Monetary Policy in the COVID Era and Beyond: Comparing the Fed and the ECB

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Abstract

This study examines monetary policy during and post-COVID by analysing innovative rules based on data from before the pandemic. It models fluctuating monetary policy rates using a stochastic trend, linking potential output growth, demographic age distribution, and inflation expectations to the prevailing interest rate trends in both the US and the Eurozone. The cyclical variations in short-term rates are associated with monetary policy through the conventional Taylor rule indicators. Whilst the standard model is robust for the US both in and out of sample, the Eurozone displays less consistent in-sample results and marked deviations in out-of-sample tests. Addressing the ECB's concerns about bond market fragmentation doesn't yield better results. Instead, a model in which the ECB follows the US example with caution and delay proves more effective. **JEL codes:** E43, E52, G12.

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1 Introduction

The unprecedented nature of the COVID era, coupled with the subsequent rise in inflation, has prompted a reevaluation of global central banks' monetary policy decisions around the world. Notably, there is a marked contrast in the timing and intensity of monetary policies between the FED and the ECB (Cavallino and De Fiore, 2020). This has sparked discussions on the suitability of these varied strategies for their respective economic contexts. The distinct actions of the FED and the ECB can be attributed to the varied shocks influencing inflation in the US and the Eurozone. In the former, the dominant impetus behind post-COVID inflation has been mainly attributed to a resounding demand shock (Blanchard and Bernanke, 2023), epitomised by the expansive fiscal response following the initial COVID shock. Meanwhile, the European inflation narrative unfolds mainly as a manifestation of supply shocks—orchestrated by the interplay of supply chain disruptions stemming from sporadic lockdowns during the pandemic epoch (Kollmann, 2021) and the amplification of energy costs due to geopolitical tensions such as the Ukraine conflict (Hoynck and Rossi, 2023). The objective of this paper is to evaluate how monetary policy rules specified and estimated on the pre-COVID data does in explaining out-of sample, in the COVID era and beyond, the behaviour of the FED and the ECB, conditional on the shocks they were confronted with. Our approach to modelling monetary policy rules extends the original Taylor (1993) approach by explicitly accounting for the drift in monetary policy rates. We claim they have a stochastic trend and we thus aim to capture it. In a world in which central banks credibly set an inflation target, this drift can only be observed if there's a drift in the natural rate of interest. Laubach and Williams (2003) demonstrate that in the standard Ramsey model household intertemporal optimisation delivers a relationship between the natural rate of interest, the economy's output growth rate, and household preferences. As it has been convincingly argued (see Holston et al. (2017), Jordà and Taylor (2019), and Mian et al. (2021)) that fluctuations in *per capita* output growth of the economy cannot fully explain the drift in natural rate, time-varying determinants of the rate of time preference of the agents in the economy should be considered. In this paper we follow Favero et al. (2022) and Lunsford and West (2019) to consider the age structure of the population as the driver of changing preferences. Initially, we demonstrate that both the growth rate of potential output and the population's age structure effectively capture the stochastic trend in the natural rate of interest in the US and the Euro area. Subsequently, we extract the cyclical components of monetary policy rates and associate them with the conventional drivers of the Taylor rules: the output gap and the inflation gap. The monetary reaction function is then specified by determining monetary policy rates in a two-equation models where the drift in rates depends on productivity, demographics and the inflation target of the central bank and monetary policy controls stationary fluctuations around the trend by responding to stationary cyclical variables, such as the output gap and the inflation gap. Having estimated the models for the FED and the ECB on pre-COVID data, we simulate them, conditional upon shocks to the output gap and the inflation gap, to assess the capability of rules estimated on the pre-COVID era to track the behaviour of central banks in the COVID era and beyond. Our results show that the FED has not significantly deviated from the rule while the evidence for the ECB is clearly different. We then proceed to modify the standard Taylor model for the ECB to assess if it omits drivers of the cyclical components of monetary policy relevant for the euro area. In particular, we conside two alternative specifications. The first one explicitly allows for the possibility that bond market fragmentation affects the behavior of the ECB. The second one reflects the concerns cited in the comparative analysis of monetary policy conducted back in 2009 by Uhlig (2009):

> *A number of observers have argued that the difference in policy shows the difference between an established central bank in the US, which knows what it is doing and acts decisively, if need be, versus a new central bank in Europe, run by a committee which is too timid and too inertial to anything in time, following the US example with too much caution and delay...* (Uhlig, 2009, p.1)

Our results show that a model in which the ECB simply tracks the FED with a lag does a much better work in explaining the data than a rule which includes bond fragmentation along with the output gap and the inflation gap as a driver of monetary policy.

1.1 Related Literature

Our paper contributes to the strand of the literature opened by the seminal contribution of Taylor (1993) aimed at identifying monetary policy rules from the fluctuations in nominal interest rates. Nominal interest rates are made of a real component, the natural rate of interest which is outside of the control of the central bank and on fluctuations around it that the central bank tries to influence to drive inflation towards its target. In the original Taylor specifications the natural rate of interest was set to a constant and the central bank behaviour was modelled through its response to two presumably stationary variables, the deviation of output from its potential level, and the deviations of inflation from the CB target. The spirit of this initial specification was kept intact in the first proposed modifications (see, for example, Gertler et al. (1999)) arguing in favour of forward-looking policy rules, in which the output and the inflation gaps were substituted by their expectations to take into account the lagged response of the economy to monetary policy. However, several successive papers (Balduzzi et al., 1998; Fama, 2006; Bauer and Rudebusch, 2020; Golinski and Zaffaroni, 2016; Favero et al., 2022) show that interest rates are drifting and the Taylor rule cannot model drifts as its specification includes a constant and stationary variables. All these papers were focussed on the US and on modelling the drift in rates by attributing it to a drift in the natural interest rates. Gorter et al. (2008) extended the forward-looking philosophy to the euro area by using Consensus Economics data for expected inflation and output growth, without addressing the drift in rates.

