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A Note of Caution on the Relation between Money Growth and Inflation

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Abstract

We assess the bivariate relation between money growth and inflation in the euro area and the United States using hybrid time-varying parameter Bayesian VAR models. Model selection based on marginal likelihoods suggests that the relation is statistically unstable across time in both regions. The effect that shocks to money growth has on inflation weakened notably after the 1980s before making a comeback after 2020. This instability implies that caution should be exercised when relating monetary aggregates to inflation.

JEL Classification: E31, E37, E47, E51

Keywords: Bayesian VAR, Time-varying parameters, Stochastic volatility, Model selection

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1. Introduction

Money has typically played a minor role in the literature on monetary policy the last thirty years or so.[1] However, the recent surge in inflation – preceded by non-standard monetary policy measures which have increased the size of central banks' balance sheets and money supply – has revived the debate regarding the role of money growth for inflation.[2] For example, Borio *et al.* (2023) argue that forecasters of inflation could have done better by taking the information contained in the bivariate relation between the two variables into account.

We add to the discussion regarding the relation between money growth and inflation by estimating bivariate Bayesian VAR (BVAR) models.[3] Specifically, we apply the hybrid time-varying parameter BVAR framework of Chan and Eisenstat (2018) to data from the euro area and the United States and use Bayesian model selection to assess if the empirical relation between money growth and inflation is stable or time varying.

2. Data and model

Our analysis employs data on CPI inflation and M3 growth in the euro area and the United States; see Figures 1 and 2. CPI inflation is given as $\pi_t = 100(P_t/P_{t-4} - 1)$, where P_t is the consumer price index at time *t*; money growth is given as $\mu_t = 100(M_t/M_{t-4} - 1)$, where M_t is M3 at time *t*. The euro area data range from 1971Q1 to 2022Q4 and the US data from 1961Q1 to 2022Q4.[4]

Defining the vector of dependent variables as $\boldsymbol{y}_t = (\pi_t \quad \mu_t)'$, we employ the framework of Chan and Eisenstat (2018) to estimate BVAR models with stochastic volatility and potentially time-varying parameters. The framework allows us to assess if there is time variation in none, one, or both equations of the model.[5]

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[1] For example, the New-Keynesian models – which have come to dominate both the academic literature and many central banks' toolboxes – generally have a stepmotherly treatment of money; focus in this type of model has instead been on the central bank's policy rate. It can, however, be noted that among central banks, the ECB has had its two-pillar strategy (where the second pillar is monetary analysis); see, for example, ECB (2003, 2021).

[2] See, for example, Issing (2021), Papadia and Camaduro (2021), Congdon (2022), King (2022) and Hall *et al.* (2023).

[3] Different conclusions have been drawn in the literature regarding the issue of stability; see, for example, De Grauwe and Polan (2005), Berger and Österholm (2011) and Dreger and Wolters (2014).

[4] The euro area data – where CPI inflation is given by HICP inflation – combine the Euro Area Business Cycle Network's Area Wide Model data and Eurostat data for the 19 members as of 2022. The US data were sourced from the FRED database of the Federal Reserve Bank of Saint Louis.

[5] For empirical analyses employing the framework to Okun's law and the Phillips curve, see Karlsson and Österholm (2020, 2023).

The model in its general form is:

$$\boldsymbol{B}_{0t}\boldsymbol{y}_t = \boldsymbol{\delta}_t + \boldsymbol{B}_{1t}\boldsymbol{y}_{t-1} + \cdots + \boldsymbol{B}_{pt}\boldsymbol{y}_{t-p} + \boldsymbol{\varepsilon}_t \tag{1}$$

where $\boldsymbol{B}_{0t}$ is a 2x2 lower triangular matrix with ones on the diagonal, $\boldsymbol{\delta}_t$ is a 2x1 vector of intercepts and $\boldsymbol{B}_{1t}, \dots, \boldsymbol{B}_{pt}$ are 2x2 matrices with the parameters describing model dynamics. The disturbances $\boldsymbol{\varepsilon}_t$ are assumed to be orthogonal, normally distributed, and subject to stochastic volatility – that is, $\varepsilon_{i,t} \sim N(0, \boldsymbol{\Sigma}_t)$ where $\boldsymbol{\Sigma}_t = diag\left(exp(h_{\pi t}), exp\left(h_{\mu t}\right)\right)$; the log volatilities are assumed to evolve as random walks:

