BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Make-up strategies and exchange rate pass-through in a low-interest-rate environment

by Alessandro Cantelmo, Pietro Cova, Alessandro Notarpietro and Massimiliano Pisani

December 2022

Number 1398

BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Make-up strategies and exchange rate pass-through in a low-interest-rate environment

by Alessandro Cantelmo, Pietro Cova, Alessandro Notarpietro and Massimiliano Pisani

Number 1398 - December 2022

ISSN 2281-3950 (online)

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

MAKE-UP STRATEGIES AND EXCHANGE RATE PASS-THROUGH IN A LOW-INTEREST-RATE ENVIRONMENT

by Alessandro Cantelmo*, Pietro Cova*, Alessandro Notarpietro* and Massimiliano Pisani*

Abstract

We evaluate the macroeconomic stabilization properties, with particular reference to the exchange rate pass-through, of price level targeting (PLT), average inflation targeting (AIT) and inflation targeting (IT) strategies when the effective lower bound on the monetary policy rate can be binding. The results of simulating the canonical open-economy New Keynesian model -- in which the assumption of local currency pricing holds and which is calibrated without loss of generality to the euro area -- are as follows. First, make-up strategies (PLT and AIT) stabilize inflation better than IT, by favoring a smaller appreciation (larger depreciation) of the nominal exchange rate in the event of disinflationary demand (supply) shocks. Second, and in connection with this, the exchange rate pass-through to import prices is more limited under make-up strategies than under IT, as the former stabilize the inflation rate of imports to a greater extent. Third, the results are robust to alternative values of import price stickiness and elasticity of substitution between domestic and imported goods. Fourth, the stabilization properties of make-up strategies are qualitatively preserved under partially backward-looking inflation expectations, although the relative gains of make-up strategies with respect to IT are smaller than under model-consistent inflation expectations.

JEL Classification: E31, E52, F31, F41.
Keywords: effective lower bound, exchange rate pass-through, local currency pricing, make-up strategies, monetary policy.
DOI: 10.32057/0.TD.2022.1398

Contents

* Bank of Italy, Directorate General for Economics, Statistics and Research.

1 Introduction[1]

The well-documented persistent decline in the natural rate of interest, coupled with sluggish growth and low inflation in some advanced economies during the pre-Covid 19 period, has shaped the debate about how to appropriately conduct monetary policy to support the economy and bring inflation at the central bank's target if the effective lower bound (ELB) is likely to constrain the monetary policy rate. While currently estimates of the natural rate of interest are surrounded by large uncertainty, secular stagnation forces are likely to keep exerting downward pressures even when inflation returns to values close to its long-run target.[2] Thus, the likelihood that the policy rate approaches again the ELB would still be non-negligible.

Most of the attention has been devoted to so-called "make-up strategies", such as average inflation targeting (AIT) and price level targeting (PLT). The key features of such strategies – as opposed to inflation targeting (IT) – is the property that "bygones are not bygones": if inflation has fallen short of the central bank target in the past, higher inflation is to be expected in the future, to compensate (i.e. make-up) for past inflation misses. These strategies are thus regarded as effective at stabilizing inflation and economic activity in a low interest rate environment by either reducing the likelihood of reaching the ELB or by providing a faster exit from it (see the related literature discussed below).

While there already exist several studies that evaluate the effectiveness of make-up strategies in closed-economy settings, their properties in open-economy remain fairly unexplored. In particular, the dynamics of the nominal exchange rate and its impact on prices (the so-called "exchange rate pass-through", ERPT) can in principle be affected not only by the type of shock hitting the economy, as pointed out by Forbes et al. (2018), and Corsetti et al. (2008) ("shock-dependent" ERPT) but also by the type of implemented monetary policy strategy. Moreover, the ERPT in turn can affect the macroeconomic stabilization properties of monetary policy in response to a given shock.

This paper evaluates the macroeconomic stabilization properties, with particular reference to the ERPT, of make-up strategies by simulating the canonical two-country New Keynesian model, in which the local currency pricing (LCP) assumption holds and the ELB is allowed to be endogenously binding with a non-negligible probability in the domestic economy. We calibrate the latter to the euro area (EA), since the ELB has been constraining the usage of the monetary policy rate in the EA over the past years. The second region is calibrated to the rest of the world (RW). We assume that the RW central bank sticks to IT. The two-country model allows us to fully exploit the general equilibrium discipline and transparency in deriving our results. We focus on the EA, which is our case study, but our results should be thought of as general

[1]The views expressed in this paper are those of the authors alone and should not be attributed to the Bank of Italy or the Eurosystem. We thank Michele Caivano, Stefano Neri, and Paolo Del Giovane for useful comments. All errors are ours.

[2]See e.g. "*How Will the Pandemic and War Shape Future Monetary Policy?*", Remarks by Gita Gopinath (IMF) Prepared for the 2022 Jackson Hole Symposium, August 26, 2022

and valid also for other advanced economies.

Specifically, we compare, for the EA, the monetary policy regimes IT, AIT, and PLT in terms of their implications for macroeconomic stability and ERPT, under the assumption that the ELB can be binding due to disinflationary demand and supply shocks. The demand shock is a EA positive risk premium shock (i.e., recessionary and disinflationary), which induces households to save in domestic currency-denominated bonds, while the disinflationary supply shock is a EA negative price markup shock (i.e., expansionary and disinflationary) to both domestic and imported goods in the EA.

In the model, each country is specialized in the production of an intermediate tradable good. Tradables are imperfect substitutes. Nominal prices of exports and imports are set in the currency of the destination markets and are sticky in the short run (the assumptions of international price discrimination and LCP hold). To gauge the robustness of our results to the interaction of exchange rate dynamics and make-up strategies, we also consider the cases of low import and export nominal price rigidities and of alternative values of the elasticity of substitution among tradables. Moreover, since the effectiveness of make-up strategies in stabilizing inflation crucially hinges on the degree of forward-lookingness of inflation expectations, we extend our analysis to the case of "hybrid" inflation expectations, modeled as a combination of model-consistent (i.e., rational) and adaptive (i.e., backward-looking) inflation expectations.

Our results are as follows.

First, make-up strategies (PLT and AIT) stabilize inflation better than IT, by favoring a smaller appreciation (larger depreciation) of the nominal exchange rate in the event of disinflationary demand (supply) shocks. Second, and in connection with this, the ERPT to import prices is more limited under make-up strategies than under IT, as the former stabilize the inflation rate of imports to a greater extent. Third, the results are robust to alternative values of import price stickiness and elasticity of substitution between domestic and imported goods. Fourth, the stabilization properties of make-up strategies are qualitatively preserved under partially backward-looking inflation expectations, although the relative gains of make-up strategies with respect to IT are smaller than under model-consistent inflation expectations.

The intuition for the results is the following. When a disinflationary shock takes the policy rate to the ELB, under make-up strategies, the central bank promises to keep the policy rate at a low level for longer than under IT. Lower current and expected future policy rates increase inflation expectations, hence reducing expected real rates and, in turn, favoring a larger improvement in current EA aggregate demand and a smaller nominal exchange rate appreciation or a larger depreciation, depending on the shock hitting the economy. Both factors further stimulate economic activity and inflation and, thus, *in equilibrium*, an earlier exit from the ELB (or the avoidance of the latter). In particular, the larger depreciation sustains exports and, jointly with the improved expected domestic aggregate demand that stimulates imports, also raises import price inflation. These effects are especially large under PLT which turns out to be the strategy that provides the best stabilization.

This paper contributes to the literature on monetary policy strategies in a low interest rate environment. In particular, Bernanke et al. (2019) discuss alternative tools that central banks could adopt in order to overcome the limits posed by the ELB. Alternative monetary policy strategies in the EA have been analyzed by Busetti et al. (2021), Coenen et al. (2021) and Erceg et al. (2021). Consistently with Bernanke et al. (2019), they all find that lower-for-longer strategies help the economy recover from periods at the ELB. Specifically, PLT is the most effective strategy in terms of stabilizing inflation and output and of reducing the duration and frequency of ELB episodes. We add to these contributions by systematically evaluating the open-economy dimension of the make-up strategies with the canonical New Keynesian open-economy model and by showing that qualitatively the results are in line with those obtained in closed-economy. Crucially, we show that the open-economy dimension offers additional insights about the transmission mechanism of macroeconomic shocks under make-up strategies, especially as regards the dynamics of the exchange rate and ERPT. A few contributions assess PLT properties in open economy. Svensson (2006) describes the "Foolproof Way", consisting of PLT, currency depreciation and commitment to a currency peg and a zero interest rate until the price-level target path has been reached. According to the author, it is likely to be the most effective policy to raise expectations on the future price level, stimulate the economy, and escape from a liquidity trap. Dib et al. (2013) explore the desirability of PLT in a small open economy with credit frictions. Different from these papers, we make a systematic comparison of PLT, AIT, and IT in terms of their macroeconomic stabilization properties.[3] Azcona (2018) simulates a small-open-economy New Keynesian model estimated with Canadian data and finds that supply shocks cause less nominal and real exchange rate volatility under PLT. Different from this contribution, we consider the properties of PLT when the ELB can be binding. Moreover, we also consider also the properties of AIT and IT and their implications for ERPT.

This paper also contributes to the literature on ERPT. Forbes et al. (2018) and Corsetti et al. (2008) evaluate how ERPT is affected in general equilibrium by different structural (demand and supply) shocks. We build on these contributions by assessing, in general equilibrium, not only the impact of different shocks but also the role of alternative monetary policy regimes in a low interest rate environment. Our results confirm the relevance for ERPT of the type of structural shock affecting the economy and suggest that the type of monetary policy regime implemented when the ELB can bind matters as well.

The paper is organized as follows. The next section describes the model setup. Section 3 reports the calibration. Section 4 contains the results. Section 5 concludes.[4]

[3]We do not analyze alternative exchange rate regimes. Balfoussia et al. (2021) show that, in general, a flexible exchange rate regime provides better output and inflation stabilization than a fixed exchange rate regime.

[4]The Appendix complements the paper by reporting the model equations, a complete set of impulse responses under alternative assumptions on import and export price stickiness and the substitutability between Home and Foreign goods, as well as under alternative assumptions on the formation of inflation expectations.

2 Model

Our analysis builds on a canonical two-country New Keynesian model, which we briefly illustrate in the following. One country is labeled Home, the other Foreign.

