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U.S. and Euro Area Monetary and Fiscal Interactions During the Pandemic: A Structural Analysis

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U.S. and Euro Area Monetary and Fiscal Interactions During the Pandemic: A Structural Analysis

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ABSTRACT: This paper employs a two-country New Keynesian DSGE model to assess the macroeconomic impact of the changes in monetary policy frameworks and the fiscal support in the U.S. and euro area during the pandemic. Moving from a previous target of "below, but close to 2 percent" to a formal symmetric inflation targeting regime in the euro area or from flexible to average inflation targeting in the U.S. is shown to boost output and inflation in both regions. Meanwhile, the fiscal packages approved in the U.S. and the euro area, and a slower withdrawal of fiscal support in the euro area, have a similar impact on output and inflation as changing the monetary policy frameworks . Simultaneously implementing these policies is mutually reinforcing, but insufficient to fully explain the unexpected increase in core inflation during 2021.

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WORKING PAPERS

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Contents

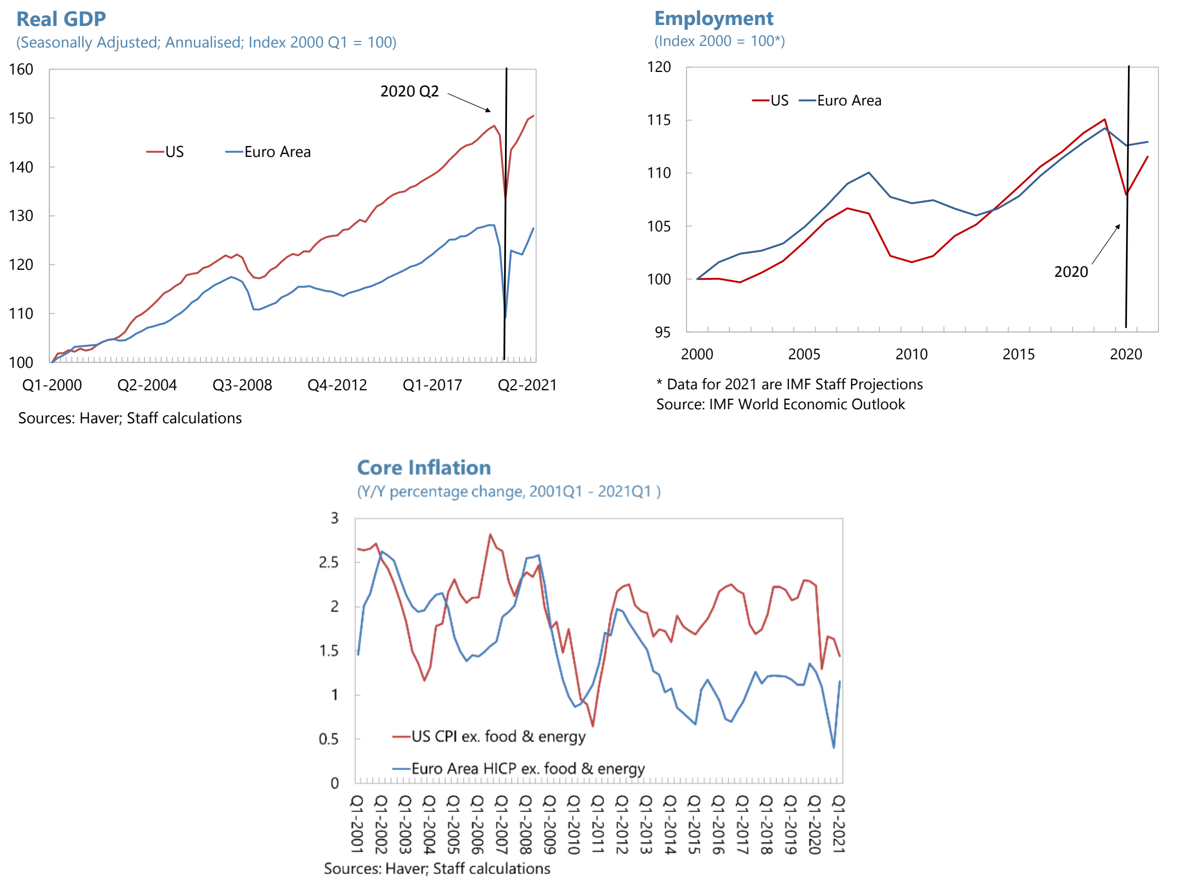
Glossary

AFP	American Families Plan
AJP	American Jobs Plan
APP	Asset Purchase Programs
ARP	American Rescue Plan
BBB	Build Back Better Act
BIF	Bipartisan Infrastructure Framework
DFR	Deposit Facility Rate
ECB	European Central Bank
ELB	Effective Lower Bound
FAIT	Flexible Average Inflation Targeting
Fed	Federal Reserve
FFR	Federal Funds Rate
FIT	Flexible Inflation Targeting
FL	Forward-looking
FOMC	Federal Open Market Committee
GFC	Global Financial Crisis
HANK	Heterogeneous Agent New Keynesian
NGEU	Next Generation European Union
PCE	Personal Consumption Expenditure
PEPP	Pandemic Emergency Purchase Program
TANK	Two-agent New Keynesian
U.S.	United States
VAR	Vector Autoregression
UIP	Uncovered Interest Rate Parity
WEO	World Economic Outlook

Introduction

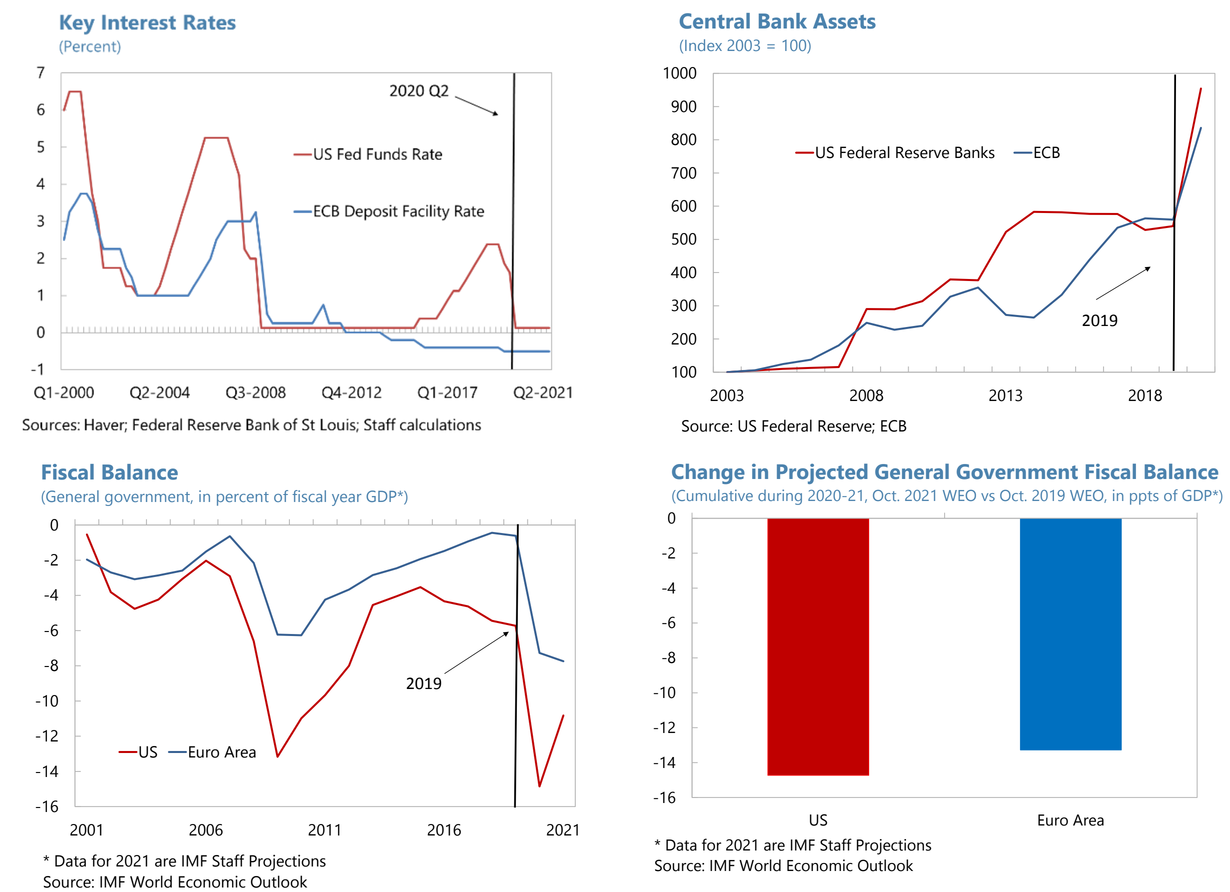
The COVID-19 pandemic has caused large-scale economic disruption in the United States (U.S.) and euro area. During 2020, lockdowns, travel restrictions and other containment measures resulted in a rapid drop in economic activity, larger than experienced following the Global Financial Crisis (GFC) of 2008 (Figure 1) and a sharp decline in inflation. The loss of employment was significant, particularly in the U.S., with the in-person services sector hardest hit. Labor market adjustment in the euro area was mainly through the intensive margin due to Job Retention Schemes.

Figure 1. Macroeconomic Impact of the COVID-19 Pandemic



Monetary and fiscal policy provided extraordinary stimulus during this pandemic period. The U.S. Federal Funds Rate (FFR) was already low at the outbreak of the pandemic and was quickly cut to the range of 0 to 0.25 percent, close to the Effective Lower Bound (ELB). In the euro area, the Deposit Facility Rate (DFR) remained at -0.5 percent (Figure 2). Both central banks significantly expanded their balance sheets, by augmenting asset purchase programs (APP) and introducing the Pandemic Emergency Purchase Program (PEPP) in the euro area, while re-commencing asset purchases in the U.S. Liquidity was made more readily available to banks and other financial institutions, with the Fed backstopping both institutions and markets (see Clarida, Duygan-Bump, and Scotti 2021; Lane, 2021). Financial conditions quickly turned around from being tight to highly accommodative (as was the intent of the policies deployed). At the same time, extraordinary fiscal stimulus was implemented in both regions. In the U.S., fiscal stimulus has been around 15 percent of GDP, as measured by the cumulative difference between the general government fiscal balance recorded during 2020–21 and that projected by IMF staff pre-pandemic in the 2019 World Economic Outlook (WEO). Using the same metric, fiscal stimulus in the euro area was also significant, at around 13 percent of GDP. Over the next 5 years, EU countries will continue benefiting from the Next Generation EU (NGEU) recovery package of €800 billion of loans and grants. In the U.S., fiscal stimulus also continued well into 2021, with the U.S. Congress approving US$1.9 trillion in pandemic-related spending in March 2021, in response to the Biden Administration's American Rescue Plan (ARP).

Figure 2. Monetary and Fiscal Response to the COVID-19 Pandemic



In the midst of the pandemic, monetary policy frameworks were also changed:

United States. While the Fed's (Federal Reserve) dual mandate of stable inflation and full employment remains unchanged, the Fed shifted from a strategy of Flexible Inflation Targeting (FIT), to a form of Flexible Average Inflation Targeting (FAIT) in August 2020. The Fed revised its statement on Longer-Run Goals and Monetary Policy Strategy to make clear that: (i) following periods when inflation has been running persistently below 2 percent, appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time; and (ii) where the employment and inflation objectives are not complementary, policy would take into account employment shortfalls (i.e., rather than deviations from full employment) and inflation deviations and the potentially different time horizons over which employment and inflation are projected to return to levels judged consistent with its mandate. Following the adoption of the new framework, in its monetary policy statements, the FOMC indicated that it expected it would be appropriate to maintain the federal funds rate at 0–0.25 percent until labor market conditions had reached levels consistent with the Committee's assessments of maximum employment and inflation has risen to 2 percent, and was on track to moderately exceed 2 percent for some time. Before changing strategy, the Fed had previously given different forward guidance, by committing to keep the FFR near zero until the economy had weathered the pandemic and was on track to achieve the Fed's maximum employment and price stability goals.[1]

Euro area. In July 2021, at the conclusion of the Strategy Review, the European Central Bank (ECB) revised the language of its forward guidance and removed the ambiguity surrounding the previous target of "below, but close to, two percent" and formally codified the Governing Council's emphasis on symmetry in recent years. (see for example, Paloviita et al (2021). The ECB's revised forward guidance formalized the evolution and now underscores its tolerance for inflation being temporarily above two percent, and its commitment to the current level of key policy rates until inflation is forecast to durably reach two percent within the medium-term projection horizon.[2]

In announcing the revised strategies, both central banks noted the decline in the neutral policy rate—the rate consistent with stable inflation and otherwise normal economic conditions—as a motivation to make these changes.[3] A lower neutral rate implies less scope, on average over time, to lower policy rates before being constrained by the ELB on nominal interest rates.

Substantial public investment is planned in coming years. Although fiscal balances are expected to improve over the medium term, partly due to automatic stabilizers and the withdrawal of stimulus, significant public investment is in the pipeline for both the U.S. and euro area. The U.S. Congress approved a Bipartisan Infrastructure Framework (BIF) in November 2021, which adds close to US$600 billion (3 percent of GDP) of public investment to previously planned spending, in transportation, water and broadband, together with funding for maintenance.[4] The Members of the European Union agreed in July 2020 and adopted in December 2020 the "Next Generation European Union" package of around €800 billion (or around 6 percent of euro area GDP) in grants and loans, which has a significant public investment component, to be distributed during 2021–

[1] Compare https://www.federalreserve.gov/newsevents/pressreleases/monetary20200729a.htm with https://www.federalreserve.gov/newsevents/pressreleases/monetary20210728a.htm. Implementation of the AIT strategy involved providing forward guidance about how long the Fed Funds Rate would be held at the ELB.

[2] See https://www.ecb.europa.eu/press/blog/date/2021/html/ecb.blog210819~c99d1b768d.en.html. The ECB had previously committed to maintaining the current policy rates until the ECB's projections were showing "the inflation outlook robustly converge to a level sufficiently close to, but below, two percent within its projection horizon."

[3] For the U.S., see https://www.federalreserve.gov/monetarypolicy/review-of-monetary-policy-strategy-tools-and-communications.htm and https://www.federalreserve.gov/newsevents/pressreleases/monetary20200827a.htm. For the euro area, see https://www.ecb.europa.eu/home/search/review/html/ecb.strategyreview_monpol_strategy_statement.en.html. In the 2021 strategy statement, the ECB noted that structural changes in the economy, including slower productivity growth and ageing of the population, have contributed to lower equilibrium real interest rates, making it challenging to rely on changes in policy rates alone to achieve the ECB's objectives.

[4] In addition, the U.S. Administration proposed a Build Back Better Act (BBB) of around 7½ percent of GDP that, ultimately, did not garner support in Congress. A version of the Build Back Better Act passed by the House of Representatives in November 2021 is described in Section VI. It has not been passed by the Senate. A smaller version of this legislation, known as the Inflation Reduction Act and focused on initiatives related to climate change, drug pricing and health care, was approved by Congress in August 2022.

27.[5] Preliminary estimates suggest that close to 77 percent of this amount will finance additional fiscal spending in the euro area with 80 percent for public investments[6].

This paper uses a general equilibrium modelling framework to analyze the impact of this unprecedented combination of changes to monetary policy frameworks and fiscal stimulus during the acute pandemic phase of late 2020 and 2021 in the U.S. and euro area. Other policy support measures including short-time work schemes or various moratoria are beyond the scope of the paper. The framework is a variant of the Erceg and Lindé (2013) two-country New Keynesian version of the Fed's SIGMA model, calibrated to the U.S. and the euro area, complemented with subjective discounting in price setting to address the so-called forward-guidance puzzle This framework allows us to assess not only the impact of individual policies on each economy but also the interaction between fiscal and monetary policies on both domestic and foreign economies. This micro-founded theoretical approach has particular value given there is: (i) no historical data on changing monetary frameworks when monetary policy is constrained by the ELB; and (ii) uncertain implications of the very large fiscal stimulus put in place in both economies. In this vein, the model is used to gauge the impact on key macro variables, most importantly on output and inflation, from changing the monetary policy frameworks and introducing fiscal stimulus in both the U.S. and the euro area.

The model shows that changes in the monetary frameworks boost domestic output and inflation, while having important positive spillover effects.

Given an initially negative AIT gap—i.e., the difference between the 2 percent target and average inflation over the past 60 months—the adoption of FAIT in the U.S. delayed the FFR liftoff by at least two quarters and weakened the U.S. dollar. It also led to higher quarterly U.S. output and core inflation over the medium term, with a peak impact of 1.5 percent and 0.3 percentage points respectively, relative to FIT. Spillovers through trade and financial channels boost quarterly output in the euro area by up to 0.4 percent over the medium term. By late 2021 the U.S. AIT gap had fallen to zero (with expansionary fiscal and monetary policy contributing to closing that gap).

The ECB strategy of "inflation rates below, but close to, 2 percent over the medium term" is modeled by assuming that the ECB reacts more vigorously to increased inflationary pressures when projected inflation one year ahead exceeds 2.5 percent. Such a strategy would be inconsequential amid a modal outlook where inflation is projected to return gradually to target during the forecast horizon. But in an environment with shock uncertainty where unfavorable shocks can drive inflation well-above its target, stochastic model simulations show that adopting fully symmetric FIT in the Euro area implies that ECB liftoff would be delayed by one-two quarters relative to the previous regime, boosting median inflation by a peak of 0.2 percentage points over the medium term and output by 1.6 percent.[7] If the ECB were to have followed the Federal Reserve approach and adopted FAIT, this would have further boosted core inflation by a peak of 0.3 percentage points and output by 1.75 percent. This improvement in inflation and activity outcomes were due to the sizeable initial euro area AIT gap (of -0.8 percent at the beginning of 2021) which then gave more scope for accommodative policy in order to more firmly anchor inflation and inflation expectations at 2 percent. Adopting FAIT would also have implied small but positive spillovers to U.S. output. A more accommodative monetary policy can also support fiscal policy by reducing the debt burden and preventing a crowding-out of private investment from fiscal stimulus.

[5] For further details, see https://ec.europa.eu/info/strategy/recovery-plan-europe_en.

[6] For estimates of the composition of spending see Freier et al., ECB Economic Bulletin, Issue 1/2022.

[7] This is the median impact implied by stochastic simulations used to model the asymmetric targeting regime. This is explained further in Section V.

The more expansionary fiscal stance in either region over the medium term not surprisingly boosts domestic output and inflation and the large U.S. fiscal packages have significant spillover effects to the euro area.