$$\boldsymbol{h}_t = \boldsymbol{h}_{t-1} + \boldsymbol{\zeta}_t \tag{2}$$

where $\boldsymbol{\zeta}_t \sim N(\boldsymbol{0}, \boldsymbol{\Sigma}_{\boldsymbol{h}})$. Finally, the free parameters of $\boldsymbol{\delta}_t$ and $\boldsymbol{B}_{it}$ are gathered in the parameter vector $\boldsymbol{\theta}_t$, which follows a random walk as well:

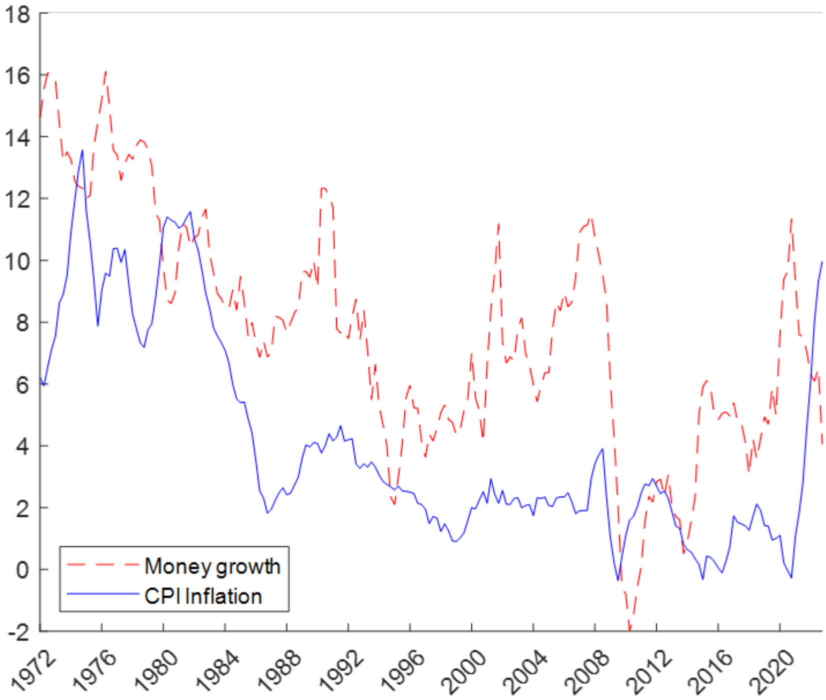
$$\boldsymbol{\theta}_t = \boldsymbol{\theta}_{t-1} + \boldsymbol{\eta}_t \tag{3}$$

where $\boldsymbol{\eta}_t \sim N(\boldsymbol{0}, \boldsymbol{\Sigma}_{\boldsymbol{\theta}})$. The vector $\boldsymbol{\theta}_t$ can be split into two – one that contains the parameters for the equation for inflation ($\boldsymbol{\theta}_{1,t}$) and one for the equation for money growth ($\boldsymbol{\theta}_{2,t}$). When the model is estimated with constant parameters, $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$ is set to zero.

The bivariate system estimated allows four different combinations of time variation: *i)* both equations have constant parameters (no time variation in $\boldsymbol{\theta}_{1,t}$ and $\boldsymbol{\theta}_{2,t}$), *ii)* time variation in the parameters of the equation for inflation ($\boldsymbol{\theta}_{1,t}$) but not for money growth ($\boldsymbol{\theta}_{2,t}$), *iii)* time variation in the parameters of the equation for the money growth ($\boldsymbol{\theta}_{2,t}$) but not for inflation ($\boldsymbol{\theta}_{1,t}$) and *iv)* time-varying parameters in both equations (time variation in both $\boldsymbol{\theta}_{1,t}$ and $\boldsymbol{\theta}_{2,t}$).