In each country, there are households that consume, supply labor under monopolistic competition to the domestic firms and invest in domestic physical capital and in financial assets.[5]

On the production side, in each country there are firms that produce final nontradable goods for consumption and investment activities under perfect competition. Moreover, there are firms producing intermediate tradables (that enter the domestic final consumption and investment bundles) under monopolistic competition using labor and physical capital supplied by the domestic household as inputs. Each firm is price-setter and short-run nominal price rigidities hold. Domestic and foreign nominal prices are set in local currency taking into account local demand conditions and quadratic price adjustment costs.[6] Thus, the assumptions of (exogenous) international price discrimination and LCP hold.[7]

Each country's central bank sets monetary policy according to a Taylor rule (subject to the ELB), where the policy rate reacts to its previous-period value (to capture inertia in the monetary policy conduct), to quarterly output growth, and to an inflation measure which, in the case of IT, is the current consumer price (CPI) inflation rate and in the cases of AIT and PLT is (backward) average CPI inflation and the consumer price level, respectively.

In what follows we report the key equations of the model, i.e., the Taylor rule's versions that describe the alternative monetary policy strategies, and the main equations related to the open-economy variables.[8]

2.1 Monetary policy rules

We assume the following specification for the benchmark (IT) monetary policy rule:

$$\frac{R_t}{\overline{R}} = max \left\{ \frac{1}{\overline{R}}, \left(\frac{R_{t-1}}{\overline{R}} \right)^{\rho_r} \left(\frac{\pi_t}{\overline{\pi}} \right)^{(1-\rho_r)\rho_\pi} \left(\frac{y_t}{y_{t-1}} \right)^{(1-\rho_r)\rho_y} \right\}. \tag{1}$$

The rule describes how the central bank conducts its monetary policy under a (flexible) IT strategy. The variable R_t is the gross policy rate and $\overline{R}$ its steady-state value. The parameters $0 \leq \rho_r \leq 1$, $\rho_\pi > 0$, ρ_y measure the sensitivity of the policy rate to its lagged value, to the gross inflation rate π_t (in deviation from the central bank target $\overline{\pi}$, which corresponds to the

[5]The assumption of cashless economy holds in the model.

[6]See Rotemberg (1982). The prices are also indexed to previous-period sector-specific inflation and to the inflation target of the central bank, with corresponding weights having values between 0 and 1 and summing to 1.

[7]Firms' profits from monopolistic competition are rebated in a lump-sum way to the domestic household.

[8]In each country households pay lump-sum taxes to the domestic government to finance public consumption (the government budget constraint is assumed to be balanced in every period). See Appendix A for a complete illustration of the model's equations.

steady-state inflation rate), and to the gross growth rate of output y_t/y_{t-1}, respectively.[9] The *max* operator takes into account the (endogenous) ELB (R is the nominal monetary policy rate in gross terms, thus it is equal to 1 at the ELB).[10]

We analyze the properties of alternative strategies. Specifically, to model PLT, we follow Eggertsson and Woodford (2003) and Bernanke et al. (2019) and modify the previous rule by substituting the price level term for the inflation term:

$$\frac{R_t}{\overline{R}} = max\left\{\frac{1}{\overline{R}}, \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_r}\left(\frac{p_t}{\overline{p}_t}\right)^{(1-\rho_r)\rho_p}\left(\frac{y_t}{y_{t-1}}\right)^{(1-\rho_r)\rho_y}\right\}, \tag{2}$$

where p_t is the period-t nominal price level, $\overline{p}_t$ the steady-state path of the nominal price level, and $\rho_p > 0$ is a parameter that measures the strength of the policy rate response to deviations of the price level from its long-run trend. The slope of the long-run trend is equal to the steady-state gross inflation rate, which is set to the central bank's target. The ratio $p_t/\overline{p}_t$ measures the "price-level gap" and is defined as the (cumulated) product of current and past inflation rate deviations from the target:

$$\frac{p_t}{\overline{p}_t} = \prod_{i=0}^{t}\left(\frac{\pi_i}{\overline{\pi}}\right). \tag{3}$$

Under PLT, the central bank commits to keeping the price level at the targeted path, therefore periods in which inflation is above its target are expected to be followed by periods in which inflation is below target, and vice versa.

In the case of an AIT strategy, the policy rate does not react to current inflation, but to the average of current and past inflation rates,

$$\frac{R_t}{\overline{R}} = max\left\{\frac{1}{\overline{R}}, \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_r}(\pi_t^{avg})^{(1-\rho_r)\rho_\pi^{avg}}\left(\frac{y_t}{y_{t-1}}\right)^{(1-\rho_r)\rho_y}\right\}, \tag{4}$$

where

$$\pi_t^{avg} \equiv \prod_{i=-k}^{0}\left(\frac{\pi_{t+i}}{\overline{\pi}}\right)^{\frac{1}{k+1}} \tag{5}$$

is the average of the last $k+1$-periods inflation rates (comprehensive of the current-period inflation rate) and $\rho_\pi^{avg} > 0$ is a parameter that measures the strength of the policy rate response to deviations of average inflation from the target. Under AIT, therefore, the central bank tends to adjust the policy rate more gradually in response to deviations of inflation from the target than under IT.

[9] The lagged interest rate ensures that the policy rate is adjusted smoothly and captures the idea that the central bank prefers to avoid large sudden changes in its policy instrument.

[10] We do not consider the case of the central bank responding to nominal exchange rate fluctuations, which could be a relevant determinant of macroeconomic conditions in small open economies, nor targeting the nominal exchange rate to favor the exit from the ELB.

2.2 Open-economy features

2.2.1 Import price setting

On the firms' side, we assume that Home and Foreign good markets are segmented and each generic firm sets one price for each destination market in local currency (international price discrimination and LCP assumptions). Following Dedola and Leduc (2001) and Burlon et al. (2018), we assume that the (generic) exporter has to pay a quadratic cost to adjust the nominal price of its exported good invoiced in the currency of the destination market. In the case of a generic Foreign firm f exporting to the Home country,

$$AC_{F,t}(f) = \frac{\kappa_F^p}{2}\left(\frac{p_t(f)/p_{t-1}(f)}{\pi_{F,t-1}^{\alpha_F}\overline{\pi}^{1-\alpha_F}} - 1\right)^2 P_{F,t}Y_{F,t}, \tag{6}$$

where $\kappa_F^p > 0$ is a parameter measuring the degree of nominal price stickiness of Foreign exports, $p_t(f)$ is the nominal price of generic exported good f, $0 \leq \alpha_F \leq 1$ measures indexation of current-period prices to the previous-period inflation rate of Home imports $\pi_{F,t-1}$, $\overline{\pi}$ is the inflation rate target set by the Home central bank, $P_{F,t}$ is the price of the Foreign export basket, and $Y_{F,t}$ is the basket.[11]

The log-linearized pricing equation, implied by the first-order condition of the export price setting problem solved by the representative Foreign firm, is[12]

$$\begin{aligned}\widehat{P}_{F,t} \quad = \quad & \frac{1}{1+k_F^p\overline{\pi}^2(\mu_F-1)(1+\beta)}\hat{S}_t \\ & +\frac{\widehat{MC}_{F,t}^*}{1+k_F^p\overline{\pi}^2(\mu_F-1)(1+\beta)} \\ & +\frac{k_F^p\pi^2(\mu_F-1)\left(\beta E_t\widehat{P}_{F,t+1}+\widehat{P}_{F,t-1}\right)}{1+k_F^p\overline{\pi}^2(\mu_F-1)(1+\beta)} \\ & +\frac{MC_F^*}{1+k_F^p\overline{\pi}^2(\mu_F-1)(1+\beta)}\hat{z}_{\mu,t},\end{aligned} \tag{7}$$

where $\widehat{MC}_{F,t}^*$ is the marginal cost of production, μ_F the steady-state markup, $\widehat{S}_t$ is the Home nominal exchange rate, defined as number of Home currency units per unit of Foreign currency, and $0 < \beta < 1$ the foreign household's discount factor. When $\kappa_F^p > 0$, the term that premultiplies the nominal exchange rate $\hat{S}_t$ is smaller than one and, thus, the direct impact of exchange rate on import prices is smaller. The higher is price stickiness (higher κ_F^p), the the smaller is the direct impact. Conversely, when κ_F^p tends to 0, import prices are (almost perfectly) flexible, the term that pre-multiplies the nominal exchange rate approaches one and, thus, the direct impact is high. The last term $\hat{z}_{\mu,t}$ in the equation multiplies the steady-state marginal cost

[11] Similar adjustment costs arise for Home firms exporting to the Foreign country.

[12] Variables with a "hat"are % deviations from the corresponding deterministic steady-state values.

MC_F^* and is a markup shock. The term suggests that the ERPT crucially depends on the type of shock affecting the economy as illustrated by Forbes et al. (2018) and Corsetti et al. (2008). As reported in Section 4, our results are in line with Forbes et al. (2018) and Corsetti et al. (2008) and suggest that also the monetary policy regime can matter for the ERPT. In our simulations, the very same markup shock also (and simultaneously) affects the domestic pricing equation of Home goods. Finally, a similar equation, albeit without the markup shock, holds for the pricing of Home goods exported to the Foreign country.

The Home aggregate demand curve for the generic imported intermediate good f is

$$\begin{aligned} Y_{F,t}(f) \quad = \quad & \left(\frac{1}{1-n}\right)(1-\gamma_H)\left(\frac{P_{F,t}(f)}{P_{F,t}}\right)^{-\theta_F}\left(\frac{P_{F,t}}{P_t}\right)^{-\phi} nC_t \\ & + \left(\frac{1}{1-n}\right)(1-\gamma_{H,I})\left(\frac{P_{F,t}(f)}{P_{F,t}}\right)^{-\theta_F}\left(\frac{P_{F,t}}{P_{I,t}}\right)^{-\phi} nI_t, \end{aligned} \tag{8}$$

where n is the Home country's size,[13] the parameters γ_H, $\gamma_{H,I}$ $(0 < \gamma_H, \gamma_{H,I} < 1)$ measure the weights of Home goods in the Home consumption and investment baskets, respectively (thus $(1-\gamma_H)$ and $(1-\gamma_{H,I})$ are the corresponding weights of Foreign goods in the Home consumption and investment bundles, respectively); the parameter $\theta_F > 1$ is the elasticity of substitution among imported brands, which is inversely related to the steady-state markup $\mu_F \equiv \theta_F/(\theta_F - 1)$; P_t and $P_{I,t}$ are the consumption and investment price deflators, respectively; $\phi > 0$ is the elasticity of substitution between Home and Foreign goods; C, I are consumption and investment bundles of the representative Home agent, respectively.

Home imports enter the Home consumption basket. The implied consumer price deflator is:

$$P_t = \left[\gamma_H P_{H,t}^{1-\phi} + (1-\gamma_H)\, P_{F,t}^{1-\phi}\right]^{\frac{1}{1-\phi}}. \tag{9}$$

Equations similar to (7), (8), and (9) hold for Home exports to the Foreign country. *Ceteris paribus*, higher Home consumption and investment demand stimulates import of Foreign goods. A given nominal exchange rate depreciation of the Home currency vis-à-vis the Foreign currency, by making Foreign goods more expensive than Home goods, favors the switching of worldwide demand towards Home-produced goods and a rise in Home consumer prices. The latter reflects the higher import price inflation associated with the exchange rate depreciation and the the increase in prices of Home domestic goods due to higher global demand. Symmetric effects are induced by a nominal exchange rate appreciation.

