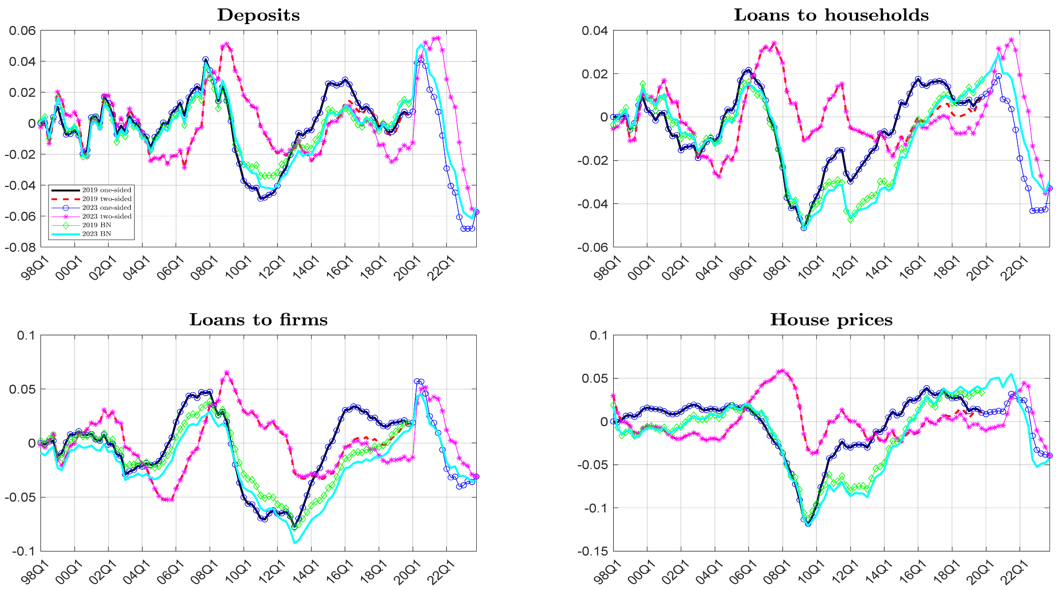
A Data

FIGURE A1. EURO-AREA MACROECONOMIC VARIABLES USED IN ESTIMATION: ALTERNATIVE DE-TRENDING METHODS



Source: Eurostat (see Gerali et al., 2010 for details). *Notes*: Variables are expressed as log deviations from the corresponding filter trend. We remove the observation corresponding to 2020:Q2 due to the outbreak of the Covid-19 pandemic.

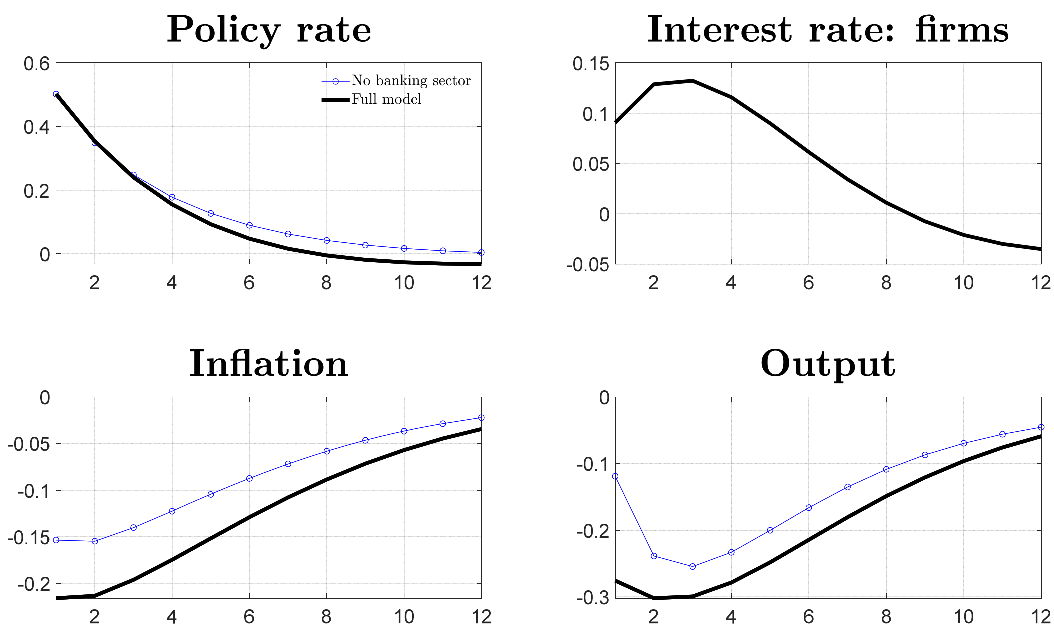
FIGURE A2. EURO-AREA FINANCIAL VARIABLES USED IN ESTIMATION: ALTERNATIVE DE-TRENDING METHODS