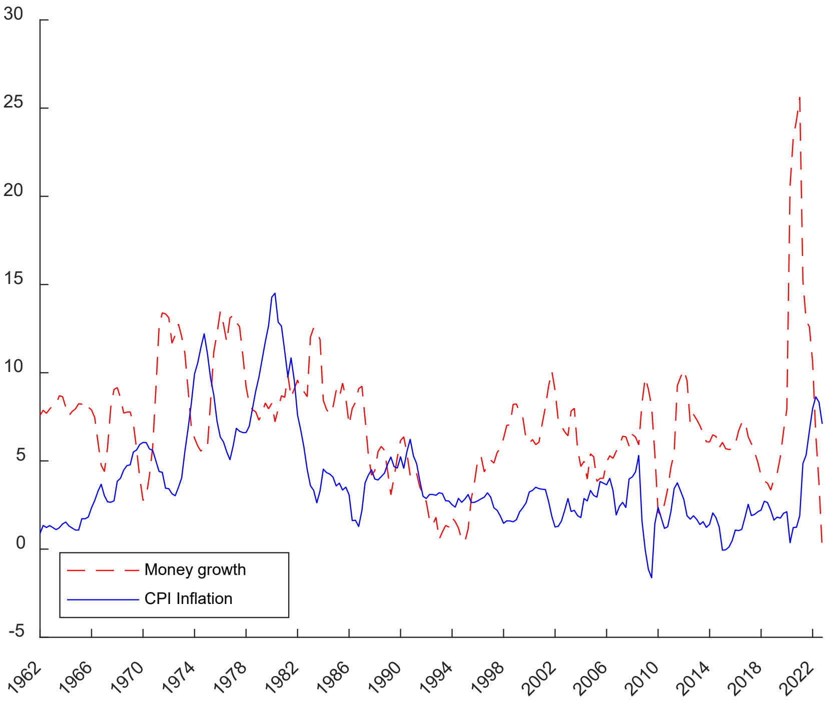
When estimating the models, we set lag length equal to $p = 4$. Concerning priors, we use an uninformative normal prior on the initial states of the regression parameters, $\boldsymbol{\theta}_{1,0}$ and $\boldsymbol{\theta}_{2,0}$, $N(0{,}5\boldsymbol{I})$ and a normal prior, $h_{i,0} \sim N(\gamma_i, 0.25)$, for the initial log volatilities, where γ_i is set to match the prior mean of $exp\left(h_{i,0}\right)$ with the residual variance of a constant parameter univariate AR(4) model. The diagonal elements of $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$ have inverse Gamma, $iG(5{,}0.08)$, priors for constants and $iG(5{,}0.0004)$ for other parameters. Finally, the diagonal elements of $\boldsymbol{\Sigma}_{\boldsymbol{h}}$ have $iG(5{,}0.4)$ priors.

Figure 1. Euro area inflation and money growth
(In percent)



Source: Euro Area Business Cycle Network, Eurostat and authors' calculations.

Figure 2. United States inflation and money growth
(In percent)



Source: Federal Reserve Bank of Saint Louis and authors' calculations.

3. Results

Table 1 indicates that the model with time-varying parameters in both equations is preferred in both the euro area and the United States, while the constant-parameter model is ranked last. To compare the strength of the evidence, we use the commonly applied scale of two times the difference in log marginal likelihood and compare the model with time-varying parameters in both equations to that with constant parameters in both equations. Using the terminology of Kass and Raftery (1995, p. 777), the evidence in favour of the model with time-varying parameters in both equations is "*very strong*." The evidence in favour of the model with time-varying parameters in both equations compared to the models with only one time-varying equation is "*positive*" or "*very strong*".

Table 1. Log marginal likelihoods.