- The ARP is shown to boost U.S. output by 4 percent during its first year of implementation, with core inflation higher by 0.3 percentage points. Implementing the U.S. BIF would boost quarterly U.S. output by 0.75 percent (additional to the impact of the ARP) and U.S. core inflation by 0.1 percentage points, peaking during the period when the bulk of the stimulus comes online. The binding ELB constraint on monetary policy provides fiscal policy with a greater macroeconomic impact than it otherwise would have. The model would imply that the ARP served to bring forward the FFR liftoff by one quarter, under the FAIT framework. If implemented, the U.S. BIF would bring forward liftoff by a further quarter. Implementing the BIF would boost euro area output and core inflation both by an additional 0.1 percentage points, via the trade channel, with a stronger U.S. dollar.
- For the euro area, the model implies that the NGEU package added around 0.5 percentage points to quarterly output in its first year of implementation, with the impact on quarterly output projected to peak in the third year of implementation at around 1.3 percent. The impact on core inflation is 0.15 percentage points. Our findings are similar to those in Freier et al (ECB, 2022). In addition, a slower pace of fiscal consolidation over the medium term compared to the IMF October 2021 WEO forecasts, but broadly in line with the latest 2022 national budgets, would boost output and limit hysteresis effects while only having a mild impact on inflation. Specifically, a two-year hike in government consumption and investment spending by one percent of GDP per year boosts euro area quarterly output by an average of over 1 percent and core inflation by 0.1 percentage points during the two years. If the same amount is split evenly between government investment and untargeted transfers, the impact would be roughly halved. Spillovers to the U.S. from these euro area policies would be minimal, given their size.

The combination of additional government investment in both regions with the implementation of the new monetary policy regimes is mutually reinforcing. Under the baseline calibration, the adoption of FAIT and FIT in U.S. and euro area, respectively, provides a significant boost to output but a mild impact on inflation without adverse international spillovers, when AIT gaps are negative. Adding on the effects of the BIF as well as a slower fiscal consolidation in the euro area creates a combined impact on output in the euro area peaking at around 3½ percent with core inflation higher by around 0.5 percentage points (i.e., more than twice the impact from the euro area fiscal stimulus alone). Similarly, the peak impact on U.S. output is 1¼ percent, with a peak inflationary impact of 0.2 percentage points. The impact on the real exchange rate and external balances of this combination of policies is relatively modest. The table below summarizes some of our key findings of each policy change, which depends on the various initial conditions.

The model nonetheless implies that the implementation of fiscal stimulus and new monetary regimes is insufficient to explain the unexpected rise in inflation during 2021. Section IX compares actual inflation outturns during 2021 with IMF staff forecasts made during 2020, which demonstrate that core inflation has been significantly higher than forecast in both the U.S. and euro area. The model implies that the implementation of measures not included in IMF staff's 2020 forecasts, including fiscal stimulus (the ARP and BIF in the U.S) as well as the adoption of FAIT in the U.S. and FIT in the Euro Area can explain around one third of the unexpected inflation in the U.S. during 2021 and around one quarter in the euro area. The amount of unexpected inflation that can be explained by the model increases significantly to around 70 percent if the price and wage Phillips curves in the model are assumed to be twice as steep. While we assume in the simulation that the slope of the Phillips curve has gone up equally in the U.S. and euro area, our results with a steeper Phillips curve resonate more in the case of the U.S. than in the euro area where wage growth has remained more subdued and higher inflation is mainly driven by energy prices. Nonetheless, the model implies that other factors are required to explain the full amount of unexpected inflation in 2021, apart from the demand-side impact of the fiscal stimulus and new monetary regimes.

The remainder of the paper outlines the modelling approach and presents simulations of monetary and fiscal policy changes. Section II provides an overview of the model, while Section III explains the baseline calibration. Sections IV and V present the results of simulations relating to changes in monetary policy frameworks in the U.S. and euro area. Sections VI and VII illustrate the impact of U.S. and euro area fiscal packages in the model, while Section VIII displays the combined impact of fiscal and monetary framework changes. Section IX computes the amount of unexpected inflation during 2021 that can be explained by fiscal stimulus and the introduction of new monetary regimes, according to the model.

Table 1. Impact of Changing Monetary Policy Frameworks and Fiscal Support Summary

Discretionary changes in policies		**Some relevant considerations**	**Peak Impact on Output (percent)**		**Peak Impact on Inflation (percentage points)**	
Monetary framework	Fiscal support		US	Euro area	US	Euro area
FIT to FAIT in the US (1)	n/a	Initial AIT gap, ELB	1.5	0.4	0.3	0.1
Asymmetric to symmetric in the euro area (2)	n/a	Initial AIT gap, ELB, stochastic simulation, modal result	n/a	1.6	n//a	0.2
FIT to FAIT in the euro area (3)	n/a	Initial AIT gap, ELB	0.3	1.7	0.03	0.35
FAIT in the US	US Fiscal package ARP (4)	Composition of spending, Phillips Curve slope, ELB, and share of hand-to-mouth agents	4	0.6	0.35	0.1
	US Fiscal package BIF (4)		0.75	0.1	0.1	0.03
FIT in the euro area, FAIT in the US	euro area Fiscal package (NGEU) (5)		0.2	1.3	0.06	0.16
	Slower fiscal consolidation in the euro area (6)		0.25	1.4	0	0.2
(4) + (6)			4	3.5	0.4	0.5

Note: the BIF is incremental, so that its impact is in addition to having ARP in place.

The Modelling Framework

The general equilibrium New Keynesian modelling framework provides a rich environment for studying the impact of monetary and fiscal policy changes on the real economy. The two-country model with endogenous capital and labor supply closely follows Erceg, Guerrieri and Gust (2006) and Erceg and Lindé (2013). Abstracting from open economy features, the specification of each country block closely resembles the estimated models of Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003, 2007). The model contains a range of features that allow it to match empirical evidence about the macroeconomic response to monetary changes. These features include sticky nominal wages and prices, habit persistence in consumption, investment adjustment costs, and a financial accelerator mechanism. To match the transmission of fiscal shocks, the model exh[8]me households consume their current after-tax income in a hand-to-mouth fashion. Blanchard, Erceg and Lindé (2017) show that a closed economy variant of the model we use matches -to euroestimated wide monetary policy and government spending shocks estimated on pre-Covid Vector Autoregression (VAR) data. Hence, the model features transmission of monetary policy and fiscal shocks in line with existing empirical evidence. To address the forward guidance puzzle when interest rates are at the ELB for a prolonged period, we inserted subjective discounting in the price setting block of the model. Hence, future monetary announcements have a smaller impact than in the rational expectations model.

The calibration and initial conditions in the model's baseline broadly reflect prevailing economic conditions and the IMF staff outlook in early 2021. The AIT gaps in the U.S. and euro area were negative and both central banks were constrained by the ELB. The projected path for inflation closely follows the early 2021 outlook.

The open economy features of the model allow for spillovers of monetary and fiscal policy across regions through trade and financial channels:

Trade. Monetary and fiscal stimulus can provide a demand impulse through the trade channel. The trade share of the U.S. and euro area economies, which are assumed to be equally large, is set about 9 percent of GDP, intended to match U.S. and euro area trade linkages. Trade occurs in both consumption and investment goods, but the import intensity of consumption goods is assumed to be smaller (3/4) than that of investment goods. This calibration is suitable for the U.S. and the euro area, which have similar GDP levels. It overstates the extent of the direct bilateral trade flows between the U.S. and the euro area, but is intended to include some indirect linkages as well.[9]

Exchange Rate. The benchmark model assumes local currency pricing, and financial markets are incomplete as only a single non-state contingent internationally traded bond is available. The exchange rate is, thus, determined by the choice of foreign and domestic bond holdings, which boils down to an uncovered interest rate parity (UIP) condition, where net foreign assets also enter to ensure stationary bond holdings. The local

[8] Gali, Lopez-Salido and Vallés (2007) show that the inclusion of non-Ricardian households helps account for structural VAR evidence indicating that private consumption rises in response to higher government spending. Debortoli and Gali (2017) argues that dynamics in TANK models mimic key aspects of the so-called Heterogeneous Agent New Keynesian (HANK) models (Kaplan, Moll and Violante, 2016).

[9] Calibrating the model for the U.S. and the rest of the world, rather than the U.S. and the euro area, would involve the same trade intensity, but would assume that the U.S. accounts for 23 percent of the world economy.

currency pricing assumption mutes the effect of exchange rate changes on import and export prices and dampens the importance of the “price” vis-à-vis the “activity” channel in determining trade flows.

Financial Markets. The model contains a financial accelerator mechanism in the spirit of Bernanke, Gertler, and Gilchrist (1999). The model exhibits a significant correlation between risk premia across regions, implying that private sector borrowing rates co-move, despite the lack of other formal financial links between the two regions.

Given that both central banks have recently set monetary policy rates at or close to the ELB, we model monetary policy in each region using a rule for the shadow policy rate, subject to the ELB:

U.S. The FFR is determined by a rule for the shadow rate i_t^{US}, subject to the ELB, which for simplicity is treated as the lower point of the actual FFR 0--0.25 target range:[10]

$$FFR_t = max[4i_t^{US}, 0]$$

The rule for the shadow non-annualized FFR reflects the dual mandate of the Federal Reserve, to achieve full employment and stable inflation. The rule embodies these objectives by making the shadow FFR dependent on (i) the deviation of average inflation (over five years) from the Federal Reserve’s two percent target,[11] in the case of FAIT and (ii) the deviation of employment (e_t^{US}) from its potential, flexible price level, as well as employment’s growth rate. We use hours worked to measure employment. The rule also reflects the inertia of the FFR., which partly depends on its lagged value:

$$i_t^{US} = \gamma_{US} i_{t-1}^{US} + (1-\gamma_{US})\left[\bar{\iota}^{US} + \gamma_{\pi,US}\left(\bar{\pi}_{t,US}^{5yr} - 2\right) + \gamma_{e,US}\left(e_t^{US} - e_t^{pot,US}\right) + \gamma_{\Delta e,US} \Delta e_{t,US}\right] + \varepsilon_t^{US} \quad (1)$$

where $\bar{\pi}_{t,US}^{5yr}$ is the average inflation gap over the previous five years.

In order to solve the model with FIT in the U.S., the term $\gamma_{\pi,US}\left(\bar{\pi}_{t,US}^{5yr} - 2\right)$ is replaced by $\gamma_{\pi,US}\left(\pi_{US_t} - 2\right)$, where π_{US_t} is the contemporaneous inflation rate, and $\bar{\iota}^{US}$ is the steady state nominal interest rate (2.5 percent annually in our calibration).

Euro area. The ECB policy rate is also determined by a rule for the shadow rate, subject to a conditional ELB. We assume -50 basis points as the conditional ELB, which means that the ECB would not cut its policy rate below 50 basis points unless the outlook worsened materially more than in the experiments considered in this paper.

$$EONIA_t = max[4i_t^{EA}, -1/2]$$

In our calibration, the rule for the shadow policy rate in the euro area reflects symmetric FIT and is similar to that in the U.S. Consistent with the empirical evidence by Paloviita and others (2021), the rule for the euro area shadow rate is augmented by an extra penalty term when modelling the previous monetary policy strategy. The

[10] The middle of the FFR range targeted by the Fed is 0.125 percent, when the nominal policy rate is lowered to its lowest non-negative level.

[11] Variables have been log-linearized around the non-stochastic steady state.

penalty term is triggered by expected inflation exceeding the two percent target by more than ½ percentage points, making the shadow rate rule nonlinear:

$$i_t^{EA} = \gamma_{EA} i_{t-1}^{EA} + (1-\gamma_{EA})\begin{bmatrix}\bar{\iota}^{EA} + \gamma_{\pi,EA}(\pi_{EA_t} - 2) + \gamma_{e,EA}(e_t^{EA} - e_t^{pot,EA}) \\ +\gamma_{\Delta e,EA}\Delta e_{t,EA}\end{bmatrix} + \gamma_{\pi,EA} max(\mathbb{E}_t[\bar{\pi}_{t+4,EA}^{1y} - 2.5], 0) + \varepsilon_t^{EA} \qquad (2)$$

where $\mathbb{E}_t \bar{\pi}_{t+4,EA}^{1y}$ is the model-consistent- forecast of average inflation over the next year, and $\bar{\iota}^{EA}$ is the steady nominal interest rate in the euro area (also set to 2.5 percent annually).

The model includes a rich array of tax and spending instruments, set to match their empirical counterparts in each region. In each region, the taxes on capital τ_{Kt}, consumption τ_{Ct} and labor income $\tau_{N,t}$, as well as government purchases g_t and the ratio to trend GDP of real transfers to 'hand to mouth' households, $tr_t^{HM} = \frac{TR_t^{HM}}{P_t Y}$ are assumed to be exogenous.[12] Government purchases have no direct effect on the utility of households, nor do they affect the production function of the private sector. Government investment is proxied by an exogenous link between some government purchases and medium-term productivity. Following Leeper, Walker and Yang (2010) and Lemoine and Lindé (2020), this link is calibrated so that a one percentage point increase in the government capital stock has a direct impact on output of around three percent, taking into account 'time to build'. The ratio to trend GDP of real transfers to all households (i.e., general transfers), $tr_t^O = \frac{TR_t^O}{P_t Y}$ can also be fixed in the short-term, since the government can issue nominal non-state contingent bonds and does not need to balance its budget each period. Over the long-term, the ratio of real general transfers to trend GDP is assumed to adjust to satisfy the government's long-run budget constraint, stabilizing the ratio of the fiscal deficit and public debt to GDP.

The parameterization of the model is otherwise completely symmetric and is discussed in further detail in the Appendix A.6.

Constructing the Baseline Outlook

The baseline projection reflects the IMF staff outlook at the beginning of 2021, providing the backdrop for experiments to gauge the impact of monetary and fiscal policy changes during 2021. The model's solution reflects the adverse macroeconomic impact of the pandemic, with monetary policy constrained by a conditional ELB.

The IMF staff outlook in early 2021 took into account the exceptional policy support implemented in 2020, such as the central bank asset purchase programs, debt moratoria, labor market programs, and the announcement of the NGEU package. We also show a counterfactual scenario without the NGEU package.

Through our calibration, we approximate the IMF staff outlook with surprise and anticipated shocks. These include negative consumption preference shocks, which induced temporarily higher savings and a drop in consumption. In addition, to reflect the possible drop in labor productivity due to "stay-home" orders, we add surprise, but relatively persistent negative technology shocks to both the US and euro area. Global supply

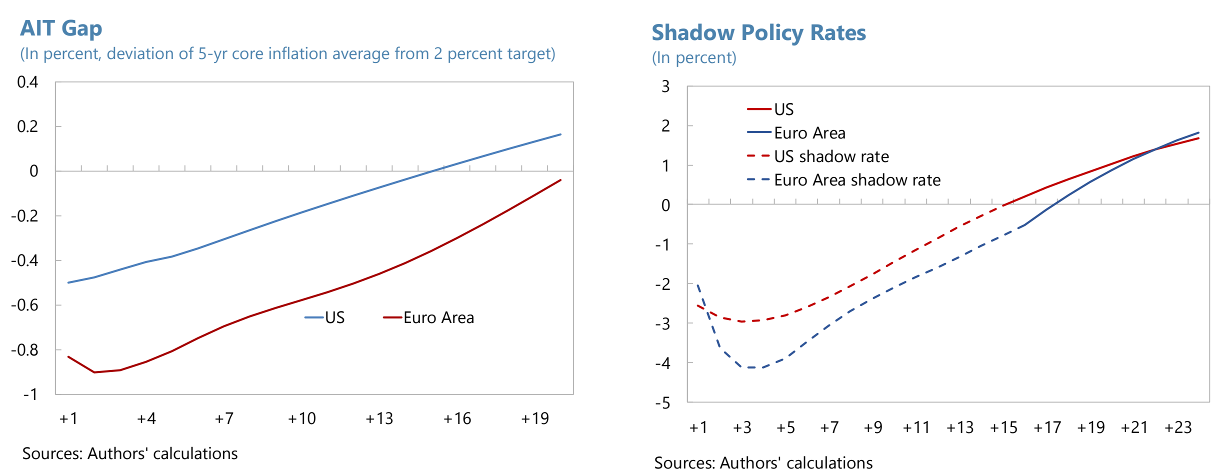
[12] Given that the central bank uses the nominal interest rate as its policy instrument, the level of seigniorage is determined by nominal money demand.

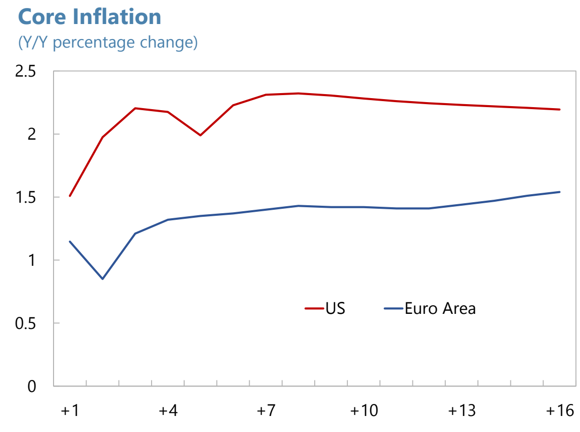
chain disruptions, on the other hand, are modelled as a combination of surprise and anticipated price markup shocks.

The rule for the shadow FFR reflects FAIT based on a 5-year trailing average of core inflation outturns, while the corresponding rule for the ECB reflects FIT with a symmetric target. As initial conditions, negative AIT gaps for the U.S. and the euro area are set to -0.5 percent and -0.8 percent in annualized terms respectively (Figure 3). This implies negative shadow policy rates in both regions initially, constraining both central banks at the ELB. The model is calibrated to have a quarterly frequency. Given these initial conditions, the AIT gaps close gradually over time under the baseline, as core inflation roughly evolves according to IMF staff projections for U.S. core Personal Consumption Expenditure (PCE) inflation and euro area core inflation at the time of the April 2021 WEO. This implies exit from the ELB in the U.S. and the euro area after 15 quarters and 17 quarters, corresponding to mid and late 2024 respectively. For the euro area, forward guidance is reflected by adding shocks that delay liftoff from the current rate, in this case by around two quarters. In this baseline, there are no significant cost-push shocks or demand-supply imbalances causing a pick-up in inflation the US and the euro area subsequently experienced.

Regarding fiscal policy, the baseline is calibrated to reflect the impact of fiscal packages that were approved by early 2021. For the U.S., the impact of the recently passed BIF is not incorporated into the baseline but is considered in the simulations (given these packages were subject to ongoing Congressional negotiations). For the euro area, fiscal policies in 2021 were highly expansionary, reflecting both automatic stabilizers and discretionary measures. The baseline is consistent with the aggregate euro area structural fiscal balance improving by 4 percentage points between 2022 and 2025, frontloaded in 2022, as was expected prior to the latest set of national 2022 budget plans. For both regions, the parameters determining the slope of the Phillips curves in the model are calibrated based on historical experience (see Box 1). For further information on the calibration of the parameters, see the Appendix A.6.

Figure 3. Baseline Outlook





Sections IV-VIII present the simulated impact of monetary and fiscal policy changes in the U.S. and euro area. We simulate a stylized characterization of the shift in the monetary policy regimes in each region (e.g. FAIT vs. FIT), followed by additional fiscal spending (e.g. BIF in the U.S.). In each case, the model is solved[13] both *with* and *without* a binding ELB constraint, where in the latter case the monetary policy rates can always equal the shadow rate and may be negative. Comparing model outcomes with and without an ELB constraint can illustrate the loss of monetary policy space caused by the ELB and the potential benefits of fiscal stimulus in these circumstances.