Source: ECB (see Gerali et al., 2010 for details). *Notes*: Variables are expressed as log deviations from the corresponding filter trend.

DSGE model. Results reported in section 4 are obtained by simulating changes to the euro-area short-term interest rate expectations between December 2021 and September 2023. The model is perturbed by a sequence of unexpected monetary policy shocks, i.e. shocks to the Taylor rule. Shocks are computed as the difference between the profile of the short-term rate included among the assumptions underlying the September 2023 ECB staff Macroeconomic Projection Exercise (MPE) and those underlying the December 2021 Eurosystem staff Broad Macroeconomic Projection Exercise (BMPE).[13] In each simulation period, agents expect the policy rate to follow the path implied by the Taylor rule, but they are surprised by the imposed policy rate path. Since the path is imposed via unexpected shocks, the forward guidance puzzle does not affect the analysis. In one simulation, the ex-post response of the interest rate on loans to NFC is replicated in a similar way, by means of unexpected shocks to the markup that banks apply to that interest rate. This allows the model to replicate the observed difference between the profile of the composite lending rate on loans to NFCs underlying the September 2023 MPE and that underlying the December 2021 BMPE.

FIGURE A3. TRANSMISSION OF A CONTRACTIONARY MONETARY POLICY SHOCK

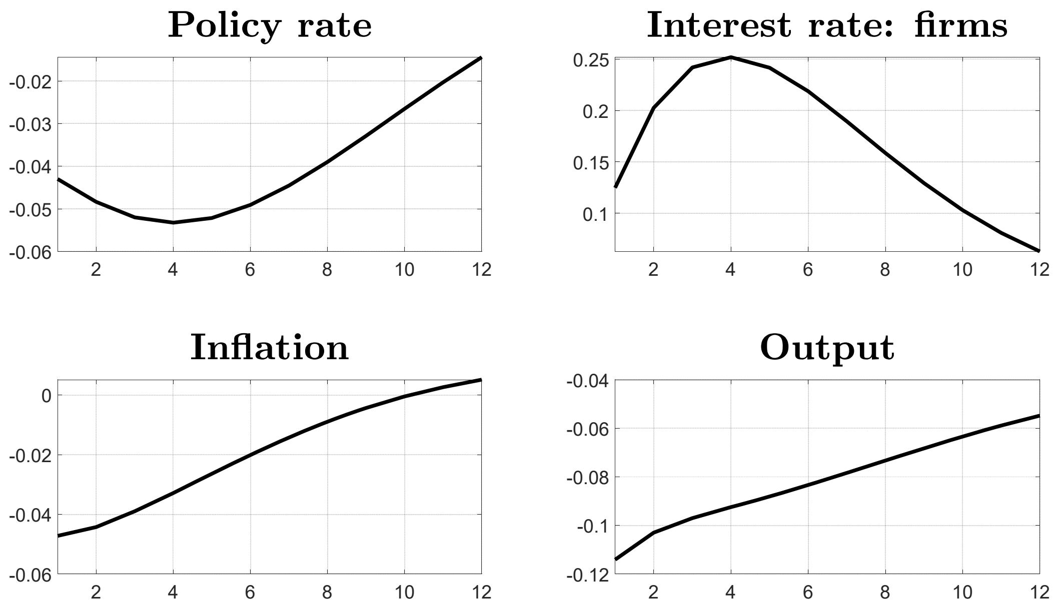


Source: authors' calculations based on the model in Gerali et al. (2010) estimated with data up to 2023:Q4.
Notes: each line corresponds to the average effect across six different model parameterizations, each corresponding to an alternative combination of detrending methods and estimation sample. Simulations are performed based on the posterior mean of the parameters. The policy rate, the lending rate and inflation are in annualized percentage deviations from the baseline. Output is in percent deviations from the baseline.