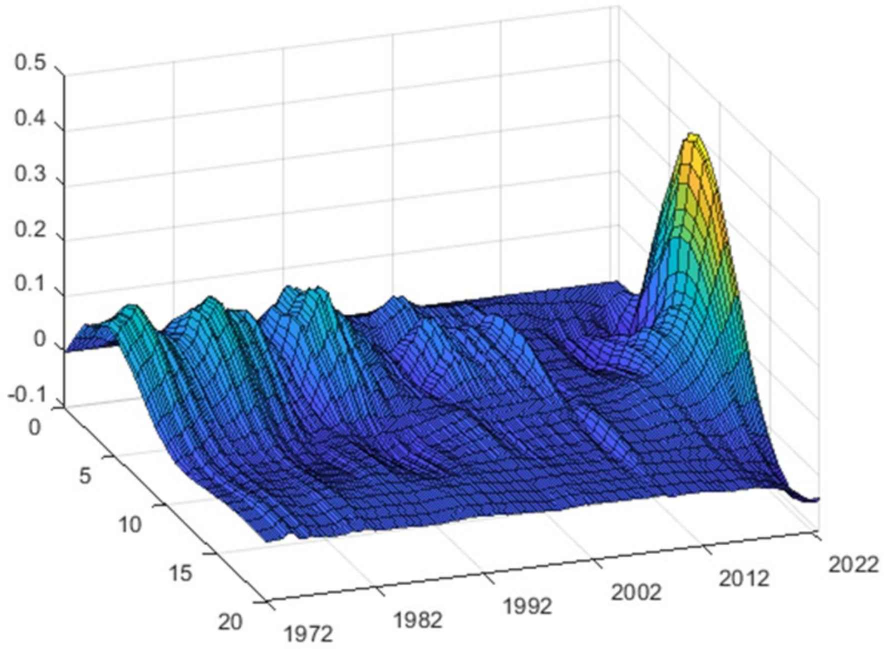
	Euro area	United States
Both equations are constant	-458.2	-622.2
Time variation in equation for π_t	-455.7	-616.4
Time variation in equation for μ_t	-452.5	-620.6
Both equations are time varying	**-449.9**	**-614.6**

Note: Highest marginal likelihood given in **bold**.

Figures 3 and 4 show the impact that a one-standard-deviation shock to money growth has on inflation in the preferred model with time-varying parameters.[6] The dynamics of the model have changed notably across the sample period in both the euro area and the Unites States. In both regions, money growth shocks had a clear positive impact on inflation in the 1980s; in the euro area, we find this also in the 1970s. However, the relationship between the two variables became very weak or non-existent starting in the 1990s before making a sudden dramatic comeback in the early 2020s.

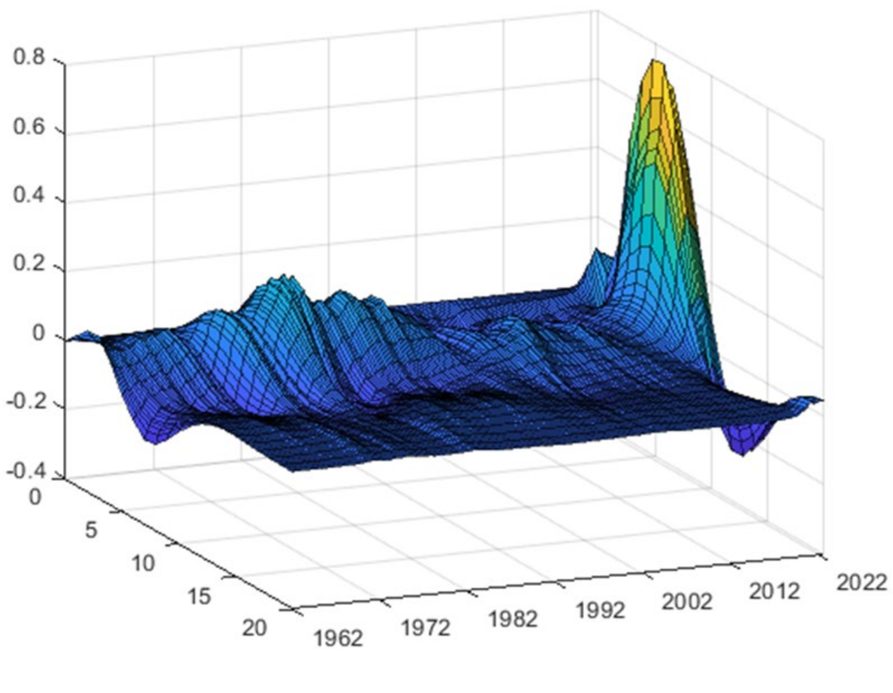
[6] Since the model has stochastic volatility, the size of the impulse is time varying; see Figures A1 and A2 in the Appendix.