[13] Home and Foreign country have size n and $1-n$, respectively, where $0 < n < 1$ and world economy size is normalized to one. The size of a country is equal to the number of households and to the number of firms operating in each (intermediate and final) sector.

2.2.2 International financial structure

Home and Foreign households trade a riskless bond denominated in the Foreign currency (international financial markets are incomplete). Home households also trade domestically a bond which is in zero net supply and is denominated in Home currency. Thus, for Home households an uncovered interest parity (UIP) condition holds, linking the differential between the Home and Foreign monetary policy rates to the expected depreciation of the Home currency vis-à-vis the Foreign currency. Up to a first-order approximation around the deterministic steady state, the UIP reads as follows:

$$\hat{R}_t + \hat{z}_{HRP,t} - \left(\hat{R}^*_t - \hat{\Phi}\left(\hat{b}_{F,t}\right)\right) = E_t\widehat{\Delta S}_{t+1}, \tag{10}$$

where $\hat{R}_t$ is the Home monetary policy rate, $\hat{R}^*_t$ is the Foreign monetary policy rate, and $E_t\widehat{\Delta S}_{t+1}$ is the expected depreciation of the Home vis-à-vis the Foreign currency, with $E_t\widehat{\Delta S}_{t+1} \equiv E_t\hat{s}_{t+1} - \hat{s}_t$. The function Φ is an adjustment cost that ensures stationarity of the Home net foreign asset position, which would otherwise introduce a unit root in the model.[14] We also allow for a shock perturbing the UIP condition: $\hat{z}_{HRP,t}$ is a risk premium shock on Home bonds; a positive shock $\hat{z}_{HRP,t}$ increases the overall return on the bond and induces Home households to substitute the Home bond for investment in physical capital, consumption, and the bond denominated in Foreign currency; thus, the increase generates recessionary and disinflationary effects in the Home economy and the appreciation of the Home currency vis-à-vis the Foreign currency in nominal terms.

Interestingly for the purposes of our paper, if the ELB holds the Home central bank cannot decrease the policy rate $\hat{R}_t$ by as much as needed to offset the disinflationary effects of a positive risk premium shock $\hat{z}_{HRP,t}$. Thus, according to Eq. (10), in period t agents would, *ceteris paribus*, expect a larger depreciation of the nominal exchange rate in $t + 1$, that is, a larger appreciation of the nominal exchange rate in t.

The Home net foreign asset position is determined by net exports and interest receipts or payments on the stock of bonds traded with the Foreign households:

$$n\frac{S_t B_{F,t}}{R^*_t\left(1 - \Phi\left(\frac{S_t B_{F,t}}{P_t} - b_F\right)\right)} = nS_t B_{F,t-1} + nS_t P^*_{H,t} Y^*_{H,t} - (1-n) P_{F,t} Y_{F,t}, \tag{11}$$

where $B_{F,t}$ are the bonds denominated in Foreign currency held at the end of period t, $P^*_{H,t}$ is

[14] The term

$$\Phi\left(\frac{S_t B_{F,t}}{P_t} - b_F\right) \equiv \phi_{b,1}\frac{\exp\left[\phi_{b,2}\left(\frac{S_t B_{F,t}}{P_t} - b_F\right)\right] - 1}{\exp\left[\phi_{b,2}\left(\frac{S_t B_{F,t}}{P_t} - b_F\right)\right] + 1} \qquad \phi_{b,1}, \phi_{b,2} \geq 0$$

is the adjustment cost on aggregate foreign bond position $B_{F,t}$, expressed in domestic consumption units (it is divided by the domestic consumption deflator P_t) as a deviation from its steady-state value $\overline{b_F}$. The adjustment cost is taken as given by each household. See Schmitt-Grohe and Uribe (2003) and Benigno (2009).

the price in Foreign currency of Home exports $Y^*_{H,t}$, $P_{F,t}$ is the price in Home currency of Home imports of Foreign goods $Y_{F,t}$.

Thus, the nominal exchange rate is determined by both the UIP condition and the net foreign asset position and its fluctuations allow for the clearing of international goods and financial markets.

2.2.3 ERPT

In what follows we measure the ERPT to import and consumer prices, consistent with Forbes et al. (2018), as the ratio of the cumulative responses to a given shock of the corresponding inflation rate relative to the nominal exchange rate change, i.e., the corresponding ratio of price level relative to the exchange rate level. Thus, the ERPT to Home import prices in the generic period t is

$$ERPT_{imp,t} \equiv \frac{P_{F,t}}{S_t}, \tag{12}$$

while the ERPT to Home consumer prices is

$$ERPT_{c,t} \equiv \frac{P_t}{S_t}, \tag{13}$$

where the considered price and exchange rate levels are computed by cumulating from period 0 (i.e., the starting period of the simulation) to period t the period-by-period inflation rates and nominal exchange rate changes, taken as deviations from their corresponding (pre-shock) steady-state values.

3 Calibration

The model is calibrated at quarterly frequency and parameter values are taken mainly from Warne et al. (2008) and Busetti et al. (2021). Home is calibrated to the EA, Foreign to the RW. For simplicity and without loss of generality we calibrate the RW economy simmetrically to the EA economy, but for home bias and size.

Table 1 reports the steady-state inflation and interest rates values and the great ratios. The net annualized inflation rate is 2.0%. The steady-state (nominal) gross policy rate equals the ratio between gross inflation and the households' discount factor.[15] The implied (net) policy rate is 2.1%, such that the (net) real interest rate is almost zero, consistent with estimates of the natural rate in advanced economies (secular stagnation hypothesis).[16] Private consumption,

[15]The economy gross growth rate is always set to 1 (thus, the net growth rate is assumed to be zero).

[16]In the (flexible-price) steady-state equilibrium, the real rate corresponds to the natural rate. Busetti et al. (2021) set it to 0%, following evidence on the natural rate in the EA (Brand et al., 2018 and Neri and Gerali, 2017). As discussed in Section 1, current estimates of the natural rate are surrounded by high uncertainty and do not exclude zero or negative values, see e.g. "*Small steps in a dark room: guiding policy on the path out of the pandemic*" speech by Fabio Panetta (ECB) at the European University Institute, February 2022. We therefore

public consumption, and investment are set to 60%, 20%, and 20% of GDP, respectively. EA imports sum up to 16% of GDP, with imports of consumption and investment goods being 11% and 5% of GDP, respectively. Conversely, the RW imports to GDP from the EA amount to 4%, consistent with the assumption of a steady-state trade balance equal to zero. The Home net foreign asset position is set to zero as well. The size of the two countries is calibrated to set the shares of world GDP to 20% and 80% in Home and Foreign, respectively.

Table 2 reports the calibration of the structural parameters. Values for the monetary policy rule are borrowed from the estimates of Warne et al. (2008). The policy rate is adjusted in a gradual way, given that the corresponding coefficient, ρ_r, is set to 0.867. The response of the policy rate to inflation, ρ_π, is relatively large and equal to 1.9. The responses of the policy rate to the price level, ρ_p in Eq. (2) and to average inflation, ρ_π^{avg} in Eq. (4), are also set to 1.9. The number of past and current inflation rates in the AIT is set to 8 (thus, the time window used to compute the average inflation is 8 quarters including the current one). The response to output growth, ρ_y, is set to 0.15.

Turning to preferences, the elasticity of intertemporal substitution is set to 1 (i.e., log preferences in consumption), the discount factor to 0.9998, consistent with, as said above, a net natural rate equal to 0.1% in steady state. The consumption habit parameter is set to 0.57, the Frisch elasticity of labor supply to 0.667. The home bias parameters are set in order to match the corresponding shares of imports to GDP in both the EA and RW, while the intratemporal elasticity of substitution between Home and Foreign goods is set to 1.5, in line with the estimate of Adolfson et al. (2007).

As regards technology parameters, in the Cobb-Douglas production function the elasticity of output to physical capital is 0.53, which ensures a steady-state share of investment to GDP equal to 20%. The depreciation rate of physical capital is set to 0.025. The investment adjustment cost is equal to 3. The elasticities of substitution among good and labor varieties are set to 6 and 4.3, respectively. They imply steady-state markups of 1.2 and 1.3, respectively.

Concerning nominal rigidities, parameters measuring the cost for adjusting the price of goods, both domestic and imported ones, are all set to 120, which would correspond, in Calvo (1983) terms, to a probability of not adjusting prices of 0.82 (with an average duration of a price spell of five quarters). The one for adjusting nominal wages is set to 300, corresponding to a Calvo (1983) probability of 0.75 (i.e. the average length among two consecutive wage adjustments is four quarters). The parameters that measure the degree of indexation to previous-period inflation are set to 0.40 and 0.64 for prices and wages, respectively. The chosen calibration allows us to obtain responses of output and inflation to main macroeconomic shocks consistent with those obtained by Warne et al. (2008) with an estimated DSGE model of the EA.

Finally, we include a shock to the risk premium on domestic (i.e., domestic-currency-denominated) bonds held by the EA households (i.e., a EA aggregate demand shock), $\hat{z}_{HRP,t}$ in Eq. (10), and

rely on less uncertain estimates prior to the unprecedented shocks that hit the euro area since 2020.

a simultaneous shock to the price markup of both EA goods sold domestically and EA imports of RW goods, i.e., the same shock $\hat{z}_{\mu,t}$ (see Eq. 7) simultaneously affects the supply of both domestic and imported goods in the EA. We do not consider a monetary policy shock. Thus, the monetary policy rate always follows the assumed instrument rule. The log of shocks follows an AR(1) process, with persistence set to 0.9, similar to Warne et al. (2008). The standard deviation of the shocks, jointly with their persistence, are calibrated to generate theoretical moments generally in line with the volatilities of the corresponding EA data for the sample 1995-2014, i.e. before the ELB on the EA policy rate started binding.[17] Table 3 reports the volatilities observed in the data and the corresponding values generated by simulating the model (disregarding the ELB).[18] The model-based volatilities are generally in line with the corresponding values observed in the data and they are also in line with Busetti et al. (2021).

