BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

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October 2023

Number 1425

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Number 1425 - October 2023

ISSN 2281-3950 (online)

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

DRIVERS OF LARGE RECESSIONS AND MONETARY POLICY RESPONSES

by Giovanni Melina* and Stefania Villa**

Abstract

Shocks to capital utilization are introduced into a structural macroeconomic closed-economy model with financial frictions to capture disruptions to the ability of the capital stock to provide capital services used in production. Estimates for the euro area and the United States show that these shocks were among the most important drivers of the output contraction during the Global Financial Crisis and the COVID-19 crisis, while financial shocks were more significant only during the Global Financial Crisis. Thanks to the timely and strong intervention of the European Central Bank and the US Federal Reserve, monetary policy shocks exerted a sizeable and positive contribution to output and inflation during the COVID-19 crisis.

JEL Classification: E4, E5, E6.
Keywords: COVID-19, Global Financial Crisis, Great Lockdown, monetary policy, capital utilization.
DOI: 10.32057/0.TD.2023.1425

Contents

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1 Introduction[1]

The global economy and much of the macroeconomic research have been dominated by the two large recessions occurred in the past fifteen years: the Great Recession that followed the Global Financial Crisis (GFC) and the COVID-19 crisis (C-19C) that followed the pandemic. Policymakers across the world came up with creative solutions to tackle the challenges created by these major crises. For instance, the GFC prompted central banks in much of the industrialized world to take unconventional monetary policy actions to overcome the constraint posed by a binding zero lower bound (ZLB) on the policy rate. COVID-19 also posed economic policy challenges, and arguably policymakers could rely on the experience acquired during the GFC to take swift policy decisions. Countries implemented, among others, packages of fiscal measures, such as discretionary fiscal stimulus measures, state guarantees for loans to firms and other liquidity support measures in response to the pandemic. Overall, the experience gained in these two crises may prove useful in the future to counter the adverse effects of rare and large shocks.

While sharing some similarities, such as an abrupt fall in output and the increase in uncertainty, these crises were originated by different shocks: financial shocks in the case of the GFC and a pandemic in that of the C-19C. Understanding the impact of these shocks on macroeconomic fluctuations is a precondition for calibrating the policy tools. For example, easing monetary policy in a demand-driven recession such as the GFC,[2] characterized by a negative output gap and deflationary pressures, is an uncontroversial policy action. Choosing the appropriate monetary policy stance in an environment such as that created by the COVID-19 shock with a combination of supply and demand factors is a much more difficult endeavor.

Focusing on two of the world's largest economies, the Euro Area (EA) and the United States, this paper attempts to answer two research questions: (i) which shocks drove the output contraction and inflation fluctuations during the GFC and C-19C? And (ii) to what extent monetary policy contributed to the recovery from these major crises?

These questions are tackled with the Bayesian estimation of a Dynamic Stochastic General Equilibrium (DSGE) model *à la* Smets and Wouters (2007) augmented with financial frictions in the spirit of Gertler and Karadi (2011). The model features a novel exogenous disturbance to capital utilization to capture disruptions that impair the ability of the capital stock to provide capital services used in production. As shown by Santacreu (2016), capacity utilization usually falls sharply during recessions as firms adjust their

[1]The views expressed in this paper are those of the authors and do not necessarily represent those of the International Monetary Fund or IMF policy, or those of the Bank of Italy. We are grateful to Stefano Neri, Tiziano Ropele, Giodano Zevi, Roberta Zizza, seminar participants at Banca d'Italia and many other colleagues for very useful comments. All remaining errors are ours.

[2]It should be noted that there is a debate in the literature on whether financial shocks act as a demand or a supply shock. This paper finds that it behaves as a demand shock in line with several contributions (e.g. Gerali et al., 2010; Furlanetto et al., 2019, among others).

productive capacity to face lower demand, as in the case of the GFC. In the case of the C-19C, capacity was heavily underutilized due to lockdowns and other containment measures. The model is estimated with macroeconomic and financial variables using data of the EA and the US economy. In both cases, estimates show that the absence of a capital utilization shock would lead to a severe underestimation of the drop in capacity utilization observed in the data during the GFC and the C-19C.

The sample covers the period 2000Q1-2022Q1 and includes times during which the policy rate reached the ZLB and unconventional monetary policy measures were taken, posing potential issues in the estimation of a log-linearized model. Following Mouabbi and Sahuc (2019) and Batini et al. (2021), the policy rate is thus replaced with the shadow rate constructed by Wu and Xia (2016, 2017, 2020).[3] This rate is a synthetic policy rate that takes into account the effects of all the conventional and unconventional monetary policies implemented by the central banks. In addition, it is free to move in the negative territory, thus circumventing the estimation issues posed by the ZLB.

The main findings can be summarized as follows. First, capital utilization shocks turned out to be important contributors to the negative components of output growth, but not of inflation fluctuations, during the GFC and the C-19C in both the EA and the US economy. Second, financial shocks played a more important role during the GFC, weighing on GDP growth for about one year after the trough, and to a greater extent in the EA compared to the US economy. Third, labor and preference shocks explained a large fraction of the remaining output contraction and of inflation fluctuations in the US economy during the C-19C, while in the EA total factor productivity (TFP) and price mark-up shocks played a more prominent role. Lastly, thanks to the timely and strong intervention of the European Central Bank and the U.S. Federal Reserve, monetary policy shocks had a sizable positive contribution to the recovery from the C-19C and to movements in inflation.

There are three caveats associated with this analysis. First, having focused on the role of monetary policy, the various fiscal measures adopted during the crisis periods have not been modeled explicitly. Moreover, the recovery after the C-19C has been influenced also by the vaccination campaign, which is only indirectly captured by the softening and reversal of shocks capturing lockdown and containment measures. Finally, the model does not distinguish between essential versus non-essential services, which were affected differently during the C-19C, but captures overall effects on aggregate macroeconomic variables.[4]

The paper is related to three main of strands of the DSGE literature. The first group of papers is represented by those aiming to analyze the role of shocks during

[3] More recent data on the shadow rate are available at Cynthia Wu's website, https://sites.google.com/view/jingcynthiawu/shadow-rates.

[4] The model also does not consider durable *versus* nondurable goods, although their dynamics differed particularly during the C-19C.

the COVID-19 pandemic. For instance, Kollmann (2021) examines the macroeconomic effects of the COVID-19 pandemic on EA GDP and inflation, using a stylized New Keynesian model, where this shock is interpreted as a combination of aggregate demand and aggregate supply disturbances, as in Bartocci et al. (2020). This analysis concludes that the dominant force driving the sharp fall of EA GDP in 2020 was an aggregate supply contraction and that COVID-19-induced aggregate demand and supply shifts were persistent. Cardani et al. (2022) and Corrado et al. (2021) also investigate the role of shocks during the pandemic. Similarly to the present contribution, these papers employ purely macroeconomic models where the pandemic is captured via shocks. In parallel, a related literature was developed to allow for the interaction between economic decisions and rates of infections (e.g., Kaplan et al., 2020; Eichenbaum et al., 2021; Giagheddu and Papetti, 2023, among others). These contributions do not employ traditional DSGE models, but they extend canonical epidemiological models to embed macroeconomic variables. The second strand consists of the plethora of model-based analyses on the GFC, which introduced financial frictions in otherwise standard DSGE models (Gerali et al., 2010; Kollmann et al., 2013; Kiley and Sim, 2014, among others). This paper uses banking sector frictions modeled in the form of incentive-compatibility constraints linking banks balance sheets with terminal wealth as in Gertler and Karadi (2011) because, as noted by Villa (2016), this model is effective at replicating the propagation of shocks. Most of these contributions, like this paper, do not focus on the interaction between fiscal policy and the financial sector, a channel investigated by other studies (e.g. Melina and Villa, 2014; Batini et al., 2019; Silva, 2021).[5] The third strand of the literature is represented by those studies finding an important role for shocks to the capital accumulation process to explain business cycle fluctuations (see Gertler and Karadi, 2011; Furlanetto and Seneca, 2014; Riggi, 2019; Bottone et al., 2021, among others).

In sum, previous contributions analyzed either one recession or one country at a time, and only in a few cases they compared the monetary policy response across the two recessions (e.g. Cortes et al., 2022). This is the first study that (i) assesses the drivers of two very different recessions, the GFC and the C-19C, combined with the role of monetary policy, using the same modeling and estimation approach across the EA and the US economy;[6]; (ii) establishes the important role of capital utilization shocks in large recessions; and (iii) quantifies the macroeconomic effects of monetary policy in the EA and the US economy in relevant periods of the recent history.

The remainder of the paper is structured as follows. Section 2 outlines the DSGE

[5]For instance Silva (2021) shows that, when government spending (or government deficits) are high, the aggregate credit risk of the financial sector and the provision of financial services are compromised.

[6]The Euro Area experienced also the sovereign debt crisis, the analysis of which would have required another modelling device as in Batini et al. (2021). It should be noted that the focus of the paper is on large recessions which affected both economies. Therefore, we deem it appropriate to use the same structural macroeconomic model for the sake of comparison.

model. Section 3 presents the data and the estimation strategy. Section 4 reports the results. Finally, Section 5 concludes. Details about the data and additional results are reported in the Appendix.

2 Model

This section summarizes the DSGE model, which is a standard Smets and Wouters (2007) economy augmented with financial frictions as in Gertler and Karadi (2011), similarly to Villa (2016). As common in the literature, the economy is populated by the following agents: households, labor unions, labor packers, retailers, final good firms, intermediate goods firms, capital producers, financial intermediaries and the policymaker.

Households consume, accumulate government bonds and supply labor. A labor union differentiates labor and sets wages in a monopolistically competitive market. Competitive labor packers buy labor services from the union, and package and sell them to intermediate goods firms. The presence of an agency problem limits the ability of financial intermediaries to obtain deposits from households as in Gertler and Karadi (2011). This feature, in turn, affects the leverage ratio of financial intermediaries.[7] Output is produced in several steps, involving a monopolistically competitive market with producers facing price rigidities. The monetary authority sets the short-term nominal interest rate according to a Taylor rule.

The remainder of this section reports the model equilibrium conditions in log-linear form in four groups: (i) households, (ii) non-financial firms, (iii) financial intermediaries, (iv) monetary authority and equilibrium.[8]

(i) Households

$$\hat{mu}_t = \frac{1}{1-h}\left(h\hat{C}_{t-1} - \hat{C}_t\right) + \varepsilon_t^b \tag{1}$$

$$\hat{\Lambda}_{t,t+1} \equiv \hat{mu}_{t+1} - \hat{mu}_t \tag{2}$$

$$\hat{\Lambda}_{t,t+1} + \hat{R}_t = 0 \tag{3}$$

$$\hat{R}_t^n = \hat{R}_t + E\left[\hat{\Pi}_{t+1}\right] \tag{4}$$

[7]As shown in Villa (2016), the introduction of financial frictions improves the models' fit compared to a standard Smets and Wouters (2007) economy, suggesting that these frictions are empirically relevant both in the EA and the US.

[8]Variables with a 'hat' denote a percentage deviation from steady state, while a variable without a time subscript denotes its steady-state value.

$$
\begin{aligned}
\hat{W}_t =& \frac{\beta}{(1+\beta)} E_t\left[\hat{W}_{t+1}\right] + \frac{1}{(1+\beta)}\hat{W}_{t-1} + \frac{\beta}{(1+\beta)} E_t\left[\hat{\Pi}_{t+1}\right] - \frac{(1+\beta\sigma_{wi})}{(1+\beta)}\hat{\Pi}_t \\
&+ \frac{\sigma_{wi}}{(1+\beta)}\hat{\Pi}_{t-1} + \frac{1}{(1+\beta)}\frac{(1-\beta\sigma_w)(1-\sigma_w)}{(1+\varepsilon_w\phi)\sigma_w} \\
&\times \left[\phi\hat{L}_t - \frac{h}{1-h}\hat{C}_{t-1} + \frac{1}{1-h}\hat{C}_t - \hat{W}_t\right] + \varepsilon_t^w
\end{aligned} \tag{5}
$$

Equation (1) is the marginal utility of consumption, $\hat{mu}_t$, where h measures the degree of habit formation in consumption, $\hat{C}_t$, and ϵ_t^b is a preference shock. Equation (2) is the definition of the stochastic discount factor, $\hat{\Lambda}_{t,t+1}$. Equation (3) is the Euler consumption equation linking the stochastic discount factor to the real interest rate $\hat{R}_t$. Equation (4) represents the Fisher identity linking the nominal interest rate, $\hat{R}_t^n$, to the real interest rate and inflation, $\hat{\Pi}_t$. Finally, Equation (5) represents the Calvo staggered wage setting, in which $\hat{W}_t$ is the nominal wage, $\hat{L}_t$ is labor in terms of hours worked, β is the households' discount factor, σ_w measures wage stickiness, σ_{wi} denotes the degree of wage indexation and ϵ_t^w is a labor supply (or wage mark-up) shock. The wage mark-up, defined as $\phi\hat{L}_t - \frac{h}{1-h}\hat{C}_{t-1} + \frac{1}{1-h}\hat{C}_t - \hat{W}_t$, is determined by the difference between the marginal rate of substitution between working and consuming and the real wage, with ϕ being the inverse of the Frisch elasticity of labor supply.