We contribute to this literature by investigating the validity of the specification of monetary rules for the FED and the ECB based on a more general approach that decomposes nominal rates into two components: a trend and a cycle. Our empirical study indicates that the real economy is primarily, though not solely, accountable for the drift in rates. While monetary policy dictates the cyclical component, it would likely influence the fluctuations of the drift component as well. This scenario arises when long-term expected inflation does not swiftly align with the constant central bank target.

We put our framework at work by contributing to the literature that assess central banks' behaviour using identified rules as benchmarks.

Reifschneider and Williams (2000) analyse the performance of different monetary policy rules for the FED during a low inflation period, such as the one experienced in the late 1990s. Filardo et al. (2022) examine whether the systematic response of monetary policy to financial imbalances matters for financial stability. Gerlach and Lewis (2011) investigate the possibility of shifts in the ECB reaction function during the Financial Crisis of 2008. Uhlig (2009) compares monetary policy in the US and EMU over the period 1998-2006, employing an estimated hybrid New Keynesian cash-in-advance model, driven by five shocks. The model based analysis leads to the conclusion that the difference between the two monetary policies to different shocks in productivity and wage demands and not to a more sluggish response in Europe to the same shocks or to different monetary policy surprise.

2 Monetary Policy Rules with Trending Data

The time-series behaviour of monetary policy rates in the US and the euro area show the presence of stochastic trend in the data, as illustrated by Figure 1, which reports the 3-month benchmark rates for the US and the Euro area[1]. The data show the presence of common features in the trends of monetary policies across the ocean, even if the available sample for the euro is more limited due to the fact that the ECB became operational only with the new millenium. This common in-the-limit behaviour motivates a common model to identify monetary policy from fluctuations in three-month rates in the US and the euro area. We proceed then to decompose the three-month rates into a non-stationary component (the trend) and a stationary one (the cycle).

The trend is mostly driven by the structure of the real economy: for a given credible inflation target, the trend in rates is determined by fluctuations in the natural real rate of interest. However, monetary policy rules mostly control the cyclical

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[1] See the Appendix A for a precise description of the series.

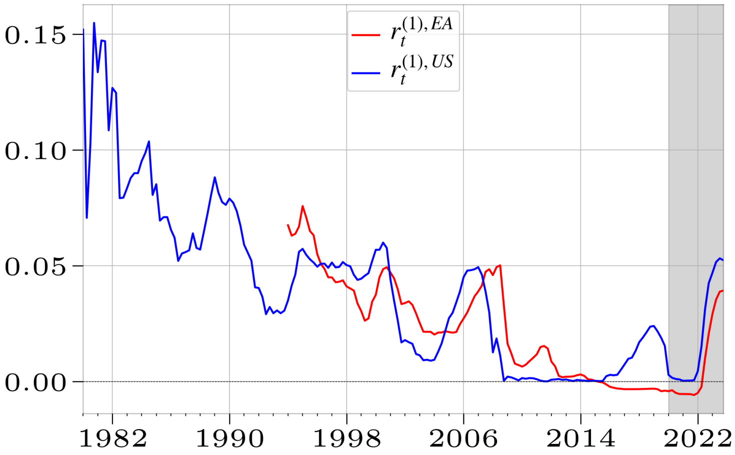

FIGURE 1. 3-month Government Bond yield, $r_t^{(1)}$, of both US and the Eurozone in the period 2000Q1-2023Q1. US variables are given in blue and EA variables in red. Shaded area indicates the post-COVID era.

component on rates and not its trend, and central bank preferences are revealed through their response to cyclical variables, such as the inflation gap and the output gap, and their preferences for interest rate smoothing.

The debate on the importance on interest rate smoothing has been rather hot in the literature (see, e.g., Woodford (1999), Woodford (2003), Clarida et al. (2000), and Rudebusch (2006)). The standard procedure to identify the preference for smoothness is to augment a baseline rule that relates police rates to stationary variables with the lagged dependent variable and relate smoothness to the estimated coefficient on it. Within this specification, the presence of a not explicitly modelled trend in rates forces the coefficient on the lagged dependent variables towards one. However, the high persistence in rates is driven by the trend, which depends on the real structure of the economy—not affected by the preferences of central banks. Our approach explicitly identifies smoothing as the persistence of the stationary components of rates that are driven by monetary policy and leads to evidence on smoothing rather different from the traditional one.

Using our permanent-transitory decomposition we first construct a predictive model for three-month rates using data available up to 2019. In subsequent analysis, out-of-sample simulations are conducted based on the realised shocks to evaluate whether the observed dynamics of short term rates in the COVID era and beyond are consistent with the model-based predictions.

3 Modelling Trends in Short-Term Rates

Short term rates are naturally decomposed in real-short term rates and expected inflation. Their very long-run forecast (the trend) is thus the sum of the long-forecast for inflation and the very long-run forecast for the real rates. If the central bank is credible, then the very long-run forecast for inflation must not deviate permanently from the central bank inflation target. The very long-run forecast for the real rates is labelled in the literature as the natural rate of interest. Laubach and Williams (2003) show that in the standard Ramsey model households intertemporal optimization delivers a relationship between the natural rate of interest, the growth rate of output in the economy, and shifts in household preferences. But Jordà and Taylor (2019) and Mian et al. (2021) illustrate that fluctuations in output growth *per capita* of the economy cannot fully explain the drift in natural rate, therefore time-varying determinants of the rate of time preference of the agents in the economy should be considered. Following Favero et al. (2016), Lunsford and West (2019), and Favero et al. (2022), we consider the age structure of the population as the driver of changing preferences.