The Impact of FAIT in the U.S.

The FAIT regime in the U.S. implies more accommodative monetary policy relative to FIT, to offset past undershooting of the two percent target. Starting with the baseline outlook in which the U.S. has an initial negative AIT gap, the model is simulated using either an FIT or an FAIT rule for the shadow rate (Figure 4 and 5). The negative AIT term in the FAIT shadow rate rule lowers the shadow rate, relative to the FIT case. This is illustrated by decomposing the shadow rate into its determining factors (the teal color area in Figure 4). The FAIT regime delays liftoff from the ELB by two quarters, resulting in higher quarterly output and inflation in the U.S. than under an FIT rule by up to 1.5 percent and 0.3 percentage points respectively over the medium term (Figure 5). In the hypothetical case when the monetary policy is unconstrained and the FFR can be cut after a shift from FIT to FAIT, Figure 5 shows that the regime change results in a higher near-term boost to output. This is because the Fed in this case cuts its policy rate and thereby stimulates the economy. Since the Phillips curve is flat and the liquidity trap is so long-lived, the effects on inflation are very similar when monetary policy is unconstrained compared to the case when the policy rate is constrained by the ELB as shown in Figure 5.

[13] The model is solved using the Dynare package (Juillard 1996).

Figure 4. Decomposition of U.S. Shadow Rates Under FAIT and FIT

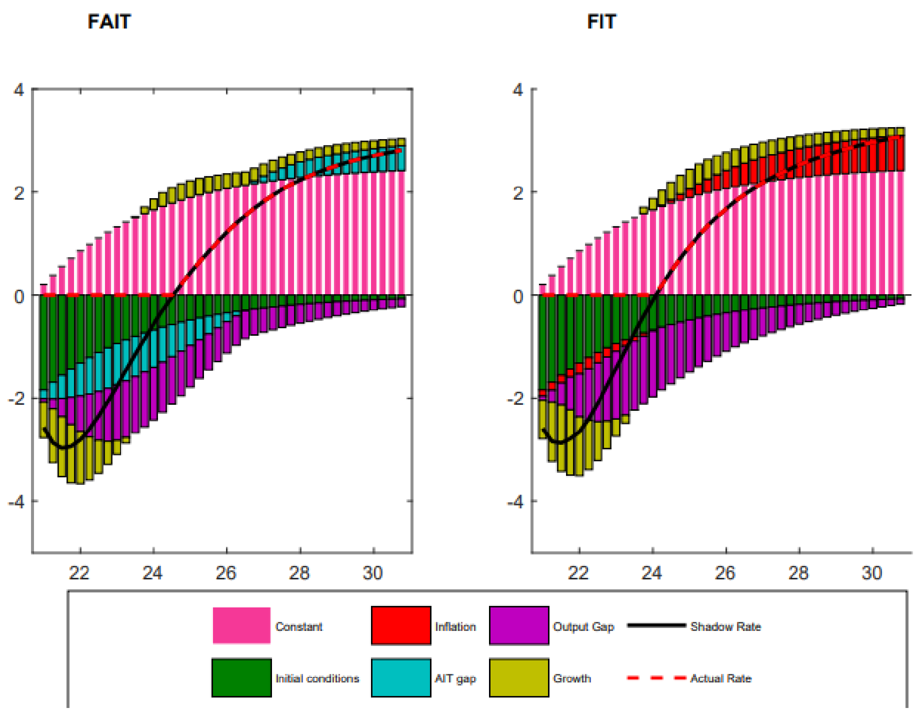
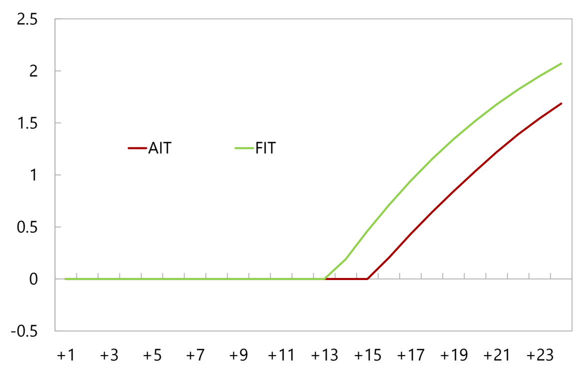


Figure 5. Impact of FAIT in the U.S., Relative to FIT

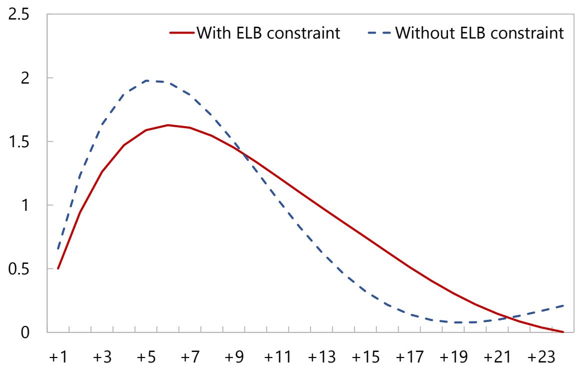
Fed Funds Rate

(With ELB constraint; In percent)



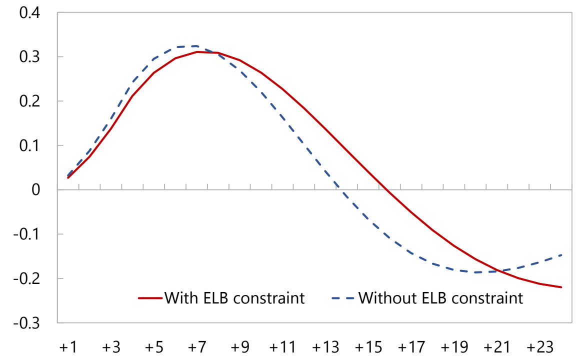
Sources: Authors' calculations

Change in US Output
(In percent)



Sources: Authors' calculations

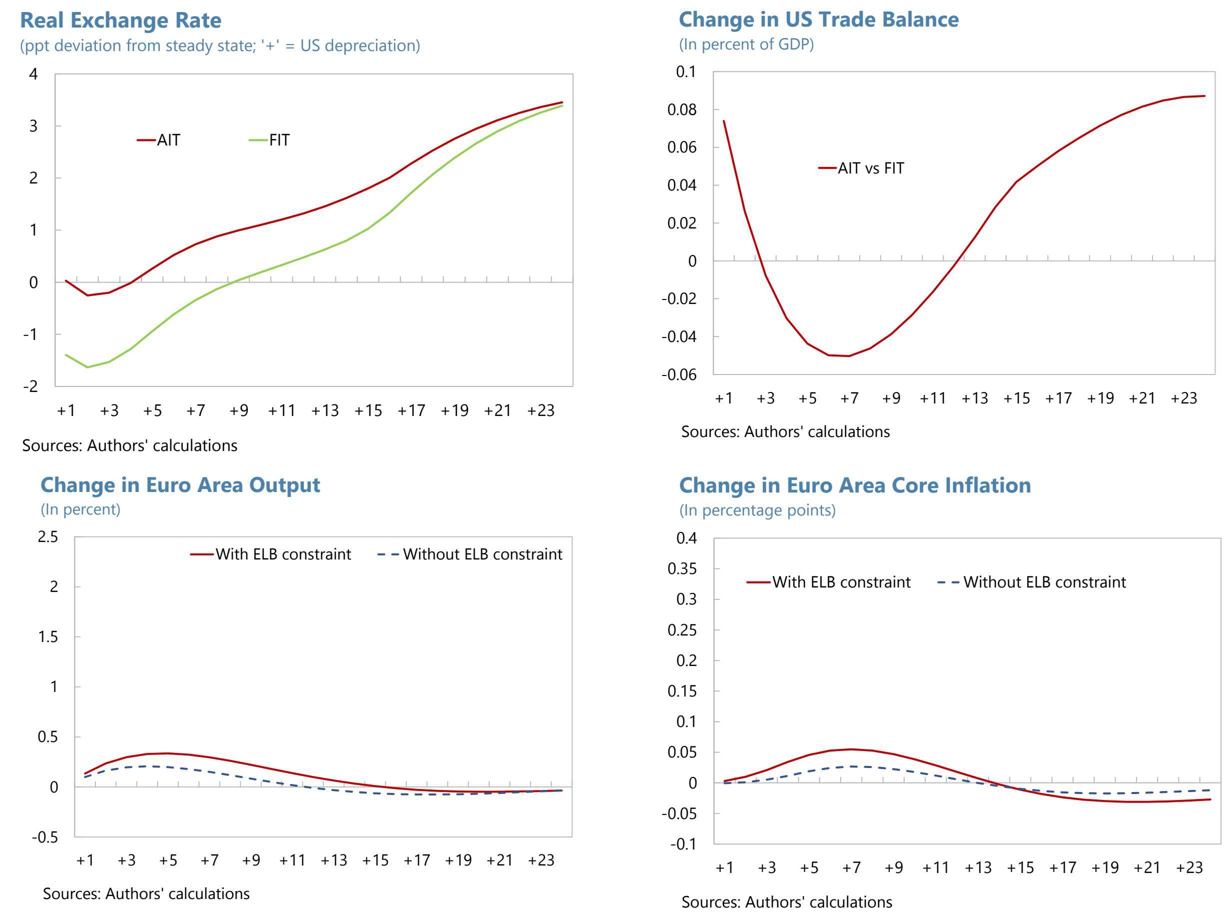
Change in US Core PCE Inflation
(In percentage points)



Sources: Authors' calculations

FAIT in the U.S. creates positive spillovers to the euro area rather than 'beggar thy neighbor' effects. The longer expected duration of the FFR at the ELB implies a weaker U.S. dollar, consistent with the UIP condition in the model (Figure 6). Nonetheless, the boost to U.S. demand implies a weaker U.S. trade balance in the near term, providing an external demand impulse to the euro area. Domestically, the financial accelerator mechanism also contributes to higher output in the euro area. This results in higher quarterly output in the euro area by up to 0.4 percent over the medium term and slightly higher euro area core inflation by up to 0.1 percentage points, roughly 15–20 percent of the domestic impact in the U.S.

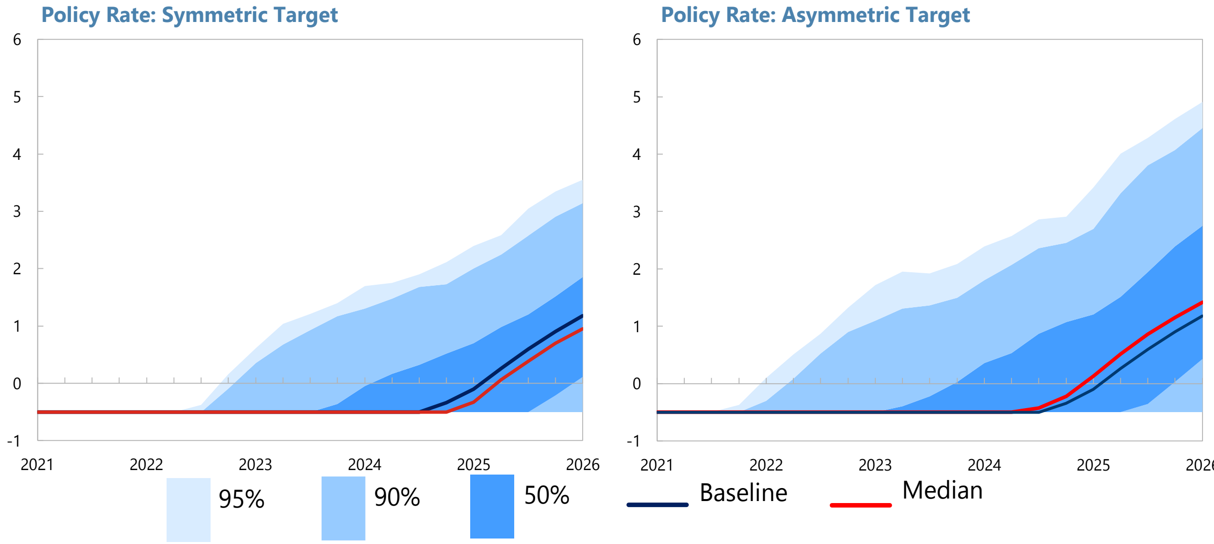
Figure 6. Spillovers from U.S. FAIT to the Euro Area



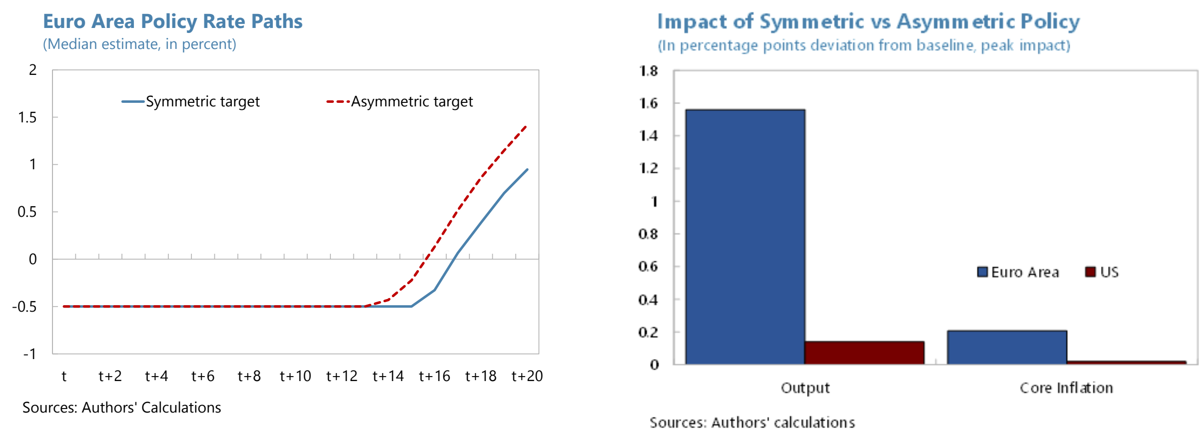
Changing the Monetary Regime in the Euro Area

The model indicates that a symmetric FIT regime would lead to a significantly more accommodative stance than what a market-perceived asymmetric inflation targeting framework would deliver. The implications of the different approaches aren't apparent under the modal outlook—since projected euro area inflation runs well below two percent in our baseline—and hence we consider stochastic simulations to highlight the differences. In particular, stochastic simulations ensure that part of the distribution of possible future inflation outcomes exceeds the two percent target, triggering the penalty term in the shadow rate rule under asymmetric inflation targeting (equation (2)). Under the stochastic simulations, the distribution of the path for the euro area policy rate demonstrates that the adoption of a symmetric FIT rule would delay the median liftoff date by one-two quarters. Comparing the model's result from a symmetric FIT against the median outcome under asymmetric targeting implies a peak medium-term increase of up to 1.6 percent and 0.2 percentage points respectively to quarterly euro area output and core inflation (Figure 7). In these simulations, the U.S. regime remains unchanged as FAIT in both the asymmetric and symmetric case. As in Erceg, Jakab and Linde (2021), a symmetric FIT regime limits the downside risk to euro area GDP while containing deflation risk (not shown) notably relative to the asymmetric rule that responds more aggressively to expected inflation impulses exceeding 2.5 percent per annum.

Figure 7. Symmetric vs. Asymmetric Inflation Targeting in the Euro Area



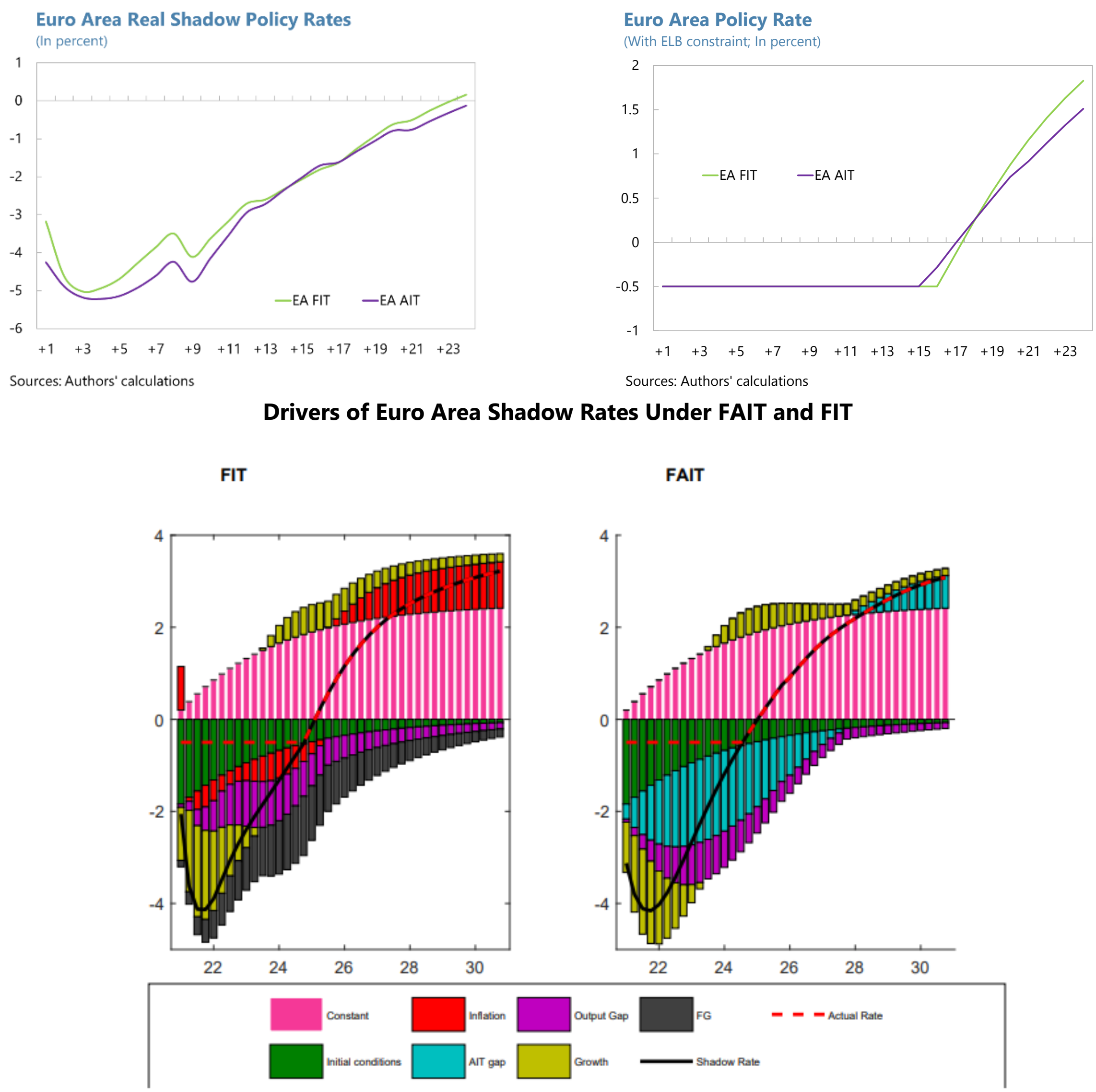
Note: The baseline scenario represents a no-shock, perfect foresight path while the median path is based on the simulated distribution. The two charts below show the difference between the median outcomes and the baseline.