(ii) Non-Financial Firms

$$
\hat{Y}_t = \varepsilon_t^a + \alpha\left(\varepsilon_t^k + \hat{K}_t + \hat{U}_t\right) + (1-\alpha)\hat{L}_t \tag{6}
$$

$$
\hat{Z}_t^k = \frac{\zeta}{1-\zeta}\left(\hat{U}_t + \varepsilon_t^u\right) \tag{7}
$$

$$
\begin{aligned}
\hat{\Pi}_t =& \frac{\sigma_{pi}}{1+\sigma_{pi}\beta}\hat{\Pi}_{t-1} + \frac{\beta}{1+\sigma_{pi}\beta}E_t\left[\hat{\Pi}_{t+1}\right] - \frac{(1-\beta\sigma_p)(1-\sigma_p)}{(1+\sigma_{pi}\beta)\sigma_p} \\
&\times \left[\varepsilon_t^a - \alpha\hat{Z}_t^k - (1-\alpha)\hat{W}_t\right] + \varepsilon_t^p
\end{aligned} \tag{8}
$$

$$
\hat{W}_t = \hat{Z}_t^k - \hat{L}_t + \hat{K}_t + \hat{U}_t \tag{9}
$$

$$
\hat{I}_t = \frac{1}{\xi(1+\beta)}\left(\hat{Q}_t + \varepsilon_t^x\right) + \frac{1}{(1+\beta)}\hat{I}_{t-1} + \frac{\beta}{(1+\beta)}E_t\left[\hat{I}_{t+1}\right] \tag{10}
$$

$$
\hat{R}_t^k = \frac{Z^k}{R^k}\hat{Z}_t^k + \frac{(1-\delta)}{R^k}\left(\hat{Q}_t + \varepsilon_t^k\right) - \hat{Q}_{t-1} \tag{11}
$$

$$
\hat{K}_{t+1} = \delta(\hat{I}_t + \varepsilon_t^x) + (1-\delta)\left(\hat{K}_t + \varepsilon_t^k\right) \tag{12}
$$

Equation (6) captures the production technology, where $\hat{Y}_t$ is output, ϵ_t^a is a technology shock, α is the capital share and ϵ_t^k is a capital quality shock. Capital, $\hat{K}_t$ is augmented by the capital utilization rate, $\hat{U}_t$, the optimality condition of which is given by equation (7), where ζ represents the positive function of the elasticity of the capital utilization adjustment cost, $\hat{Z}_t^k$ is the marginal product of capital and ϵ_t^u is a capital utilization shock. This shock is meant to capture exogenous disturbances affecting the process through which the capital stock turns into capital services via its utilization rate. Staggered price stickiness is incorporated in the model through limiting the ability of firms to reset their prices every period with a probability equal to σ_p, as shown by equation (8), where σ_{pi} governs the degree of price indexation and ϵ_t^p is a price mark-up shock. Cost minimization by firms leads to equation (9), implying that the marginal product of capital is negatively related to the capital-labor ratio and positively related to real wages. Investment, $\hat{I}_t$ is described by equation (10), where $\hat{Q}_t$ is the current value of capital stock, ξ is the elasticity of the investment adjustment cost and ϵ_t^x is an investment-specific technology shock. The arbitrage condition for the value of capital is given by equation (11), where $\hat{R}_t^k$ is the external cost of funding and δ is the capital depreciation rate. The law of motion of installed capital is given by equation (12).

(iii) Financial Intermediaries

$$\hat{EP}_t = E_t\left[\hat{R}_{t+1}^k\right] - \hat{R}_t \tag{13}$$

$$\hat{K}_{t+1} + \hat{Q}_t = \hat{lev}_t + \hat{N}_t \tag{14}$$

$$\hat{lev}_t = \hat{D}_t + \frac{V}{\lambda - V}\hat{V}_t \tag{15}$$

$$\hat{D}_t = \theta\beta Z E_t[\hat{\Lambda}_{t,t+1} + \hat{Z}_{t,t+1} + \hat{D}_{t+1}] \tag{16}$$

$$\hat{Z}_{t,t+1} = \frac{1}{Z}\left[levR^k E_t\left[\hat{R}_{t+1}^k\right] + R(1-lev)\hat{R}_t + (R^k - R)lev\hat{lev}_t\right] \tag{17}$$

$$\begin{aligned}\hat{V}_t =& \frac{(1-\theta)\beta}{V}[R^k - R]E_t\left[\hat{\Lambda}_{t,t+1}\right] + \frac{(1-\theta)\beta}{V}\left[R^k E_t\left[\hat{R}_{t+1}^k\right] - R\hat{R}_t\right] \\ &+ \theta\beta X E_t[\hat{X}_{t,t+1} + \hat{V}_{t+1} + \hat{\Lambda}_{t,t+1}]\end{aligned} \tag{18}$$

$$\hat{X}_{t,t+1} = E_t\left[\hat{lev}_{t+1}\right] + \hat{Z}_{t,t+1} - \hat{lev}_t \tag{19}$$

$$\hat{N}_t = \frac{N^e}{Y}\frac{Y}{N}\hat{N}_t^e + \frac{N^n}{Y}\frac{Y}{N}\hat{N}_t^n \tag{20}$$

$$\hat{N}_t^e = \hat{N}_{t-1} + \frac{1}{Z}\left[levR^k E_t\left[\hat{R}_{t+1}^k\right] + R(1-lev)\hat{R}_t + (R^k - R)lev\hat{lev}_t\right] \tag{21}$$

$$\hat{N}_t^n = \hat{Q}_t + \hat{K}_t \tag{22}$$

Financial intermediaries raise funds from households and grant loans to intermediate producers. Due to a moral-hazard costly enforcement problem, the presence of financial intermediation leads to an endogenous credit spread, $\hat{EP}_t$ captured by equation (13), as a difference between the cost of funding state-contingent asset of non-financial firms and the gross nominal interest rate paid on deposits to households.[9]

As described by equation (14), the maximum amount of lending financial intermediaries can obtain depends on the total net worth, $\hat{N}_t$ and on the ratio of loan asset to equity capital, $\hat{lev}_t$. The leverage is endogenously determined by equation (15) and depends on the gain of increasing one unit of net worth, $\hat{D}_t$, on the gain of expanding assets, $\hat{V}_t$, and on the fraction λ that bankers could divert from the project and transfer it back to their household. The gain from having net worth, equation (16), hinges on the stochastic discount factor, Λ_t, associated with the household problem, the probability of bankers' surviving in the next period, θ, and on the gross growth rate of net worth, $\hat{Z}_{t,t+1}$, the law of motion of which is given by equation (17). The gain of expanding assets, equation (18), is mainly affected by the gross growth rate in assets, $\hat{X}_{t,t+1}$, which evolves as in equation (19).

Total net worth is given by the sum of net worth of existing bankers, $\hat{N}_t^e$ and of new bankers, $\hat{N}_t^n$, in equation (20). The net worth of existing bankers equals earnings on assets held in the previous period and the growth of the net worth, as specified by equation (21), while the net worth of new banks, equation (22), takes into account the "start-up" funds from the households they belong to, equal to the fraction χ of total assets.[10]

(iv) Monetary Authority and Equilibrium

$$\begin{aligned}\hat{R}_t^n =&\rho_i \hat{R}_{t-1}^n + (1-\rho_i)\left[\rho_\pi \hat{\Pi}_t + \rho_y\left(\hat{Y}_t - \hat{Y}_t^p\right)\right] \\ &+ \rho_{\Delta y}\left[\hat{Y}_t - \hat{Y}_t^p - \left(\hat{Y}_{t-1} - \hat{Y}_{t-1}^p\right)\right] + \varepsilon_t^r \end{aligned} \tag{23}$$

$$\hat{Y}_t = \frac{C}{Y}\hat{C}_t + \frac{I}{Y}\hat{I}_t + \frac{G}{Y}\varepsilon_t^g + Z^k\frac{K}{Y}\hat{U}_t \tag{24}$$

The monetary authority follows a Taylor rule, equation (23), where ρ_i, ρ_π, ρ_y and $\rho_{\Delta y}$ are policy parameters referring to interest-rate smoothing, and the responsiveness of the nominal interest rate to inflation deviations, to the output gap and to changes in the output gap, respectively. The term $\hat{Y}_t^p$ represents the level of output that would prevail under flexible prices and wages without the two mark-up shocks, while ϵ_t^r is a monetary policy shock. Finally, the resource constraint, equation (24), completes the model, with ϵ_t^g being a government spending shock.

[9] In this model at the beginning of each period the banker can choose to divert the fraction λ of available funds from the project and transfer them back to the household. Depositors can force the intermediary into bankruptcy and recover the remaining fraction $1-\lambda$ of total assets. However, costly enforcement implies that it is too costly for the depositors to recover the diverted fraction of funds by the banker.

[10] While parameter χ affects the steady-state of the model, it is not featured in the log-linearized version of the definition new banks' net worth.

Each of the nine exogenous shocks follow an AR(1) process,[11] except the price and wage mark up shocks which follow ARMA(1,1) processes. The inclusion of the MA term in these two exogenous disturbances allows capturing high-frequency fluctuations in inflation. This specification is common in the DSGE literature (e.g., Smets and Wouters, 2007; Justiniano et al., 2010, among many others).

3 Estimation

This section reports the results of the Bayesian estimation. Section 3.1 discusses the data and the estimation strategy while Section 3.2 discusses the calibration and presents parameter estimates.

3.1 Data and Measurement Equations

The model is estimated with quarterly data for the period 2000Q1-2022Q1, using as observables: (i) real GDP, (ii) real investment, (iii) real private consumption, (iv) the capital utilization rate, (v) hours worked, (vi) GDP deflator inflation, (vii) real wage, (viii) the shadow nominal interest rate, (ix) the interest rate spread and (x) the net worth of financial intermediaries. The starting date is dictated by the availability of data on EA net worth.

Most of EA data come from the Area Wide Model database (see Fagan et al., 2005, for details), complemented by capital utilization in manufacturing from the ALFRED database of the Federal Reserve Bank of St. Louis, the net worth extracted from Euro Area Statistics, the interest rate spread computed by Gilchrist and Mojon (2018), and hours worked, which combine observations computed by Ohanian and Raffo (2012) until 2016Q4 and from the Eurostat dataset afterwards.

Most of the US data are extracted from the ALFRED database, complemented with the series of the credit spread computed by Favara et al. (2016). All series are seasonally adjusted by their sources.

GDP, consumption, investment and wages are logged and, together with capital utilization, are expressed in first differences. Hours worked are logged and demeaned, while net worth is expressed as a ratio of GDP. The inflation rate is measured as the quarterly log-difference of the GDP deflator. Consistently, nominal interest rate and the spread are expressed in quarterly terms. More granular details on data sources and transformations are reported in Appendix A.

[11] The literature adopts a variety of approach in modelling monetary policy shocks (see, e.g. Taylor and Wieland, 2012). We follow Carrillo et al. (2018), who find that, when the framework contains enough information, a policy rule with interest rate inertia and serially correlated shocks satisfactorily matches the data.

The following set of measurement equations show the link between the observables in the dataset and the endogenous variables of the DSGE model:

$$\begin{bmatrix} \Delta Y_t^o \\ \Delta C_t^o \\ \Delta I_t^o \\ \Delta W_t^o \\ \Delta U_t^o \\ L_t^o \\ \frac{N}{Y}^o \\ \pi_t^o \\ r_t^{n,o} \\ EP_t^o \end{bmatrix} = \begin{bmatrix} \gamma \\ \gamma \\ \gamma \\ \gamma \\ \bar{u} \\ \bar{\ell} \\ \frac{\bar{N}}{\bar{Y}} \\ \bar{\pi} \\ \bar{r}^n \\ \bar{EP} \end{bmatrix} + \begin{bmatrix} \hat{Y}_t - \hat{Y}_{t-1} \\ \hat{C}_t - \hat{C}_{t-1} \\ \hat{I}_t - \hat{I}_{t-1} \\ \hat{W}_t - \hat{W}_{t-1} \\ \hat{U}_t - \hat{U}_{t-1} \\ \hat{L}_t \\ \bar{N}\hat{N}_t - \bar{Y}\hat{Y}_t \\ \hat{\Pi}_t \\ \hat{R}_t^n \\ \hat{EP}_t \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \varepsilon_{EP}^{me} \end{bmatrix} \tag{25}$$

where γ is the common quarterly trend growth rate of GDP, consumption, investment and wages; $\bar{u}$, $\bar{L}$ and $\frac{\bar{N}}{\bar{Y}}$ are the average change in capital utilization, average hours worked and the average ratio of net worth of financial intermediaries to GDP, respectively; $\bar{\pi}$, $\bar{r}^n$ and $\bar{EP}$ are the steady-state quarterly inflation rate, the nominal interest rate and spread, respectively. The term ε_{EP}^{me} represents a measurement error in the equation for the spread, which accounts for a possible mismatch between the financial variables in the model and those in the data, analogously to what Castelnuovo and Nisticó (2010) do for stock prices, among others.

The choice of including the utilization rate shock and the capital utilization in manufacturing as an observable variable stems from the inability of the canonical model to endogenously generate the large movements of the series itself observed in the data. Figure 1 shows the (demeaned) series of EA and US capital utilization in the data, its one-step-ahead forecast produced by the baseline model, and a counterfactual model estimated without capital utilization shocks. The baseline model helps forecast the utilization rate in a much more compelling way than the counterfactual model. While the counterfactual model is still able to generate pro-cyclical series, it displays a considerably smaller volatility, and is unable to match the large contractions observed during the crisis periods.

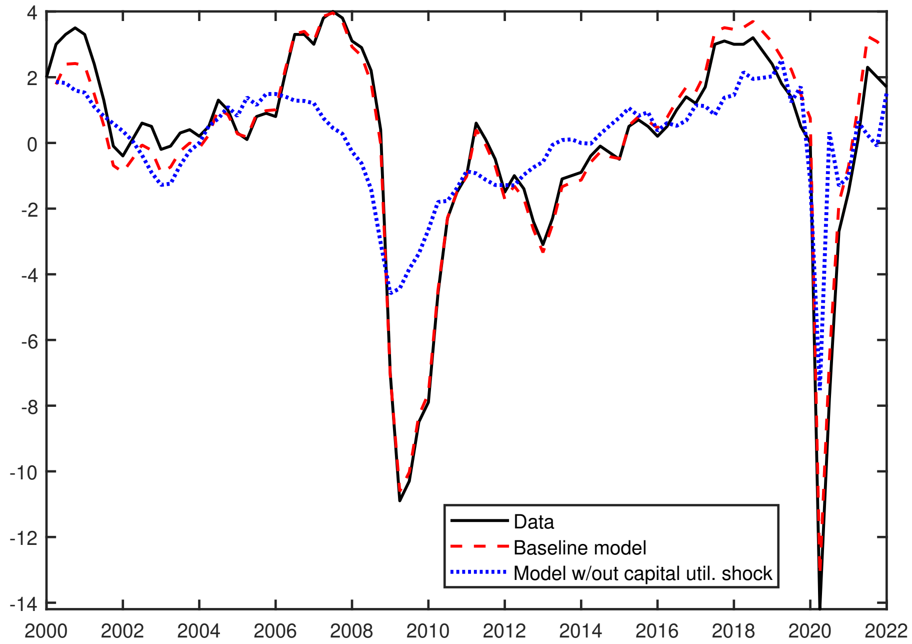
3.2 Calibration and Estimates

The parameters that cannot be identified in the data and/or are related to steady-state values of endogenous variables are calibrated. Given that quarterly data are employed for the estimation, the frequency implied by the calibrated parameters is also quarterly. Table 1 reports the parameters common to both countries and those taking country-specific values.