The impact of demographics trends on the natural rate works through two different channels: the first one is related to the age-structure of the population while the second one is related to fluctuations in longevity (Carvalho et al., 2023).

The first channel is well understood in an overlapping generation model in which the agents live three-periods (young, middle-aged and old) and save only in the central part of their life (Geanakoplos et al., 2004).

The life-cycle portfolio behavior (Bakshi and Chen, 1994) determines equilibrium rates. Consumption smoothing by the agents, given a demographic structure featuring alternating twenty-year periods of booms and busts, requires that when the ratio of middle-aged to young, MY, is large there will be excess supply of saving by a large cohort of middle-aged and for the market to clear, equilibrium rates should adjust, that is, decrease, so that consumption is encouraged for the middle-aged. The model predicts that the price of all financial assets should be positively related to MY and it therefore also predicts the negative correlation between rates and MY.

The second channel is related to the increase in life expectancy at the age of 65 in OECD countries, which has been of about four hours a day over the last 50 years. From about 13 years to about 20 years (Bisetti et al., 2017). Carvalho et al. (2016) show that there is dynamic effect of increased longevity. The impact effect of rising longevity is initially downward pressure on real interest rates, as people save more in anticipation of a longer retirement, but eventually upward pressure on real interest rates is generated by a higher ratio of retirees dis-saving relative to workers saving.

Our baseline model for the trend in three month rates in the US and the Euro area is specified as follows:

$$
\begin{aligned}
r^{i}_{f,t} &= r^{*,i}_{f,t} + u^{i}_{t} & (1)\\
r^{*,i}_{t} &= \gamma_1 MY^{i}_{t} + \gamma_2 \Delta y^{pot,i}_{t} + \gamma_3 \pi^{LR,i}_{t} & (2)
\end{aligned}
$$

where $i \in \{US, EA\}$.

The model is naturally interpreted within a cointegration (Engle and Granger, 1987) approach to model the stochastic drift in rates: if demographics, productivity and the inflation target of the central bank successfully capture the trend in nominal rates, then $u^{US}_{t} := r^{US}_{f,t} - r^{*,US}_{f,t}$, $u^{EA}_{t} := r^{EA}_{f,t} - r^{*,EA}_{f,t}$ should be stationary.

3.1 Empirical Results

Figure 2 reports the drivers of the trend in monetary policy in the US and Europe: the proxy for productivity $\Delta y^{pot,i}_{t}$,the annual percentage change in potential output) , the demographics (MY^{i}_{t}, the ratio of middle-aged (40-49) to young (20-29) population) and the long-term expectations for inflation $\pi^{LR,i}_{t}$. π^{LR}_{t} for the US is the survey-based measure of long-run inflation expectations, used in the Fed's FRB/US model[2]. Similarly, $\pi^{E,LR}_{t}$ for the ECB is the survey-based measure of long-run inflation expectations[3]. Our sample period for the FED starts with Paul Volcker's appointment as Fed chairman, because of evidence that monetary and macroeconomic dynamics changed at that time (e.g., Gertler et al., 1999). The sample period for the euro area is unbalanced as it begins when the ECB became operational.

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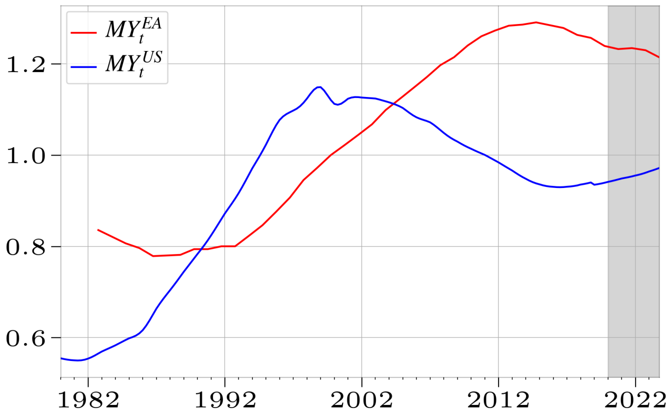
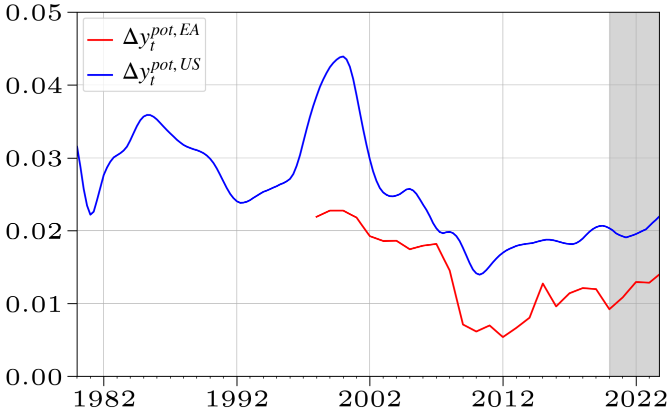
[2] Available at `https://www.federalreserve.gov/econres/us-models-package.htm`.