[13] The assumptions for short-term interest rates are based on future-based expectations of the three-month EURIBOR.

The absence of the banking sector is obtained by assuming, as in Gerali et al. (2010), that the banking sector is perfectly competitive, lending rates are perfectly flexible, and the collateral and debt-deflation channels are de-activated. Figure A3 reports impulse response functions to a standard, unexpected 50 bps increase in the policy rate, both in the benchmark model (black solid lines) and in the no-banking sector setup (blue lines with cross). Figure A4 reports the responses to a shock to the markup set by banks on the interest rate charged on loans to firms. The shock is calibrated to induce an initial increase of about 10 bps in the interest rate on loans to firms.

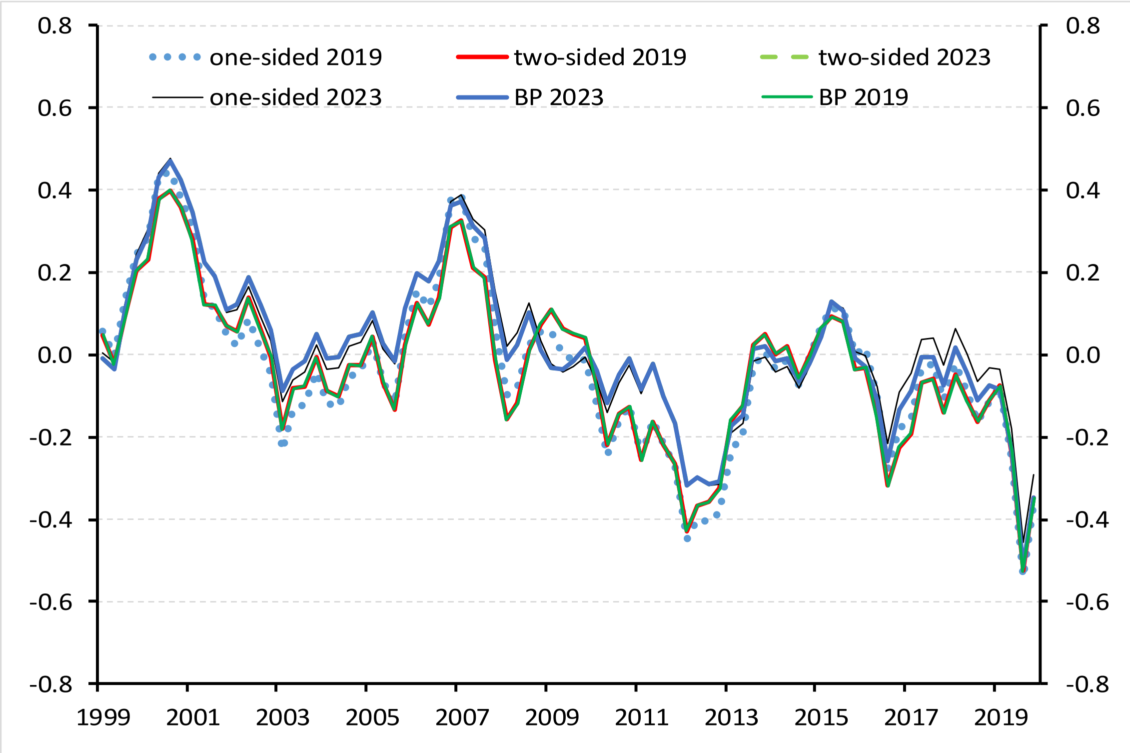
FIGURE A4. TRANSMISSION OF A LOAN MARKUP SHOCK



Source: authors' calculations based on the model in Gerali et al. (2010) estimated with data up to 2023:Q4. *Notes*: each line corresponds to the average effect across six different model parameterizations, each corresponding to an alternative combination of detrending methods and estimation sample. Simulations are performed based on the posterior mean of the parameters. The policy rate, the lending rate and inflation are in annualized percentage deviations from the baseline. Output is in percent deviations from the baseline.