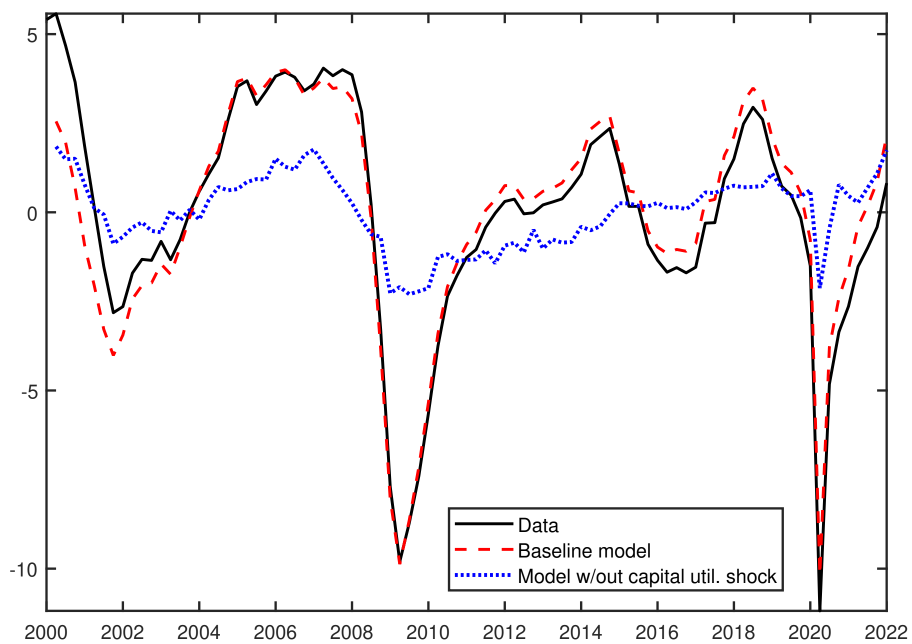
The common parameters are assigned very standard values in line with the DSGE

Figure 1: Capital Utilization in the Data (Demeaned), in the Baseline Model (One-Step-Ahead Forecast) and in a Counterfactual Model Without Capital Utilization Shocks (One-Step-Ahead Forecast).

(a) Euro Area



(b) United States



literature. The capital depreciation rate, δ, is set to 0.025, corresponding to an annual depreciation rate of 10 percent. The discount factor, β, is set to 0.99 and capital share of income, α, is equal to 0.33. The elasticities of substitution in goods and labor markets,

Table 1: Calibrated Parameters

Parameters	Value		Steady-state target/reference
Common	Euro area	United States	
Capital deprec. rate, δ	0.025		10% depreciation rate p.a. (standard)
Discount factor, β	0.99		4% risk-free real rate p.a. (standard)
Cap. share of income, α	0.33		labour share 2/3 of income (standard)
Elast. of subst. goods, ε	6		mark-up of 20% (Christiano et al., 2014)
Elast. of subst. labor, ε_w	6		mark-up of 20% (Christiano et al., 2014)
Surv. rate of bankers, θ	0.969		avg life of 8 yrs (Gelain and Ilbas, 2017)
Country-specific			
Gov. spend. to GDP, g_y	0.193	0.205	OECD and NIPA tables data
Frac. assets new banks, χ	0.003	0.003	leverage of 3.75 (Gelain and Ilbas, 2017)
Frac. of divert. assets, λ	0.683	0.393	spread 107; 203 a.bps. (Gilchrist and Mojon, 2018; Gilchrist and Zakrajšek, 2012)

ε and ε_w are equal to 6 in order to target a gross steady-state mark-up of 1.20, as in Christiano et al. (2014), among many others. The survival rate of financial intermediaries, θ, is set equal to 0.969 to target an average life of 8 years, as common in studies employing the Gertler-Karadi setting for the financial sector (as, e.g., in Gelain and Ilbas, 2017).[12]

As regards the country-specific parameters, the government spending to GDP ratio, g_y, is set equal to 20.7 percent for the EA and to 18.8 percent for the US economy, in line with OECD and NIPA tables data, respectively. The parameter representing the fraction of assets given to the new bankers, χ, is set equal to 0.003 for the EA and to 0.001 for the US economy, while the fraction of divertible assets, λ, is set equal to 0.393 for the EA and to 0.663 for the US economy. The combination of these two parameters and the rest of the calibration yield a leverage of 3.75 in both countries (as, e.g., in Gelain and Ilbas, 2017) and a steady-state credit spread of 107 and 203 annual basis points for the EA and the US economy, respectively, in line with the data (Gilchrist and Mojon, 2018; Gilchrist and Zakrajšek, 2012).

Table 2 shows the assumptions for the prior distributions, which are the same for both countries. This approach is line with other studies in the literature (e.g., Lubik and Schorfheide, 2005; Smets and Wouters, 2005; Giovannini et al., 2019, among others) and is meant to let the data determine cross-country differences in the estimated parameters. The table reports the prior mean and standard deviation of almost all parameters. The only exception is the standard error of innovations, for which the degrees of freedom of

[12]The parameter is not directly observable in the data. However, indicators related to bank failures suggest that it has not changed significantly during the C-19C, both in the EA and the US economy (see, e.g., the number of failed U.S. institutions reported by the Federal Deposit Insurance Corporation and the probability of simultaneous default of two or more large banks available in the ECB Statistical Data Warehouse). Moreover, this paper assumes the same magnitude for parameter θ in the two economies, given that contributions employing EA and US data adopted similar values (Gertler and Karadi, 2011; Hirakata et al., 2013; Lim and McNelis, 2016; Sahuc, 2016; Coenen et al., 2018; Quint and Tristani, 2018).

Table 2: Prior and Posterior Distributions of Estimated Structural Parameters, Constants and Exogenous Processes (95 percent credible intervals in square brackets)

		Prior distribution			Posterior mean	
Parameters		Distr	Mean	Std./df	Euro area	United States
Structural parameters						
Habit parameter	h	Beta	0.7	0.1	0.13 [0.10;0.16]	0.12 [0.10;0.13]
Inv. of Frisch elasticity	ϕ	Gamma	0.33	0.25	0.22 [0.20;0.24]	0.41 [0.17;0.63]
Calvo prices	σ_p	Beta	0.5	0.05	0.75 [0.72;0.79]	0.71 [0.66;0.76]
Calvo wages	σ_w	Beta	0.5	0.05	0.31 [0.28;0.34]	0.78 [0.65;0.91]
Price indexation	σ_{pi}	Beta	0.5	0.15	0.16 [0.05;0.26]	0.57 [0.50;0.64]
Wage indexation	σ_{wi}	Beta	0.5	0.15	0.47 [0.27;0.67]	0.67 [0.46;0.88]
Inv. adj. costs	ξ	Normal	4	0.5	3.21 [3.00;3.44]	3.54 [3.07;4.00]
Elasticity of capital util	ζ	Beta	0.25	0.15	0.62 [0.53;0.71]	0.64 [0.56;0.71]
Inflation - Taylor rule	ρ_π	Normal	1.7	0.15	2.05 [1.86;2.25]	1.78 [1.58;1.97]
Output - Taylor rule	ρ_y	Gamma	0.125	0.05	0.02 [0.01;0.03]	0.11 [0.07;0.14]
Taylor rule changes in y	ρ_{Δ_y}	Normal	0.0625	0.05	0.11 [0.07;0.14]	0.08 [0.05;0.11]
Taylor rule smoothing	ρ_i	Beta	0.75	0.1	0.67 [0.60;0.74]	0.76 [0.71;0.80]
Constants						
Trend	$\bar{\gamma}$	Normal	0.4	0.2	0.02 [0.00;0.04]	0.29 [0.25;0.32]
Inflation	$\bar{\pi}$	Gamma	0.5	0.1	0.58 [0.48;0.69]	0.66 [0.47;0.83]
Interest rate	$\bar{R}$	Normal	0.8	0.2	0.31 [0.12;0.49]	0.33 [0.13;0.52]
Hours	$\bar{\ell}$	Normal	0.0	2.0	-0.12 [-2.21;1.88]	3.45 [2.04;5.00]
Utilization rate	$\bar{U}$	Normal	0.0	0.2	-0.27 [-0.30;-0.24]	0.01 [-0.02;0.04]
Spread	$\bar{S}$	Gamma	0.5	0.1	0.37 [0.28;0.46]	0.44 [0.36;0.52]
Net worth over GDP	$\bar{NY}$	Normal	0.05	0.2	0.08 [-0.25;0.40]	0.06 [-0.26;0.38]
Exogenous processes						
Technology	ρ_a	Beta	0.5	0.2	0.93 [0.88;0.97]	0.84 [0.78;0.91]
	σ_a	IG	0.1	2	0.85 [0.74;0.96]	0.75 [0.65;0.85]
Price mark-up	ρ_p	Beta	0.5	0.2	0.99 [0.97;1.00]	0.91 [0.87;0.95]
	σ_p	IG	0.1	2	0.28 [0.23;0.34]	0.24 [0.19;0.29]
	μ_p	Beta	0.5	0.2	0.51 [0.39;0.62]	0.69 [0.58;0.80]
Labor	ρ_w	Beta	0.5	0.2	0.97 [0.95;0.99]	0.98 [0.96;0.99]
	σ_w	IG	0.1	2	0.30 [0.24;0.35]	0.72 [0.59;0.85]
	μ_w	Beta	0.5	0.2	0.18 [0.05;0.30]	0.75 [0.65;0.84]
Capital utilization	ρ_u	Beta	0.5	0.2	0.92 [0.89;0.95]	0.84 [0.77;0.91]
	σ_u	IG	0.1	2	2.82 [2.30;3.32]	1.83 [1.54;2.12]
Capital quality	ρ_{kq}	Beta	0.5	0.2	0.96 [0.94;0.98]	0.74 [0.68;0.79]
	σ_{kq}	IG	0.1	2	0.12 [0.09;0.15]	0.36 [0.28;0.45]
Inv. specific	ρ_x	Beta	0.5	0.2	0.19 [0.09;0.28]	0.39 [0.28;0.52]
	σ_x	IG	0.1	2	7.50 [6.21;8.78]	4.71 [3.72;5.67]
Preference	ρ_b	Beta	0.5	0.2	0.77 [0.69;0.86]	0.99 [0.99;0.99]
	σ_b	IG	0.1	2	1.12 [0.90;1.32]	3.28 [2.74;3.85]
Monetary policy	ρ_m	Beta	0.5	0.2	0.35 [0.25;0.44]	0.45 [0.38;0.52]
	σ_m	IG	0.1	2	0.27 [0.22;0.32]	0.19 [0.16;0.22]
Government spending	ρ_g	Beta	0.5	0.2	0.63 [0.48;0.78]	0.91 [0.87;0.96]
	σ_g	IG	0.1	2	1.94 [1.70;2.18]	2.94 [2.58;3.30]
Std- Measurement error		IG	0.1	2	0.15 [0.13;0.17]	0.15 [0.13;0.17]

the inverse Gamma distribution are reported. In line with many studies conducting a Bayesian estimation of DSGE models (e.g. Smets and Wouters, 2003, 2005, 2007, among many others), choosing 2 degrees of freedom guarantees a large domain for the prior of the volatility of all shocks. The functional form and the prior mean of the distribution of all parameters and constants largely correspond to those available in the literature (see, e.g. Smets and Wouters, 2003, 2007; Kollmann et al., 2015; Villa, 2016; Gelain and Ilbas, 2017; Albonico et al., 2019b).

The mean of the estimated parameters for each model is computed with two chains of the Metropolis–Hastings algorithm, each with a sample of 500,000 draws. Table 2 reports the posterior mean with 95 percent probability intervals in parentheses for the EA and the US economy. Posterior estimates are broadly in line with previous studies. Due to the presence of financial frictions, the estimated value of the habit parameter in consumption is lower than in other papers (Smets and Wouters, 2007). This finding is in line with several contributions in the literature (e.g., De Graeve, 2008; Smets and Villa, 2016), since financial frictions generate enough endogenous propagation to account for the persistence of the consumption process. The response of the nominal interest rate to inflation is higher in the EA than in the US economy, while the policy rate is more aggressive to output in the US economy compared to the EA. The estimates of the exogenous processes reveal that, in general, shocks are more volatile in the US economy compared to the EA, except for capital utilization, investment-specific technology and monetary policy shocks.[13] The persistence of the monetary policy shock is relative low, similarly to Smets and Wouters (2007). As far as the capital utilization shocks are concerned, these are rather persistent, capturing empirical features in the data. The posterior estimates of constants in the measurement equations capture the sample averages of the observable times series used in the estimation.[14]

For some parameters, such as the habit parameter and the responsiveness of the nominal interest rate to the output gap, the estimates are close to the extremes of the prior distributions. We investigate whether a different prior distribution can affect the estimation results (see, for example, Meenagh et al., 2022) in Appendix C.2, which reports posterior estimates, as well as all the results on the role of shocks on economic activity and inflation, under an alternative specification of the prior distributions of relevant parameters.

4 Results

This section presents the results of the paper. Subsection 4.1 discusses the dynamic properties of the model via an analysis of the estimated impulse response functions. Subsection 4.2 investigates the sources of business cycles fluctuations during the GFC

[13]As discussed in Smets and Wouters (2005), if the posterior estimate of a parameter in one model falls in the estimated confidence band for the same parameter of the other model, the two estimated parameters can be considered similar.

[14]These may vary substantially across the two regions because of the underlying differences in the data, as in the case of trend growth, hours worked and the utilization rate.

and the C-19C with historical shock decompositions. Finally, Subsection 4.3 focuses on the contribution of monetary policy shocks.

4.1 Dynamic Properties of the Estimated Model

As mentioned in Subsection 3.1, the estimated model features nine structural shocks, most of which are common in the DSGE literature (e.g. Smets and Wouters, 2007). One notable exception is the capital utilization shock. While endogenous capital utilization is a rather standard element in this class of models (e.g. Smets and Wouters, 2007; Albonico et al., 2014), exogenous disturbances to this variable have so far been neglected. The C-19C triggered by the COVID-19 pandemic involved several necessary containment measures impairing the use of existing capital goods, which can be captured by an exogenous disturbance to capital utilization.