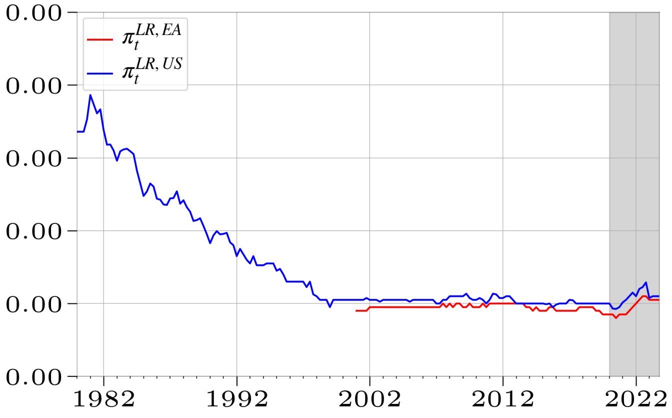
[3] Available at `https://www.ecb.europa.eu/stats/ecb_surveys/survey_of_professional_forecasters/html/table_hist_hicp.en.html`.



(A) Middle-to-Young (age groups) ratio.



(B) Potential output (log) growth rates.



(C) Long run inflation (log) growth rate.

Figure 2. The three chosen drivers of the 3-month rate trend: MY_t^i, the ratio between the middle-age people and the young people; $\Delta y_t^{pot,i}$, the YoY (log) growth rate of quarterly given potential output; and $\pi_t^{LR,i}$, the long-run expectations of intflantion YoY (log) growth rate. US variables are given in blue and EA variables in red.

The data reveals a noticeable trend in MY and a discernible shift in the mean of potential output growth. This shift is particularly pronounced in the case of the US when comparing the periods before and after 2000. Examining the post-2000 sample, long-term inflation expectations remain remarkably stable at approximately two percent for both the US and the euro area. On the other hand, the pre-2000 US data demonstrates a substantial downward trend, with long-term inflation expectations declining from around seven percent in the early eighties to two percent by the turn of the millennium. The relevant coefficients for the US and the euro are estimated via SUR by imposing cross-equations restrictions on the coefficients on MY_t^i and $\Delta y_t^{pot,i}$ while unrestricted the coefficients on the inflation target. As the long-term inflation expectations are virtually at two constant for the full sample in the Euro area case and for the second half of the sample in the US case, we do not include a constant in the specification. Therefore our system estimation by SURE with cross-equation restrictions on all coefficients but the constant gets very close to an unbalanced panel estimation with fixed effect.[4]

We report in Table 1 the estimated coefficients, which show a positive impact of the rate of growth of potential output on the natural interest rate, and a negative impact of the coefficient on MY_t in line with the predictions of the (Geanakoplos et al., 2004) model. Interestingly, the coefficient on the long-run inflations expectations is larger than one both in the ECB and the FED case. This evidence is consistent with the intepretation that the central banks apply the Taylor principle to stabilise long-term expectations towards their inflation target. Since the null hypothesis of residual stationarity is not rejected, the empirical model effectively captures the drift

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[4] It would be exactly a panel estimation with fixed effect if the two long-run target inflation were constant at a fixed level.

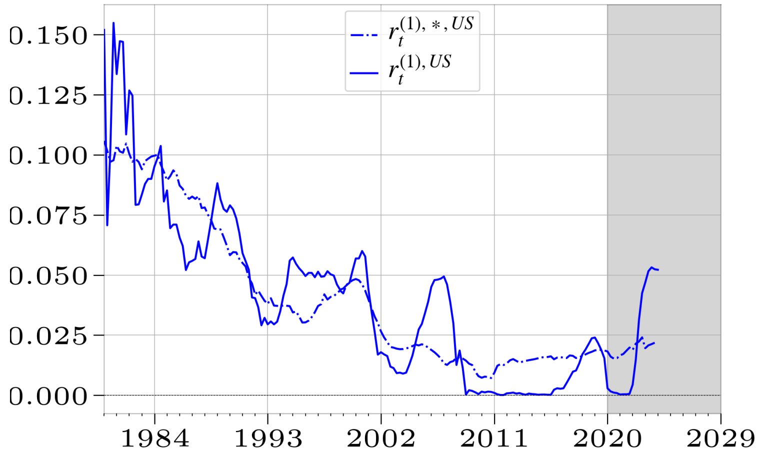
	$r_{f,t}^{EA}$	$r_{f,t}^{US}$
MY_t	-0.038^{***}	-0.038^{***}
	(0.003)	(0.003)
Δy_t^{pot}	1.506^{***}	1.506^{***}
	(0.133)	(0.133)
π_t^*	2.293^{***}	1.185^{***}
	(0.133)	(0.071)

Table 1. System SUR estimation of the parameters determining the stochastic trends in three-month rates in the United States and the Euro area. The sample period used is 1980Q1-2019Q4 for the US and 2000Q1-2019Q4 for the Eurozone. Standard errors are reported in parenthesis.

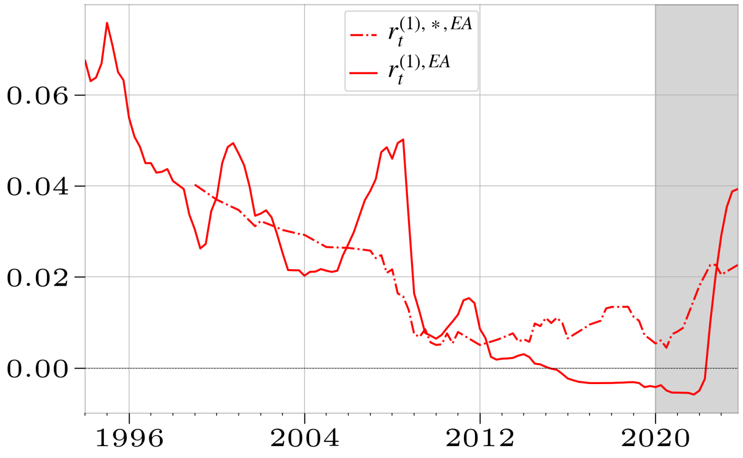
in nominal three-month rates in both the US and the Euro area.