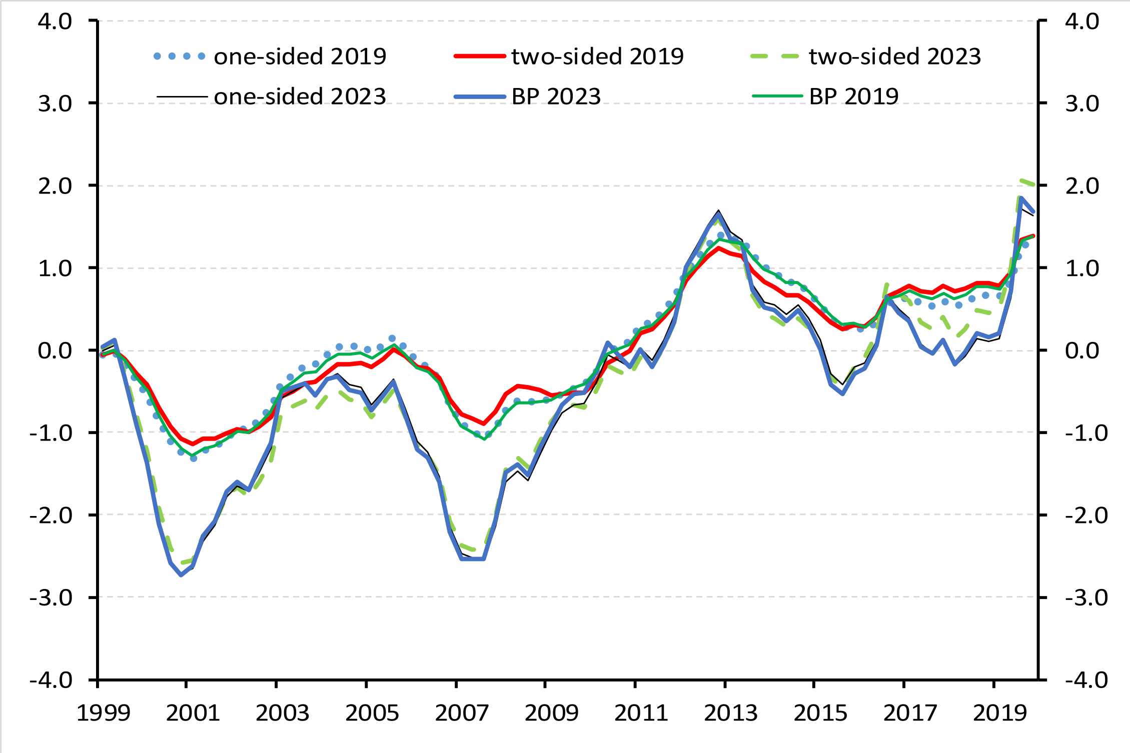
Figure A5. HISTORICAL DECOMPOSITION OF POLICY RATE: CONTRIBUTION OF MONETARY POLICY SHOCKS

(*percentage points*)



Source: authors' calculations based on the model in Gerali et al. (2010) estimated with data up to 2023:Q4.