4 Results

To study the stabilization properties of make-up strategies in an open-economy setting, we start by reporting the impulse responses of EA variables to disinflationary demand and supply shocks that individually hit the EA. Similarly to what Busetti et al. (2021) do in a closed-economy setting, for the impulse response analysis we set the size of each shock such that the policy rate hits the ELB under the IT regime, for illustration purposes. These calibrated shock sizes are not necessarily in line with empirical evidence. For example, for values of the markup shock in line with empirical evidence the ELB would not be hit starting from the assumed steady-state value of the policy rate. Therefore, impulse responses under IT, AIT, and PLT implemented in the EA necessarily provide only an illustrative evaluation of the monetary policy strategies in response to a single shock. Conversely, in the (quantitative) moment analysis of Section 4.2 the shocks are calibrated in line with before-ELB empirical evidence and we evaluate the alternative monetary policy strategies on the basis of simulated moments and frequency and duration of the ELB episodes. The overall analysis is performed under the assumption of perfect foresight. Thus, uncertainty and risk considerations do not enter the decisions of households and firms. In the impulse-response analysis agents are surprised by the shock only in the initial period and fully anticipate its future dynamics. In the stochastic simulations, different from the impulse responses, agents are surprised by a new realization of the shocks in every period. Throughout the overall analysis it is assumed that the RW follows the IT regime. We initially report results under the benchmark calibration, i.e. high import and export price stickiness. Subsequently, we consider the case of low import and export price stickiness, we assess the role of high elasticity of substitution between domestic and imported tradables and the impact of monetary policy regimes on ERPT. Finally, we report the results of the moment analysis, performed also under the assumption of "hybrid", i.e. partially model- consistent and partially adaptive, inflation

[17]The same values are used to generate the stochastic simulations analyzed in Section 4.2.

[18]Data are from the Area Wide Model dataset (Fagan et al., 2001), except for imports and exports (both growth rates and deflators) for which we exclude intra-EA trade flows.

expectations.

In our simulations we consider a symmetric equilibrium, i.e., in each economy there is a representative household, a representative firm in the final nontradable sector, and a representative firm in the intermediate tradable sector. Each of them satisfies the corresponding first order conditions, budget and technology constraints, while the central banks follow the corresponding monetary policy rules, the government satisfies its budget constraint and the market clearing conditions hold.

4.1 Impulse responses

4.1.1 Positive EA risk premium shock

Fig. 1 plots the impulse responses of EA variables to a positive (i.e. recessionary and disinflationary) risk premium shock (i.e., a negative aggregate demand shock) in the EA under the alternative monetary policy strategies. The shock is modeled as an exogenous increase in the return of the bond denominated in EA currency. It is the term $\hat{z}_{HRP,t}$, in the UIP condition, Eq. (10).[19]

The shock induces households and firms to reduce consumption and investment (black-solid lines depict the case without the ELB, red-dashed lines depict the case when it is allowed for, both under IT). As a consequence, firms cut inputs (labor and capital, not reported), production and prices. Thus, the CPI inflation rate falls. Import price inflation decreases as well, contributing to the overall fall in inflation. The drop in import price inflation is triggered not only by the lower EA aggregate demand but also by the EA currency nominal appreciation vis-à-vis the RW currency. The latter is associated with the increase in the gross return on EA bonds, due to its shock component $\hat{z}_{HRP,t}$. EA export prices, set in RW currency, increase, consistent with the EA currency nominal appreciation.

Given the assumption of import price stickiness (LCP, see Eq. 7), *ceteris paribus* inflation of imported goods does not decrease one-for-one with respect to the nominal exchange rate appreciation. Thus, imports fall following the drop in EA aggregate demand, even if the nominal exchange rate appreciates. The nominal exchange rate appreciation also makes EA exports to the RW less competitive and favors their decrease, adding disinflationary pressure on EA economic conditions.

The ELB amplifies the effects of the recessionary shock, because the EA central bank cannot lower the policy rate as much as needed to stabilize domestic macroeconomic conditions. Thus, the fall in inflation and output is larger, as is the appreciation of the nominal exchange rate and the drop in import price inflation. Both exports and imports drop to a larger extent, consistent

[19]This shock has been widely used in New Keynesian models to generate business cycle comovement among macroeconomic variables and is key to build quantitative models where the ELB is relevant for monetary policy design (see Amano and Shukayev, 2012). It can be interpreted as a structural shock to the demand for safe and liquid assets (Fisher, 2015).

with the larger exchange rate appreciation and drop in aggregate demand, respectively.

Turning to the make-up strategies, adopting the PLT or the AIT regime (green lines with crosses and blue-dotted lines, respectively) reduces the ELB duration. With respect to IT, the monetary policy rate is only gradually decreased and never reaches the ELB.[20] The promise to keep the policy rate "lower for longer" positively affects households' and firms' expectations about future economic activity. The anticipation of a more accommodative monetary policy stance and, thus, of a faster improvement in future macroeconomic conditions induces households and firms to reduce consumption and investment less than under IT. As a result, CPI inflation also falls by less. *In equilibrium*, the policy rate does not hit the ELB. In particular, under PLT the central bank is able to further stabilize output and CPI inflation, because it credibly promises to keep the policy rate low to fully offset all past inflation misses.[21]

Under the make-up strategies, consistent with the expectation of a more accommodative stance, the exchange rate appreciates to a lesser extent and in a less persistent way than under IT. The fall in import price inflation is smaller than under IT, reflecting the lower reduction in EA aggregate demand and the more contained appreciation of the nominal exchange rate, which is passed-through, even if in a incomplete way, to import prices. Importantly, the lower fall in import price inflation contributes to the lower drop in CPI inflation. Imports fall to a smaller extent, consistent with the lower reduction in EA aggregate demand. Exports deteriorate less, because the smaller exchange rate appreciation implies a lower loss of international price competitiveness.

Overall, in the case of a domestic risk premium shock make-up strategies do favor macroeconomic stability when the ELB can be binding, also by inducing a smaller appreciation of the nominal exchange rate, which limits the disinflationary pressures due to lower import price inflation and sustains export competitiveness.[22]

4.1.2 Negative EA price markup shock

Fig. 2 reports the impulse responses to a negative (i.e. expansionary and disinflationary) price markup shock to both domestic and imported goods in the EA (i.e., an expansionary shock to the

[20] If the time window for computing average inflation is increased, then the responses under AIT get closer to those under PLT.

[21] Indeed, households anticipate the prolonged period of low interest rates and thus raise aggregate demand. In equilibrium, the implied higher inflation induces the central bank to raise the policy rate (more than under IT). Our results are not plagued by the forward-guidance (FG) puzzle, because we do not impose monetary policy shocks to keep the policy rate constant. What matters is the systematic component of the Taylor rule, that is, the fact that the policy rate reacts to the price level (PLT) rather than the inflation rate (IT). Moreover, Section 4.2.3 and Appendix C show that our results are robust to relaxing the assumption of model-consistent expectations (on which the FG puzzle rests) and allowing for a mix of model-consistent and adaptive expectations.

[22] It could be possible to engineer a disinflationary demand shock that induces a nominal depreciation of the EA currency, as opposed to an appreciation. The depreciation would support EA inflation by sustaining import price inflation dynamics. Under such conditions, make-up strategies would still cause a larger nominal depreciation and, thus, sustain CPI inflation to a larger extent than IT. Hence, the conclusions about the relative effectiveness of make-up strategies in stabilizing inflation compared to IT would be unaltered. Moreover, the ERPT would still depend on the monetary policy regime. In particular, it would be lower under make-up strategies than under IT, as shown in Section 4.1.5.

supply of goods available to EA households), under the alternative monetary policy strategies. The shock makes domestic and import prices fall and domestic output increase.

Under all strategies, the central bank lowers the policy rate to bring CPI inflation back to target. The presence of the ELB exacerbates the disinflationary effects of the shock, while at the same time partly offsetting the expansion in output, because of a larger increase in the real interest rate. AIT and PLT are more effective at stabilizing CPI inflation than IT. Under the two make-up strategies the policy rate stays at low levels – namely, at the ELB under PLT or close to it under AIT – for a prolonged amount of time, to offset the large initial drop in inflation and make up for inflation shortfalls from the target, thus stabilizing the average inflation rate in the case of AIT and the price level in the case of PLT.

The supply-side nature of the shock creates a trade-off for the central bank between stabilizing inflation and output. Indeed, under AIT and PLT, the increase in output is larger than under IT, due to the more accommodative stance which dictates a lower-for-longer policy rate and therefore a lower real interest rate compared to IT. PLT turns out to be the most expansionary strategy, similarly, in relative terms, to the case of a disinflationary demand (risk premium) shock.

Consistently with the larger expected accommodation provided by make-up strategies, the EA nominal exchange rate depreciates relatively more under PLT and AIT than under IT, limiting the fall in imported inflation.[23] The additional boost to aggregate demand makes imports increase more under PLT (and AIT) compared to IT. EA exports initially decrease in a similar way under all strategies, because EA firms temporarily raise the price of exports and offset the negative impact of lower domestic prices on overall profits. Export prices decrease slightly more in the medium run under PLT because the larger nominal exchange rate depreciation induces a slightly larger improvement in exports.

Overall, in the case of a disinflationary markup shock, make-up strategies do favor inflation stabilization when the ELB binds also through a larger exchange rate depreciation. This happens at the "cost" of a larger increase in aggregate demand and output (which are less stable reflecting the procyclicality of the strategies), leading to a larger increase in imports. Similarly to the case of a demand shock, the dynamics triggered by the negative supply shock are in line with those reported by Busetti et al. (2021).[24]

[23] The larger depreciation of the nominal exchange rate under PLT is consistent with the smaller appreciation under the same regime in the case of the risk-premium shock reported in the previous section.

[24] The sign of spillovers to the RW depends on the shock hitting the EA. On the one hand, higher EA aggregate demand increases RW exports and, thus, improves RW macroeconomic conditions. On the other hand, the dynamics of the exchange rate depends on whether the EA is hit by disinflationary demand or supply shocks, ultimately determining the responses of RW inflation and output. In case of a demand shock, make-up strategies in the EA stabilize also inflation and output in the RW mainly because of the smaller appreciation of the EA currency vis-à-vis the RW currency. Conversely, after a supply shock RW inflation and output respond more under make-up strategies in the EA than under IT because of the larger depreciation of the EA currency vis-à-vis the RW currency. Overall, the size of the spillovers is not large, because the RW is a large and closed economy relative to the EA. Results are reported in the Appendix (see Fig. A1).

4.1.3 Low import import and export price stickiness

In this section, we set the stickiness parameters in the quadratic adjustment costs on EA import and export prices to a value close to zero. The parameters (see Eq. 7 for the case of EA import prices; a similar equation holds for EA export prices) affect the extent to which, *ceteris paribus,* exchange rate movements are transmitted to import prices and ultimately to consumer prices. The smaller the parameter, the larger the direct impact of the exchange rate on import prices.