If the euro area were to have also adopted an FAIT regime with similar parameterization to that of the U.S., output and inflation in the euro area would have received a further boost. A shift to from an FIT to an AIT regime in the euro area puts downward pressure on the shadow rate in the near term given the starting point of large negative AIT gap of -0.8 percent (reflecting the euro area's inability to get inflation back to 2 percent during the pre-pandemic period). The FAIT approach would boost inflation and inflation expectations, thereby reducing the real rate path and bringing forward the liftoff of the nominal policy rate from the current rate (Figure 8). This would further boost quarterly output and inflation by a peak of 1.7 percent and 0.35 percentage points over the medium term beyond that already achieved by switching to FIT from the "below, but close to" targeting approach. Relative to the output gains of a fully credible shift to a Fed FAIT regime shown in Figure 5, Figure 8 shows similar effects for euro area output when monetary is constrained by the ELB. This finding reflects two opposite forces. On the one hand, the euro area has a more negative initial AIT gap than the U.S. (around -0.8 vs. --0.5 percent) and should hence in principle benefit more from a shift in regime. On the other hand, the ECB has less scope to maneuver with the policy rate which limits the gains. In a hypothetical case when the ELB is not binding, the larger negative euro area AIT gap results in a larger initial boost to output relative to the case with unconstrained U.S. monetary policy in Figure 5 (peak effect 2.5 percent in euro area versus 2 percent in the U.S.). The more accommodative euro area policy under FAIT weakens the euro relative to the U.S. dollar, but the net spillovers to U.S. output and inflation remain positive, although relatively small (Figure 9).

Figure 8. The Potential Impact of FAIT in the Euro Area

(Deviations from baseline FIT regime, percentage points)



NB: 'FG' denotes forward guidance.

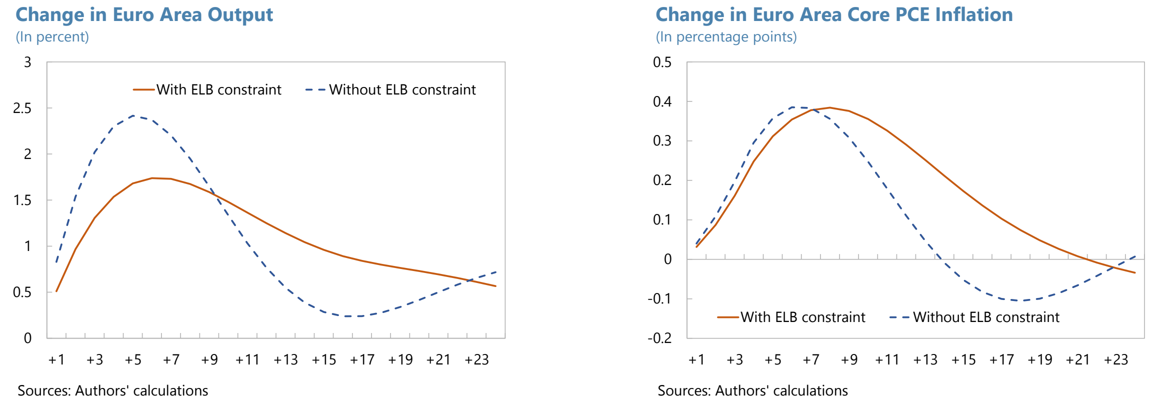
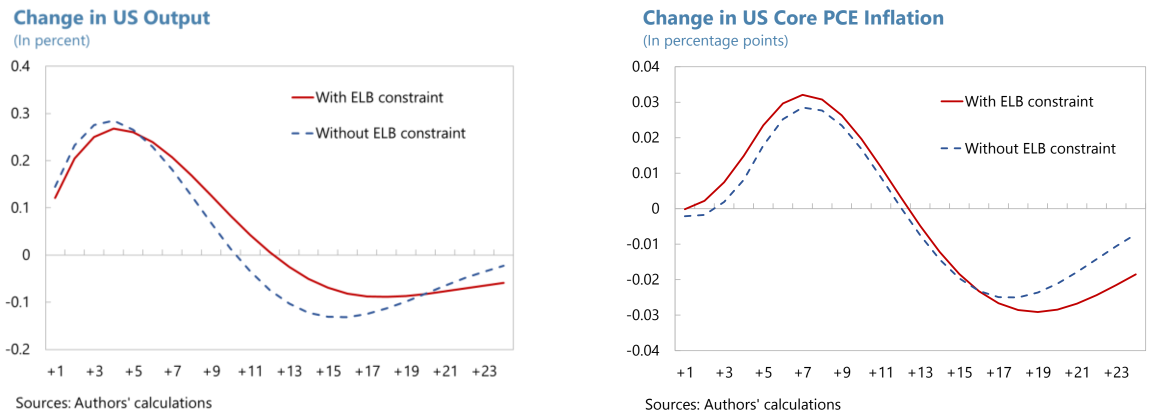


Figure 9. Spillovers of Euro Area FAIT to the U.S.



U.S. Fiscal Packages

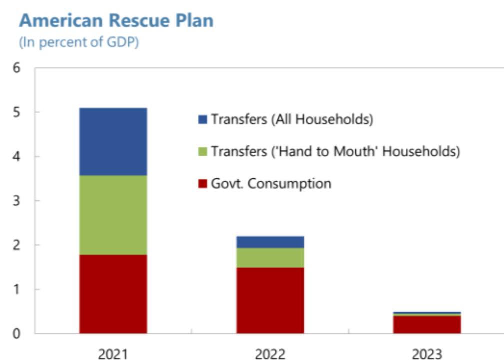
The U.S. Congress advanced major fiscal packages in 2021, both as pandemic-related relief and to address structural challenges facing the U.S. economy:

Pandemic relief. The U.S. Congress approved a US$1.9 trillion bill (around 8½ percent of GDP) in March 2021, implementing a version of the Biden Administration’s ARP. It consisted mainly of transfers to households, in the form of stimulus checks (2 percent of GDP), expanded unemployment benefits (1.5 percent of GDP), expansions of the Child Tax Credit and Earned Income Tax Credit (0.5 percent of GDP), as well as government consumption by funding health expenditure and the expenditure of state and local governments (over 1.5 percent of GDP). The bill followed significant pandemic-related fiscal spending in 2020, including the US$2.2 trillion CARES Act (around 10 percent of GDP, March 2020) and the US$900 billion Appropriations Bill (around 4 percent of GDP, December 2020).

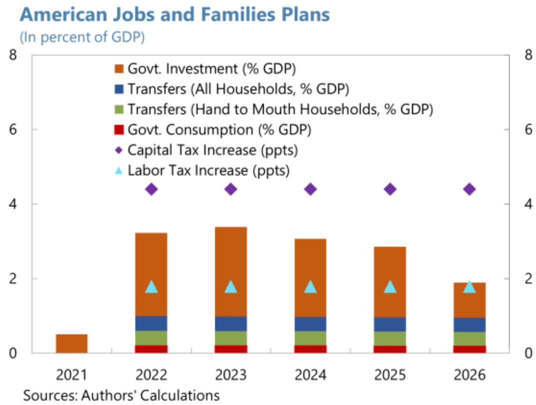
Public investment and structural reforms. The U.S. Congress approved a BIF (US$1.2 trillion, formally known as the Infrastructure Investment and Jobs Act) in November 2021, that includes around US$600 billion in newly planned public investment in transportation, broadband and water infrastructure, together with funding for maintenance and strengthening environmental resilience. The U.S. House of Representatives also approved a US$1.75 trillion (8 percent of GDP) Build Back Better (BBB) Act in November 2021 that would fund social spending and climate change initiatives over a horizon of up to ten years, depending on the spending item. This version of the BBB Act includes significant transfers to households, including extending the Child Tax Credit, Earned Income Tax Credit and Health Insurance Tax Credits for a fixed number of years (1.5 percent of 2021 GDP), while funding a paid family leave scheme (0.9 percent of 2021 GDP). There is also proposed government consumption in the form of funding for universal pre-school (0.5 percent of 2021 GDP), childcare (1.2 percent of GDP) and home care for the elderly and disabled (0.6 percent of 2021 GDP). The largest component of this BBB Act is designed to combat climate change, providing tax incentives for clean energy, while investing in clean technology and climate resilience (2.4 percent of 2021 GDP). Ultimately, though, the BBB failed to garner congressional support and its prospects remain uncertain, although a smaller package focused on climate change, as well as initiatives related to the cost of drug pricing and health care – known as the Inflation Reduction Act - was approved by Congress in August 2022. The combined size of the BIF and the House of Representatives version of the BBB Act is significantly smaller than the Biden Administration's preferred proposals, in the American Jobs, Families and Tax Plans (AJP and AFP), with the amount of spending reduced during Congressional negotiations. The tax measures and other savings that will partly offset the cost of the BIF (and BBB Act, if passed) are also more modest than the significant increases to the effective rates of corporate and personal income tax that the Biden Administration proposed along with the AJP and AFP.

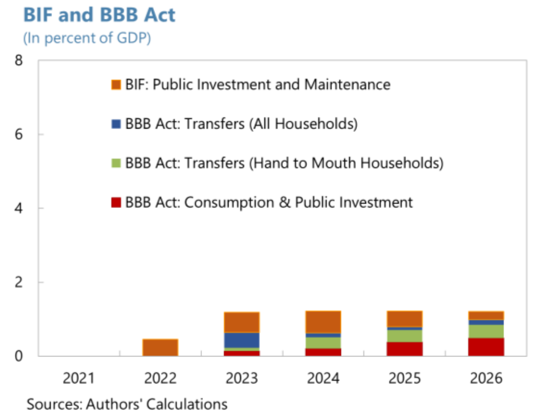
The impact of the U.S. fiscal packages is simulated in the model using its rich array of fiscal instruments. Figure 10 shows how the different components of the 2021 U.S. packages are treated in the model. The ARP has the largest component of 'targeted transfers', which are received by 'hand to mouth' households in the model and spent contemporaneously. The ARP also has a significant component of government consumption. The BIF is treated as public investment, modeled as government consumption that boosts productivity, as discussed in Section II. The BBB Act passed by the House of Representatives is split between targeted transfers and 'general transfers' which are lump sum transfers received by both 'hand to mouth' and forward-looking households. The assumed schedule for implementation of the BBB Act is lagged by one year, relative to what is assumed in the version passed by the House of Representatives, since the delay in securing Senate approval of the BBB Act makes the original schedule no longer feasible. The tax measures in the BIF (and House of Representatives version of the BBB Act) are far more modest than in the AJP and AFP and it is unclear to what extent they will raise average corporate and personal income tax rates. As a result, no increases to tax rates are included in model simulations of the BIF and BBB Act.

Figure 10. U.S. Fiscal Packages



Sources: Authors' Calculations

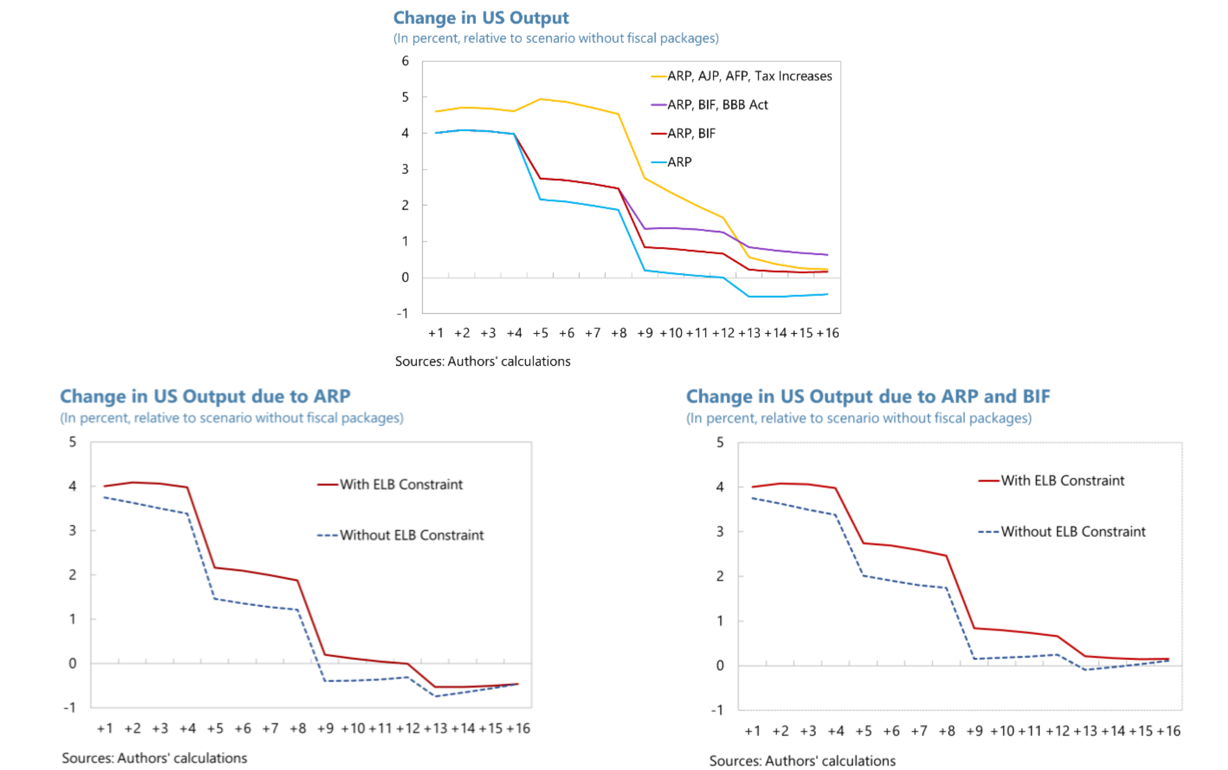




The model implies significant effects of the 2021 U.S. fiscal packages on output. The impact on output of the ARP is larger and more frontloaded than the BIF, with quarterly output boosted by up to 4 percent over the medium term (Figure 11).[14] This reflects the ARP's larger size, more frontloaded phasing and composition, with a significant share of the ARP comprising- transfers to 'hand to mouth' consumers (Figure 10). The implied cumulative fiscal multiplier from the ARP is 0.8 after both one year and three years. The BIF also has a sizable impact on quarterly output over the medium term, with a peak effect of an additional 0.75 percent. This is less than the Biden Administration's planned AJP and AFP, due to the smaller size of the packages negotiated in Congress. The implied cumulative fiscal multiplier from the BIF is 1.3 after three years, reflecting the longer horizon of spending and greater share of public investment in the package. If the BBB Act was passed by the Senate and implemented, this would boost quarterly output by a further 0.6 percent further out in the medium term, due to the impact of fiscal transfers, particularly to 'hand to mouth' consumers. The impact on output from the fiscal packages is larger than implied in a model without an ELB constraint, reflecting the added benefits of fiscal stimulus when monetary policy is constrained (Figure 11). The aforementioned fiscal multipliers are in line with multipliers above 1 estimated in the literature, especially when monetary policy is at the ELB. Relevant estimates include 1.6-2.8 (Amendola and others, 2019), 1.5 (Ramey and Zubairy 2018), 3.6-3.8 (Serio, Fragetta and Gasteiger, 2020), 1–2.7 with the median value of 1.8 (ECB Strategy Review 2021). Nevertheless, there exists uncertainty around the precise value of the multiplier and the composition of fiscal spending is likely to be important.

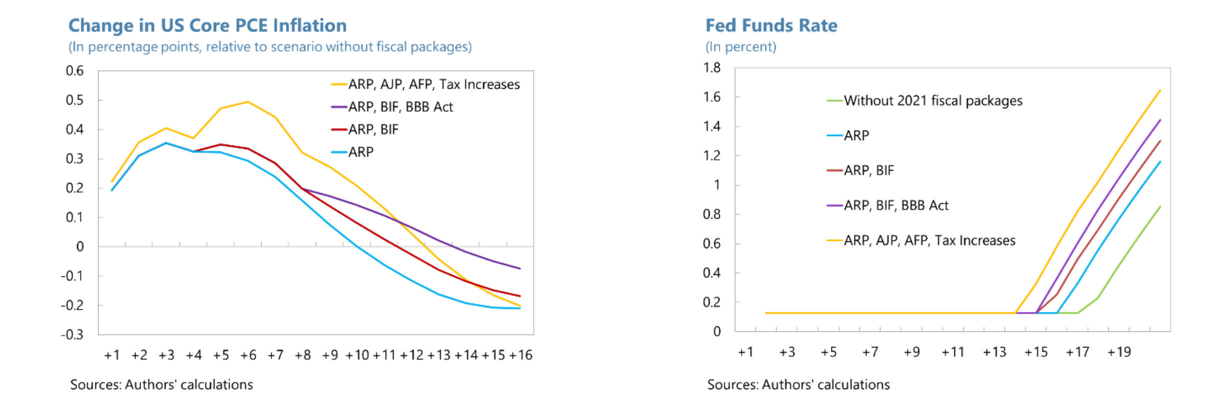
[14] In the first few periods of the simulations, the model is solved under the assumption that agents do not know the full size and duration of the ARP and BIF. As a result, forward looking agents gradually incorporate information about the fiscal stimulus into their expectations, making its impact less front-loaded.

Figure 11. Implications of U.S. Fiscal Packages on Output



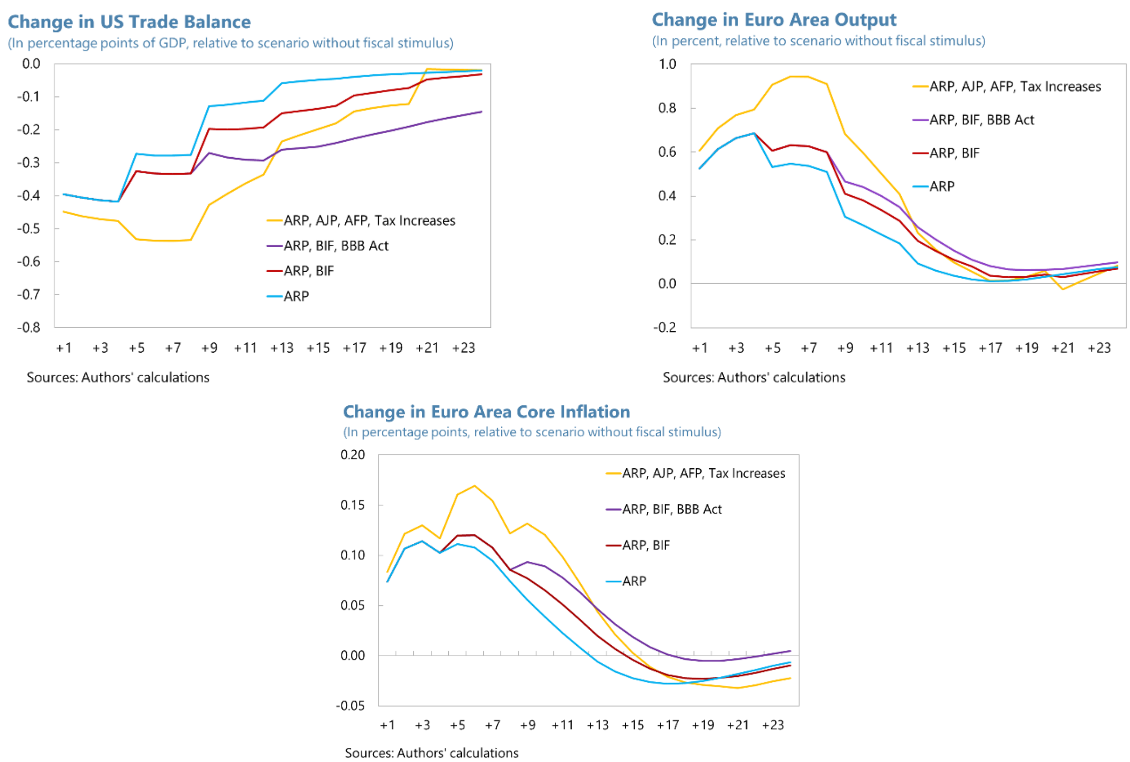
Implementing the U.S. fiscal packages leads to a more front-loaded policy rate path. The higher output, employment and inflation produced by the fiscal stimulus boost the shadow rate, according to the FAIT rule, making it less likely that the ELB will bind. The liftoff date for the FFR resulting from the additional demand support is brought forward by 2 quarters due to the ARP+BIF, with inflation higher by 0.35 percentage points in the near term relative to a scenario without any of the 2021 U.S. fiscal packages (Figure 12). The BBB Act would steepen the pace of monetary tightening and have a peak impact on inflation of around 0.1 percentage points, according to the model.