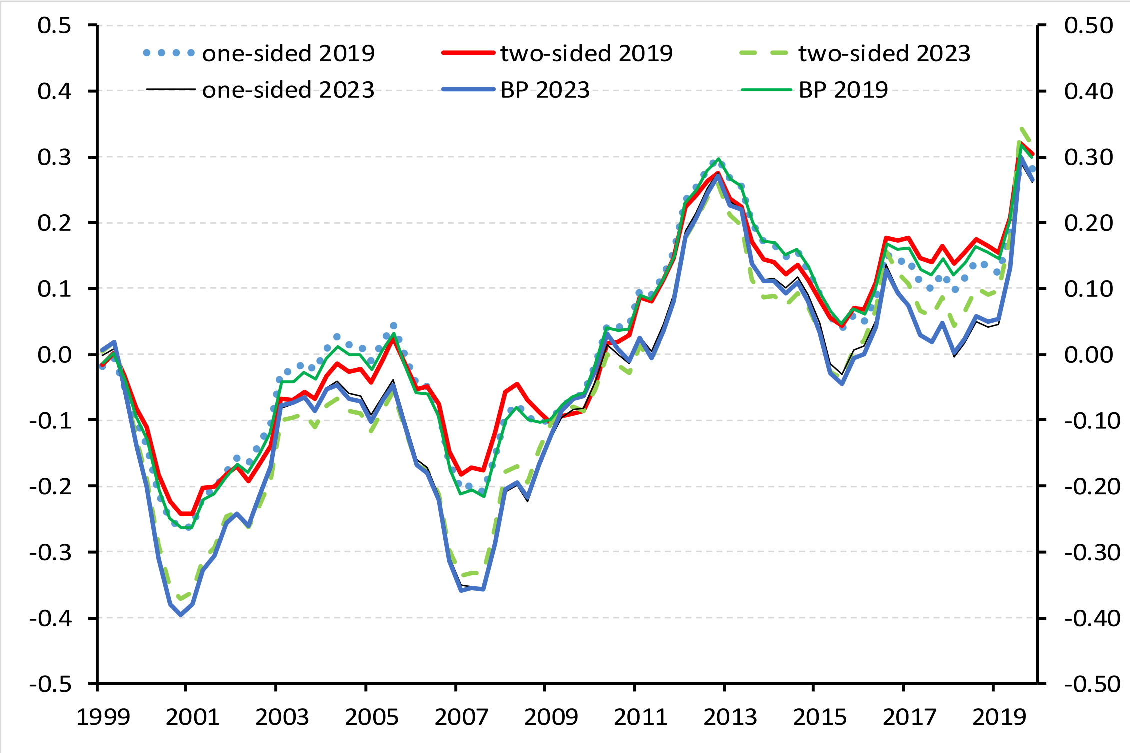
Figure A6. HISTORICAL DECOMPOSITION OF OUTPUT: CONTRIBUTION OF MONETARY POLICY SHOCKS
(*percentage points*)



Source: authors' calculations based on the model in Gerali et al. (2010) estimated with data up to 2023:Q4.

Figure A7. HISTORICAL DECOMPOSITION OF INFLATION: CONTRIBUTION OF MONETARY POLICY SHOCKS

(*percentage points*)



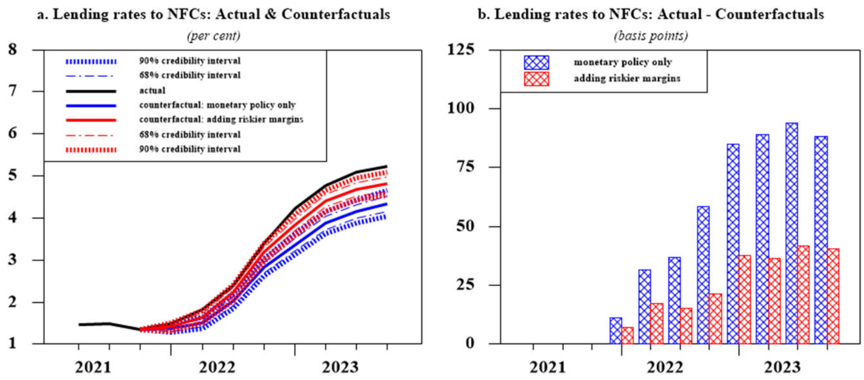
Source: authors' calculations based on the model in Gerali et al. (2010) estimated with data up to 2023:Q4.