Figure 3. Impulse-response function: Effect of shocks to money growth on inflation in the euro area. Model with time-varying parameters in both equations.



Note: Size of impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.
Source: Authors' calculations.

Figure 4. Impulse-response function: Effect of shocks to money growth on inflation in the United States. Model with time-varying parameters in both equations.



Note: Size of impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.
Source: Authors' calculations.

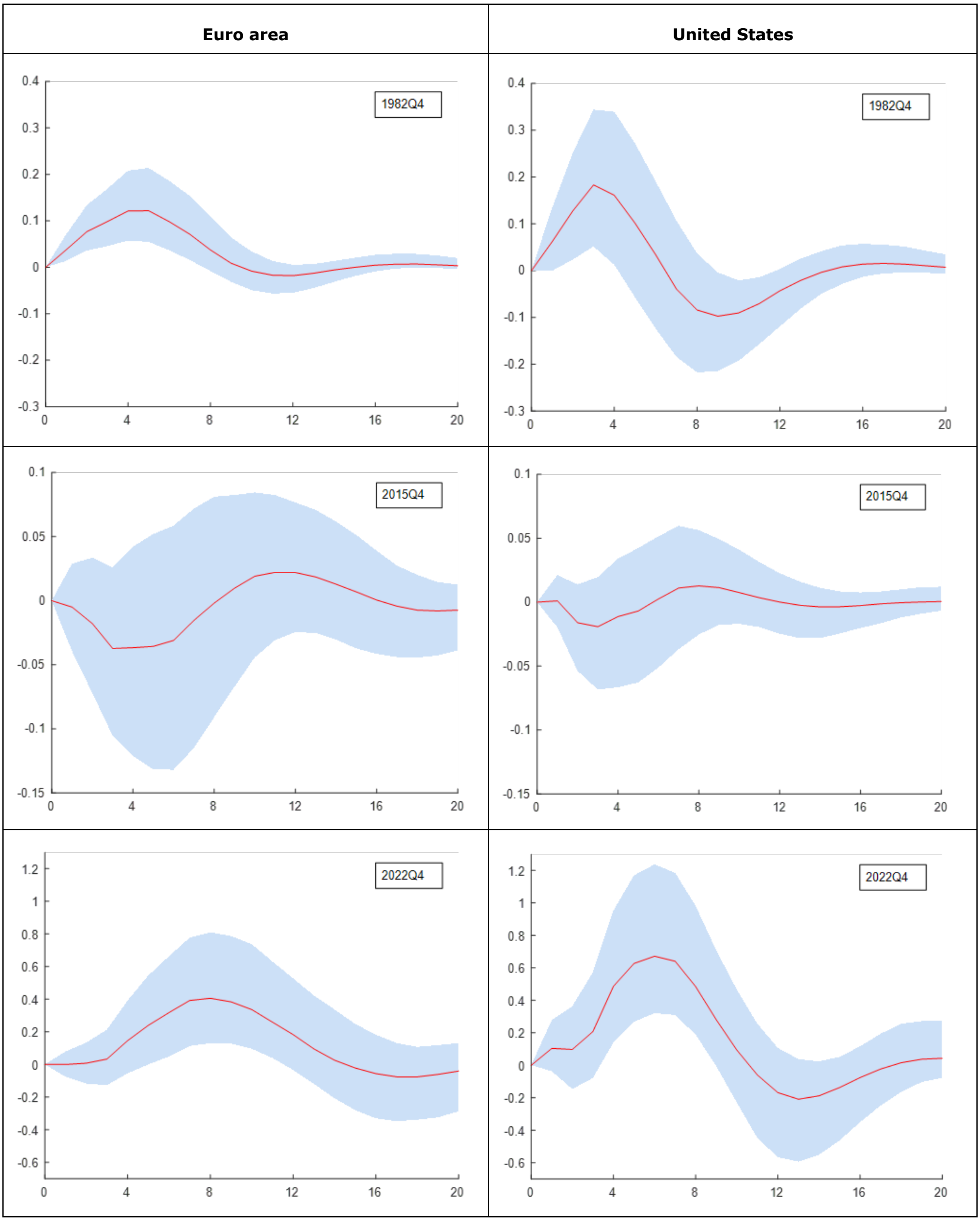
The snapshots in Figure 5 further illustrate these changing dynamics. Shocks to money growth had an inverted u-shape effect on inflation in 1982Q4, while in 2015Q4 – at a time when inflationary pressure was low and both the ECB and the Federal Reserve were struggling to increase inflation – the response was indistinguishable from zero. In 2022Q4, we see that inflation increases again with a shock to money growth, albeit with more of a delay. The quantitative larger effect in the United States in the third period is related to the larger underlying shock (see Figure A2 in the Appendix).