Fig. 3 reports the impulse responses of the policy rate, CPI inflation, nominal exchange rate, output, import and export inflation to the positive risk premium shock in the EA. The top row shows the dynamics under high import price stickiness (benchmark case, the responses are the same as in Fig. 1), while the bottom row reports the responses with low import price stickiness in both EA and RW.[25]

The properties of the alternative monetary policy strategies illustrated in the case of high import price stickiness carry through to the case of low import price stickiness. Specifically, AIT and PLT continue to be more effective than IT in stabilizing inflation and output at the ELB. Interestingly, low import price stickiness deteriorates the performance of the IT regime. The nominal exchange rate appreciation induces a larger decrease in import price inflation and, thus, a larger decrease in overall EA inflation. The policy rate stays for one additional period at the ELB compared to the case of high import price stickiness. The additional decrease in inflation further raises the real interest rate at the ELB and thus induces an additional decrease in aggregate demand and output.

Make-up strategies continue to show a better inflation stabilization performance than IT, based on the promise to keep the policy rate lower for longer, which exploits the strength of the (current and future expected) real interest rate channel of monetary policy and the implied lower appreciation of the nominal exchange rate. Exports and imports decrease in the short run to a larger and lesser extent (see Fig. A9 in the Appendix), respectively, than under high import price stickiness under all regimes. The size of the fall is always smaller in the case of make-up strategies, as the latter limit the nominal exchange rate appreciation (favoring exports) and the drop in EA aggregate demand (favoring imports).

A similar picture emerges in the case of a EA negative markup shock, as reported in Fig. 4.[26] Under IT, with a binding ELB and low import and export price stickiness, the nominal exchange rate appreciates in equilibrium. The appreciation is needed to balance goods and financial markets and reflects the insufficient decrease in EA current and expected future interest rates in response to the large fall in inflation when the ELB binds. As a result, the EA economy faces a larger drop in inflation if IT holds and the prices of imports and exports are relatively flexible.[27]

[25] Fig. A9 in the Appendix reports the impulse responses of the full set of macroeconomic variables under low import price stickiness and the three monetary policy strategies at study.

[26] Fig. A10 of the Appendix reports the impulse responses of the full set of macroeconomic variables under low import price stickiness and the three monetary policy strategies at study.

[27] Fig. A11 reports the spillovers to the RW of the two shocks when the import price stickiness is low. Following the EA risk premium shock, relative to the case of high import price stickiness (see Fig. A1), RW inflation

Summing up, the superior effectiveness of make-up strategies at stabilizing inflation compared to IT is confirmed and is clearer under the assumption of low import price stickiness. The implied smaller appreciation or larger depreciation of the nominal exchange rate favors inflation stabilization to a larger extent than under high import price stickiness.

4.1.4 The elasticity of substitution between domestic and imported goods

A key parameter in the transmission of aggregate demand and supply shocks and, thus, in the stabilization properties of alternative monetary policy strategies, is the intratemporal elasticity of substitution between Home and Foreign goods (labelled ϕ). This parameter governs the degree by which agents are willing to substitute domestic and foreign goods for a given change in international relative prices. It enters the consumption and investment aggregators and, hence, the corresponding demand curves and price aggregators (see Eqs. 8 and 9). Thus, we perform sensitivity analysis on ϕ. For simplicity, we analyze the stabilization role of the alternative monetary policy strategies only under low import and export price stickiness.[28]

Fig. 5 reports the impulse responses of the policy rate, CPI inflation, nominal exchange rate, output, import and export price deflator inflation to a positive risk premium shock (top row) and a negative price markup shock (bottom row) in the EA, under, alternatively, the baseline calibration of the elasticity ($\phi = 1.5$) and a larger value ($\phi = 3$).[29]

Different values of the elasticity of substitution do not substantially alter the responses of inflation, policy rate, and output under a given monetary policy strategy.

Following a risk premium shock, the degree of substitutability among Home and Foreign goods only very marginally alters the dynamics of the policy rate, CPI inflation, and nominal exchange rate, while output falls to a larger extent with a larger elasticity of substitution. Indeed, in this case EA imports (not shown) tend to increase on impact following the nominal exchange rate appreciation because of the ensuing favorable competitiveness effect, negatively contributing to EA output dynamics. The differences with respect to the benchmark calibration are stark in the case of IT, because of the larger exchange rate appreciation.[30]

Turning to the price markup shock, the bottom row of Fig. 5 shows that the performance of make-up strategies does not greatly change across the two calibrations. Instead, the stabiliza-

and output initially increase because of the appreciation of the EA currency (i.e., the depreciation of the RW currency), which induces a larger favorable competitiveness effect on RW goods. Make-up strategies continue to provide better inflation stabilization than IT. Under low import price stickiness and negative EA price markup shock, the positive response of RW inflation is amplified relative to the case of high import price stickiness. In particular this is the case under EA PLT, consistent with the larger increase in RW export implied by the larger rise in EA aggregate demand.

[28] In the case of high import and export price stickiness, results do not greatly change relative to the benchmark calibration of ϕ. Results are available upon request.

[29] Fig. A12 and A13 of the Appendix show the dynamics of the full set of macroeconomic variables to each shock.

[30] We have also simulated the case of the positive risk premium shock in the EA with alternatively the baseline calibration of the elasticity ($\phi = 1.5$) and a halved value ($\phi = 0.75$). Results (available upon request) are similar to those reported for the case of high elasticity, the only difference is that changes in exports and imports are more muted, consistently with the lower substitutability.

tion properties of IT deteriorate in the high-elasticity case. The nominal exchange rate widely appreciates under IT. Given the low import and export price stickiness, there is a large fall in import price inflation and, thus, in overall CPI inflation. The policy rate immediately hits the ELB. In equilibrium, output increases by a lower extent and inflation decreases more than under the benchmark calibration of the elasticity.

All in all, make-up strategies prove to be more effective than IT at stabilizing inflation and output, regardless of the degree of intratemporal elasticity of substitution between domestic and imported goods.

4.1.5 ERPT and the monetary policy regime

The top row of Fig. 6 reports, for the first four quarters in the case of the risk premium shock, the EA ERPT to consumer, import and export prices, measured, consistent with the literature, as the ratio of the corresponding EA price level response to the EA exchange rate response.[31] The key finding is that, consistent with the results previously illustrated, the ERPT is much lower in absolute value under make-up strategies, in particular under PLT, than under IT when the ELB holds, because the former stabilize import price and consumer price inflation rates to a larger extent than IT.

The bottom row of Fig. 6 reports the ERPT in the case of a price markup shock. [32] As for the risk-premium shock, under make-up strategies the ERPT is smaller than under IT, in absolute value terms, because EA import and consumer prices decrease less while the exchange rate depreciates more.[33]

The top row of Fig. 7 reports the EA ERPT to consumer, import and export prices in the case of the risk-premium shock and low import and export price stickiness. Consistent with the low import and export price rigidities, the ERPT is larger in absolute value than in the corresponding simulations run under the (benchmark) assumption of high import and export price stickiness. As in those simulations, make-up strategies reduce the ERPT in absolute value relative to IT by stabilizing price dynamics to a larger extent.

The bottom row of Fig. 7 reports the EA ERPT to consumer, import and export prices in the case of a price markup shock and low import and export price stickiness.[34] Consistent with

[31]The price levels are computed by cumulating the corresponding quarterly inflation rates, the nominal exchange rate by cumulating the EA nominal exchange rate quarterly changes, all in deviations from the corresponding steady-state values. We focus on the first four quarters as it is the time horizon consistent with the notion of short run. Moreover, the ERPT responses display in some cases kinks beyond the four-quarter horizon due to the exchange rate becoming very small or to the price level changing sign.

[32]For the sake of clarity and readability of the figure, the row charts of the ERPT figures do not report the case of IT with the ELB binding because responses are much larger in absolute value than in the other monetary policy regimes.

[33]The ERPT is negative because the exchange rate depreciates (the depreciation is an increase in the EA exchange rate, thus it is positive) while import prices decrease (the decrease has a minus sign, i.e., the price decreases are negative).

[34]For the sake of clarity and readability of the figure, the row charts of the ERPT figures do not report the case of IT with the ELB binding because responses are much larger in absolute value than in the other monetary policy regimes.

the low import and export price rigidities, the ERPT is larger in absolute value than in the corresponding simulations run under the assumption of high import and export price stickiness. As in those simulations, make-up strategies reduce the absolute value of the ERPT relative to IT when the ELB holds by stabilizing price dynamics to a larger extent.

Fig. 8 shows the EA ERPT under the assumption of low import and export price stickiness and high elasticity of substitution among tradables (the calibration is the same as in Section 4.1.4). Results are similar to those reported in Fig. 7.

Overall, our results on ERPT are in line with and complement those by Forbes et al. (2018) and Corsetti et al. (2008). ERPT is not only shock-dependent but also monetary policy-regime dependent.

4.2 Moment-based analysis

We have so far evaluated the stabilization properties of make-up strategies *conditional* on the realization of a specific shock. We now assess how they perform relative to IT when the economy is buffeted by both demand and supply shocks, by resorting to stochastic simulations.

We assume that in each period households and firms are surprised by a new realization of both shocks, and do not expect further disturbances in the future. Hence, in each period they are surprised by a new mix of shocks' realizations. As discussed in Section 3, and similarly to Busetti et al. (2021), we set the variance of the shocks such that (i) under IT, the policy rate is at its ELB about 20% of the time, and (ii) the standard deviation of output growth and inflation, as well as other macroeconomic variables, is in line with empirical evidence for the euro area.[35]

We assess the performance of each monetary policy regime by comparing the following measures: i) the mean probability (frequency) and duration of ELB episodes; ii) the mean and standard deviations of annualized inflation (consumption deflator, import and export deflators) and annualized policy rate; iii) the standard deviations of the nominal exchange rate quarterly change and of the quarterly growth rates of output, consumption, investment, exports, and imports.

4.2.1 Benchmark calibration

Table 4 reports the simulated moments for the benchmark calibration. The third column depicts the hypothetical case of IT when the ELB is not allowed to bind, which serves as a benchmark case. The remaining cases allow for the ELB under alternatively: i) IT (fourth column); ii) AIT (fifth column); iii) PLT (sixth column).[36]

[35]We feed the model with the exact same realizations of shocks under the alternative monetary policy strategies. The standard deviation of the shocks is reported in Table 2. We run the simulations over 500 samples, with each sample having a length of 200 quarters. After discarding the first 100 quarters as burn-in, we compute statistics from the simulated samples.

[36]Note that the moments reported in the third column of Table 4 (under IT without the ELB) are slightly different from the corresponding theoretical moments shown in Table 3. Indeed, while the former are obtained

The following results emerge. First, as expected, the presence of the ELB prevents a complete inflation stabilization under IT, as testified by the lower mean and higher standard deviation of inflation. The nominal exchange rate and the import price inflation rate are correspondingly more volatile. Second, make-up strategies reduce both the probability and duration of ELB episodes. As a consequence, CPI inflation is closer to target under AIT than under IT, and it is kept at target under PLT (by construction). Inflation volatility is likewise reduced under make-up strategies. AIT and PLT also deliver less volatility of the exchange rate and thus of imported goods inflation. Finally, make-up strategies reduce the volatility of real variables, including imports and exports.