Figure 12. Implications of U.S. Fiscal Packages for Monetary Policy and Inflation



The fiscal packages that have been approved should deliver significant positive spillovers to the euro area through the trade channel. The demand impact of the fiscal packages that have already been legislated (i.e., ARP and BIF) implies tighter monetary policy and a stronger U.S. dollar. Euro area exports rise as the result of euro depreciation and stronger U.S. domestic demand, hence a deterioration in the bilateral U.S. trade balance with the euro area (Figure 13). Euro area GDP also expands thanks to higher net exports. The ELB plays a role in limiting the response of nominal interest rates, implying lower real interest rates and crowding in of consumption and investment because of the ELB. This has a peak impact on output and inflation in the euro area of 0.6 and 0.1 percentage points.

Figure 13. Spillovers from U.S. Fiscal Packages to the Euro Area



Fiscal Trajectory in the Euro Area

The introduction of the NGEU package has contributed significantly to the recovery, with the peak GDP impact expected in 2023-2024 but with a mild impact on inflation. Going forward, a slower pace of fiscal consolidation in the euro area than envisaged in the 2021 WEO would imply a faster and more complete recovery of output.

While the baseline calibration based on the early 2021 WEO projections had already included the introduction of the NGEU package, a counterfactual simulation shows that without the NGEU, quarterly output and inflation would have been around 0.5 and 0.05 percentage points lower in the first year of implementation. Because the NGEU largely focuses on long-term investment, which is assumed to boost productivity and long-term potential, the immediate impact on output and inflation is relatively mild (Figure 14). We assume that 77 percent of the €800 billion (or 6 percent of GDP) will lead to additional fiscal measures, 80 percent of which will be via public investment. By the third year of implementation, the impact of the NGEU on quarterly output rises to over one percentage point, with the impact on inflation reaching almost 0.15 percentage points. Due to the expected schedule of disbursements of NGEU and the phasing-in of public investments, the impact is expected to peak in 2023-2024. The implied cumulative fiscal multiplier from the implementation of this package over the first three years is 1.4, reflecting the large public investment component. The NGEU package also brings forward liftoff of the monetary policy rate by around one quarter, according to the model, all else equal.

Under the baseline calibration, if government spending (including both public consumption and investment) is higher by 1 percent of GDP each year for two years (quarters 4 through 12), the quarterly peak of the euro area output would be higher by 1.4 percent (Figure 14).[15] The implied cumulative multiplier over this two-year period is 1.3 in the model. The multiplier is similar to that found for the NGEU, which reflects that both scenarios involve a mix of government consumption and investment. However, the NGEU is slightly more investment-oriented. Besides the slower euro area consolidation, all other policy settings are as in the baseline calibration described in Section III (Figure 3). This way, the simulations provide a partial effect amid the information set available early 2021.

The impact on core inflation remains mild as supply capacity increases over time after the initial boost to aggregate demand. Once fiscal support is implemented, core inflation would pick up, peaking at 0.2 percentage points higher than the baseline projection. This result is similar to simulations from the euro area New Area-Wide model in which a fiscal stimulus of 1 percent of steady state GDP could raise inflation by 0.1 percentage point at peak (Coenen, Montes-Galdon and Smets, 2021, Pfeiffer et al, 2021). This effect is equivalent to an increase in asset purchases by the ECB of 3 to 6 percent of GDP (Rostagno and others, 2021; Lhuissier and Nguyen 2021), demonstrating the relatively stronger effect of fiscal policy at the ELB. In the outer years, since the temporary demand boost would fade away but the increase in productivity is more persistent, the output gap would be less positive, reducing inflationary pressure.

Changing the composition of the additional spending to be half government spending and half untargeted transfers to all households lowers the implied fiscal multiplier from 1.3 to 0.6 and results in a smaller impact on quarterly output of up to 0.6 percent, and on core inflation by 0.1 percentage points (Figure 15).

The additional spending has a larger impact on output when monetary policy is constrained by the ELB than would otherwise be the case, as shown by comparing the impact on output from the model with and without a binding ELB constraint. The higher output and inflation coincide with an earlier liftoff of the ECB policy rate, by around two quarters in the case of higher investment (Figure 15).

Spillovers to the U.S. would be small. The fiscal stimulus from slower consolidation in the euro area would be too small to generate significant spillovers to the U.S. economy. The peak impact on U.S. output is around ¼ percent only. The impact on U.S. inflation is effectively zero. As the euro area is treated as one entity, the domestic impact of fiscal stimulus and spillovers to the U.S. do not account for the heterogeneity across member states. Presumably, more fiscal stimulus in countries with stronger ties to the U.S. could generate more spillovers.

[15] In the first few periods of the simulations, the model is solved under the assumption that agents do not know the full size and duration of the slower fiscal consolidation. As a result, forward looking agents gradually incorporate information about the fiscal stimulus into their expectations, making its impact less front-loaded.

Figure 14. NGEU and Higher Government Investment in the Euro Area

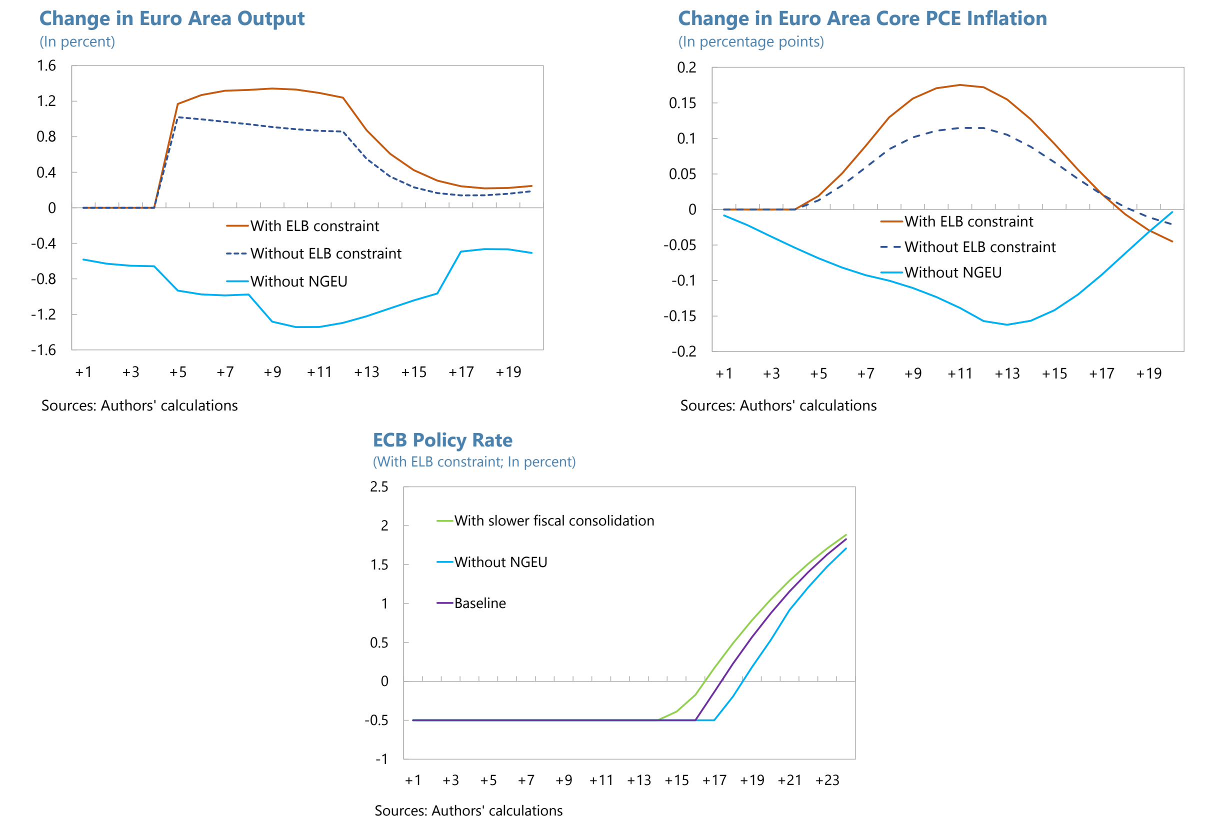
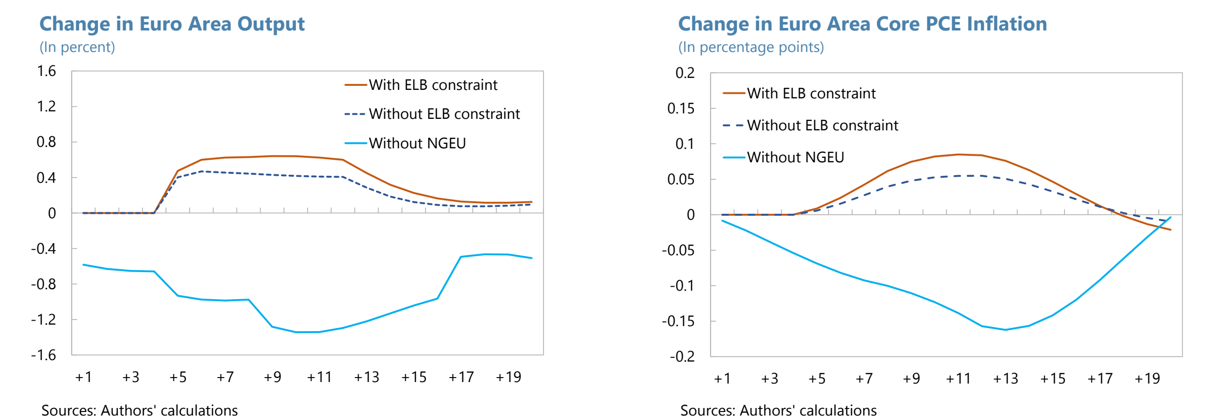


Figure 15. Higher Government Investment and Transfers in the Euro Area



Synchronized Fiscal Policy Changes in the U.S. and Euro Area

Government investment in both the U.S. and euro area can be mutually reinforcing, boosting output and inflation when monetary policy is constrained at the ELB. This scenario combines the U.S. ARP and

BIF with the slower pace of consolidation in the euro area described above, where euro area government spending is higher than under the baseline calibration by 1 percent of GDP per year for two years (quarters 4 through 12). The impact on U.S. and euro area output and inflation of these combined policies is larger than implied by the individual impacts of these policies when simulated separately, as discussed earlier in this paper, particularly in the euro area.

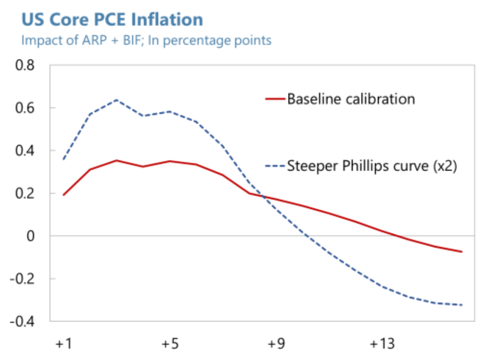
Box 1. The Slope of the New Keynesian Phillips Curve

Altering the calibrated slope of the New Keynesian Phillips Curves in the model is found to change modestly the impact of government spending on core inflation, while the impact of introducing new monetary regimes changes more substantially. This is illustrated by modifying the baseline calibration, so that the coefficients on current marginal costs and labor wedges in the model's New Keynesian price and wage Phillips curves are calibrated to be twice as steep. This change is informed by estimating the benchmark Smets and Wouters (2007) model for the pre-COVID period (1985Q1–2019Q4) and an extended sample including the COVID pandemic episode (1985Q1-2021Q4). The estimated slope (i.e. coefficient on current marginal cost) in the price Phillips curve over the full sample is nearly double that estimated using only the pre-COVID sample. There is also some evidence in the literature of non-linear Phillips Curves that steepen when inflation is higher (see Forbes, Collins and Gagnon, 2021; Linde and Trabandt, 2019).

The combined impact of the ARP and BIF on quarterly U.S. core inflation would be around 0.2-0.3 percentage points higher in the near term because of the steeper Phillips Curve. The impact of slower fiscal consolidation in the euro area (with government consumption higher by one percentage point per year for two years) would change by a similar amount. The peak impact of introducing FAIT on core inflation would be around 1-1.1 percentage points higher in the near term under the steeper Phillips Curve, in both the U.S. and the euro area.

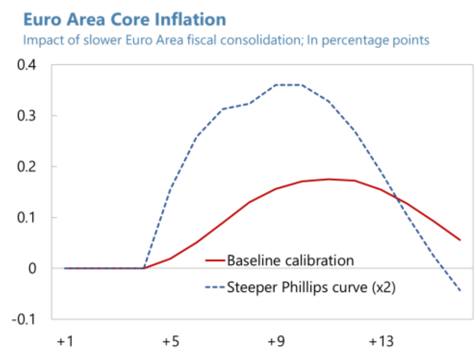
Inflationary Impact of Fiscal Spending

U.S.



Sources: Authors' calculations

Euro Area



Sources: Authors' calculations

Box 1. The Slope of the New Keynesian Phillips Curve (concluded)

Inflationary Impact of New Monetary Regimes

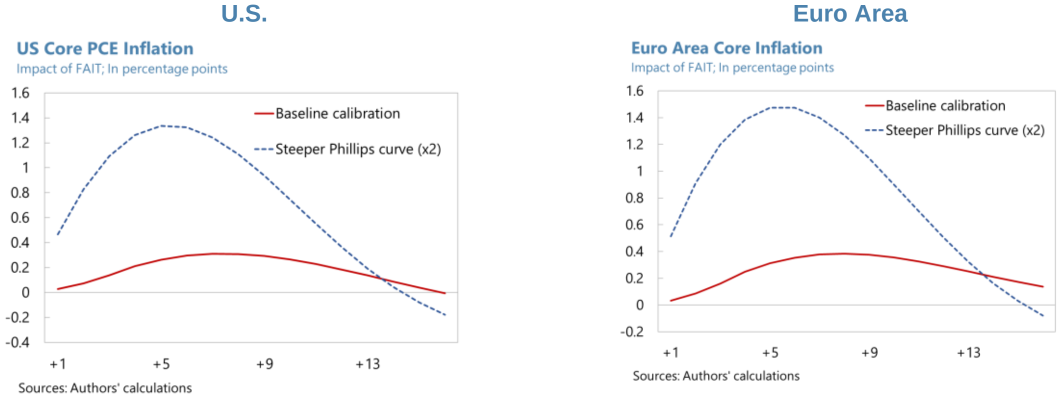
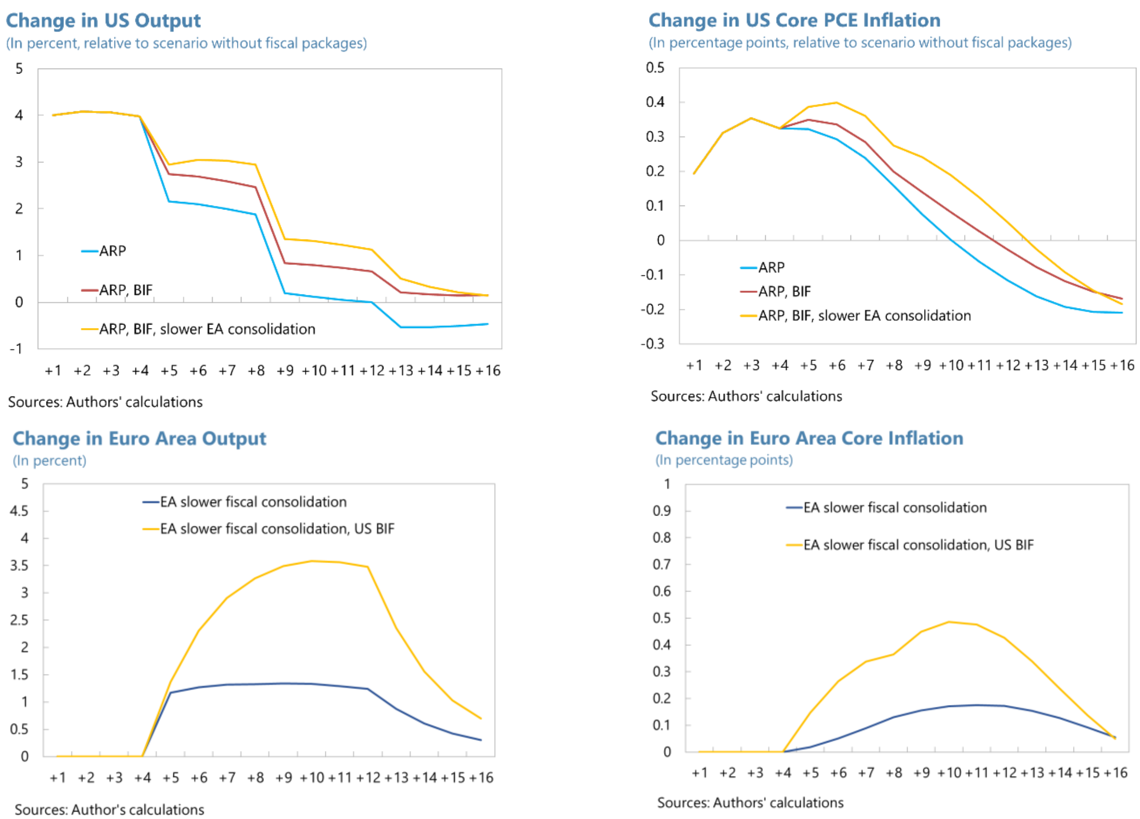