It is also important to highlight that the focus on the long-run trend remains crucial for forecasting short-term rates over the long term. The model's design naturally facilitates the creation of short-term rate forecasts over an extended horizon, leveraging readily available or derived long-term predictions for factors such as potential output growth, population age structure, and central bank inflation targets.

Furthermore, the model-based long-term forecasts for short-term rates take into explicit account non-stationarity, thereby circumventing the issues associated with interest rate forecasting through VAR (Vector Autoregression) under the incorrect assumption of stationarity.



(A) United States



(B) Euro area

FIGURE 3. Actual 3-month rate vs its trend. We use our results in Table 1 to obtain the trend series $r^{*,i}_{f,t}$.

4 Modelling Monetary Policy

We use the most standard ingredients of a monetary policy rule to model u_t^{US} and u_t^{EA}. In particular, we consider monetary policy smoothing, the output gap and the inflation gap as potential drivers of monetary policy and we estimate the following model for the US and the euro area:

$$u_t^i = \rho u_{t-1}^i + \beta_1 \pi_t^{gap,i} + \beta_2 y_t^{gap,i} + v_t^i \tag{3}$$

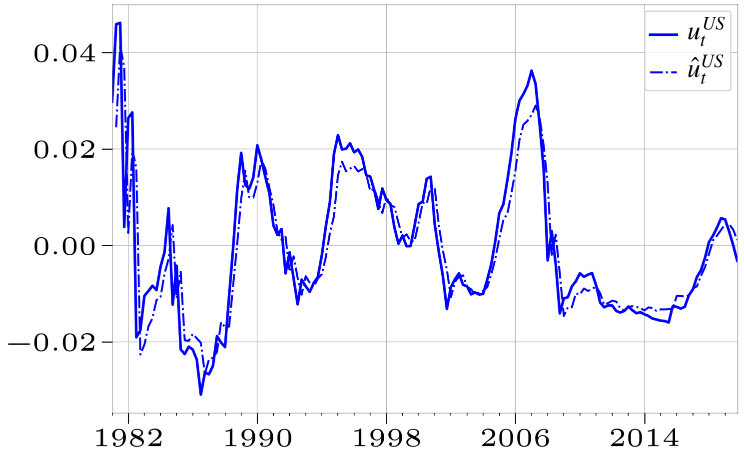
where $\pi_t^{gap,i} := \pi_t^i - \pi_t^{LR,i}$ and $y_t^{gap,i} := y_t^i - y_t^{pot,i}$, and $i \in \{EA, US\}$.

	u_t^{EA}	u_t^{US}
u_{t-1}	0.922^{***}	0.778^{***}
	(0.033)	(0.027)
π_t^{gap}	0.142^{***}	0.171^{***}
	(0.043)	(0.052)
y_t^{gap}	-0.0	0.061^{***}
	(0.0)	(0.014)

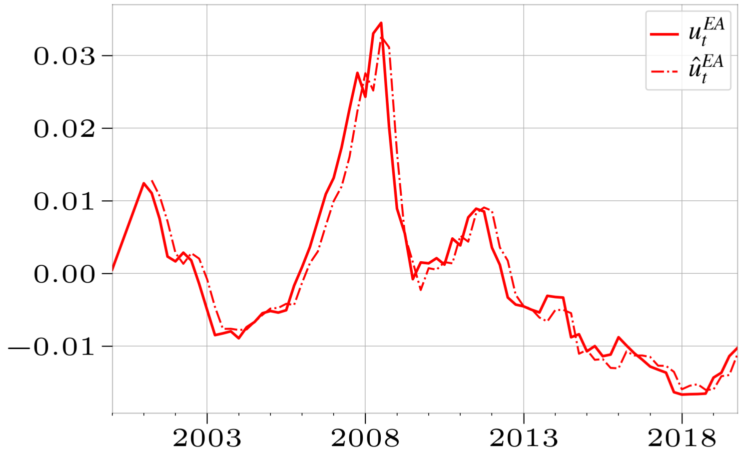
Table 2. System SUR estimation of the parameters determining the deviations of three-month rates in the United States and the euro area from their stochastic trends. The sample period used is 1980Q1-2019Q4 for the US and 2000Q1-2019Q4 for the Eurozone. Standard errors are reported in parenthesis.

Several comments on the above specification are in order. First, as our measure of u_t^i is stationary, the choice of modelling it with stationary variables is consistent with the nature of data. Moreover, the persistence parameter ρ is not pushed towards one by the non-stationarity of the dependent variables (this is confirmed by our results in Table 2) and it has better chance of mesuring the preferences for monetary policy smoothing by the central banks. Second, our rule is specified in terms of contemporaneous rather than expected inflation and output gaps. This follows the approach in the original specification of the Taylor rule but it is different for successive developments. If the central banks were to respond to expected variables current and inflation and output gaps are to be interpreted as instruments for the relevant future expected variables. In this case our model would still correctly measure the response of central banks to current shocks to the output and inflation gaps. However, care should be exercised in interpreting our estimated parameters as they would be a convolution of the response of central banks to expected variables and the projections of future expected variables on current instruments for them. Our empirical results, reported in Table 2, are based on a system estimation of the monetary policy rules in the US and the Euro Area.

No restrictions are imposed across equations to allow for heterogeneity in the FED and the ECB preferences. The estimates show a stronger preference for smoothing for the ECB which is remarkably more aggressive towards inflation in the long-run than the FED, while the short-run response is much more similar. The estimated response to output gap by the FED is close to that to the inflation gap while the responses of the ECB to this variable is not significantly different from zero. Cyclical component and the series explained by the model (3) are reported in Figure 4.