Another important implication of the C-19C was the inability of a large fraction of workers to reach their workplace or to provide their usual amount of labor services remotely. This aspect is captured by a shock to labor supply introduced as a standard wage mark-up shock. This shock is observationally equivalent to the labor disutility disturbance in terms of dynamics because both shocks enter households' intratemporal optimality condition (e.g. Smets and Wouters, 2007).[15]

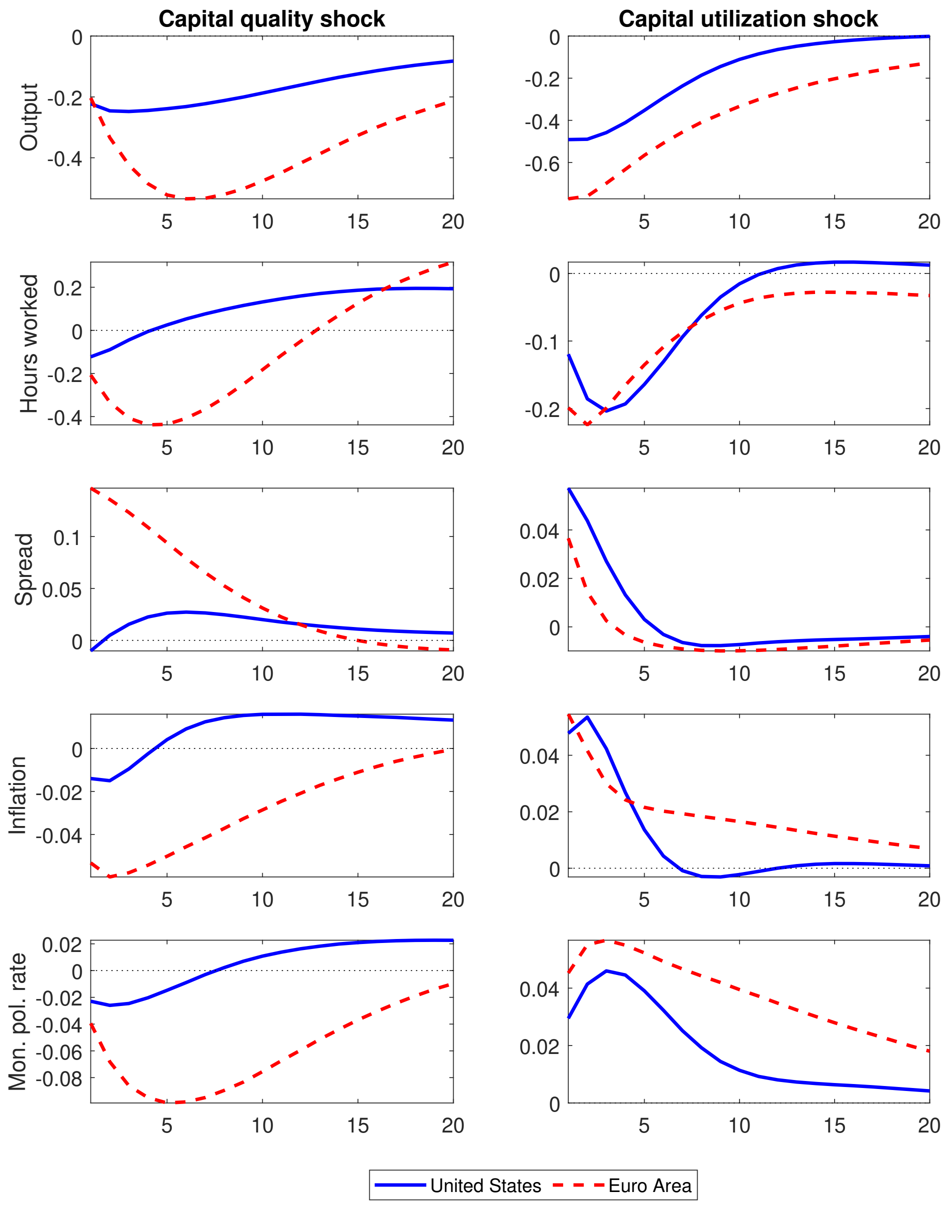
The inclusion of financial frictions and of a financial shock, such as the capital quality shock as in Gertler and Karadi (2011), is warranted primarily because the estimation sample includes the GFC, but also to capture disturbances to the financial sector in the rest of the sample.

Both the capital quality shock and the capital utilization shock affect the amount of capital that effectively enters the production function. It is, therefore, important that the responses of the model's endogenous variables to these two shocks display sufficiently different dynamics for them to be correctly identified. Figure 2 reports the posterior median impulse response functions (IRFs), for the EA and the US economy, of important macroeconomic variables to a capital quality and a capital utilization shock of sizes equal to their respective estimated standard deviations. The sign of the shocks is such that they trigger a decline in output. Both shocks cause a fall in hours worked and an increase in the credit spread. The crucial difference between the two lies in the response of inflation, which declines in the case of a capital quality shock and rises in that of the capital utilization shock. In other words, while the capital quality shock behaves as a demand shock,[16] the capital utilization shock acts as a supply shock by affecting the production

[15]Some contributions have disentangled the two shocks by imposing different spectral profiles (Justiniano et al., 2013) or by introducing unemployment (Galí et al., 2012; Foroni et al., 2018).

[16]The mechanism is the following: the capital quality shock directly translates into a shock to banks' balance sheets because of the identity between capital and assets. Because of the presence of moral hazard, depositors require banks not to be overleveraged. Hence they are forced to reduce lending. The reduction in the lending volume makes the incentive constraint tighter, leading to a higher spread.

Figure 2: Posterior Median Impulse Response Functions to One-Standard-Deviation Capital Quality and Capital Utilization Shocks



function. The monetary policy rate closely tracks the path of inflation due to the high weight inflation takes in the estimated Taylor rules. The typical responses of output to both shocks are more pronounced for the EA than they are for the US economy, largely due to their higher estimated volatility and/or persistence.

As regards the other more standard structural shocks, their IRFs are reported in Appendix B (Figure B.1 and B.2). The dynamics of the IRFs of output, inflation and the monetary policy rate have the expected sign and shape, as well as relatively narrow

Nonfinancial firms observe a rise in borrowing costs and consequently reduce their demand for capital, leading to a fall in investment.

confidence bands (at a 95-percent confidence level). While the shocks to investment, preferences, monetary policy and government spending behave as demand shocks, the responses to shocks to TFP, price mark-up and labor supply display dynamics in line with a supply shock.

4.1.1 Investigating Heterogeneity

While the core of this paper investigates aggregate results for the EA and the US economy as a whole, this subsection examines potential cross-country or cross-states heterogeneity. For example, some empirical studies for the EA (Cortes et al., 2022; Spiegel, 2022) find heterogeneous impacts of policy shocks on economic and financial outcomes. As far as monetary policy shocks are concerned, Corsetti et al. (2022) emphasize the ECB's "one money, many market" feature of monetary policy decisions. Also for the US economy, there is evidence of heterogeneous impacts of monetary policy (Beraja et al., 2019; Amir-Ahmadi et al., 2020), while Brinca et al. (2021) emphasize differences at the sectoral level. Unlike currency-union models (e.g. Batini et al., 2021), the model employed in this paper does not have a multi-country or a multi-sectoral structure. However, alternative parametrizations may help shed light on the role of regional or sectoral heterogeneity in the transmission of shocks. Given the novelty of capital utilization shocks and the abovementioned debate on monetary policy shocks, this subsection focuses precisely on these disturbances. The choice of parameters is motivated by characteristics that may affect more directly the transmission of these shocks. In particular, given the estimated parameters, we investigate whether IRFs are stable when changing a relevant parameter at a time.

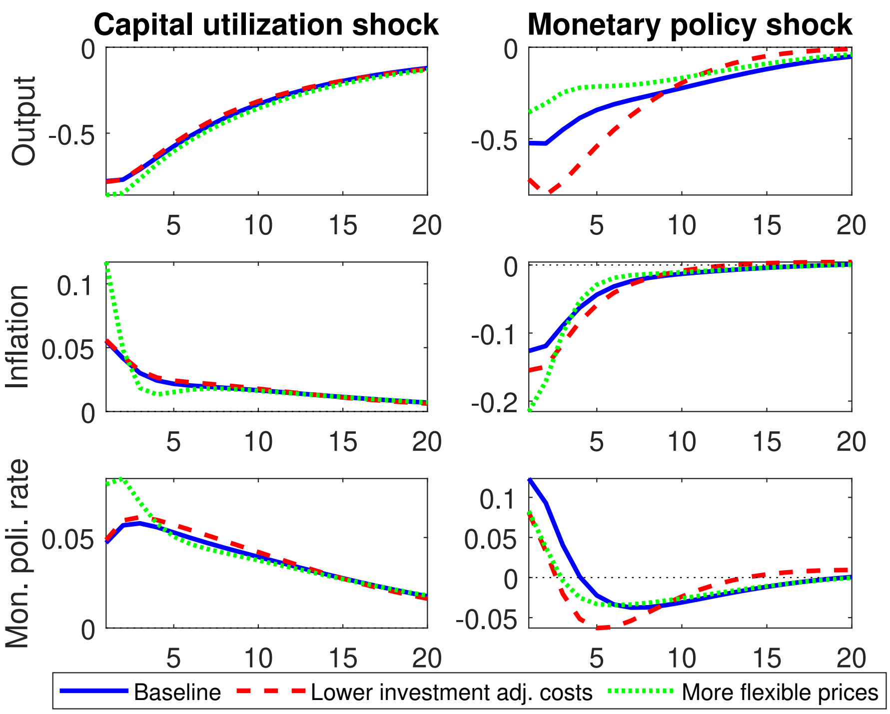
Gautier et al. (2022), using micro-data, find that while differences in price rigidity for most EA countries are small, there are also cases of significantly lower price rigidity. The average quarterly frequency of price changes found by these authors is 29.5 percent, which translates into a Calvo parameter of $\sigma_p = 0.71$, equivalent to changing prices almost every 3.5 quarters on average. This estimate, although obtained using a very different empirical approach, is close to the DSGE-based point estimate presented in this paper ($\sigma_p = 0.75$, equivalent to changing prices every 4 quarters on average). In the country-specific estimates by Gautier et al. (2022), the minimum probability of changing prices corresponds to resetting them every two quarters ($\sigma_p = 0.5$). Therefore, Figure 3(a) shows a comparison of impulse responses to a capital utilization shock and a monetary policy shock between the baseline case (in line with aggregate EA estimates presented in Table 2) and an alternative specification with $\sigma_p = 0.5$.[17]

As regards the investment adjustment cost parameter, ξ, the DSGE literature using

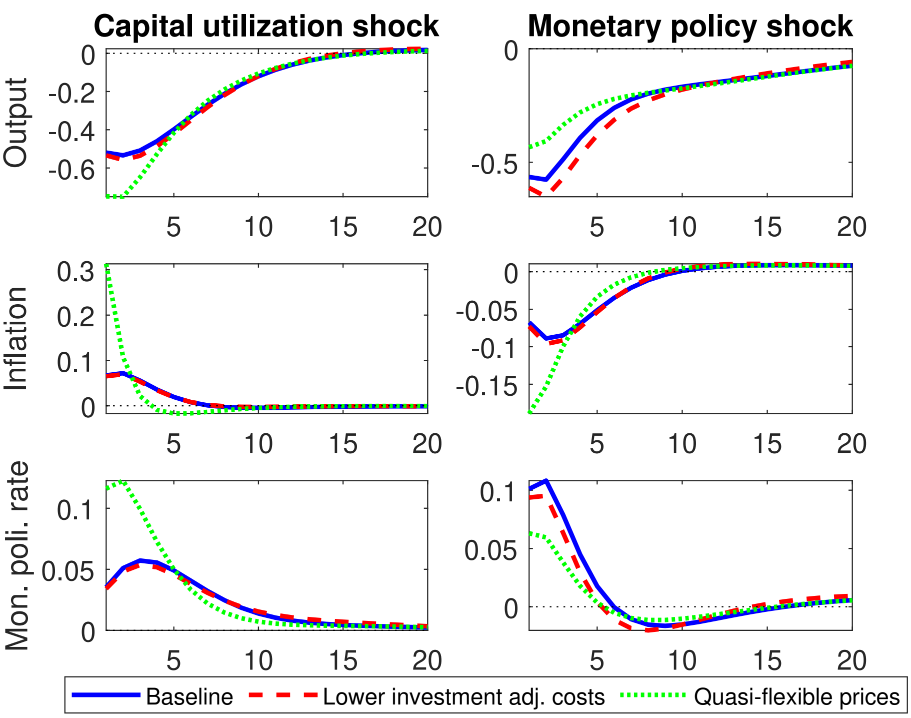
[17]Alternatively, a parameter potentially capturing regional heterogeneity in the EA could be wage indexation to past inflation, which differs across states (ECB, 2008). This parameter affects the dynamics of the monetary policy shock, having virtually no role in the transmission of the capital utilization shock.

Figure 3: Impulse Responses to Capital Utilization and Monetary Policy Shocks Under Alternative Parametrizations

(a) Euro Area



(b) United States



estimated or calibrated models employing EA data (at the level of monetary union or single countries) generally report values in a neighborhood of our estimate of 3.21. For example, Forni et al. (2010) set $\xi = 3.5$ for Belgium, Germany and the rest of the EA, while Drygalla et al. (2020) estimate $\xi = 3.91$ using German data. There are, however, some studies that estimate or calibrate this parameter at considerably different values, indicating that there may be some heterogeneity owing to the use of a different country coverage and/or a different estimation/calibration period. For instance, Breuss and Rabitsch (2009) estimate $\xi = 0.86$ and $\xi = 1.76$ for Austria and the EA, respectively; Poutineau and Vermandel (2015) estimate $\xi = 0.63$ and $\xi = 1.87$ for core and peripheral EA, respectively; and Gerali et al. (2018) calibrate $\xi = 1$ both for Italy and the EA. Therefore, Figure 3(a) also shows a comparison of impulse responses between the baseline case and an alternative specification with $\xi = 0.63$, which is the value (among those cited) that differs the most from the EA estimate of 3.21 presented in Table 2.

Results confirm the abovementioned studies arguing that intra-EA heterogeneity may matter for the transmission of some shocks. For example, price rigidity has a considerable impact in the case of capital utilization and monetary policy shocks. In countries with more flexible prices, the real effects of a monetary policy shocks are dampened, in line with a large literature on monetary economics (e.g. Woodford, 2003). Conversely, output contracts to a larger extent in response to a negative capital utilization shock if prices are more flexible. In countries with lower investment adjustment costs, the effects of monetary policy shocks may be amplified due to the higher investment responsiveness. This feature does not have a big impact in the case of capital utilization shocks.

While for the EA there are several contributions on the heterogeneity of price stickiness across member countries, for the US economy estimates are available at the aggregate national level. However, regional differences, such as varying inflation rates, industry compositions, and labor market conditions, could impact the level of price stickiness at the state level. For instance, Nakamura and Steinsson (2008) investigate the heterogeneity at the sector level and find that the (approximated) quarterly frequency of price changes ranges from 10 percent in the case of apparel to 99 percent in the case of vehicle fuel, equivalent to Calvo parameters of $\sigma_p = 0.90$ and $\sigma_p = 0.01$, respectively. In other words, across sectors, prices range from being as sticky as not changing for 10 quarters (on average) to almost flexible (within the quarter). As an illustration, Figure 3(b) shows a comparison of impulse responses between the baseline case and an alternative specification with $\sigma_p = 0.01$, which is the value (among those cited) that differs the most from the US estimate of 0.71 presented in Table 2.

Also for the investment adjustment cost parameter, there is no study employing a DSGE framework investigating cross-regional differences. However, there is some empirical evidence showing that these costs vary across sectors (Groth and Khan, 2010) and across types of agents (Iacoviello, 2015). Therefore, it is plausible that diverse sectoral compositions and/or agents' distributions across states also imply different levels of investment adjustment costs. Cantelmo and Melina (2018) build a two sector DSGE model with durable and non-durable good, and patient and impatient agents, where the baseline estimates of the investment adjustment cost parameter range between $\xi = 1.77$ and $\xi = 3.79$. As an example, Figure 3(b) shows impulse responses obtained with an alternative specification of ξ equal to 1.77, which is the value that differs the most from the US estimate of $\xi = 3.54$ presented in Table 2.