Figure 16. U.S. BIF and Higher Government Investment in the Euro Area



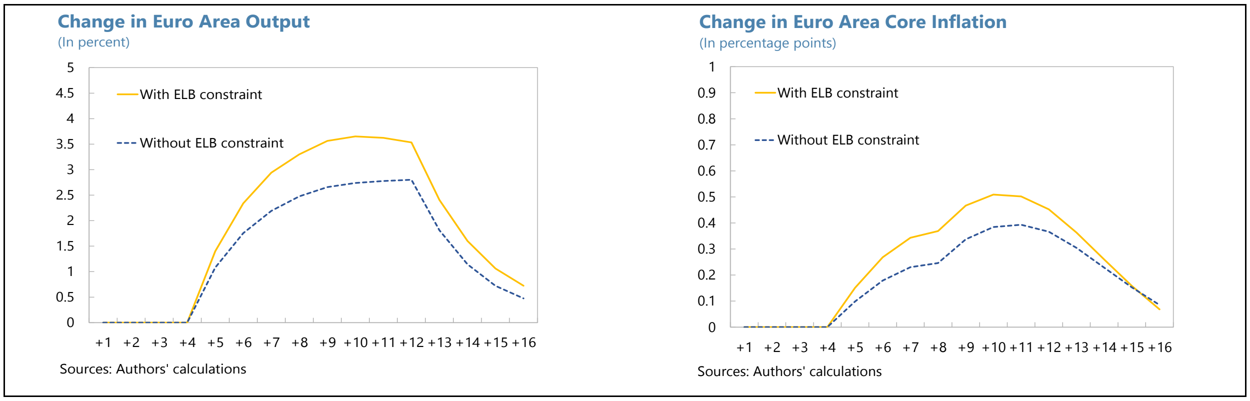
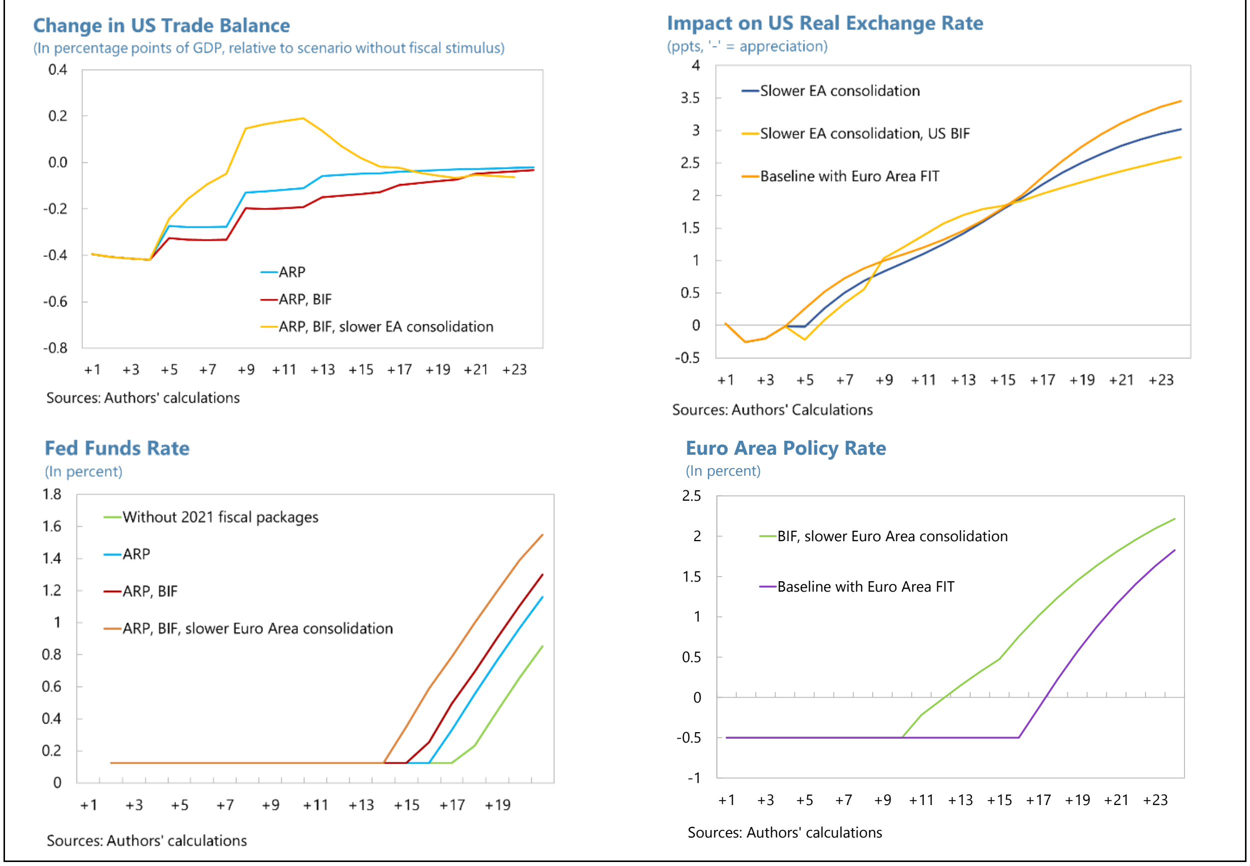


Figure 17. Spillovers and Implications for Monetary Policy of Combined Fiscal Action

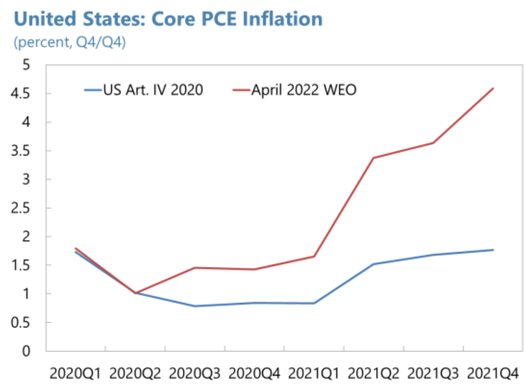


Adding the U.S. fiscal packages to a simulation with slower euro area consolidation boosts euro area output significantly. Quarterly output in the euro area is higher by up to 3.5 percent over the medium term, while core inflation is higher by 0.5 percentage points, larger than what would be implied by simulating higher euro area investment and the spillovers from U.S. investment independently (Figure 16). Fiscal stimulus has an added impact because monetary policy is constrained by the ELB, as shown by comparing the model results with and without a binding ELB constraint. The bilateral U.S. trade balance increases significantly, despite a somewhat stronger U.S. dollar (Figure 17). The net effect of these policies brings forward liftoff from the ELB in both the U.S. and euro area by around a year, relative to a scenario without these fiscal policies, reflecting the expansionary impact of the looser fiscal stance and its impact in the U.S. FAIT and euro area FIT shadow rate rules.

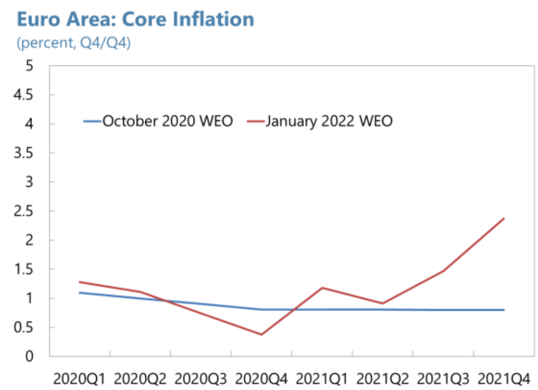
Contribution of Fiscal and Monetary Policies to Recent Inflation

Inflation increased by significantly more than forecast in both the U.S. and euro area during 2021, amid recovery from the pandemic. Figure 18 compares the IMF staff forecasts made during 2020 with actual outturns during 2021. For the U.S., IMF staff forecasts from 2020 are those from 2020 Article IV Consultation Staff Report, released before the adoption of FAIT, while for the euro area the forecasts are from the October 2020 WEO. Earlier in 2021, the pick-up in core inflation appeared relatively narrow and linked to a subset of items affected by pandemic-related supply constraints (e.g., autos in the U.S.), but it became more broad-based in late 2021 as supply-demand imbalances persisted and labor markets tightened. Core inflation in the euro area increased more than expected mainly due to more persistent supply-demand mismatches and indirect effects from higher energy prices. The economic recovery in the U.S. has been relatively rapid and IMF staff assess that output had returned to the pre-pandemic trend by late-2021. The recovery in the euro area was somewhat less robust, with output remaining below the pre-pandemic at end-2021 (although having surpassed its pre-pandemic level). However, labor market conditions improved significantly, with labor force participation and employment rates exceeding pre-pandemic levels.

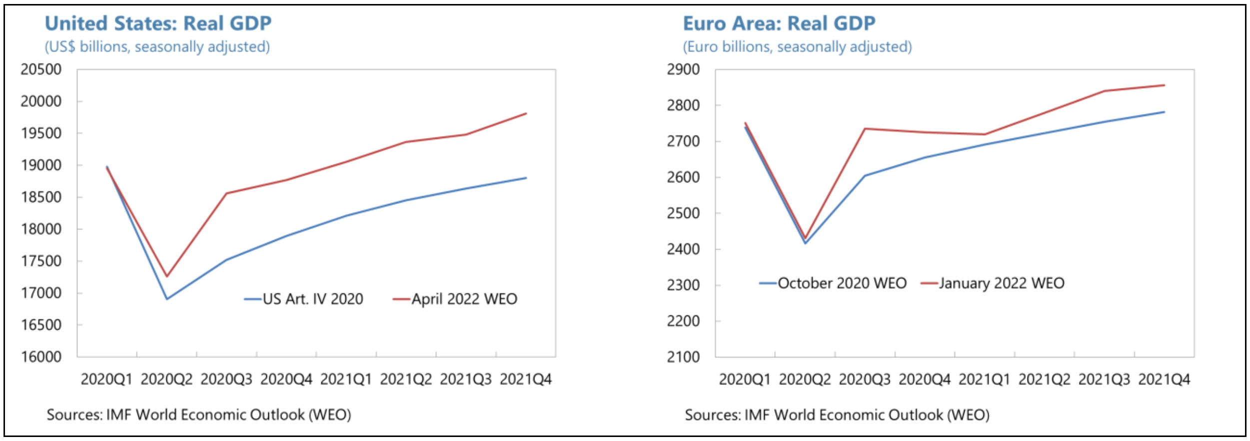
Figure 18. Macroeconomic Developments in 2021



Sources: IMF World Economic Outlook (WEO)



Sources: IMF World Economic Outlook (WEO)



Our simulations indicate that fiscal stimulus and new monetary regimes implemented in 2021, but not included in IMF staff's 2020 forecasts, can explain a sizeable share, but not all, of the higher inflation in 2021. Figure 19 shows the actual path of core inflation in the U.S. and euro area (dashed blue line) and compares it with model-based projections. Under the baseline calibration, we start with the scenario without fiscal stimulus and the new monetary regimes: i.e., without the ARP and BIF in the U.S., and with the Fed pursuing FIT and the ECB hypothetically pursuing a stylized asymmetric inflation target. The mean of this forecast (solid blue line) is normalized to match the IMF staff projections in the October 2020 WEO, with the model-implied uncertainty surrounding these forecasts shown in lighter shades of blue. Adding to this projection is the median simulated result (yellow line), when FAIT has been implemented in the U.S. and the euro area officially adopted a symmetric inflation target. The projection also assumes the implementation of the ARP and BIF in the U.S. These simulations indicate that the combination of fiscal stimulus packages and the introduction of the two new monetary regimes can explain around 30 percent of the unexpected inflation in the U.S. during 2021 and around 24 percent in the euro area. The second row of figure 19 shows an alternative scenario in which the slopes of the price and wage Phillips curves in the model are calibrated to be twice as steep, motivated by estimating the Smets and Wouters (2007) workhorse model including the post-COVID sample period. Including data for the post-COVID period, the estimated SW model implies that the Phillips curve slope has doubled (see Box 1 for further details), which in levels implies an estimated slope in line with pre-global financial crisis experience.[16]

The alternative calibration with higher sensitivity of price and wage inflation magnifies the policy impact on aggregate demand and inflation, and the monetary and fiscal stimulus in this case account for 70 percent of the surprise in inflation. So even with a notably higher sloped Phillips curve informed on data including the surge in inflation, the model still indicates that the combined impact from all policy measures is insufficient to explain the large and unexpected pick-up in 2021 core inflation.

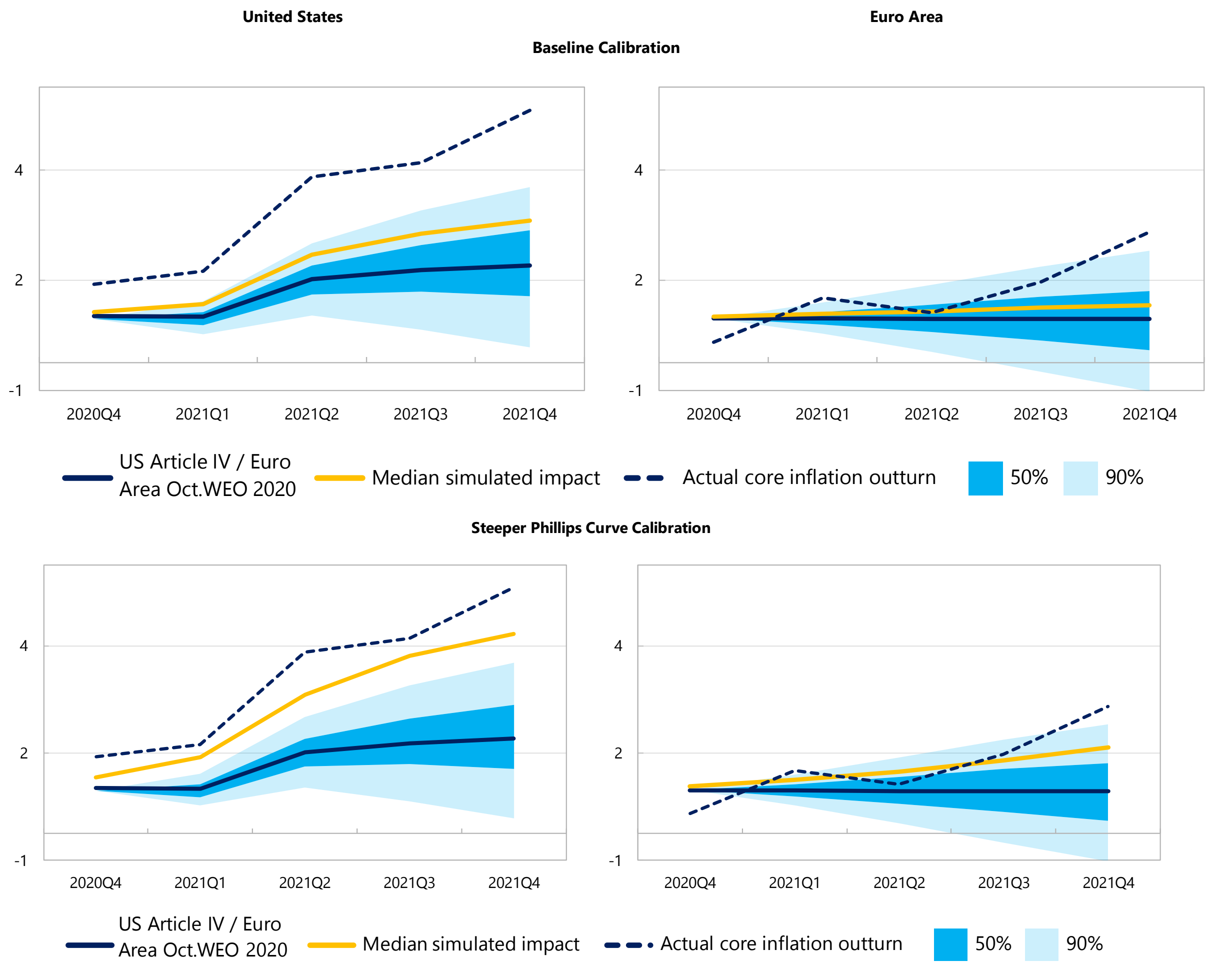
The fiscal stimulus likely had a greater impact on inflation than the change in monetary regimes (see Figure 20). The model simulations indicate that the introduction of FAIT in the U.S. and symmetric FIT in the euro area can explain around 0.2 percentage points on average of the difference between U.S. core inflation and the October 2020 WEO. For the euro area, the amount of unexpected core inflation in 2021 explained by

[16] To be concrete, the estimated slope of the domestic price Phillips curve in our baseline calibration equals 0.007, which is lower than estimates in prominent studies using pre-GFC data, for instance the seminal paper by Gali and Gertler (1999) which reports a slope of around 0.012. Our alternative calibration which features a slope of 0.014 is hence closer to pre-crisis estimates.

the new monetary regimes is small, at less than 0.02 percentage points. These amounts are modest, given that the October 2020 WEO projections may have already considered the introduction of FAIT in the U.S. to some extent. Meanwhile, the U.S. fiscal stimulus can explain around 0.5 percentage points of the average unexpected core inflation in 2021 and 0.8 percentage points of the difference at the end of the year. The relative importance of fiscal stimulus reflects its size and composition, including the significant share of transfers to 'hand to mouth' consumers in the U.S. ARP disbursed in 2021 (see Section VI, Figure 10).

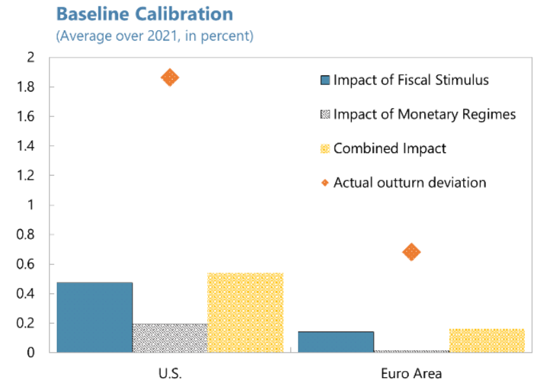
Figure 19. Contribution of Policies to Inflation in 2021

(Percentage points)



Sources: Authors' Calculations.

Figure 20. Contribution of Policies to Inflation in 2021: Decomposition



Sources: Authors' Calculations; and Haver Analytics.

Conclusion

The model-based analysis indicates that the adoption of FAIT boosted output and inflation in the U.S. and had the potential to do so in and euro area, strengthening the effectiveness of monetary policy and creating positive international spillovers. Comparing results when the ELB constraint is binding illustrates that the adoption of FAIT can have an important impact when monetary policy is constrained by the ELB. FAIT creates an upward move in near-term inflation expectations which boosts demand (by lowering the ex-ante real interest rate) and helps get the economy more quickly back to full employment and 2 percent inflation. This has positive international spillovers via the trade channel. Formalizing a symmetric inflation target in the euro area instead of the previous "below, but close to, 2 percent" language, but not going all the way to adoption of FAIT, results in more limited gains in terms of employment and inflation outcomes as compared to an FAIT regime.