4.2.2 Low import and export price stickiness

We then turn to the case of low import and export price stickiness. Table 5 reports the results. Not surprisingly, the main difference relative to the benchmark case of high import and export price stickiness (Table 4) lies in the largely higher volatility of inflation rates. The frequency and duration of ELB episodes is also higher and the undershooting of inflation under IT and AIT is more pronounced, while PLT still manages to keep it at 2%. The nominal exchange rate is only slightly more volatile, while the differences in volatility are larger as regards real macroeconomic variables. Despite these effects, the main takeaways from our analysis carry through. While a lower price stickiness reduces their relative gains in terms of frequency and duration of ELB episodes compared to IT, make-up strategies still provide better macroeconomic stabilization.

All in all, we confirm and support the findings highlighted by the impulse responses analysis. Make-up strategies entail better inflation stabilization properties than IT, in particular by reducing the frequency and time in which the policy rate is constrained by the ELB and the corresponding effects on inflation and economic activity. This is especially true under PLT which is able to better stabilize inflation and output than both AIT and IT. It must be said that the superiority of PLT rests on the dominance of demand over supply shocks. If the opposite were true, then the procyclicality of PLT would still be effective in stabilizing inflation but at the cost of higher real output instability. These results are in line with those for closed economies (e.g., Busetti et al., 2021) and, in addition, show that make-up strategies are also more effective than IT at reducing the volatility of both nominal and real variables related to the open-economy dimension.

4.2.3 Hybrid inflation expectations

We have so far assumed that households and firms form their expectations, in particular inflation expectations, in a rational fashion, meaning that they are formed in a model-consistent way, i.e., efficiently using all the available information and consistently with the model, and are inherently

---

by simulating 500 artificial samples of length 200 quarters, the latter are the theoretical moments obtained by solving the model in the absence of the ELB.

forward-looking. Under such assumption, inflation expectations swiftly incorporate the implicit forward guidance embedded in make-up strategies, which promise an accommodative stance, i.e. a lower-for-longer monetary policy rate, after disinflationary demand or supply shocks.

In order to shed light on the role of inflation expectations in our open-economy setting, following Gelain et al. (2019) and Busetti et al. (2021), we depart from the rational expectations assumption and employ a "hybrid" form of inflation expectations. We focus on expectations about CPI inflation because it is the central bank's objective. In particular, we consider hybrid expectations, i.e., each period agents' expectations over next period's CPI inflation rate, $\hat{E}_t\pi_{t+1}$, are a weighted average of two terms:

$$\hat{E}_t\pi_{t+1} = \omega F_t\pi_{t+1} + (1-\omega)E_t\pi_{t+1}, \tag{14}$$

where F_t and E_t represent the adaptive and rational (i.e., model-consistent) expectations, respectively. Parameter ω $(0 \leq \omega \leq 1)$ is the weight of the adaptive component and can be interpreted as the fraction of households who employ the adaptive forecast rule for inflation. When $\omega = 0$, expectations collapse to the standard fully-rational case.

Adaptive expectations are formed according to

$$F_t\pi_{t+1} = F_{t-1}\pi_t + \lambda_\pi(\pi_t - F_{t-1}\pi_t), \tag{15}$$

where λ_π $(0 < \lambda_\pi \leq 1)$ captures the response to the most recent forecast error of inflation. When $\lambda_\pi = 1$, households employ a simple random walk forecast rule. We assume a non-negligible weight of adaptive expectations by setting $\omega = 0.20$ and also assume that agents attach a large weight to forecast errors by calibrating $\lambda_\pi = 0.90$.[37]

Table 6 reports the simulated moments when inflation expectations are hybrid. The impulse-response analysis is reported in the Appendix.[38] Relative to the case of model-consistent expectations, the backward-looking component of inflation expectations induces more frequent and long-lasting ELB episodes under all monetary policy strategies. The relative gains of make-up strategies with respect to IT are somewhat smaller than in the benchmark case. The stabilization properties of make-up strategies are qualitatively preserved. Under AIT and PLT, CPI inflation is closer to or exactly at the target, and the standard deviation of both nominal and real variables is generally reduced relative to IT (when the ELB is allowed to bind). Such differences are, however, smaller compared to the benchmark case of fully rational (forward-looking) inflation expectations.

[37]This calibration ensures the smallest possible deviation from the fully rational expectations solution that generates non-negligible effects, while also preserving the numerical feasibility of the solution with hybrid expectations.

[38]The calibration of the parameters governing the expectation formation process (equations 14 and 15 in the text) is the same as for the impulse response analysis, reported in the Appendix (see Figs. A2–A8). The shocks realizations used in the simulation are the same used in the case of rational expectations.

5 Conclusions

We have evaluated the macroeconomic stabilization properties, with particular reference to the ERPT, of make-up strategies, by simulating the canonical two-country New Keynesian model, in which the LCP assumption holds and the ELB may be binding with a non-negligible probability.

According to our results, make-up strategies (PLT and AIT) stabilize inflation better than IT, by favoring a smaller appreciation (larger depreciation) of the nominal exchange rate in the event of disinflationary demand (supply) shocks. The ERPT to import prices is more limited under make-up strategies than under IT, as the former stabilize the inflation rate of imports to a greater extent. Moreover, the results are robust to alternative values of import price stickiness and elasticity of substitution between domestic and imported goods. Finally, the stabilization properties of make-up strategies are qualitatively preserved under partially backward-looking inflation expectations, although the relative gains of make-up strategies with respect to IT are smaller than under model-consistent inflation expectations.

In our analysis we have focused on make-up strategies and ERPT in a single open economy where the ELB limits policy rate movements. The interaction among the strategies, ERPT, and the ELB can be considered when both make-up strategies and the ELB hold simultaneously in more than one country. Their implications for international monetary policy coordination could be examined. We leave these issues to future research.

References

Adolfson, M., Laseen, S., Linde, J., and Villani, M. (2007). Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics*, 72(2):481–511.

Amano, R. and Shukayev, M. (2012). Risk Premium Shocks and the Zero Bound on Nominal Interest Rates. *Journal of Money, Credit and Banking*, 44(8):1475–1505.

Azcona, N. (2018). Can Price-Level Targeting Reduce Exchange Rate Volatility? *Eastern Economic Journal*, 44(3):400–436.

Balfoussia, H., Dellas, H., Papageorgiou, D., and Vourvachaki, E. (2021). How does the ZLB affect the properties of alternative exchange rate systems? *Oxford Economic Papers*, 73(4):1404–1426.

Benigno, P. (2009). Price Stability with Imperfect Financial Integration. *Journal of Money, Credit and Banking*, 41(s1):121–149.

Bernanke, B. S., Kiley, M. T., and Roberts, J. M. (2019). Monetary Policy Strategies for a Low-Rate Environment. Finance and Economics Discussion Series 2019-009, Board of Governors of the Federal Reserve System (US).

Brand, C., Bielecki, M., and Penalver, A. (2018). The natural rate of interest: estimates, drivers, and challenges to monetary policy. Occasional Paper Series 217, European Central Bank.

Burlon, L., Notarpietro, A., and Pisani, M. (2018). Exchange rate pass-through into euro area inflation. An estimated structural model. Temi di discussione (Economic working papers) 1192, Bank of Italy, Economic Research and International Relations Area.

Busetti, F., Neri, S., Notarpietro, A., and Pisani, M. (2021). Monetary policy strategies in the New Normal: A model-based analysis for the euro area. *Journal of Macroeconomics*, 70(C).

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12(3):383–398.

Coenen, G., Montes-Galdón, C., and Schmidt, S. (2021). Macroeconomic stabilisation and monetary policy effectiveness in a low-interest-rate environment. Working Paper Series 2572, European Central Bank.

Corsetti, G., Dedola, L., and Leduc, S. (2008). High exchange-rate volatility and low pass-through. *Journal of Monetary Economics*, 55(6):1113–1128.

Dedola, L. and Leduc, S. (2001). Why Is the Business-Cycle Behaviour of Fundamentals Alike across Exchange-Rate Regimes? *International Journal of Finance & Economics*, 6(4):401–419.

Dib, A., Mendicino, C., and Zhang, Y. (2013). Price-level targeting rules and financial shocks: The case of Canada. *Economic Modelling*, 30(C):941–953.

Eggertsson, G. B. and Woodford, M. (2003). The zero bound on interest rates and optimal monetary policy. *Brookings Papers on Economic Activity*, 2003(1):139–211.

Erceg, C. J., Jakab, Z., and Lindé, J. (2021). Monetary policy strategies for the european central bank. *Journal of Economic Dynamics and Control*, page 104211.

Fagan, G., Henry, J., and Mestre, R. (2001). An area-wide model (AWM) for the euro area. Working Paper Series 42, European Central Bank.

Fisher, J. D. (2015). On the Structural Interpretation of the Smets–Wouters "Risk Premium" Shock. *Journal of Money, Credit and Banking*, 47(2-3):511–516.

Forbes, K., Hjortsoe, I., and Nenova, T. (2018). The shocks matter: Improving our estimates of exchange rate pass-through. *Journal of International Economics*, 114(C):255–275.

Gelain, P., Iskrev, N., J. Lansing, K., and Mendicino, C. (2019). Inflation dynamics and adaptive expectations in an estimated DSGE model. *Journal of Macroeconomics*, 59(C):258–277.

Neri, S. and Gerali, A. (2017). Natural rates across the Atlantic. Temi di discussione (Economic working papers) 1140, Bank of Italy, Economic Research and International Relations Area.

Rotemberg, J. J. (1982). Monopolistic Price Adjustment and Aggregate Output. *Review of Economic Studies*, 49(4):517–31.

Schmitt-Grohe, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61(1):163–185.

Svensson, L. E. (2006). Monetary Policy and Japan's Liquidity Trap. Working Paper Series 126, CEPS.

Warne, A., Coenen, G., and Christoffel, K. (2008). The new area-wide model of the euro area: a micro-founded open-economy model for forecasting and policy analysis. Working Paper Series 944, European Central Bank.

Table 1: Steady-state equilibrium

Variable	EA	RW
Monetary policy		
Inflation rate (400*($\overline{\pi}$-1))	2.0	2.0
Nominal interest rate (400*($\overline{R}$-1))	2.1	2.1
Real interest rate	0.1	0.1
National accounts		
Private consumption	60.0	60.0
Public consumption	20.0	20.0
Investment	20.0	20.0
Imports of consumption goods	11.0	2.75
Imports of investment goods	5.0	1.25
Trade balance	0.0	0.0
Net foreign asset position	0.0	0.0
Share of world GDP	20.0	80.0

Note: inflation and interest rates are reported as net annualized percentage point values. Other variables as % of GDP.