Results found with different specifications for the US economy are qualitatively similar to those obtained using EA alternative specifications. The model predicts that, in states with a sector composition biased toward categories of goods and services with more flexible prices, the effects of capital utilization shocks are expected to be stronger than those at the average national level. For monetary policy shocks, the reverse is true, given the well-known feature of monetary policy affecting more the demand of goods and services with stickier prices. In line with EA findings, in states with lower investment adjustment costs, the effects of monetary policy shocks may be enhanced, while this feature is less relevant for capital utilization shocks.

4.2 The Role of Shocks on Economic Activity and Inflation

This subsection focuses on the historical contribution of structural shocks in explaining quarterly output growth and inflation fluctuations in the period of the GFC and of the C-19C in order to provide a comparison between the two recessions across the two economies. In Figures 4 and 5, each color represents the contribution of an individual shock. Two exceptions, implemented to simplify the charts, are the green bars, which combine the TFP and the price mark-up shocks, and the light blue bars merging (monetary and fiscal) policy shocks.

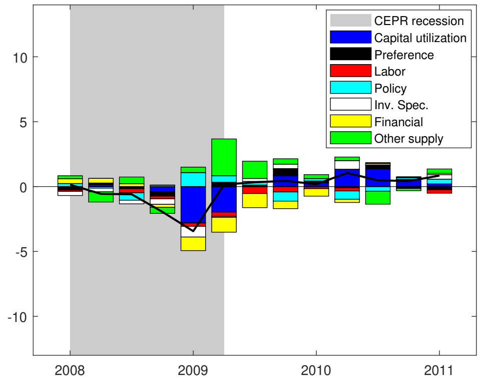
4.2.1 Output

The historical decomposition of quarterly GDP growth is shown in Figure 4. At the trough of the GFC, in the EA the capital utilization shock is the largest contributor to output growth, while policy shocks provided the second largest contribution, as reported in Figure 4(a). Financial shocks also played a non-negligible role, persistently weighing on GDP growth for about one year after the trough. Over the GFC, capital utilization shocks confirmed their dominant role together with the other two supply shocks and the financial shocks. These results broadly agree with those by Kollmann et al. (2016) and Cardani et al. (2022), who estimated much richer DSGE models for the EA, finding a non-negligible role also for trade shocks, absent in the closed-economy model employed in this paper. During the GFC, foreign demand shocks played a relevant role particularly for some countries, such as France (Albonico et al., 2019a).

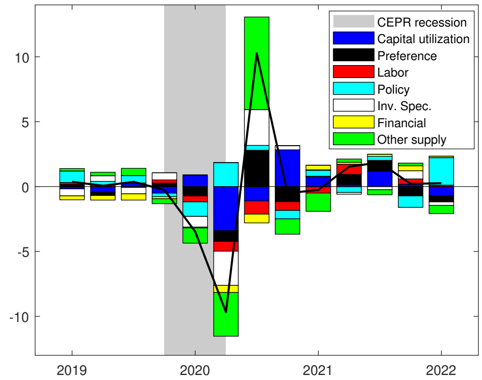
At the trough of the C-19C (Figure 4(b)), the capital utilization shock and the other supply shocks account for half of the output contraction, in line with Kollmann (2021) who

Figure 4: Historical Shock Decomposition of Quarter-on-Quarter GDP Growth (Demeaned)

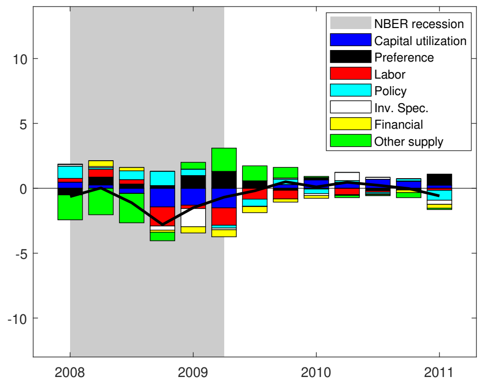
(a) Euro Area GFC



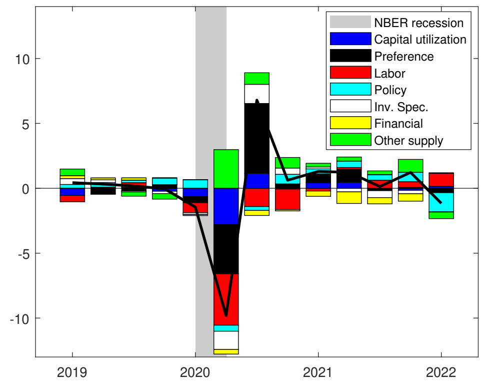
(b) Euro Area C-19C



(c) United States GFC



(d) United States C-19C



finds that an aggregate supply contraction is identified as the dominant force driving the sharp fall of EA GDP in 2020. Investment-specific technology shocks played a noteworthy role while labor and preference shocks explain only a minor fraction of the total variation in output growth.

In the US, at the trough of the GFC, the capital utilization shock was one of the main driver of the output contraction together with the labor (or wage mark-up) shock, as shown in Figure 4(c). The latter was much more important in the US economy than in the EA, confirming the results by Smets and Wouters (2005) over an earlier sample (1975Q1-2002Q2). The negative prolonged role of the labor supply shocks is consistent with the fact that the recovery from this crisis has been defined "jobless" (see Cantore et al., 2014, among others). The larger role of labor shocks can be explained by labor market variables in the US economy being more reactive to business cycle fluctuations, given the looser employment protection than in the EA (e.g. Nunziata, 2003; Gnocchi et al., 2015). The rate of labor reallocation into and out of unemployment observed in the US is indeed much higher than that observed in European countries (e.g. Elsby et al., 2009) and movements in the labor supply are likely to affect output fluctuations to a large extent. Policy shocks contributed notably to support GDP growth at the trough of the GFC. Surprisingly, financial shocks played a limited role in accounting for GDP fluctuations, while other shocks had a more prominent role. There are two possible explanations. First, investment-specific technology shocks dominate in 2009Q1 in correspondence with the massive drop observed in investment. Second, shocks to capital utilization are found to be particularly relevant in explaining the large fall in the utilization rates observed during the GFC, as shown in Figure 1b.

At the trough of the C-19C (Figure 4(d)), labor and preference shocks explained half of the output fluctuations. In line with Christiano et al. (2011), preference shocks capture exogenous disturbances affecting desired savings. Saving rates have indeed reached unprecedented levels during the pandemic, and this explains its important role on business cycle fluctuations. Other supply shocks drove output up, and capital utilization shocks played a relevant role similarly to the GFC.[18] In line with purely empirical papers (see, e.g., Christiano et al., 2005; Ramey and Zubairy, 2018, among many others), the estimated model implies lagged effects of monetary and fiscal policy. This explains why a positive GDP effect of policy shocks is detectable only with lags.

4.2.2 Inflation

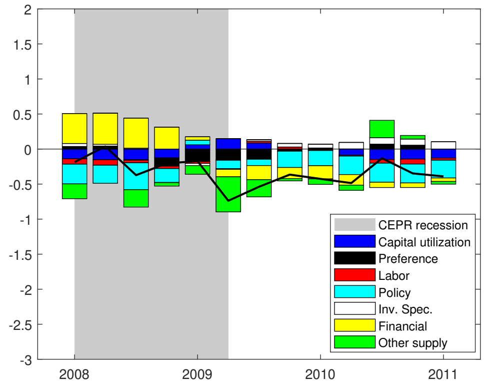
Figure 5 shows the shock decomposition for inflation. Over the GFC, EA financial shocks played an important role in driving inflation fluctuations (Figure 5(a)). Interestingly, financial shocks contributed positively to inflation for the four quarters of 2008, then their contribution turned negative. There is a large discussion in the literature on whether financial shocks act as a demand or a supply shock (e.g. Gerali et al., 2010; Meh and Moran, 2010; Furlanetto et al., 2019, among others), as well as on the missing deflation puzzle in the GFC (see Kara and Pirzada, 2020; Harding et al., 2022, among others).[19] In this model, similarly to Gerali et al. (2010), inflationary pressures may originate from the dynamics of bank lending standards, the easing of which in 2006 and 2007 could have had persistent effect on inflation due to the high estimated persistence of the financial shock. From 2009 onward, in combination with higher borrowing costs and a tightening of credit standards, financial shocks contributed negatively on inflation. Supply shocks

[18] The positive contribution of other supply shocks at the trough of the C-19C, followed by smaller contributions in subsequent quarters, is broadly in line with some empirical studies on the US economy (e.g., Fernald and Li, 2022) arguing for accelerated productivity growth at the beginning of the pandemic followed by more modest increases afterwards. One interpretation is the fast adoption of digital technology associated with teleworking. This paper follows most of the DSGE literature in employing stationary data for the estimation, which may downplay the contribution of TFP shocks, found to be sizable by Le et al. (2021) who use non-stationary data in the estimation.

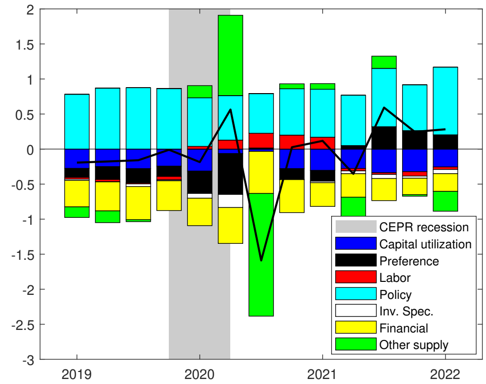
[19] In a DSGE model estimated for the EA, Gerali et al. (2010) also find that the role of financial shocks turned negative from positive in accounting for movements in inflation during the financial crisis. In a BVAR estimated on US data, Abbate et al. (2016) find that contractionary financial shocks temporarily increase inflation, thereby helping explain the missing disinflation during the GFC.

Figure 5: Historical Shock Decomposition of Quarter-on-Quarter Inflation Rate (Demeaned)

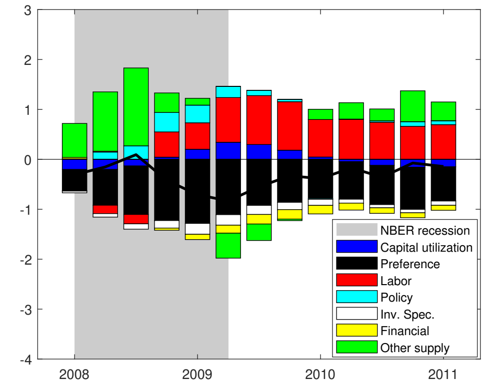
(a) Euro Area GFC



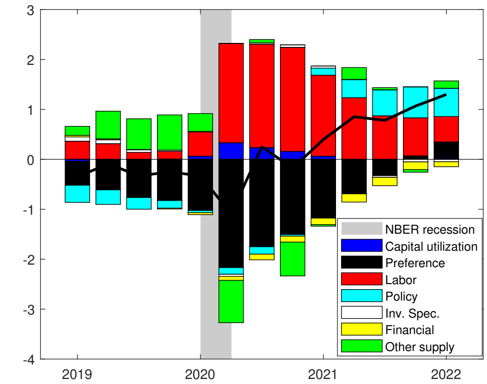
(b) Euro Area C-19C



(c) United States GFC



(d) United States C-19C



contributed mainly negatively to inflation. In particular, the positive contribution of the TFP shock was more than offset by the negative contribution of the price mark-up shock. The signs of these supply shocks are in line with the study by Kollmann et al. (2016). Both monetary and fiscal shocks contributed negatively to inflation fluctuations during the period 2008Q1-2011Q4. Their contribution turned large and positive around 2014 when the ECB embraced strongly accommodative policy actions.

During the C-19C reported in Figure 5(b), policy shocks contributed positively to EA inflation fluctuations, while financial shocks pushed inflation down, in line with the results by Cardani et al. (2022).[20] The positive effect of policy shocks is dominated by the contribution of monetary policy (displayed in Figure 7(a)). The expansionary phase of EA monetary policy started in 2015, it paused before the C-19C, and intensified in response to the pandemic. This pattern is mirrored in the contributions of policy shocks

[20]It should be noted that inflation is measured as quarter-on-quarter change in the GDP deflator. This can be particularly relevant when examining the role of monetary policy shocks in the EA during the C-19C, when the divergence between this measure of inflation and year-on-year HICP inflation gets very large.

to inflation with some lags, implied by their usual transmission mechanism. Supply shocks had a dominant and negative effect on inflation in 2020Q3, when the easing of restrictions over the summer can be interpreted as expansionary supply shocks reducing inflation and increasing GDP. The demand-side effects of easing restrictions initially had a much more muted impact on inflation, while they contributed positively toward the end of the estimation horizon.

Figure 5(c) includes the shock decomposition of inflation for the US over the GFC. Differently from the EA, there is an evident effect of contractionary demand shocks, mainly preference shocks (and financial shocks to a minor extent) which contributed negatively to inflation fluctuations; and contractionary supply shocks, mainly labor shocks, providing a positive contribution to inflation. Expansionary policy shocks, due to the timely intervention of policy-makers, pushed inflation up, though very little. Overall, demand shocks dominate over supply shocks in accounting for movements in inflation.

Lastly, during the C-19C reported in Figure 5(d), overall supply shocks dominated over demand shocks in explaining movements in inflation in line with the results by Del Negro et al. (2022). Policy shocks contributed positively to inflation from 2021Q1 onward.

4.3 The Contribution of Monetary Policy

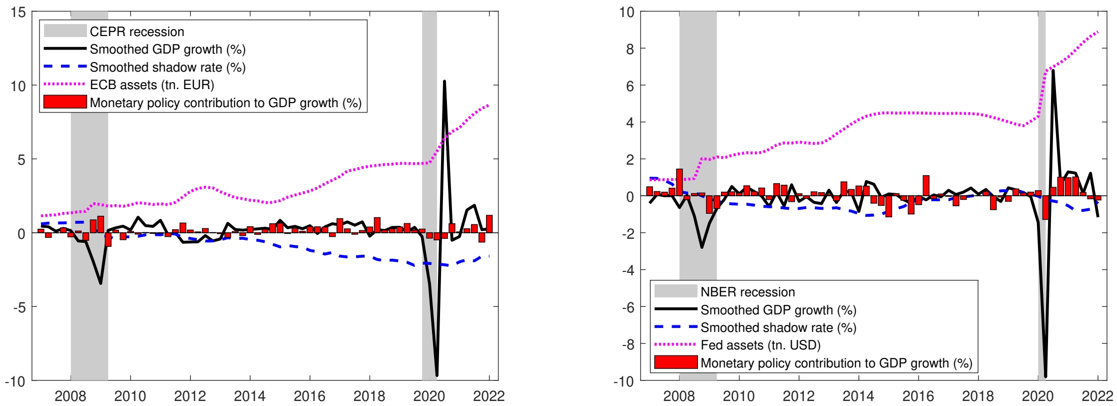
This subsection focuses on the role of monetary policy shocks. Since the GFC, a major issue concerning both the EA and the US economy was the ZLB reached by the monetary policy rate, due to the repeated rate cuts. To overcome this constraint, the two central banks (as other monetary policy institutions around the world) pursued unconventional monetary policy measures, such as asset purchases and forward guidance. In the estimation, this enhanced policy intricacy is captured by using the shadow rate derived by Wu and Xia (2016, 2017, 2020).