(A) United States



(B) Euro area

FIGURE 4. Cyclical component of the 3-month rate obtained after using our model (1) versus the fitted series using the cycle model (3).

5 Evaluating the Performance of Rules in the COVID era and beyond

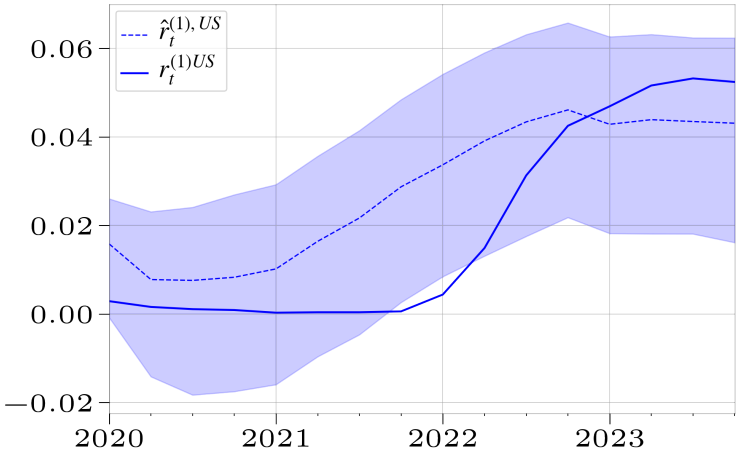
In this section we evaluate the performance of our model of short term interest rates by track out-of sample over the period 2020-2023 the dynamic evolution of model-simulated and actual variables in the US and the euro area. The model for simulation is specified as follows:

$$
\begin{aligned}
r_{f,t}^{US} &= \gamma_1 MY_t^{US} + \gamma_2 \Delta y_t^{pot,US} + \gamma_3 \pi_t^{LR,US} + \left(r_{f,t}^{US} - r_{f,t}^{*,US} \right) && (4) \\
\left(r_{f,t}^{US} - r_{f,t}^{*,US} \right) &= \rho_1 \left(r_{f,t-1}^{US} - r_{f,t-1}^{*,US} \right) + \beta_1 \pi_t^{gap,US} + \beta_2 y_t^{US} + v_t^{US} && (5) \\
r_{f,t}^{EA} &= \gamma_1 MY_t^{EA} + \gamma_2 \Delta y_t^{pot,EA} + \gamma_4 \pi_t^{*,EA} + \left(r_{f,t}^{EA} - r_{f,t}^{*,EA} \right) && (6) \\
\left(r_{f,t}^{EA} - r_{f,t}^{*,EA} \right) &= \rho_2 \left(r_{f,t-1}^{EA} - r_{f,t-1}^{*,EA} \right) + \beta_3 \pi_t^{gap,EA} + \beta_4 x_t^{EA} + v_t^{EA} && (7)
\end{aligned}
$$

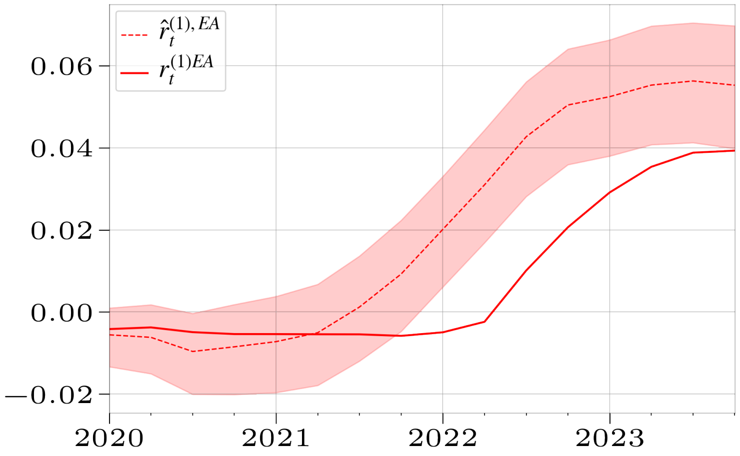
The model is dynamically simulated by using the fitted values for the coefficients obtained over the pre-COVID era sample and reported in the previous sections and by keeping the drivers of the trends and cycles as exogenous. The relevant question we ask is if the simulation allows to detect deviations from the estimated rules given the observed output gaps and inflation gaps. The model is simulated stochastically by bootstrapping jointly the residual v_t^{US}, v_t^{EA} to preserve their within-sample observed correlation in the out-of-sample simulations.

5.1 Empirical Results

Figure 4 reports the results of the out-of-sample dynamic simulation of the short-term rates in the US and the euro area. In the case of the US the observed rates violates rarely and only marginally the confidence bounds of the simulated data. The level of three-month is in line with the modle based one over the course of 2021, the actual rates are then lower than the model predicted to violate the lower bound for the simulated data at the end of 2021. In the period 2022-23 the tightening of monetary policy pushes the actual rate above the simulated ones to reach the upper bound of the confidence interval at the end of the simulation period. Interpreting the actual monetary policy of the FED with the lenses of the model the conclusion that the Fed did not systematically violate its rule but stepped in late with the tightening and then made up for the lost ground in the following period. The empirical evidence for the ECB is different as a systematic and significant violation of the confidence intervals of the model emerges, with observed ECB monetary policy being sizeably less restrictive than the model predicted one.



(A) United States



(B) Euro area

FIGURE 5. Out-of-sample simulation of our baseline model described in equations (4) to (7) in the after COVID era (2020Q1-2023Q1). Coloured band is the confidence interval at the 5% level computed by means of bootstrapping over the full sample of each case.