Table 2: Calibration

Parameter	Value
Monetary policy	
Interest rate smoothing (ρ_r)	0.867
Response to inflation under IT (ρ_π)	1.9
Response to price level under PLT (ρ_p)	1.9
Response to average inflation under AIT (ρ_π^{avg})	1.9
Response to output growth (ρ_y)	0.15
Preferences	
Elasticity of intertemporal substitution ($1/\sigma$)	1
Discount factor (β)	0.9998
Habit in consumption (b_c)	0.57
Frisch elasticity of labor supply ($1/\zeta$)	0.667
EA net foreign asset position premium ($\phi_{b,1}$, $\phi_{b,2}$)	0.01
EA home bias in consumption good (γ_H)	0.82
EA home bias in investment good ($\gamma_{H,I}$)	0.75
RW home bias in consumption good (γ_F)	0.95
RW home bias in investment good ($\gamma_{F,I}$)	0.94
Intratemporal elasticity of substitution between domestic and imported goods (ϕ)	1.5
Technology	
Share of capital in production (α)	0.53
Capital depreciation rate (δ)	0.025
Investment adjustment cost (ψ)	3.0
Elasticity of substitution among brands (θ_H, θ_F)	6.0
Elasticity of substitution among labor varieties (θ_w)	4.3
Nominal rigidities	
Price stickiness domestic goods (Rotemberg, κ_H^p, κ_F^p)	120
Price stickiness exported goods (Rotemberg, κ_H^{p*}, κ_F^{p*})	120
Wage stickiness (Rotemberg, κ_W, κ_W^*)	300
Price indexation to previous-period inflation ($\alpha_H, \alpha_F, \alpha_H^*, \alpha_F^*$)	0.40
Wage indexation to previous-period inflation (α_w, α_w^*)	0.64
EA shock persistence (AR(1) coefficient)	
Risk premium to return on domestic bond	0.9
Price markup	0.9
EA shock standard deviation	
Risk premium to return on domestic bond	0.4
Price markup	2.2

Note: calibration is the same for EA and RW unless otherwise stated.

Table 3: Standard deviations of selected variables

	Data	Model
Short-term interest rate	1.82	2.92
Consumption deflator	0.31	0.62
Import deflator	2.12	0.68
Export deflator	1.26	0.19
GDP	0.60	0.88
Consumption	0.42	1.11
Investment	1.41	2.53
Exports	2.50	0.33
Imports	1.96	1.54
Nominal effective exchange rate	2.41	2.50

Note: For deflators, nominal exchange rate, GDP and its components we report the quarterly percent changes. Model-based GDP (output) and its components are computed at steady-state relative prices (real terms). Interest rate in annualized percentage points. Data moments refer to the period 1995-2014 (before the ELB on the EA policy rate started binding) and are from the Area Wide Model dataset, except for imports and exports (both growth rates and deflators) for which we exclude intra-EA trade flows.

Table 4: Simulated moments: benchmark calibration

		IT (without ELB)	IT	AIT	PLT
ELB	Frequency	21.8	19.0	13.8	15.7
	Duration	5.18	4.34	2.96	3.60
Policy rate	Mean (r)	2.29	2.93	2.45	2.35
	$\sigma\,(r)$	2.45	2.27	1.66	1.69
Nominal exchange rate	$\sigma\,(\Delta s)$	2.53	4.69	3.57	1.92
Import deflator	Mean (π_F)	2.10	0.86	1.66	2.00
	$\sigma\,(\pi_F)$	2.54	5.19	3.37	0.98
Consumption deflator	Mean (π)	2.10	0.86	1.65	2.00
	$\sigma\,(\pi)$	2.33	4.81	3.12	0.73
Export deflator	Mean (π_H^*)	2.00	2.00	1.99	1.99
	$\sigma\,(\pi_H^*)$	0.74	1.10	0.86	0.70
Output	$\sigma\,(\Delta Y)$	0.90	1.26	1.19	0.75
Consumption	$\sigma\,(\Delta C)$	1.13	1.96	1.63	0.92
Investment	$\sigma\,(\Delta I)$	2.55	5.05	3.76	2.43
Exports	$\sigma\,(\Delta Y_H^*)$	0.32	0.42	0.36	0.31
Imports	$\sigma\,(\Delta Y_F)$	1.57	2.24	2.03	1.42

IT: inflation targeting; AIT: average inflation targeting; PLT: price level targeting. ELB Frequency: frequency of ELB episodes (% of simulated periods); ELB Duration: mean duration of ELB (quarters). For output and its components we report the quarterly changes. Output and its components are computed at steady-state relative prices (real terms). For deflators we report the annualized quarterly changes (i.e., annualized inflation rate in pp, $\pi = 400 * (\Pi - 1)$); for the nominal exchange rate we report the quarterly change in pp. Policy rate in annualized pp ($r = 400 * (R - 1)$); $\sigma(x)$: standard deviation of variable x.

Table 5: Simulated moments: low import and export price stickiness

		IT (without ELB)	IT	AIT	PLT
ELB	Frequency	23.1	19.3	15.4	17.3
	Duration	5.31	4.30	3.38	4.05
Policy rate	Mean (r)	2.29	3.03	2.48	2.38
	$\sigma\,(r)$	2.58	2.37	1.74	1.77
Nominal exchange rate	$\sigma\,(\Delta s)$	2.45	5.08	3.70	1.93
Import deflator	Mean (π_F)	2.12	0.37	1.51	2.01
	$\sigma\,(\pi_F)$	4.09	9.25	6.22	2.06
Consumption deflator	Mean (π)	2.10	0.38	1.47	2.00
	$\sigma\,(\pi)$	2.62	6.21	3.90	0.91
Export deflator	Mean (π_H^*)	2.00	2.03	2.00	1.99
	$\sigma\,(\pi_H^*)$	1.43	3.51	2.21	1.28
Output	$\sigma\,(\Delta Y)$	0.94	1.41	1.29	0.79
Consumption	$\sigma\,(\Delta C)$	1.08	2.12	1.64	0.92
Investment	$\sigma\,(\Delta I)$	2.59	5.51	3.79	2.60
Exports	$\sigma\,(\Delta Y_H^*)$	0.57	1.27	0.84	0.52
Imports	$\sigma\,(\Delta Y_F)$	1.49	2.04	1.68	1.53

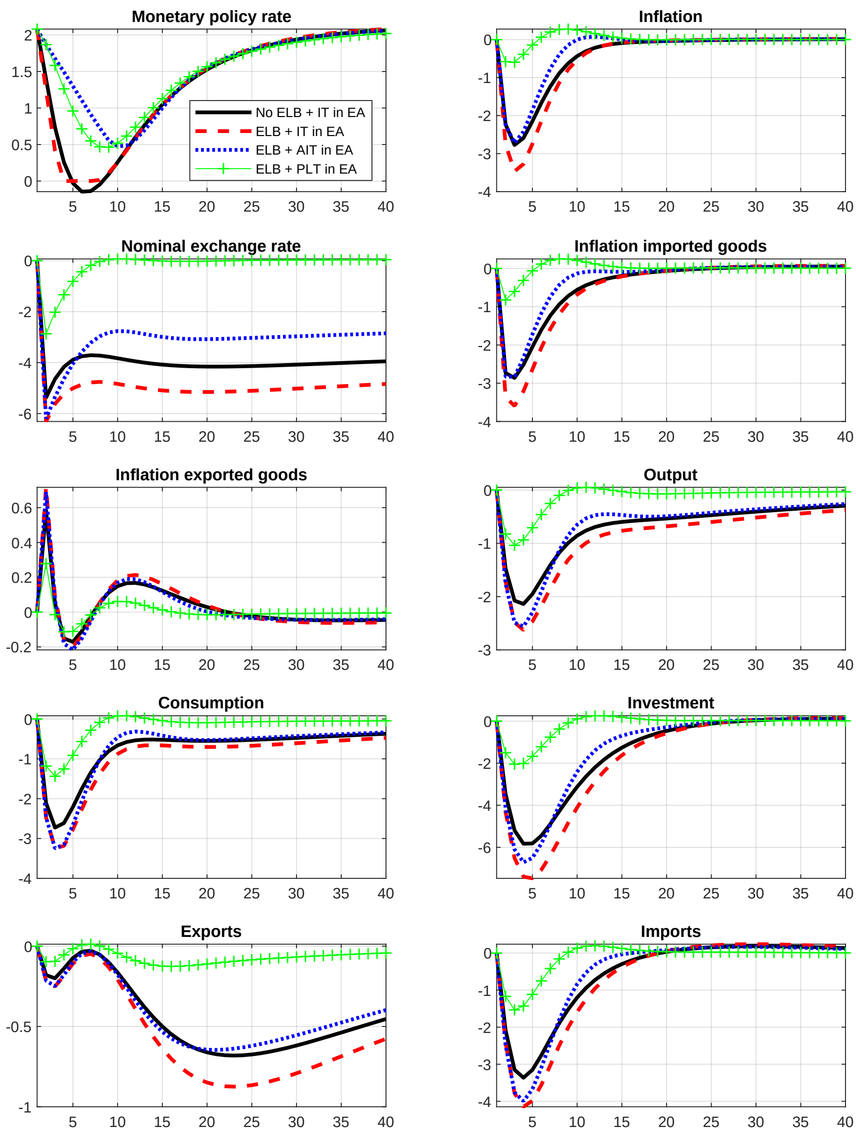
IT: inflation targeting; AIT: average inflation targeting; PLT: price level targeting. ELB Frequency: frequency of ELB episodes (% of simulated periods); ELB Duration: mean duration of ELB (quarters). For output and its components we report the quarterly changes. Output and its components are computed at steady-state relative prices (real terms). For deflators we report the annualized quarterly changes (i.e., annualized inflation rate in pp, $\pi = 400 * (\Pi - 1)$); for the nominal exchange rate we report the quarterly change in pp. Policy rate in annualized pp ($r = 400 * (R - 1)$); $\sigma(x)$: standard deviation of variable x.