As shown in Figure 6, the shadow rates declined during the GFC, capturing monetary policy easing that exerted a positive impact on GDP growth as early as 2008 in the US economy and as 2009 in the EA. Afterwards, the shadow rate path shows continued easing of US monetary policy until 2015, thanks to both the monetary policy rate being kept at the effective ZLB from 2009 to 2015 and various rounds of quantitative easing, mirrored in an expansion of the Fed's balance sheet. In the EA, monetary policy was tightened to an extent during the sovereign debt crisis that started in 2010. However, after the "Whatever it takes" speech of then ECB's President Mario Draghi, the monetary policy rate was brought first to the ZLB and then turned negative, before the Asset Purchase Program began in 2015.

It follows that, between 2007 and 2009—the period broadly coinciding with the GFC—on average, monetary policy shocks had positive contributions to EA and US GDP growth

Figure 6: Contribution of Monetary Policy Shocks to Quarter-on-Quarter GDP Growth (Demeaned)

(a) Euro Area (b) United States



as shown in Table 3. The average annualized contribution of monetary policy shocks from the historical decomposition was 0.1 percentage points in the EA and 0.55 percentage points in the US economy. Slightly higher average contributions on annual GDP growth are found for the period between 2010 and 2014 (0.32 percentage points for the EA and 0.66 percentage points for the US economy). A key difference between the EA and the US is the period between 2015 and 2020. While the continued expansion of the ECB's balance sheet, as well as the additional non-standard measures, contributed positively to EA GDP growth (1 annual percentage point on average), in the US economy negative contributions dominate (-0.05 annual percentage points on average), due to repeated interest rate hikes between 2016 and 2019, mirrored in an increase in the shadow rate. Overall, these contributions are sizeable, especially if compared to the average annual growth rate of the two economies over the entire estimation period, which amount to

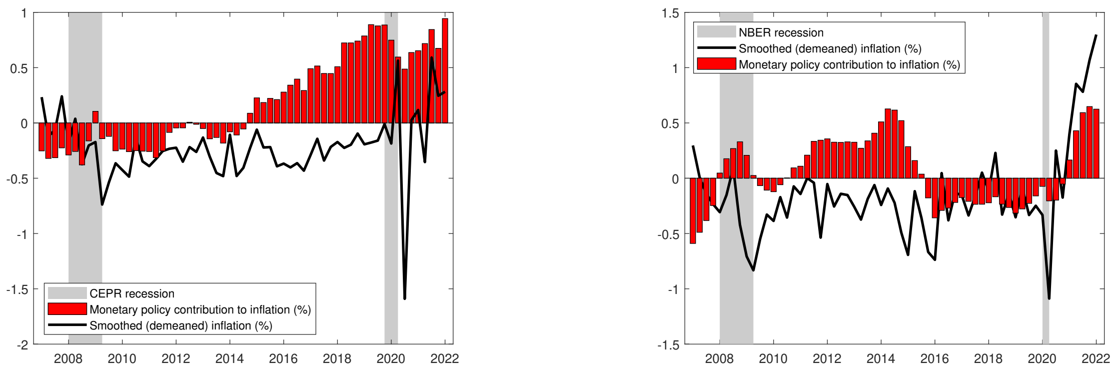
Table 3: Contributions of Monetary Policy Shocks to Annual EA and US GDP Growth

	Average contribution of monetary policy shocks to annual GDP growth (Percentage Points)	
	Euro Area	United States
2007Q1-2022Q1	0.61	0.31
2007Q1-2009Q4	0.10	0.55
2010Q1-2014Q4	0.32	0.66
2015Q1-2022Q1	1.00	-0.05
2009Q2-2011Q1	-0.67	0.43
2020Q2-2022Q1	0.59	0.99

Figure 7: Contribution of Monetary Policy Shocks to Quarter-on-Quarter Inflation (Demeaned)

(a) Euro Area

(b) United States



1.27 and 2.02 percent for the EA and the US economy, respectively.

The greatest similarity that can be observed between the EA and the US monetary policy conduct is the swift and significant measures taken during the C-19C. The Fed brought the monetary policy rate again to the effective ZLB and expanded its balance sheet via a massive operation of bond purchases, and the ECB implemented a similar plan, the Pandemic Emergency Purchase Programme. These measures had the intended effects of boosting the recovery from the C-19C, contributing positively to GDP growth. In the two years from the trough of the C-19C (2020Q2-2022Q1) monetary policy shocks had an average contribution to annualized GDP growth of almost 0.6 and 1 percentage point in the EA and the US economy, respectively. In the EA context, this outcome stems from a more active policy-making approach compared to that adopted in the two years covering the Great Recession and beyond (2009Q2-2011Q1).[21]

The different timing in the monetary policy actions between the EA and the US economy is reflected also in their contributions to inflation (Figure 7). The EA shows mostly negative contributions of monetary policy shocks to inflation until the start of the ECB's Asset Purchase Program in 2015, and positive contributions until the end of the sample, including during the C-19C. In the US economy, monetary policy shocks had positive contributions to inflation during the GFC and for most of the period in which quantitative easing was in place. Contributions turned negative in 2015 and then again positive during the C-19C.

[21] The important role of the PEPP and other pandemic-related measures to support euro area growth in the period 2020-2023 is also found in ECB (2023).

5 Conclusions

The GFC and the C-19C represented not only two major economic global crises but also two important triggers of large and new policy actions. Understanding the drivers of the economic fallout around those episodes is essential to the analysis of the policy response also to future rare but large shocks. This paper focuses precisely on this issue by investigating the shocks that drove the output contraction and movements in inflation during the GFC and C-19C and by assessing to what extent monetary policy contributed to the recovery from these major crises.

The analysis is conducted with the Bayesian estimation of a DSGE closed-economy model augmented with financial frictions. A novel feature of the model is the addition of an exogenous disturbance to capital utilization, which proves important to replicate the capital utilization rate in crises periods. Given that the sample includes the ZLB period, the estimation is conducted employing a shadow monetary policy rate as an observable variable.

The main conclusions are as follows. Capital utilization shocks are found to be important contributors to the negative components of output growth during the GFC and the C-19C in both the EA and the US economy, while they played a limited role in accounting for inflation fluctuations. Moreover, the timely and strong intervention of the European Central Bank and the U.S. Federal Reserve is found to have had an important contribution to the recovery from the C-19C, having also a positive impact on inflation. It follows that the experience acquired by monetary policy makers during, and in the aftermath of, the GFC was arguably instrumental to the recovery from the C-19C.

Future research may investigate three main issues: (i) the role of open economy features in assessing the relative importance of various domestic and foreign shocks; (ii) the relevance of durable and non-durable goods, whose dynamics differed during the C-19C; and (iii) the large volatility of the COVID-19 shock, in the spirit of Lenza and Primiceri (2022). Enriching the model to include these features may shed light on additional mechanisms potentially relevant in the transmission of shocks in crisis times.

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Appendix

A Data

This section discusses the sources and transformation of the ten variables used in the estimation. Following Smets and Wouters (2007), GDP, consumption and investment are transformed in per-capita terms by dividing their real values by the labor force. Real wages are computed by dividing compensation per hour by the GDP deflator. As shown in the measurement equations in Subsection 3.1, the observable variables of GDP, consumption, investment and wages are logged and expressed in first differences. Capital utilization is computed as the first difference of the log of the rate of capacity utilization. The corresponding code is BSCURT02EZQ160S for the EA (computed from the business tendency surveys for manufacturing) and TCU for the US economy, both extracted from the ALFRED database.[22]

EA data on hours worked come from Ohanian and Raffo (2012) until 2016Q4 for the following available countries: Austria, Finland, France, Germany, Ireland, Italy, and Spain. The EA variable is created by aggregating countries series weighted by countries' nominal GDP. From 2017Q1 onward EA data are extracted from Eurostat, code lfsi_ahw_q. US data are computed as average weekly hours in the nonfarm business sector (PRS85006023).

EA real net worth is computed as the difference between loans and deposits of households and corporates, divided by the GDP deflator. EA credit spread is computed as the spread of non-financial corporates with respect to domestic sovereign bonds.[23] US real net worth is given by the difference between bank credit (TOTBKCR) and deposits (DPSACBW027SBOG) of all commercial banks, divided by the GDP deflator. The credit spread is computed as in Gilchrist and Zakrajšek (2012) because, as noted by Gelain and Ilbas (2017), this is closely related to measures of financial intermediary health, which makes the spread a good predictor of distress in the financial intermediation sector.

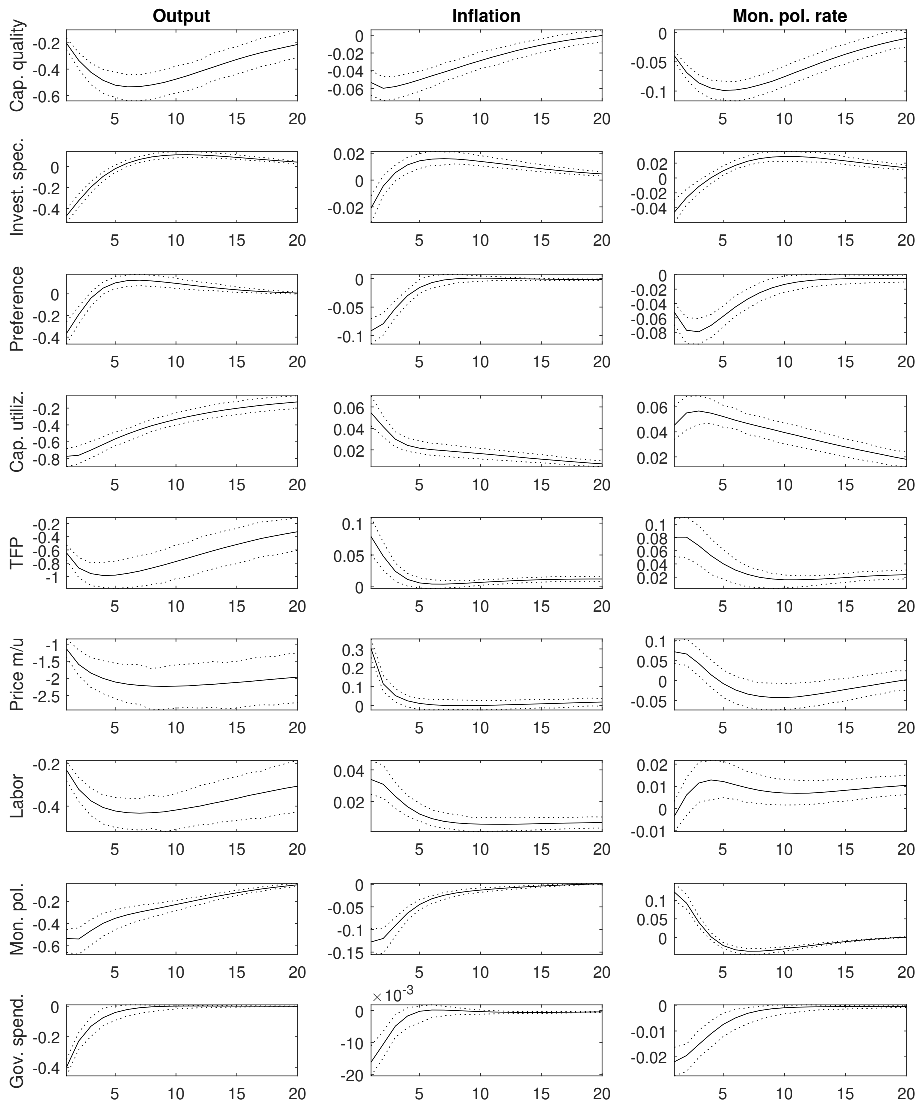
B Model Dynamics

Figures B.1 and B.2 report posterior impulse responses of output, inflation and the monetary policy rate to all shocks in the estimated models for the EA and the US economy, respectively. All shocks are of size equal to their estimated standard deviations

[22]Both measures refer to the manufacturing sector. Capital utilization rates in the service sector are generally measured less precisely and long time series comparable between the eruo area and the United States are not available.

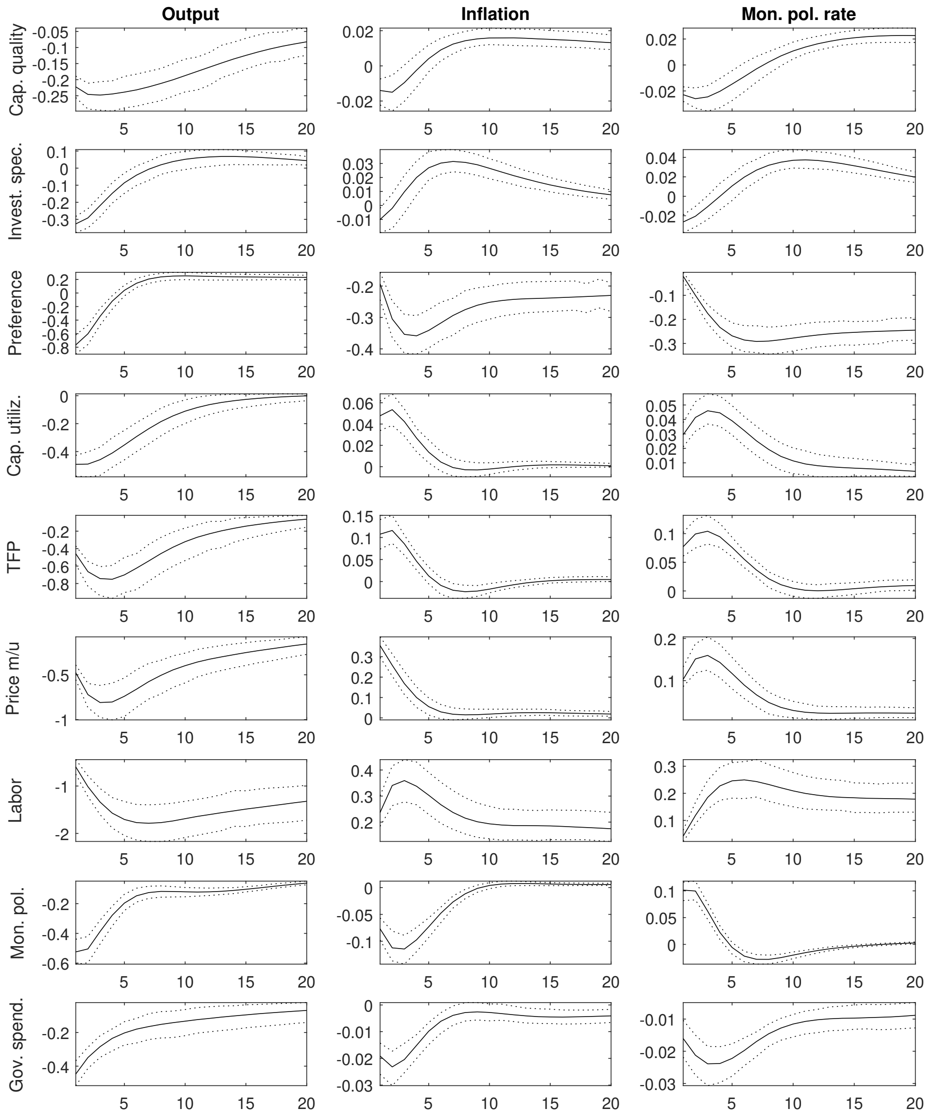
[23]Data on balance sheets and on credit spreads are available at https://www.euro-area-statistics.org/ and https://publications.banque-france.fr/en/economic-and-financial-publications-working-papers/credit-risk-euro-area, respectively.