The significant fiscal support implemented during 2021 in the U.S. and euro area has also had a significant macroeconomic impact and was mutually reinforcing, particularly in an FAIT environment. The cumulative fiscal multipliers implied by the model from implementing the ARP, BIF and NGEU programs and having a slower pace of euro area fiscal consolidation are above one and the impact of the fiscal support is larger for as long as the ELB is binding. The impact on core inflation in each region of these fiscal support programs implied by the model is modest (consistent with the empirical findings of a relatively flat trade-off between slack and wages or prices). Synchronized fiscal stimulus in both the U.S. and euro area can create positive spillovers to output in each region, via the trade channel, without exacerbating trade imbalances and result in a larger multiplier for both fiscal packages. The greater accommodation provided by an FAIT framework in the U.S. can help maximize these spillover effects.

The model indicates that the introduction of new monetary regimes and fiscal stimulus in 2021 that was not assumed in IMF staff 2020 forecasts cannot fully explain the unexpected rise in inflation during 2021. The combined impact of these policies can explain less than one third of the unexpected inflation in the U.S., according to the model, and a smaller amount in the euro area, with fiscal stimulus contributing significantly more to inflation than the new monetary regimes. The amount of explained inflation increases to 70 percent if the Phillips curve in the model is steeper, but the analysis suggests that other factors must play a substantial role. While not an exhaustive list, these factors may include supply-demand imbalances not captured by the model, including those associated with a shift in the composition of consumption towards goods during the pandemic, which strained supply chains.

Appendix I. Technical Appendix: The Open Economy New Keynesian Model

The open economy model closely follows the Erceg and Lindé (2013) variant of the Erceg, Guerrieri and Gust (2006) SIGMA model. The main difference with respect to Erceg and Lindé is that we allow for discounting in the pricing bloc to address the forward-guidance puzzle (see Del Negro, Giannoni and Patterson, 2015) by making inflation and inflation expectations less sensitive to macroeconomic news, including fiscal policy changes, in prolonged liquidity traps).

The model consists of two countries (or regions), the U.S. and euro area, that are treated as equally sized, and allows for endogenous investment, hand-to-mouth (HM) or Keynesian households, sticky wages as well as sticky prices, trade adjustment costs, and incomplete financial markets across the two countries. Given the isomorphic structure of the two economies in the model, our exposition below largely focuses on the structure of one of the two countries (or regions).

The model also features a financial accelerator channel which closely parallels earlier work by Bernanke, Gertler, and Gilchrist (1999) and Christiano, Motto, and Rostagno (2008). Given that the mechanics underlying this particular financial accelerator mechanism are well-understood, we simplify our exposition in this Appendix by focusing on a special case of our model which abstracts from the financial accelerator. However, we conclude our model description with a brief description of how the model is modified to include the financial accelerator (Section A.6).

A.1. Firms and Price Setting

A.1.1. Production of Domestic Intermediate Goods

There is a continuum of differentiated intermediate goods (indexed by $i \in [0,1]$) in each economy, each of which is produced by a single monopolistically competitive firm. In the domestic market, firm i faces a demand function that varies inversely with its output price $P_{Dt}(i)$ and directly with aggregate demand at home Y_{Dt}:

$$Y_{Dt}(i) = \left[\frac{P_{Dt}(i)}{P_{Dt}}\right]^{\frac{-(1+\theta_p)}{\theta_p}} Y_{Dt}, \tag{A.1}$$

where $\theta_p > 0$, and P_{Dt} is an aggregate price index defined below. Similarly, firm i faces the following export demand function:

$$X_t(i) = \left[\frac{P^*_{Mt}(i)}{P^*_{Mt}}\right]^{\frac{-(1+\theta_p)}{\theta_p}} M^*_t, \tag{A.2}$$

where $X_t(i)$ denotes the quantity demanded of domestic good i in the foreign economy, $P^*_{Mt}(i)$ denotes the price that firm i sets in the foreign market, P^*_{Mt} is the import price index abroad, and M^*_t is an aggregate of the economy's imports (we use an asterisk to denote the foreign country's variables).

Each producer utilizes capital services $K_t(i)$ and a labor index $L_t(i)$ (defined below) to produce its respective output good. The production function is assumed to have a constant-elasticity of substitution (CES) form:

$$Y_t(i) = \left[\omega_K^{\frac{\rho}{1+\rho}} K_t(i)^{\frac{1}{1+\rho}} + \omega_L^{\frac{\rho}{1+\rho}} \left(Z_t L_t(i)\right)^{\frac{1}{1+\rho}}\right]^{1+\rho}. \quad \text{(A.3)}$$

The production function exhibits constant-returns-to-scale in both inputs, and Z_t is a country specific shock to the level of technology. Firms face perfectly competitive factor markets for hiring capital and labor. Thus, each firm chooses $K_t(i)$ and $L_t(i)$, taking as given both the rental price of capital R_{Kt} and the aggregate wage index W_t (defined below). Firms can costlessly adjust either factor of production, which implies that each firm has an identical marginal cost per unit of output, MC_t. The (log-linearized) technology shock is assumed to follow a stationary AR(2) process:

$$\Delta z_t = \rho_{z,1}\Delta z_{t-1} - \rho_{z,2} z_{t-1} + \epsilon_{z,t}. \quad \text{(A.4)}$$

The prices of the intermediate goods are determined by Calvo-style staggered contracts (see Calvo, 1983). In each period, a firm selling its goods in the domestic market faces a constant probability, $1-\xi_t$, of being able to re-optimize its price $\left(P_{Dt}(i)\right)$. This probability of receiving a signal to reoptimize is independent across firms and time. If a firm is not allowed to optimize its prices, we follow Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003), and assume that the firm must reset its domestic price as a weighted combination of the lagged and steady state rate of inflation $P_{Dt}(i) = \pi_{t-1}^{\iota_p} \pi^{\iota_p} P_{Dt-1}(i)$ for the non-optimizing firms. This formulation allows for structural persistence in price-setting if ι_p exceeds zero.

When a firm i is allowed to reoptimize its price in period t, the firm maximizes:

$$\max_{P_{Dt}(i)} \mathrm{E}_t \sum_{j=0}^{\infty} \psi_{t,t+j} \xi_p^j \left[\prod_{h=1}^{j} \pi_{t+h-1} \left(P_{Dt}(i) - MC_{t+j}\right) Y_{Dt+j}(i)\right]. \quad \text{(A.5)}$$

The operator E_t represents the conditional expectation based on the information available to agents at period t. The firm discounts profits received at date $t+j$ by the state-contingent discount factor $\psi_{t,t+j}$; for notational simplicity, we have suppressed all of the state indices.[17] The first-order condition for setting the contract price of good i is:

$$\mathrm{E}_t \sum_{j=0}^{\infty} \psi_{t,t+j} \xi_p^j \left[\frac{\prod_{h=1}^{j} \pi_{t+h-1}(i) P_{Dt}(i)}{(1+\theta_p)} - MC_{t+j}\right] Y_{Dt+j}(i) = 0. \quad \text{(A.6)}$$

For the goods sold abroad, we assume local currency pricing (LCP). Although the price-setting problem for the exporting firms is isomorphic to the problem for the firms selling goods on the domestic market, the LCP

[17] We denote $\xi_{t,t+j}$ to be the price in period t of a claim that pays one dollar if the specified state occurs in period $t+j$ (see the household problem below); then the corresponding element of $\psi_{t,t+j}$ equals $\xi_{t,t+j}$ divided by the probability that the specified state will occur.

assumption implies that the price of foreign import goods $P^*_{M,t}$ will deviate from the producer currency price as follows (in log-linear form)

$$\delta^*_t = -p^*_{M,t} - s_t + p_{X,t}, \tag{A.7}$$

where $p_{X,t} = p_{D,t}$. The deviations from the law of one price are due to price stickiness for the exported goods.

A.1.2. Production of the Domestic Output Index

Because households have identical Dixit-Stiglitz preferences, it is convenient to assume that a representative aggregator combines the differentiated intermediate products into a composite home-produced good Y_{Dt}:

$$Y_{Dt} = \left[\int_0^1 Y_{Dt}\,(i)^{\frac{1}{1+\theta_p}} di\right]^{1+\theta_p}. \tag{A.8}$$

The aggregator chooses the bundle of goods that minimizes the cost of producing Y_{Dt}, taking the price $P_{Dt}(i)$ of each intermediate good $Y_{Dt}(i)$ as given. The aggregator sells units of each sectoral output index at its unit cost P_{Dt}:

$$P_{Dt} = \left[\int_0^1 P_{Dt}\,(i)^{\frac{-1}{\theta_p}} di\right]^{-\theta_p}. \tag{A.9}$$

We also assume a representative aggregator in the foreign block who combines the differentiated domestic products $X_t(i)$ into a single index for foreign imports:

$$M^*_t = \left[\int_0^1 X_t\,(i)^{\frac{1}{1+\theta_p}} di\right]^{1+\theta_p}, \tag{A.10}$$

and sells M^*_t at price $P^*_{M,t}$:

$$P^*_{Mt} = \left[\int_0^1 P^*_{Mt}\,(i)^{\frac{-1}{\theta_p}} di\right]^{-\theta_p}. \tag{A.11}$$

A.1.3. Production of Consumption and Investment Goods

Final consumption goods are produced by a representative consumption goods distributor. This firm combines purchases of domestically-produced goods with imported goods to produce a final consumption good (C_{At}) according to a constant-returns-to-scale CES production function:

$$C_{At} = \left({\omega_C}^{\frac{\rho_C}{1+\rho_C}} {C_{Dt}}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} (\varphi_{Ct} M_{Ct})^{\frac{1}{1+\rho_C}}\right)^{1+\rho_C}. \tag{A.12}$$

where C_{Dt} denotes the consumption good distributor's demand for the index of domestically produced goods, M_{Ct} denotes the distributor's demand for the index of foreign-produced goods, and φ_{Ct} reflects costs of adjusting consumption imports. The final consumption good is used by both households and by the government.[18] The form of the production function mirrors the preferences of households and the government sector over consumption of domestically-produced goods and imports. Accordingly, the quasi-share parameter

[18] Thus, the larger-scale model constrains the import share of government consumption to equal that of private consumption.

ω_C may be interpreted as determining the preferences of both the private and public sector for domestic relative to foreign consumption goods, or equivalently, the degree of home bias in consumption expenditure. Finally, the adjustment cost term φ_{Ct} is assumed to take the quadratic form:

$$\varphi_{Ct} = \left[1 - \frac{\varphi_{M_C}}{2}\left(\frac{\frac{M_{Ct}}{C_{Dt}}}{\frac{M_{Ct-1}^{agg}}{C_{Dt-1}^{agg}}} - 1\right)^2\right]. \tag{A.13}$$

This specification implies that it is costly to change the proportion of domestic and foreign goods in the aggregate consumption bundle, even though the level of imports may jump costlessly in response to changes in overall consumption demand. We assume that the adjustment costs for each distributor depend on distributors' current import ratio $\frac{M_{Ct}}{C_{Dt}}$ relative to the economy-wide ratio in the previous period $\frac{M_{Ct-1}^{agg}}{C_{Dt-1}^{agg}}$ so that adjustment costs are external to individual distributors.

Given the presence of adjustment costs, the representative consumption goods distributor chooses (a contingency plan for) C_{Dt} and M_{Ct} to minimize its discounted expected costs of producing the aggregate consumption good:

$$\min_{C_{Dt+k}, M_{Ct+k},} \mathbb{E}_t \sum_{k=0}^{\infty} \psi_{t,t+k}(P_{Dt+k}C_{Dt+k} + P_{Mt+k}M_{Ct+k}) + P_{Ct+k}\Bigg[C_{A,t+k} - \left(\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt+k}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}}(\varphi_{Ct+k}M_{Ct+k})^{\frac{1}{1+\rho_C}}\right)^{1+\rho_C}\Bigg] \tag{A.14}$$

The distributor sells the final consumption good to households and the government at a price P_{Ct}, which may be interpreted as the consumption price index (or equivalently, as the shadow cost of producing an additional unit of the consumption good).

We model the production of final investment goods in an analogous manner, although we allow the weight ω_I in the investment index to differ from that of the weight ω_C in the consumption goods index.[19]

A.2. Households and Wage Setting

We assume a continuum of monopolistically competitive households (indexed on the unit interval), each of which supplies a differentiated labor service to the intermediate goods producing sector (the only producers demanding labor services in our framework) following Erceg, Henderson and Levin (2000). A representative labor aggregator (or employment agency) combines households labor hours in the same proportions as firms would choose. Thus, the aggregator's demand for each household's labor is equal to the sum of firms' demands. The aggregate labor index L_t has the Dixit-Stiglitz form:

$$L_t = \left[\int_0^1 \left(\zeta N_t(h)\right)^{\frac{1}{1+\theta_w}} dh\right]^{1+\theta_w} \tag{A.15}$$

where $\theta_w > 0$ and $N_t(h)$ is hours worked by a typical member of household h.

[19] Government spending is assumed to fall exclusively on consumption, so that all investment is private investment.

The parameter ζ is the size of a household of type h, and effectively determines the size of the population in the home country. The aggregator minimizes the cost of producing a given amount of the aggregate labor index, taking each household's wage rate $W_t(h)$ as given, and then sells units of the labor index to the production sector at their unit cost W_t:

$$W_t = \left[\int_0^1 W_t(h)^{\frac{-1}{\theta_w}} dh\right]^{\theta_w} \tag{A.16}$$

The aggregator's demand for the labor services of a typical member of household h is given by

$$N_t(h) = \left[\frac{W_t(h)}{W_t}\right]^{-\frac{1+\theta_w}{\theta_w}} L_t/\zeta \tag{A.17}$$

We assume that there are two types of households: households that make intertemporal consumption, labor supply, and capital accumulation decisions in a forward-looking manner by maximizing utility subject to an intertemporal budget constraint (FL households, for "forward-looking"); and the remainder that simply consume their after-tax disposable income (HM households, for "hand-to-mouth" households). The latter type receives no capital rental income or profits, and choose to set their wage to be the average wage of optimizing households. We denote the share of FL households by $1-\varsigma$ and the share of HM households by ς.

We consider first the problem faced by FL households. The utility functional for an optimizing representative member of household *h* is

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \begin{array}{c} \frac{1}{1-\sigma}\left(C^O_{t+j}(h) - \aleph C^O_{t+j-1} - C^O \nu_{ct+j}\right)^{1-\sigma} \\ + \frac{\chi_0 Z_{t+j}^{1-\rho}}{1-\chi}\left(1-N_{t+j}(h)\right)^{1-\chi} + \mu_0 F\left(\frac{MB_{t+j+1}(h)}{P_{Ct+j}}\right) \end{array} \right\} \tag{A.18}$$

where the discount factor β satisfies $0 < \beta < 1$. As in Smets and Wouters (2003, 2007), we allow for the possibility of external habit formation in preferences, so that each household member cares about its consumption relative to lagged aggregate consumption per capita of forward-looking agents C^O_{t-1}.

The period utility function depends on each member's current leisure $1 - N_t(h)$, his end-of-period real money balances, $\frac{MB_{t+1}(h)}{P_{Ct}}$, and a preference shock, ν_{ct}. The subutility function $F(.)$ over real balances is assumed to have a satiation point to account for the possibility of a zero nominal interest rate; see Eggertsson and Woodford (2003) for further discussion.[20] The (log-linearized) consumption demand shock ν_{ct} is assumed to follow an AR(1) process:

$$\nu_{ct} = \rho_\nu \nu_{ct-1} + \varepsilon_{\nu_c,t} \tag{A.19}$$

[20] For simplicity, we assume that μ_0 is sufficiently small that changes in the monetary base have a negligible impact on equilibrium allocations, at least to the first-order approximation we consider.

Forward-looking household h faces a flow budget constraint in period t which states that its combined expenditure on goods and on the net accumulation of financial assets must equal its disposable income:

$$P_{Ct}(1+\tau_{Ct})C_t^O(h) + P_{It}I_t(h) + MB_{t+1}(h) - MB_t(h) + \int_s \xi_{t,t+1}B_{Dt+1}(h) - B_{Dt}(h) + P_{Bt}B_{Gt+1}(h) + S_t\frac{P_{Bt}^* B_{Ft+1}(h)}{\phi_{bt}} = (1-\tau_{Nt})W_t(h)N_t(h) + \Gamma_t(h) + TR_t(h) + (1-\tau_{Kt})R_{Kt}K_t(h) + P_{It}\tau_{Kt}\delta K_t(h) - P_{Dt}\phi_{It}(h) + S_tB_{Ft}(h) + B_{Gt}(h) \quad \text{(A.20)}$$

Consumption purchases are subject to a sales tax of τ_{Ct}. Investment in physical capital augments the per capita capital stock $K_{t+1}(h)$ according to a linear transition law of the form:

$$K_{t+1}(h) = (1-\delta)K_t(h) + I_t(h) \quad \text{(A.21)}$$

where δ is the depreciation rate of capital.

Financial asset accumulation of a typical member of FL household h consists of increases in nominal money holdings $\left(MB_{t+1}(h) - MB_t(h)\right)$ and the net acquisition of bonds. While the domestic financial market is complete through the existence of state-contingent bonds B_{Dt+1} , cross-border asset trade is restricted to a single non-state contingent bond issued by the government of the foreign economy.[21]

The terms B_{Gt+1} and B_{Ft+1} represent each household member's net purchases of the government bonds issued by the domestic and foreign governments, respectively. Each type of bond pays one currency unit in the subsequent period, and is sold at price (discount) of P_{Bt} and P_{Bt}^*, respectively. S_t is the nominal exchange rate. To ensure the stationarity of foreign asset positions, we follow Turnovsky (1985) by assuming that domestic households must pay a transaction cost when trading in the foreign bond. The intermediation cost depends on the ratio of economy-wide holdings of net foreign assets to nominal GDP, $P_{Dt}Y_{Dt}$, and are given by:

$$\phi_{bt} = exp\left(-\phi_b\left(\frac{B_{Ft+1}}{P_{Dt}Y_{Dt}}\right)\right) \quad \text{(A.22)}$$

If the domestic economy is in an overall net lender position internationally, then a household will earn a lower return on any holdings of foreign bonds; conversely, if the domestic economy is a net debtor position, the domestic households pay a higher return on their foreign liabilities. Given that the domestic government bond in the domestic economy and foreign bond have the same payoff, the price faced by home residents net of the transaction cost is identical, so that $P_{Bt} = \frac{P_{Bt}^*}{\phi_{bt}}$. The effective nominal interest rate on domestic bonds (and similarly for foreign bonds) hence equals $i_t = 1/P_{Bt} - 1$.