6 Alternative Specifications for Monetary Policy in the euro area

The results of the simulations in the previous section call for an evaluation of alternative specifications for the rule determining the cycle of three-month rates in the euro area. We consider two alternative specifications of the equation for $r_{f,t}^{EA} - r_{f,t}^{EA,*}$.

The first one is driven by the possibility of an institutional concern for bond market fragmentation in the euro area, that has been expressed in institutional speeches and has led to the establishment of the so called Transmission Protection Instrument (Schnabel, 2022). The second one is driven by the observed lead-lag relationship betweeen the US and the euro area cycles.

In practice, the first specification augments the standard Taylor-rule based arguments of the cyclical component of rates with the (lagged) cross-sectional standard deviation of 10-year yields spreads on bunds for all member countries (that have been so since the start of our European sample, i.e., 2000Q1). We denote this variable as $\sigma\left(S_t^{10Y,EA}\right)$, where $S_t^{10Y,EA}$ represents the tuple of spreads at time t. This is an interesting variable as it has the potential of explaining both the success of the standard Taylor type specification for the US case, in which bond market fragmentation does not occur, and its failure in the Euro Area case.

$$\left(r_{f,t}^{EA} - r_{f,t}^{*,EA}\right) = \rho\left(r_{f,t-1}^{EA} - r_{f,t-1}^{*,EA}\right) + \beta_1 \pi_t^{gap,EA} + \beta_2 y_t^{gap,EA} + \beta_3 \sigma\left(S_{t-1}^{10Y,EA}\right) + v_t^{EA} \quad (8)$$

The second specification instead substitutes EA inflation and output gaps with the lagged US interest rates cycle:

$$\left(r_{f,t}^{EA}-r_{f,t}^{*,EA}\right)=\rho\left(r_{f,t-1}^{EA}-r_{f,t-1}^{*,EA}\right)+\beta_1\left(r_{f,t-1}^{US}-r_{f,t-1}^{*,US}\right)+v_t^{EA} \tag{9}$$

The estimation results are reported in Table 3 The following figure illustrates the simulation results for the EA based on the two alternative specifications. The red dashed line and band represent the simulated series together with the confidence interval at the 5% obtained by bootstrapping over the series of residuals of (8), whose coefficients (second column of Table 3) are estimated over the pre COVID era. The purple dashed line and band represent the same objects but with respect to the second alternative model (9), and whose coefficients (first column of Table 3) are estimated also over the pre-COVID era. It is pertinent to observe that, in the latter scenario, the bootstrapped residuals of the United States manifest within the cyclical component of the estimated 3-month rate for the Euro Area (EA). Upon examining Figure 6, it becomes evident that the simulated series, under these circumstances,

	u_t^{EA}	u_t^{EA}
u_{t-1}^{US}	0.121^{***}	
	(0.026)	
$\left(\sigma\left(s^{10Y}\right)\right)_{t-1}$		-0.001^{**}
		(0.001)
u_{t-1}	0.91^{***}	0.957^{***}
	(0.03)	(0.039)
π_t^{gap}		0.174^{***}
		(0.046)
y_t^{gap}		0.0^{*}
		(0.0)

Table 3. SURE estimation sample 2000Q1-2019Q4. Standard errors are reported in parenthesis.

exhibits significantly improved characteristics compared to the scenario in which the United States lacks a direct impact on the cyclical dynamics of the EA. This prompts consideration regarding the potential substantial influence of US monetary policy on the monetary policy of the Euro Area.

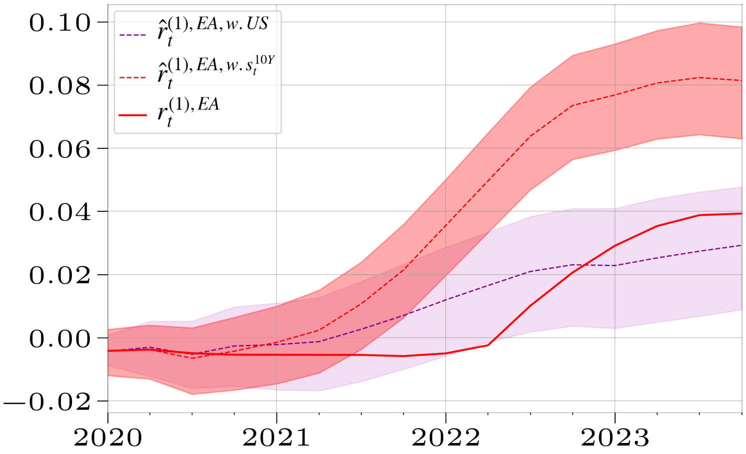


FIGURE 6. Out-of-sample simulation of the alternative model described in the equations (8) and (9), respectively, in the post-COVID era (2020Q1-2023Q1). Coloured band is the confidence interval at the 5% level computed by means of bootstrapping over the full sample of each case.

7 Conclusions

Modelling monetary policy using short-term rates poses significant challenges. The complexities arise from two key factors. Firstly, given the widely acknowledged notion that real interest rates are influenced by underlying real forces and are beyond the direct control of monetary policy, coupled with the unobservable nature of inflation expectations, the initial challenge surfaces in accurately identifying the portion of short-term rates that falls under the purview of central banks.

Secondly, short term rates are drifting: they are non-stationary. The econometric modelling aimed at forecasting necessitates the identification of the stochastic trend component from the stationary cyclical element. Modelling them econometrically for forecasting requires the identification of the (stochastic) trend component and the stationary cyclical component to use the appropriate different techniques to predict each of them. Our study embarks on addressing both these challenges through an innovative coordinated approach.