Figure B.1: Posterior Impulse Response Functions to All Shocks in the Euro Area (All Shocks Are Set to Produce a Downturn)



and set to display an output contraction in all cases. Demand and supply shocks behave in the expected manner as far as the sign of the inflation response is concerned.

Figure B.2: Posterior Impulse Response Functions to All Shocks in the United States (All Shocks Are Set to Produce a Downturn)



C Robustness checks

C.1 Estimation Excluding the War in Ukraine

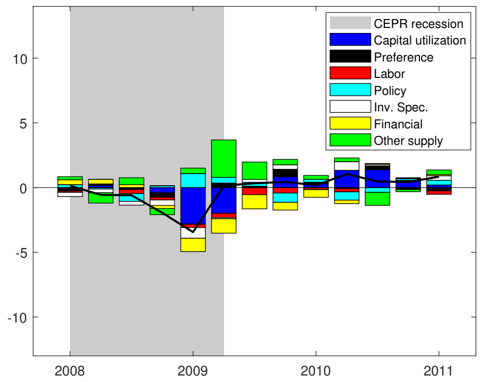
Given that the sample spans from 2000Q1 to 2022Q1, it includes the start of the war in Ukraine. This war triggered first-moment (negative) and second-moment (increasing uncertainty) shocks globally, especially in commodity markets, which affected capital utilization and inflation. As a robustness check, the model is re-estimated excluding the last quarter of the sample. Table C.1 shows that posterior parameter estimates are virtually the same as those obtained using the baseline sample.

Table C.1: Prior and Posterior Distributions of Structural Parameters, Constants and Exogenous Processes–Excluding 2022Q1 (95 percent credible intervals in square brackets)

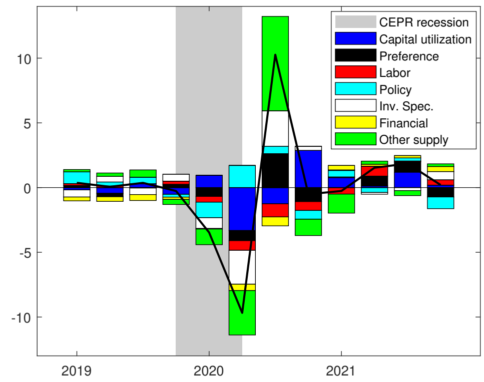
		Prior distribution			Posterior mean	
Parameters		Distr	Mean	Std./df	Euro area	United States
Structural parameters						
Habit parameter	h	Beta	0.7	0.1	0.13 [0.10;0.15]	0.12 [0.10;0.13]
Inv. of Frisch elasticity	ϕ	Gamma	0.33	0.25	0.22 [0.20;0.24]	0.39 [0.15;0.61]
Calvo prices	σ_p	Beta	0.5	0.05	0.76 [0.72;0.79]	0.72 [0.67;0.77]
Calvo wages	σ_w	Beta	0.5	0.05	0.31 [0.28;0.34]	0.78 [0.65;0.92]
Price indexation	σ_{pi}	Beta	0.5	0.15	0.15 [0.05;0.24]	0.57 [0.50;0.64]
Wage indexation	σ_{wi}	Beta	0.5	0.15	0.49 [0.29;0.70]	0.67 [0.47;0.87]
Inv. adj. costs	ξ	Normal	4	0.5	3.20 [3.00;3.41]	3.63 [3.15;4.10]
Elasticity of capital util	ζ	Beta	0.25	0.15	0.61 [0.52;0.69]	0.63 [0.56;0.71]
Inflation - Taylor rule	ρ_π	Normal	1.7	0.15	2.03 [1.83;2.22]	1.78 [1.59;1.98]
Output - Taylor rule	ρ_y	Gamma	0.125	0.05	0.02 [0.01;0.03]	0.11 [0.07;0.14]
Taylor rule changes in y	ρ_{Δ_y}	Normal	0.0625	0.05	0.12 [0.09;0.16]	0.08 [0.05;0.11]
Taylor rule smoothing	ρ_i	Beta	0.75	0.1	0.65 [0.58;0.72]	0.76 [0.72;0.81]
Constants						
Trend	$\bar{\gamma}$	Normal	0.4	0.2	0.02 [0.00;0.05]	0.28 [0.25;0.32]
Inflation	$\bar{\pi}$	Gamma	0.5	0.1	0.57 [0.47;0.67]	0.68 [0.50;0.86]
Interest rate	$\bar{R}$	Normal	0.8	0.2	0.30 [0.12;0.48]	0.35 [0.16;0.55]
Hours	$\bar{\ell}$	Normal	0.0	2.0	-0.39 [-2.43;1.71]	3.34 [1.86;5.00]
Utilization rate	$\bar{U}$	Normal	0.0	0.2	-0.27 [-0.30;-0.23]	0.00 [0.03;0.03]
Spread	$\bar{S}$	Gamma	0.5	0.1	0.37 [0.27;0.46]	0.44 [0.36;0.52]
Net worth over GDP	$\bar{NY}$	Normal	0.05	0.2	0.06 [-0.26;0.38]	0.06 [-0.26;0.36]
Exogenous processes						
Technology	ρ_a	Beta	0.5	0.2	0.93 [0.98;0.99]	0.86 [0.80;0.93]
	σ_a	IG	0.1	2	0.81 [0.70;0.91]	0.73 [0.63;0.83]
Price mark-up	ρ_p	Beta	0.5	0.2	0.99 [0.98;1.00]	0.91 [0.87;0.94]
	σ_p	IG	0.1	2	0.28 [0.22;0.33]	0.24 [0.19;0.29]
	μ_p	Beta	0.5	0.2	0.50 [0.38;0.62]	0.69 [0.58;0.81]
Labor	ρ_w	Beta	0.5	0.2	0.97 [0.94;0.99]	0.98 [0.96;0.99]
	σ_w	IG	0.1	2	0.30 [0.24;0.35]	0.72 [0.59;0.86]
	μ_w	Beta	0.5	0.2	0.18 [0.05;0.31]	0.75 [0.65;0.85]
Capital utilization	ρ_u	Beta	0.5	0.2	0.92 [2.38;3.43]	0.83 [0.76;0.91]
	σ_u	IG	0.1	2	2.90 [0.94;0.98]	1.83 [1.56;2.10]
Capital quality	ρ_{kq}	Beta	0.5	0.2	0.96 [0.94;0.98]	0.73 [0.67;0.79]
	σ_{kq}	IG	0.1	2	0.12 [0.09;0.15]	0.37 [0.28;0.46]
Inv. specific	ρ_x	Beta	0.5	0.2	0.18 [0.09;0.28]	0.40 [0.29;0.52]
	σ_x	IG	0.1	2	7.55 [6.26;8.80]	4.86 [3.78;5.94]
Preference	ρ_b	Beta	0.5	0.2	0.78 [0.70;0.87]	0.99 [0.99;0.99]
	σ_b	IG	0.1	2	1.10 [0.88;1.31]	3.29 [2.78;3.84]
Monetary policy	ρ_m	Beta	0.5	0.2	0.38 [0.29;0.47]	0.44 [0.37;0.52]
	σ_m	IG	0.1	2	0.27 [0.22;0.31]	0.19 [0.16;0.22]
Government spending	ρ_g	Beta	0.5	0.2	0.63 [0.48;0.77]	0.91 [0.87;0.96]
	σ_g	IG	0.1	2	1.90 [1.66;2.14]	2.83 [2.47;3.17]
Std- Measurement error		IG	0.1	2	0.15 [0.13;0.17]	0.15 [0.13;0.17]

Figure C.1: Historical Shock Decomposition of Quarter-on-Quarter GDP Growth (Demeaned)–Excluding 2022Q1

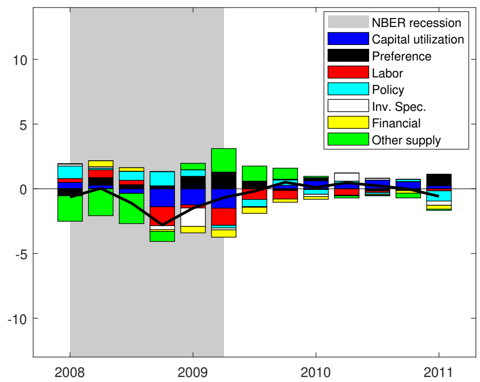
(a) Euro Area GFC



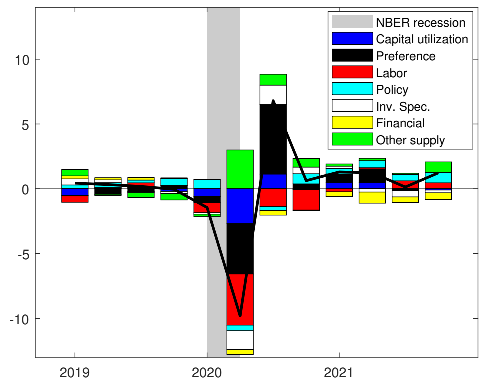
(b) Euro Area C-19C



(c) United States GFC



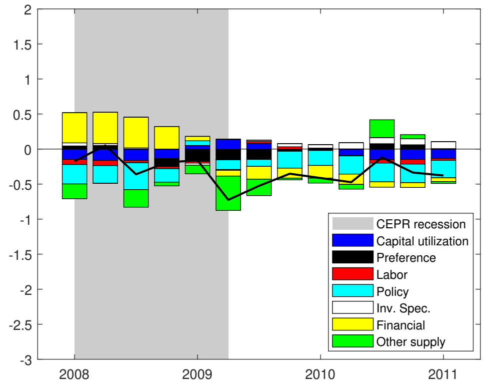
(d) United States C-19C



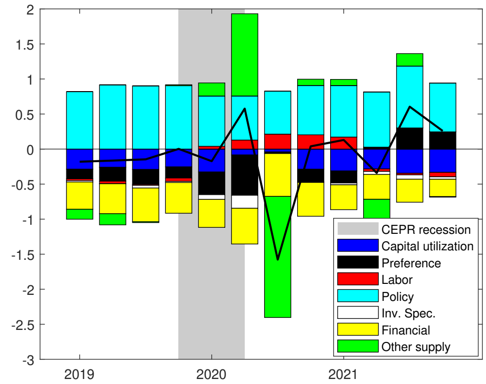
Figures C.1, C.2, C.3 and C.4 show that the results of the paper are very robust to the exclusion of the last quarter of the sample.

Figure C.2: Historical Shock Decomposition of Quarter-on-Quarter Inflation Rate (Demeaned)–Excluding 2022Q1

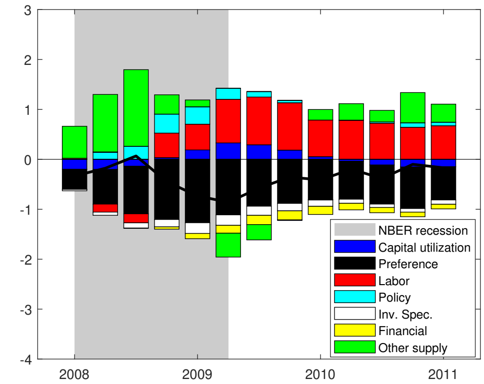
(a) Euro Area GFC



(b) Euro Area C-19C



(c) United States GFC



(d) United States C-19C

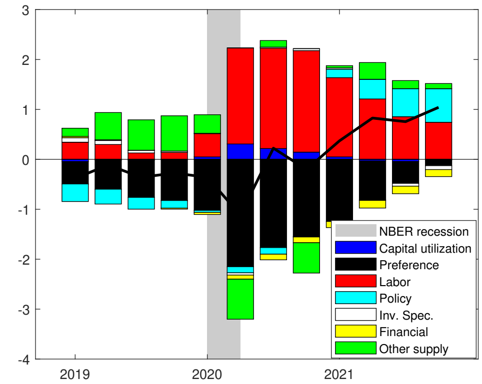
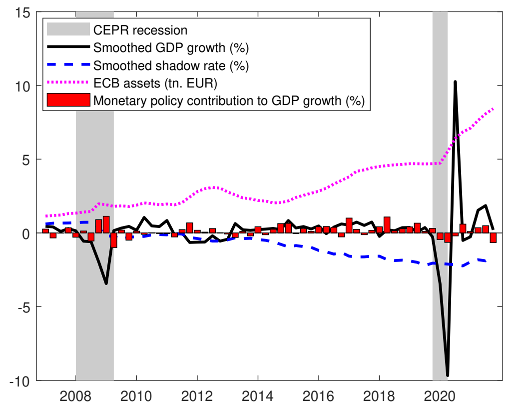


Figure C.3: Contribution of Monetary Policy Shocks to Quarter-on-Quarter GDP Growth (Demeaned)–Excluding 2022Q1

(a) Euro Area



(b) United States

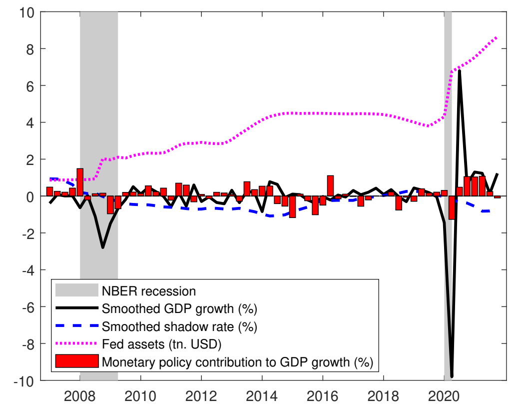
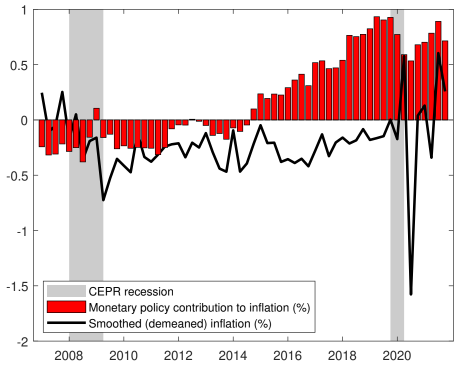
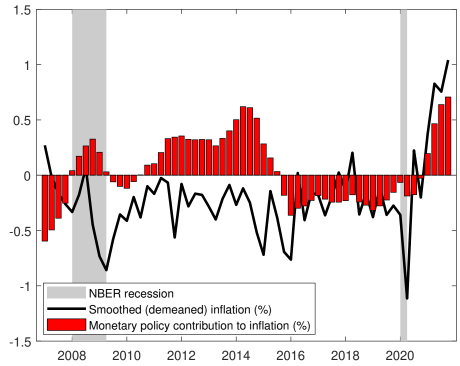


Figure C.4: Contribution of Monetary Policy Shocks to Quarter-on-Quarter Inflation (Demeaned)–Excluding 2022Q1

(a) Euro Area



(b) United States



C.2 Estimation with Alternative Priors

The posterior estimates of the habit formation (EA and US economy), wage and price stickiness (EA and US economy), and the responsiveness of the nominal interest rate to the output gap (EA) are close to the extremes of the prior distributions. As noted by Meenagh et al. (2022), the inappropriate choice of priors could bias Bayesian estimates. We then conduct a robustness exercise by changing the prior mean of habit parameter to 0.25 (from 0.7), the prior standard deviations of the price and wage stickiness and of the Taylor rule parameter to 0.1 (from 0.05).