B BVAR

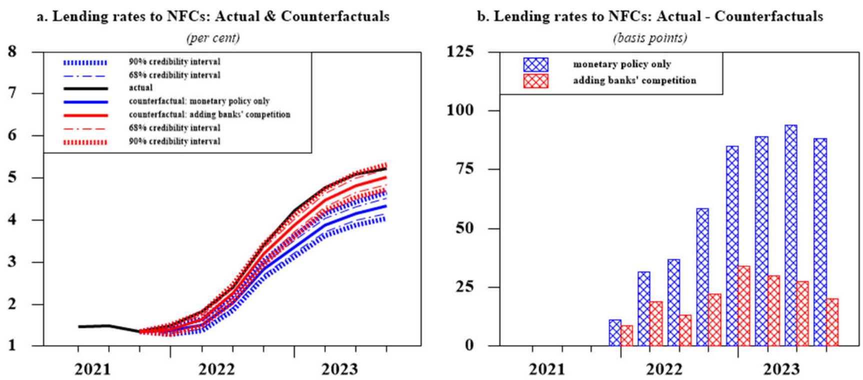
B.1 Lending rates and drivers of credit supply tightening

Figure B1. ALTERNATIVE BLS INDICATORS AND LENDING RATES IN THE 2022-23 HIKING CYCLE.

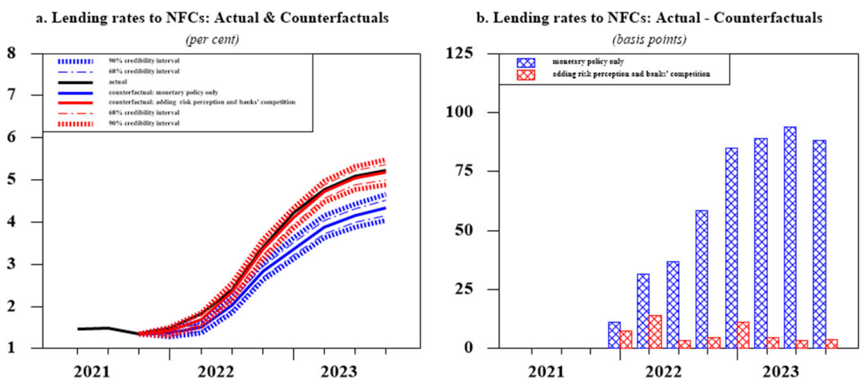
a. Replacing risk perception with margins on riskier loans



b. Replacing risk perception with banks competition



c. Simultaneously accounting for risk perception and banks competition



Source and notes: see Figure 7.

B.2 Conditional forecasting and scenario analysis

We briefly sketch here the methodology adopted in Section 4.1, in order to better explain the exercise ran for computing the impact of the ECB tightening cycle on economic activity and consumer prices. We closely follow the paper by Crump et al. (2024), which show the connection between conditioning on shocks and conditioning on observables and where the reader can find further technical details. In order to obtain the IRFs for each variables included in the VAR model, we need to compute the difference between a policy and a non-policy scenario, i.e. the difference between a scenario in which a policy intervention is implemented (e.g. an increase in government spending or the policy rate) and another one in which the system is not perturbed by any shock.

This follows from the definition of IRF below:

$$\frac{\partial Y_{i,T+s}}{\partial u_{j,T}} = \mathbb{E}\left(Y_{i,T+s} | Y_{i,1:T-1}, u_{j,T} = 1, \theta\right) - \mathbb{E}\left(Y_{i,T+s} | Y_{i,1:T-1}, \theta\right) \quad (2)$$

where Y_i is the generic *i*-th variable of the model, u_j denotes a generic *j*-th structural shock of the model, which are linear combinations of reduced-form errors $u_{j,T} = \delta^{'} \varepsilon_t$ and θ indicates the vector of estimated VAR parameters. It is possible to re-write the scenarios in terms of forecast errors