We propose a coordinate solution to the two challenges by identifying the drift components and considering real-short term rates as the predominant factor in determining its fluctuations while monetary policy is the predominant factor in determining the cyclical components. If the central bank is credible and long-run inflation expectations are anchored to the inflation target, then the trend in short-term rates can be successfully modelled by the annual change in potential output and the age structure of population. Long-term predictions for these exogenous variables are readily available and long-term forecasts for short-term rates are then naturally built by applying stationary VAR models to the drivers of the cyclical components of monetary policy.

The modelling strategy is applied to identify monetary policy rules for the FED and the ECB and to assess the performance of rules estimated on pre-COVID data in the COVID era and beyond.

Our empirical results show the demographics structure of population, the annual rate of change in potential and long-term inflation expectations are capable of modelling the drift in US and euro area short-term rates. We then consider the traditional drivers of monetary policy in a Taylor rule, i.e. the output gap and the inflation gap, as the drivers of the cyclical components of rates.

Remarkably, the traditional model performs very well within sample for the US and out-of-sample simulation conditional on the observed shocks to the output and the inflation gap show an overall robustness of the rule, with monetary policy modestly lagging initially behind the rule to make up for the lost ground in the final part of the simulation.

The results are different for the case of the euro area, where the evidence from within sample data is weaker and out-of-sample simulations reveal that actual data are persistently outside the 95 per confidence intervals from the simulation model. Intriguingly, augmenting the traditional rule with variables addressing ECB concerns over bond market fragmentation does not rectify the shortcoming. Instead, the most effective rule, validated within and beyond the sample, is one where the euro area's cyclical rate components slowly align with the US cycle.

The natural extension of our approach to short-term rate modelling is to full-term structure modelling based on the decomposition of yields at longer maturity as the average of future one-period yields over the residual maturity of the bond and the term premium.

Our trend-cycle decomposition approach for the one-period yields seems particularly appropriate for the long-term forecasting needed to model yields at the long end of the term structure.

In summary, our paper not only pioneers a coordinated approach to addressing the challenges of modelling monetary policy through short-term rates but also sheds light on the nuanced interplay between different policy determinants. This contribution augments our understanding of monetary policy dynamics in diverse economic contexts.

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Appendix

A Data

We employ quarterly data for both the US and the euro area.

In the case of the US, our we proxy for the monetary policy rate in the US is the 1-period bond yields which is the end-of-quarter 3-month Treasury bill rates from the Federal Reserve's H.15 release. Our sample period starts with Paul Volcker's appointment as Fed chairman, because of evidence that monetary and macroeconomic dynamics changed at that time (e.g., Gertler et al., 1999).

The Federal Reserve's perceived target rate (PTR) for inflation is a survey-based measure of long-run inflation expectations[5].

MY is available until 2050 and is hand-collected from various past Census reports[6]. Potential output[7] is available until 2030.

In general, we are taking the same data tha Favero et al. (2022) use in their paper and extending it until 2023Q1.

The data on the Euro Area (EA) one-period (3 month) yield come from the *Organization for Economic Co-operation and Development* (OECD)[8].

The Harmonised Index of Consumer Prices (HICP) data comes from `EUROSTAT`. We have chosen the index of all items (code `CP00`) with a base year of 2015 (the most recent available). Analogously with the PTR on the US, we have used long-term expectations (five years ahead) made by ECB's professional forecasters[9].

Unfortunately, we have not been able to find European potential GDP at the quarterly frequency, neither at the country level nor at the EA level. However, there

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[5] PTR is used in the Fed's FRB/US model and available at `https://www.federalreserve.gov/econres/us-models-package.htm`. Last access: February 11, 2024.

[6] See `https://www.census.gov/data.html`. Last access: February 11, 2024.

[7] It can be downloaded at `https://fred.stlouisfed.org/series/GDPPOT`. Last access: February 11, 2024.

[8] Organization for Economic Co-operation and Development, Interest Rates: 3-Month or 90-Day Rates and Yields: Interbank Rates: Total for the Euro Area (19 Countries) [`IR3TIB01EZM156N`], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IR3TIB01EZM156N, July 28, 2023.

[9] Available at the last column of: `https://www.ecb.europa.eu/stats/ecb_surveys/survey_of_professional_forecasters/html/table_hist_hicp.en.html`. Last access: February 11, 2024.

are data at the yearly frequency for the Euro zone in the AMECO database[10]. Then it can be interpolated linearly, easily. This makes sense because potential output is seen as the highest level of economic activity that can be sustained over the long term and the series in levels is nearly linear. There are also data on the output gap at the OECD[11]. The output gap is defined as the percentage difference between real GDP and potential GDP.

Finally, we have obtained cross-country data on demographic structure from `EUROSTAT`, utilising the code `DEMO_PJANIND`. Specifically, we have focused on three age groups: the old group (above 60), the middle-age group (40-49 years old) and the young group (20-29 years old). We have computed the mid-to-young ratio, denoted as MY_t, by simply dividing the number of individuals in the middle-aged group by the number in the young age group. It is worth noting that this data is also available on an annual basis. Hence, we have performed the same linear interpolation procedure to address this issue. As in the case of potential GDP, we do not lose much information by doing this because of the low natural variation of the series. Also, `EUROSTAT` provides different demographic forecasts with different scenarios taking into account different levels of fertility, inmigration, etc.

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[10] See https://economy-finance.ec.europa.eu/economic-research-and-databases/economic-databases/ameco-database/download-annual-data-set-macro-economic-database-ameco_en. Last access: February 11, 2024.

[11] See: https://stats.oecd.org/index.aspx?queryid=51655. Last access: February 11, 2024.