Table C.2 shows that parameter estimates both of the above-mentioned parameters and all the other structural parameters are similar to the baseline estimation. The same result applies to the estimated exogenous processes. Although there are small differences, the mean estimates of the parameters under this alternative specification fall in the estimated confidence band for the same parameter of the baseline model (Table 2). This can be interpreted as a rough measure of similarity.

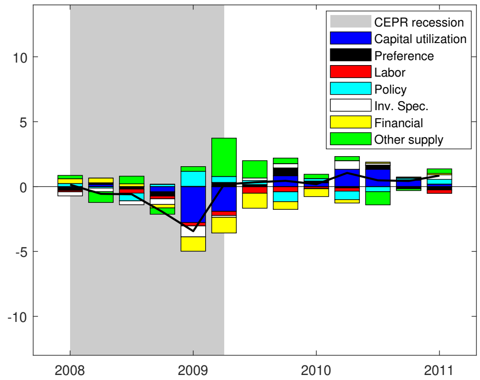
Consequently, Figures C.5, C.6, C.7 and C.8 show that the results of the paper are robust to the use of the alternative priors.

Table C.2: Distributions of Structural Parameters, Constants and Exogenous Processes–Alternative Priors

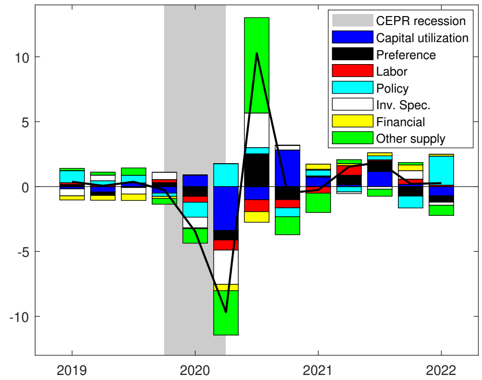
			Prior distribution				Posterior mean			
Parameters		Distr	Mean		Std./df		Euro area		United States	
			Base	Alter.	Base	Alter.	Base	Alter.	Base	Alter.
Structural parameters										
Habit parameter	h	Beta	0.7	0.25	0.1		0.13	0.11	0.12	0.10
Inv. of Frisch elasticity	ϕ	Gamma	0.33		0.25		0.22	0.21	0.41	0.41
Calvo prices	σ_p	Beta	0.5		0.05	0.1	0.75	0.78	0.71	0.77
Calvo wages	σ_w	Beta	0.5		0.05	0.1	0.31	0.30	0.78	0.72
Price indexation	σ_{pi}	Beta	0.5		0.15		0.16	0.15	0.57	0.59
Wage indexation	σ_{wi}	Beta	0.5		0.15		0.47	0.47	0.67	0.67
Inv. adj. costs	ξ	Normal	4		0.5		3.21	3.12	3.54	3.64
Elasticity of capital util	ζ	Beta	0.25		0.15		0.62	0.62	0.64	0.63
Inflation - Taylor rule	ρ_π	Normal	1.7		0.15		2.05	2.05	1.78	1.79
Output - Taylor rule	ρ_y	Gamma	0.125		0.05	0.1	0.02	0.02	0.11	0.11
Taylor rule changes in y	ρ_{Δ_y}	Normal	0.0625		0.05		0.11	0.11	0.08	0.08
Taylor rule smoothing	ρ_i	Beta	0.75		0.1		0.67	0.67	0.76	0.76
Constants										
Trend	$\bar{\gamma}$	Normal	0.4		0.2		0.02	0.02	0.29	0.28
Inflation	$\bar{\pi}$	Gamma	0.5		0.1		0.58	0.58	0.66	0.66
Interest rate	$\bar{R}$	Normal	0.8		0.2		0.31	0.31	0.33	0.33
Hours	$\bar{\ell}$	Normal	0.0		2.0		-0.12	-0.16	3.45	3.53
Utilization rate	$\bar{U}$	Normal	0.0		0.2		-0.27	-0.27	0.01	0.00
Spread	$\bar{S}$	Gamma	0.5		0.1		0.37	0.37	0.44	0.43
Net worth over GDP	$\bar{NY}$	Normal	0.05		0.2		0.08	0.04	0.06	0.03
Exogenous processes										
Technology	ρ_a	Beta	0.5		0.2		0.93	0.93	0.84	0.86
	σ_a	IG	0.1		2		0.85	0.84	0.75	0.74
Price mark-up	ρ_p	Beta	0.5		0.2		0.99	0.99	0.91	0.90
	σ_p	IG	0.1		2		0.28	0.25	0.24	0.22
	μ_p	Beta	0.5		0.2		0.51	0.54	0.69	0.69
Labor	ρ_w	Beta	0.5		0.2		0.97	0.97	0.98	0.95
	σ_w	IG	0.1		2		0.30	0.31	0.72	0.59
	μ_w	Beta	0.5		0.2		0.18	0.18	0.75	0.81
Capital utilization	ρ_u	Beta	0.5		0.2		0.92	0.93	0.84	0.84
	σ_u	IG	0.1		2		2.82	2.80	1.83	1.82
Capital quality	ρ_{kq}	Beta	0.5		0.2		0.96	0.96	0.74	0.72
	σ_{kq}	IG	0.1		2		0.12	0.12	0.36	0.37
Inv. specific	ρ_x	Beta	0.5		0.2		0.19	0.19	0.39	0.39
	σ_x	IG	0.1		2		7.50	7.38	4.71	4.74
Preference	ρ_b	Beta	0.5		0.2		0.77	0.80	0.99	0.99
	σ_b	IG	0.1		2		1.12	1.09	3.28	3.32
Monetary policy	ρ_m	Beta	0.5		0.2		0.35	0.35	0.45	0.44
	σ_m	IG	0.1		2		0.27	0.27	0.19	0.18
Government spending	ρ_g	Beta	0.5		0.2		0.63	0.63	0.91	0.91
	σ_g	IG	0.1		2		1.94	1.93	2.94	2.92
Std- Measurement error		IG	0.1		2		0.15	0.15	0.15	0.15

Figure C.5: Historical Shock Decomposition of Quarter-on-Quarter GDP Growth (Demeaned)–Alternative Priors

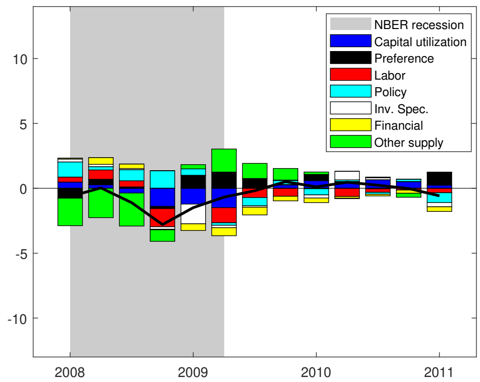
(a) Euro Area GFC



(b) Euro Area C-19C



(c) United States GFC



(d) United States C-19C

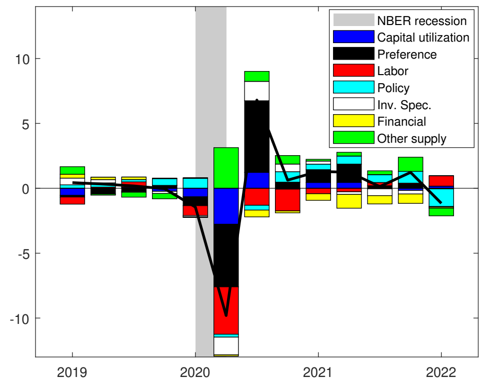
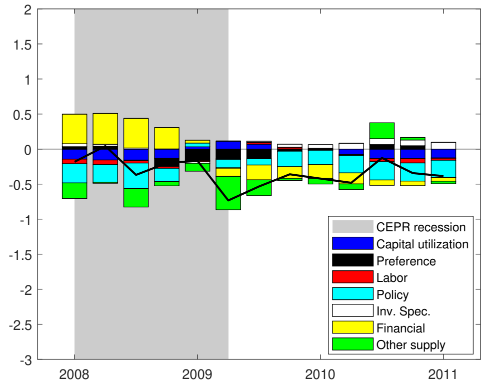
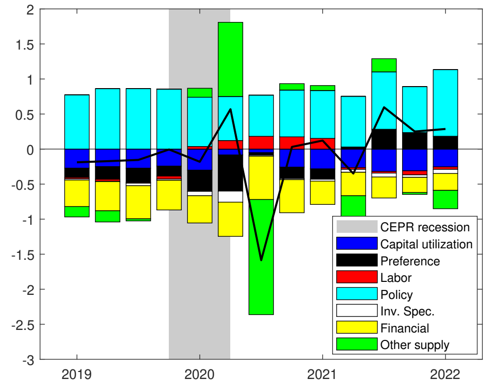


Figure C.6: Historical Shock Decomposition of Quarter-on-Quarter Inflation Rate (Demeaned)–Alternative Priors

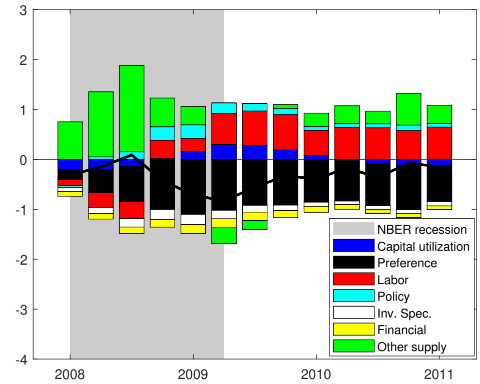
(a) Euro Area GFC



(b) Euro Area C-19C



(c) United States GFC



(d) United States C-19C

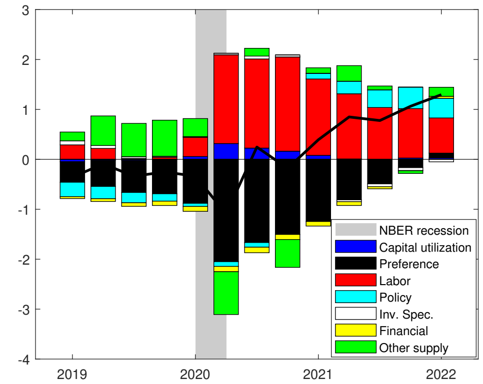
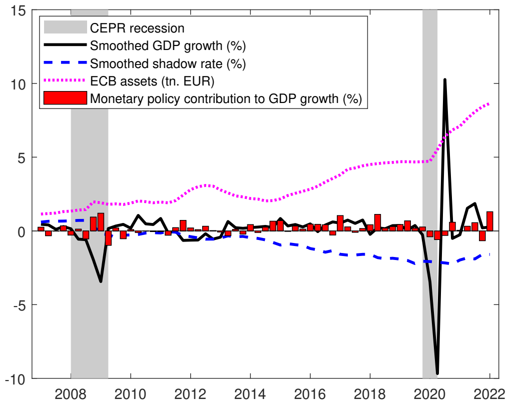


Figure C.7: Contribution of Monetary Policy Shocks to Quarter-on-Quarter GDP Growth (Demeaned)–Alternative Priors

(a) Euro Area



(b) United States

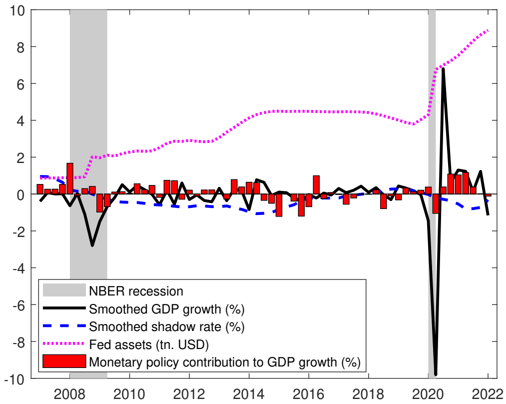
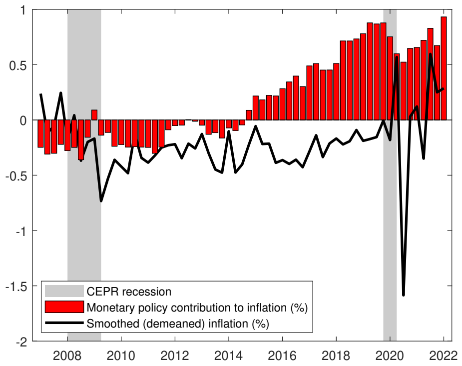
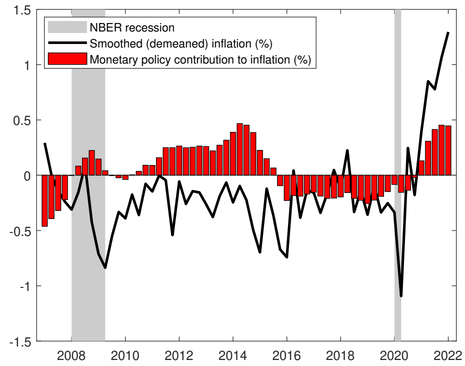


Figure C.8: Contribution of Monetary Policy Shocks to Quarter-on-Quarter Inflation (Demeaned)–Alternative Priors

(a) Euro Area



(b) United States



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