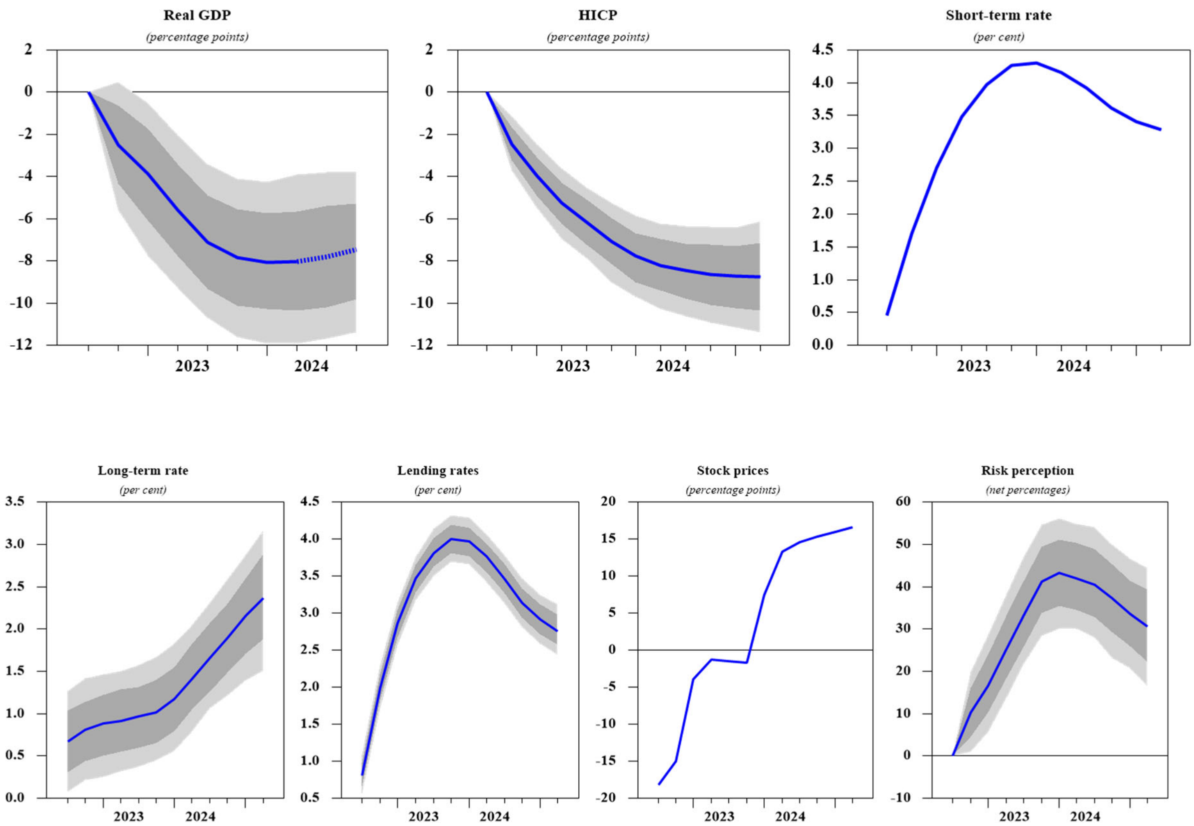
$$\mathbb{E}(Y_{T+s} | Y_{1:T}, C_T, \theta) = \mathbb{E}(Y_{T+s} | Y_{1:T}, S_T, \theta) \quad (3)$$

where:

$$S_T = \{\delta' \tilde{\varepsilon}_{T+s}, s = 1, 2, \dots\} \quad (4)$$

and where S_T is the combination or sequence of shocks with the highest likelihood of having generated the conditional path of observables C_T. Moreover, one can impose a number of restrictions on δ' to ensure that the sequence of shocks which have likely driven the scenario is effectively narrowed down, providing an advantage in terms of economic and causal interpretation. This is exactly what we did in our empirical application of this methodology in Section 4.1.

Figure B2. THE IMPACT OF CONVENTIONAL MONETARY POLICY ON MACROECONOMIC VARIABLES IN 2022-24: DIFFERENCES BETWEEN TIGHTENING AND NO-TIGHTENING SCENARIO



Source: authors' calculations based on ECB, Eurostat and LSEG quarterly data. *Notes:* for each variable, the blue line is the (posterior median) difference between the tightening and the no tightening scenario. The dark (light) grey shaded area represents the correspondent 16-84% (5-95%) percentiles of the empirical posterior distribution. Estimation sample is 2003:Q1-2022:Q2; counterfactual sample is 2022:Q3 – 2024:Q4.