We conclude that the effect that a shock to money growth has on inflation varies substantially over time. Ignoring the lack of stability in the response of inflation to an unexpected increase in money growth and assuming instead a model with constant parameters over time (see Figures A3 and A4 in the Appendix) would provide a misleading description of economic circumstances for policymakers.

4. Conclusions

This paper provides evidence that the bivariate relation between money growth and inflation in the euro area and the United States has changed over time. Model selection based on marginal likelihoods confirms that the relation is statistically unstable across time in both regions. Results from models with time-varying parameters illustrate that the dynamic relation between money growth and inflation weakened notably after the 1980s before making a comeback after 2020. This strongly suggests policy makers should remain cautious when relating changes in monetary aggregates to inflation outcomes.

Figure 5. Impulse-response functions: Effect of shocks to money growth on inflation at different timepoints. Model with time-varying parameters in both equations.



Note: Size of impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters on horizontal axis. Shaded band is 68 percent credible interval.

Source: Authors' calculations.

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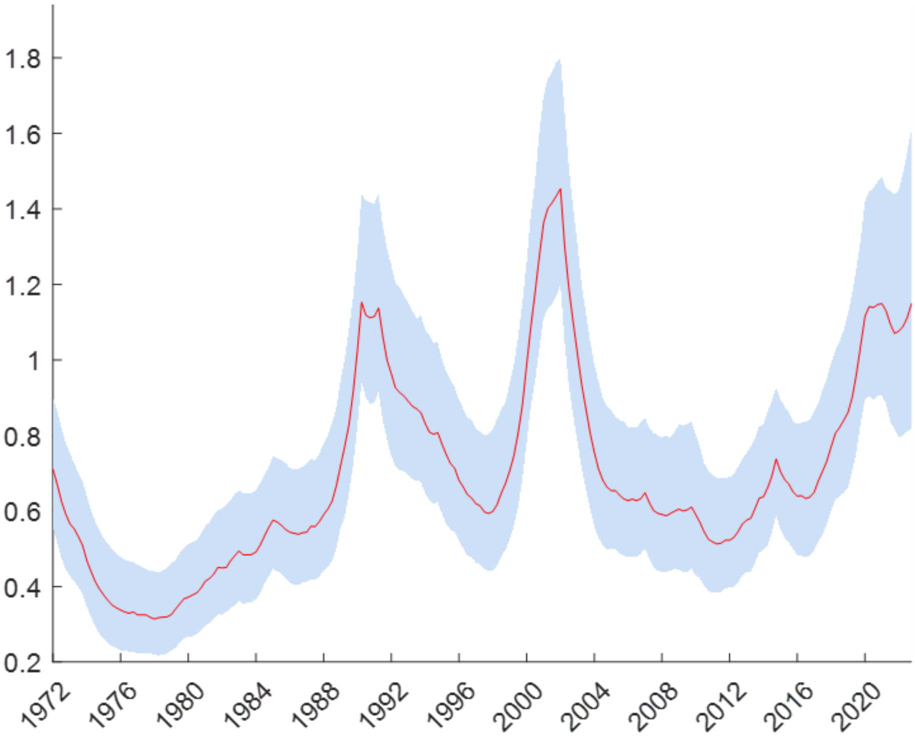
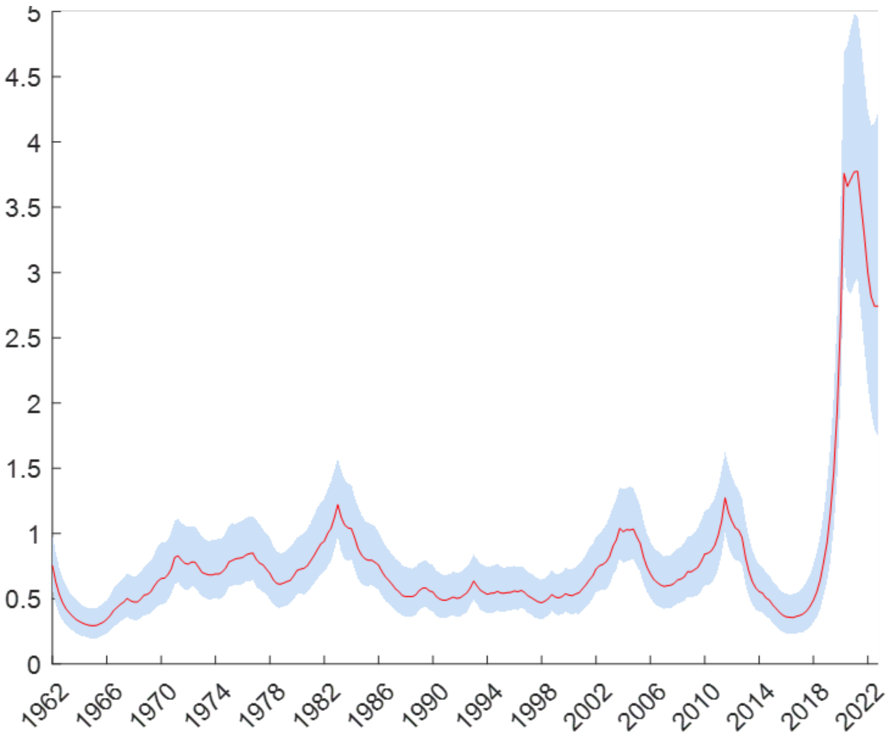
Appendix

Figure A1. Standard deviation of shocks to money growth in the euro area.



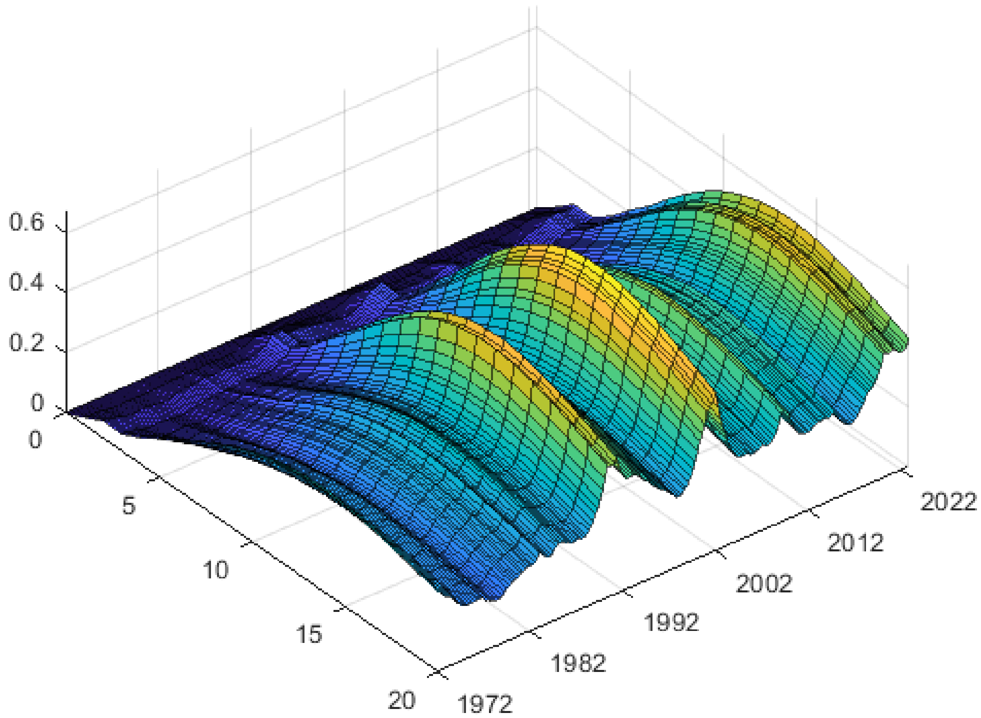
Note: Estimated standard deviation of structural shock. Shaded band is 68 percent credible interval.
Source: Authors' calculations.