Each member of FL household h earns after-tax labor income, $(1-\tau_{Nt})W_t(h)N_t(h)$, where τ_{Nt} is a stochastic tax on labor income. The household leases capital at the after-tax rental rate $(1-\tau_{Kt})R_{Kt}$, where τ_{Kt} is a stochastic tax on capital income. The household receives a depreciation write-off $P_{It}\tau_{Kt}\delta$ per unit of capital. Each member also receives an aliquot share $\Gamma_t(h)$ of the profits of all firms and a lump-sum government transfer, $TR_t(h)$ (which is negative in the case of a tax). Following Christiano, Eichenbaum and Evans (2005), we assume that it is costly to change the level of gross investment from the previous period, so that the acceleration in the capital stock is penalized:

[21] The domestic contingent claims B_{Dt+1} are in zero net supply from the standpoint of the domestic economy as a whole.

$$\phi_{It}(h) = \frac{1}{2}\phi_I \frac{(I_t(h)-I_{t-1})^2}{I_{t-1}} \tag{A.23}$$

In every period t, each member of FL household h maximizes the utility functional (A.18) with respect to its consumption, investment, (end-of-period) capital stock, money balances, holdings of contingent claims, and holdings of domestic and foreign bonds, subject to its labor demand function (A.17), budget constraint (A.20), and transition equation for capital (A.21). In doing so, a household takes as given prices, taxes and transfers, and aggregate quantities such as lagged aggregate consumption and the aggregate net foreign asset position.

Forward-looking (FL) households set nominal wages in staggered contracts that are analogous to the price contracts described above. In particular, with probability $1-\xi_w$, each member of a household is allowed to reoptimize its wage contract. If a household is not allowed to optimize its wage rate, we assume each household member resets its wage according to:

$$W_t(h) = \omega_{t-1}^{\iota_\omega}\omega^{1-\iota_\omega}W_{t-1}(h) \tag{A.24}$$

where ω_{t-1} is the gross nominal wage in inflation rate in period $t-1$, i.e. W_t/W_{t-1}, and $\omega = \pi$ is the steady state rate of change in the nominal wage (equal to gross price inflation since steady state gross productivity growth is assumed to be unity). Dynamic indexation of this form introduces some element of structural persistence into the wage-setting process. Each member of household h chooses the value of $W_t(h)$ to maximize its utility functional (A.18) subject to these constraints.

Finally, we consider the determination of consumption and labor supply of the hand-to-mouth (HM) households. A typical member of a HM household simply equates his nominal consumption spending, $P_{Ct}(1+\tau_{Ct})C_t^{HM}(h)$, to his current after-tax disposable income, which consists of labor income plus lump-sum transfers from the government:

$$P_{Ct}(1+\tau_{Ct})C_t^{HM}(h) = (1-\tau_{Nt})W_t(h)N_t(h) + TR_t(h): \tag{A.25}$$

The HM households are assumed to set their wage equal to the average wage of the forward-looking households. Since HM households face the same labor demand schedule as the forward-looking households, this assumption implies that each HM household works the same number of hours as the average for forward-looking households.

A.3. Monetary and Fiscal Policy

Monetary policy regimes in the model differ for the U.S. and the euro area and are discussed earlier in Section II. The government does not need to balance its budget each period, and the aggregate end of period *t* debt D_{Gt+1} law of motion evolves according to:

$$D_{Gt+1} = P_{Ct}G_t + TR_t^O + TR_t^{HM} - \tau_{N,t}W_tL_t - \tau_{Ct}P_{Ct}C_t - \tau_{Kt}(R_{Kt} - \delta P_{It})K_t + (1+i_{Gt-1})D_{Gt} - (MB_{t+1} - MB_t) \tag{A.26}$$

where C_t is total private consumption and i_{Gt} is the effective interest rate on outstanding government debt. Equation (A.27) aggregates the capital stock, money and bond holdings, and transfers and taxes over all households so that, for example, $TR_t^O = \int_0^O TR_t^O(h)dh$. The taxes on capital τ_{Kt}, consumption τ_{Ct} and labor income $\tau_{N,t}$, as well as the ratio of real transfers to (trend) GDP to hand to mouth households, $tr_t^{HM} = \frac{TR_t^{HM}}{P_t Y}$, are also assumed to be fixed.[22] Government purchases have no direct effect on the utility of households, nor do they affect the production function of the private sector.

The debt accumulation equation (A.26) allows for long-term government debt following Krause and Moyen (2016).[23] In log-linearized form, their model implies that i_{Gt} is determined as follows. First, the effective interest rate on newly issued debt is given by,

$$i_{Gt}^{new} = \vartheta_{new} i_t + (1 - \vartheta_{new}) E_t i_{Gt+1}^{new},$$

where $\vartheta_{new} = (i + \vartheta)/(1 + i)$ and ϑ is the probability of the stochastic bond maturing in the next quarter and *i* is the steady state short-term nominal interest rate. Now, the debt stock is only gradually maturing, so the effective interest rate on the debt stock is only gradually updated according to

$$i_{Gt} = \vartheta_{long} i_{Gt}^{new} + \left(1 - \vartheta_{long}\right) i_{Gt-1},$$

where ϑ_{long} =1-(1-λ)/(1+π) which approximatively equals λ when π is low (we have π=0.005 in our calibration). Notice that this approach allows us to nest a framework with one-period debt by setting λ=0, since then i_{Gt} equals i_t.

The process for the (log of) government spending is given by an AR(1) process:

$$(g_t - g) = \rho_G (g_{t-1} - g) + \varepsilon_{g,t}; \tag{A.27}$$

where $\varepsilon_{g,t}$ is independently normally distributed with zero mean and standard deviation σ_G. When we study the impact of government investment, we assume some positive spillover on the stationary technology shock z_t in eq. (A.4) by setting $\Delta z_t = 0.7\Delta z_{t-1} - 0.005 z_{t-1} + \epsilon_{z,t} + 0.003 g_t$. This implies, in line with recent work of Lindé and Lemoine (2020), that a transient increase in government investment has a gradually increasing yet limited transient impact on the stationary technology level.

We assume that policymakers adjust the labor income tax rate to stabilize the debt/GDP ratio and the deficit, according to:

$$\tau_{N,t} - \tau_N = \upsilon_1 \left(\tau_{N,t-1} - \tau_N\right) - (1 - \upsilon_1)[\upsilon_2 (b_{Gt} - b_G) + \upsilon_3 (\Delta b_{Gt+1} - \Delta b_{Gt})], \tag{A.28}$$

[22] Given that the central bank uses the nominal interest rate as its policy instrument, the level of seigniorage is determined by nominal money demand.

[23] The central element of their approach is an approximation of the maturity structure of public debt in terms of a stochastic, long-term, government bond. Each period, an individual bond of this type pays the interest determined when the bond was issued or matures with a given probability, in which case it pays back the face value plus interest. Technically, the bond is a callable perpetuity with stochastic call date, which is independent across bonds. Since the government issues a large number of these bonds, the fraction of bonds maturing each period is identical to the call probability. Private agents are assumed to hold the same, representative, portfolio of the bonds. The stochastic bond allows to calibrate the average maturity of outstanding debt to that observed in the data.

where $b_{Gt} = B_{Gt}/(4\overline{P}_t Y)$, i.e. government debt as a share of annualized nominal trend output.

A.4. Resource Constraint and Net Foreign Assets

The domestic economy's aggregate resource constraint can be written as:

$$Y_{Dt} = C_{Dt} + I_{Dt} + \phi_{It} + \frac{\zeta^*}{\zeta} M_t^*; \tag{A.29}$$

where ϕ_{It} is the adjustment cost on investment aggregated across all households. The final consumption good is allocated between households and the government:

$$C_{At} = C_t + G_t; \tag{A.30}$$

where C_t is (per capita) private consumption of FL (optimizing) and HM households:

$$C_t = (1-\varsigma)C_t^O + \varsigma C_t^{HM}. \tag{A.31}$$

Total exports may be allocated to either the consumption or the investment sector abroad:

$$M_t^* = M_{Ct}^* + M_{It}^*. \tag{A.32}$$

The evolution of net foreign assets can be expressed as:

$$\frac{P_{B,t}^* B_{F,t+1}}{\phi_{bt}} = B_{F,t} + P_{Mt}^* \frac{\zeta^*}{\zeta} M_t^* - P_{Mt} M_t. \tag{A.33}$$

This expression can be derived from the budget constraint of the FL households after imposing the government budget constraint, the consumption rule of the HM households, the definition of firm profits, and the condition that domestic state-contingent non-government bonds (B_{Dt+1}) are in zero net supply.

Finally, we assume that the structure of the foreign economy is isomorphic to that of the domestic economy.

A.5. Production of capital services

The model is amended to include a financial accelerator mechanism into both country blocks of our benchmark model following the basic approach of Bernanke, Gertler and Gilchrist (1999). Thus, the intermediate goods producers rent capital services from entrepreneurs (at the price R_{Kt}) rather than directly from households. Entrepreneurs purchase physical capital from competitive capital goods producers (and resell it back at the end of each period), with the latter employing the same technology to transform investment goods into finished capital goods as described by eqs. (A.21) and (A.23). To finance the acquisition of physical capital, each entrepreneur combines his net worth with a loan from a bank, for which the entrepreneur must pay an external finance premium (over the risk-free interest rate set by the central bank) due to an agency problem. Banks obtain funds to lend to the entrepreneurs by issuing deposits to households at the interest rate set by the central bank, with households bearing no credit risk (reflecting assumptions about free competition in banking and the ability of banks to diversify their portfolios). In equilibrium, shocks that affect entrepreneurial net worth i.e., the leverage of the corporate sector induce fluctuations in the corporate finance premium.[24]

A.6. Calibration and Solution Method

The model is calibrated at a quarterly frequency. The country size parameter $\zeta = 1$; so that the domestic and foreign countries are equally large. The trade share of the U.S. economy is set to 9.3 percent of its GDP, which intended to match U.S. trade with the euro area and plus some indirect trade linkages. This pins down the trade share parameters ω_C and $\omega_I \rho_C = \rho_I = 2.75$ $\theta_p = 0.1$, , which together with our price markup is consistent with a long-run price elasticity of demand for imported consumption and investment goods of [1.5]$\varphi_{M_C} = \varphi_{M_I} = 1$ ϕ_b, which slightly damps the near-term relative price sensitivity. The financial intermediation parameter is set to a very small value (0.001), which is sufficient to ensure the model has a unique steady state.

The relative risk aversion parameter σ is set to a benchmark value in the literature (2), while the habit persistence parameter in consumption $\aleph$ is set to 0.8 (following empirical evidence). The utility parameter χ_0 is set so that labor market activity comprises half of the household's time endowment, while the Frisch elasticity of labor supply is targeted to equal 1/2, which implies setting $\chi = 4$. Real balances are kept small by setting the parameter μ_0 on the subutility function at an arbitrarily low value (so that variation in real balances do not affect equilibrium allocations). We set the share of HM agents $\varsigma = 0.55$; implying that these agents account for about one third of aggregate private consumption spending (the latter is much smaller than the population share of HM agents because the latter own no capital). This is consistent with Johnson, Parker, and Souleles (2006) and Parker et al. (2013) who find evidence of a substantial response of household spending, particularly for liquidity-constrained households, to the temporary U.S. tax rebates of 2001 and 2008, using micro data from the Consumer Expenditure Survey. On the macro side, Galí, López-Salido, and Vallés (2007) presents evidence from structural VARs that government spending shocks tend to boost private consumption, and show how the inclusion of rule-of-thumb agents in their DSGE model helps to account for this behavior. Nonetheless, a smaller share of HM agents will particularly lower the impact of fiscal stimulus.

The parameter determining investment adjustment costs $\phi_I = 3$ following the evidence in Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2007). The depreciation rate of capital is set at 0.025 (consistent with an annual depreciation rate of 10 percent). The parameter ρ in the CES production function of the intermediate goods producers is set to -1; implying a zero-elasticity of substitution between capital and labor $(1+\rho)/\rho$, i.e. a Leontief production function technology. The quasi-capital share parameter $\omega_K = 0.3$ - together with the price markup parameter of $\theta_P = 0.1$ - is chosen to imply a steady state investment to output ratio of about 20 percent. In the augmented version of the model with a financial accelerator, our calibration of parameters follows Bernanke, Gertler and Gilchrist (1999). In particular, the monitoring cost, μ, expressed as a proportion of entrepreneurs total gross revenue, is set to 0.12. The default rate of entrepreneurs is 3 percent per year, and the variance of the idiosyncratic productivity shocks to entrepreneurs is 0.28.

The Calvo domestic price contract duration parameter is set to be $\xi_p = 0.92$, the import/export contract parameter $\xi_m = 0.90$, while the wage contract duration parameter is $\xi_w = 0.88$. We set the degree of price indexation ι_p to unity and wage and import price indexation parameters $\iota_w = \iota_m = 0.5$. In line with Smets and

[24] We follow Christiano, Motto and Rostagno (2008) by assuming that the debt contract between entrepreneurs and banks is written in nominal terms (rather than real terms as in Bernanke, Gertler and Gilchrist, 1999). For further details about the setup, see Bernanke, Gertler and Gilchrist (1999), and Christiano, Motto and Rostagno (2008). An excellent exposition is also provided in Christiano, Trabandt and Walentin (2011).

Wouters (2007) we set the wage markup is $\theta_W = 1/3$.[25] To address the forward guidance puzzle (see Del Negro, Giannoni and Patterson, 2015), we allow for the possibility that labor unions and firms form expectations in a non-rational fashion outside of the steady state. Our modeling of behavioral expectations in the pricing and wage equations follows the spirit of Gabaix (2020) $X_{t+1|t}^{BR} = \varphi X_{t+1|t}$ where $X_{t+1|t}$ is the rational t+1 expectation given the state in period t. The superscript BR abbreviates bounded rationality and the cognitive discount parameter φ is set equal to 0.95. This approach is implemented by replacing each forward-looking variable $X_{t+1|t}$ in the linearized wage and price Phillips curves with $\varphi X_{t+1|t}$. Relative to Gabaix (2020), who uses these assumptions about expectations formation to rederive the first order conditions, our approach clearly involves some simplifications. However, it captures the spirit of both Gabaix and related work—including McKay, Nakamura, and Steinsson (2016)—that a number of factors, including myopia and liquidity constraints, are likely to dampen the role of expectations in firms pricing and labor unions wage setting decisions.
As discussed in the main text, the parameters of the monetary rules are set so that the model can match the outlook for the federal funds rate and the Eonia with the concurrent inflation outlooks in respective economy at the beginning of 2021. This implies setting the interest smoothing parameter γ_{EA}=$\gamma_{US} = 0.92$ and the employment growth parameter $\gamma_{\Delta e,EA} = \gamma_{\Delta e,US}$=0.25 for both the U.S. and the ECB. For the employment gap γ_e we set a slightly higher parameter for the U.S. (0.25 annualized) relative to the ECB (0.125 annualized). Finally, the AIT gap coefficient $\gamma_{\pi,US}$ for the Fed is set to 4.3, whereas the inflation coefficient $\gamma_{\pi,EA}$ for the ECB is set to 5. Without these aggressive response coefficients on inflation, our model cannot account for the long-lived expected ELB episodes priced in markets in early 2021. With the discount factor set at $\beta = 0.99875$, and the inflation target at 2 percent, the steady state nominal interest rate is 2.5 percent.

The parameters pertaining to fiscal policy are intended to roughly capture the revenue and spending sides of the U.S. and EA government budgets, respectively. The share of government spending on goods and services is set equal to 19 (25) percent of steady state output in the U.S. (EA). The government debt to GDP ratio, b_G, is set to roughly 130 (100) percent of annualized GDP, roughly equal to the average level of consolidated debt at end-2020 in the U.S. (EA). The ratio of transfers to GDP is set to 15 percent. The steady state sales (i.e., VAT) tax rate τ_C is set to 7 (20) percent, while the capital tax τ_K is set to 0.21 (0.26) in the U.S. (EA) and we allow for full tax-deduction of capital depreciation (i.e. $\delta_\tau = \delta$). Given the annualized steady state real interest rate (of 0.5 percent), the government's intertemporal budget constraint then implies that the average labor income tax rate τ_N equals 0.30 (0.32) percent in the U.S. (EA) in steady state. We assume an unaggressive tax adjustment rule (equation A.29) by setting $\upsilon_1 = 0.985$ and $\upsilon_2 = \upsilon_3 = 0.1$. Finally, following Krause and Moyen (2016), we set ϑ=0.055, consistent with a 4.5 year steady state maturity structure of government debt.

To analyze the behavior of the model, we log-linearize the model's equations around the non-stochastic steady state. Nominal variables are rendered stationary by suitable transformations. To solve the unconstrained version of the model, we compute the reduced-form solution of the model for a given set of parameters using the numerical algorithm of Anderson and Moore (1985), which provides an efficient implementation of the solution method proposed by Blanchard and Kahn (1980).

[25] Given strategic complementarities in wage-setting, the wage markup in influences the slope of the wage Phillips Curve.

Summary Table of Parameters		
Parameters	Symbol	Value
Relative country size	ζ	1
Trade share	1-ω_C, 1-ω_I	1-ω_C=0.095, 1-ω_I= 0.136 => trade share 9.3% of GDP
Trade price elasticity	$\frac{1+\rho_C}{\rho_C} = \frac{1+\rho_I}{\rho_I}$	1.5
Price markup	θ_p	0.1
Import adjustment cost	$\varphi_{M_C} = \varphi_{M_I}$	1
Financial intermediation cost abroad	ϕ_b	0.001
Relative risk a version	σ	2
Habit persistence	$\aleph$	0.8
Leisure in utility	χ_0	1
Share of work to time endowment	s_e	0.5
Labor utility curvature parameter	χ	4
Real money balance utility	μ_0	0.001
Share of hand-to-mouth agents	ς	0.55
Investment adjustment cost	ϕ_I	3
Capital depreciation (10% per year)	δ	0.025
Elasticity of substitution between intermediate goods	ρ	-1
Quasi-capital share	ω_K	0.3
Monitoring cost	μ	0.12
Default rate for entrepreneurs	$F(\bar{\omega})$	3 percent / year
Variance of idiosyncratic productivity shock	$var(log\omega)$	0.28
Calvo domestic price contract duration	ξ_p	0.92
Calvo Import/export contract duration	ξ_m	0.9
Calvo wage contract duration	ξ_w	0.88
Wage and import price indexation	$\iota_w = \iota_m$	0.5
Wage markup	θ_W	1/3
Cognitive discounting in price setting	φ	0.95
Interest rate smoothing	γ_{EA}=γ_{US}	0.92
Employment growth	$\gamma_{\Delta e,EA} = \gamma_{\Delta e,US}$	0.25
Employment gap	γ_e	US = 0.25/4, ECB = 0.125/4
AIT/FIT gap coefficients	γ_π	US = 4.3, ECB =5
Discount factor	β	0.99875
Bond maturing probability	ϑ	0.055
Tax adjustment rule	$\upsilon_1, \upsilon_2, \upsilon_3$	$\upsilon_1 = 0.985, \upsilon_2 = \upsilon_3 = 0.1$
Steady state gov't debt/GDP (%)	b_G	US: 130, EA: 100
Gov't consumption/GDP (%)	g_y	US: 19, EA: 25
Steady state transfers/GDP (%)	tr_t^O, tr_t^{HM}	$tr_t^O = 6.75, tr_t^{HM} = 8.25$
Steady state labor income tax rate (%)	τ_N	US: 32, EA: 30
Steady state consumption tax rate (%)	τ_C	US: 7, EA: 20
Steady state capital tax rate (%)	τ_K	US: 21, EA: 26
Steady state inflation, inflation target (annual, %)	$\bar{\pi}$	2
Steady state nominal interest rate (annual, %)	i	2.5

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