Figure A2. Standard deviation of shocks to money growth in the United States.



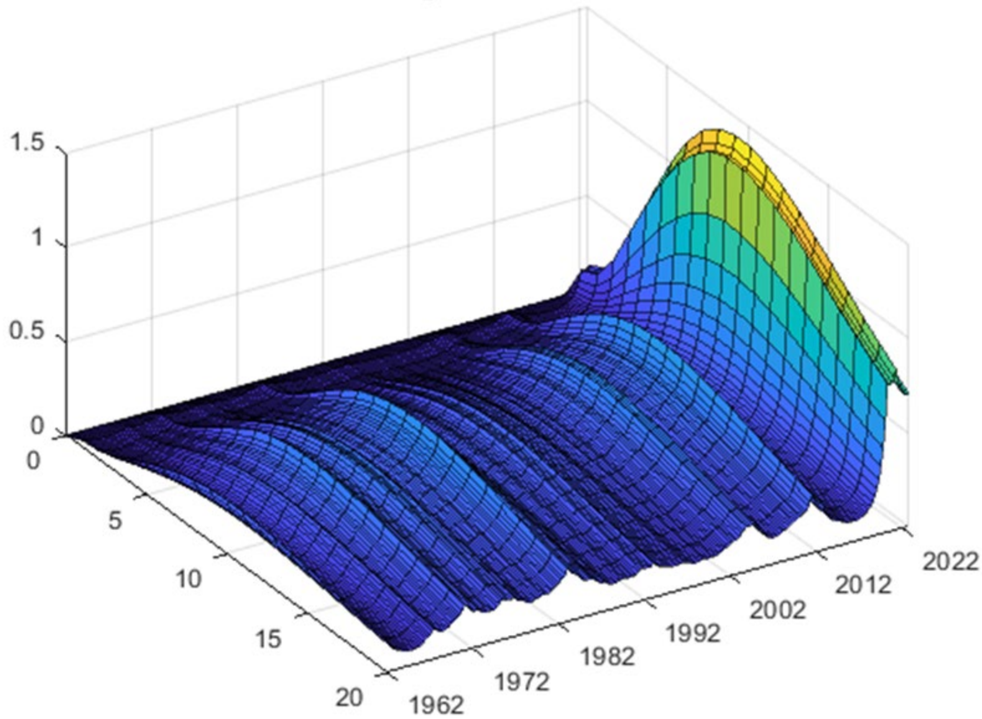
Note: Estimated standard deviation of structural shock. Shaded band is 68 percent credible interval.
Source: Authors' calculations.

Figure A3. Impulse-response function: Effect of shocks to money growth on inflation in the euro area. Model with constant parameters in both equations.



Note: Size of impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.
Source: Authors' calculations.

Figure A4. Impulse-response function: Effect of shocks to money growth on inflation in the United States. Model with constant parameters in both equations.



Note: Size of impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.
Source: Authors' calculations.