Table 6: Simulated moments: hybrid expectations

		IT (without ELB)	IT	AIT	PLT
ELB	Frequency	22.8	19.6	15.2	17.1
	Duration	5.41	4.52	3.27	3.94
Policy rate	Mean (r)	2.31	2.93	2.52	2.37
	$\sigma\,(r)$	2.57	2.31	1.75	1.76
Nominal exchange rate	$\sigma\,(\Delta s)$	2.47	4.46	3.86	1.93
Import deflator	Mean (π_F)	2.11	0.97	1.46	2.00
	$\sigma\,(\pi_F)$	2.73	4.86	4.13	1.10
Consumption deflator	Mean (π)	2.11	1.01	1.45	2.00
	$\sigma\,(\pi)$	2.51	4.48	3.84	0.84
Export deflator	Mean (π_H^*)	2.00	2.05	1.99	1.99
	$\sigma\,(\pi_H^*)$	0.81	1.12	1.05	0.77
Output	$\sigma\,(\Delta Y)$	0.91	1.15	1.25	0.76
Consumption	$\sigma\,(\Delta C)$	1.14	1.79	1.80	0.93
Investment	$\sigma\,(\Delta I)$	2.55	3.92	4.18	2.48
Exports	$\sigma\,(\Delta Y_H^*)$	0.35	0.42	0.42	0.34
Imports	$\sigma\,(\Delta Y_F)$	1.59	1.97	2.12	1.45

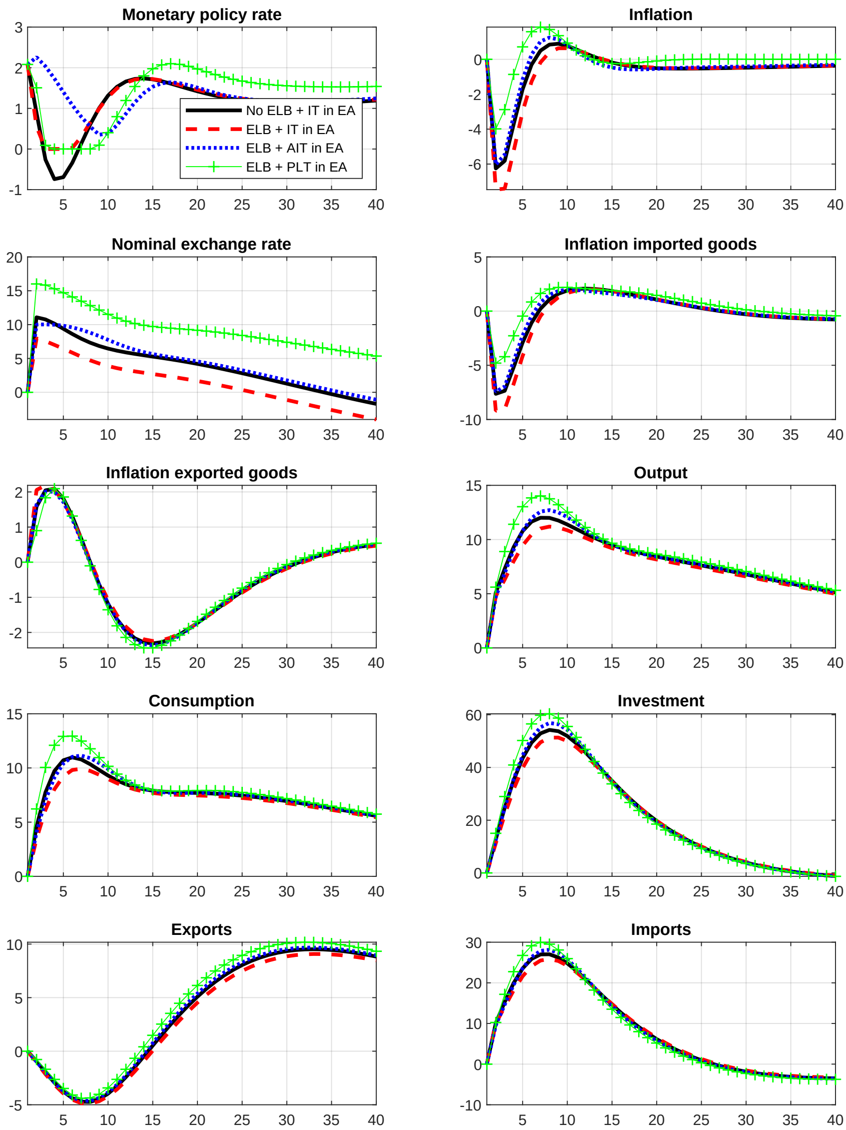
IT: inflation targeting; AIT: average inflation targeting; PLT: price level targeting. ELB Frequency: frequency of ELB episodes (% of simulated periods); ELB Duration: mean duration of ELB (quarters). For output and its components we report the quarterly changes. Output and its components are computed at steady-state relative prices (real terms). For deflators we report the annualized quarterly changes (i.e., annualized inflation rate in pp, $\pi = 400 * (\Pi - 1)$); for the nominal exchange rate we report the quarterly change in pp. Policy rate in annualized pp ($r = 400 * (R - 1)$); $\sigma(x)$: standard deviation of variable x.

Figure 1: Positive EA risk premium shock.



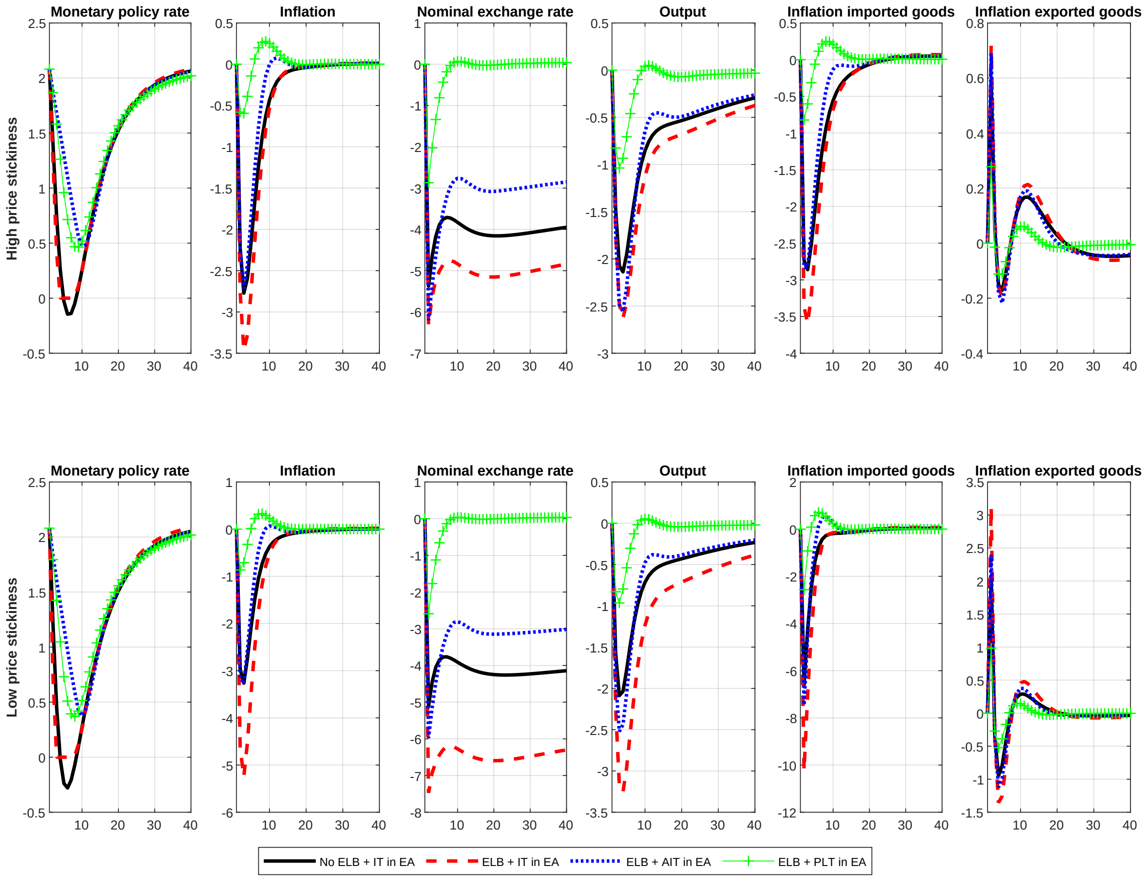
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure 2: Negative EA price markup shock.



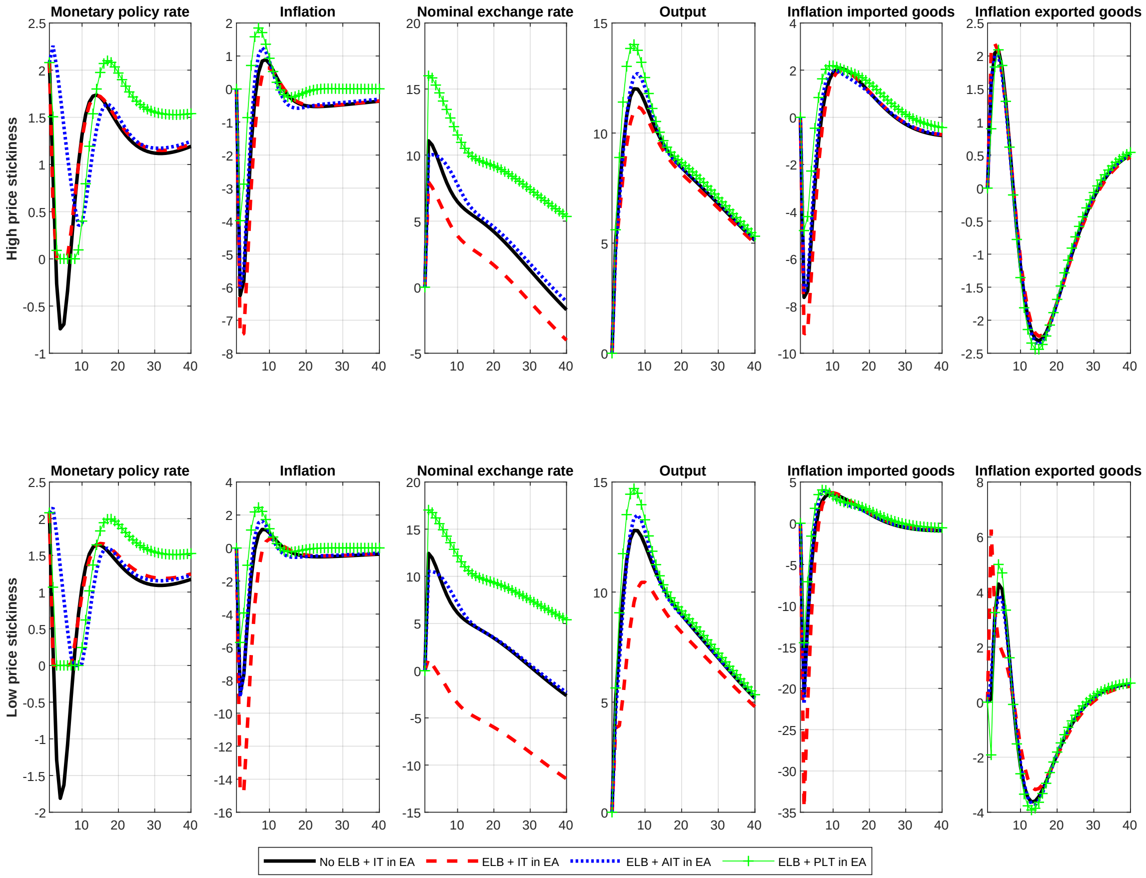
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure 3: Positive EA risk premium shock: high vs low import and export price stickiness.



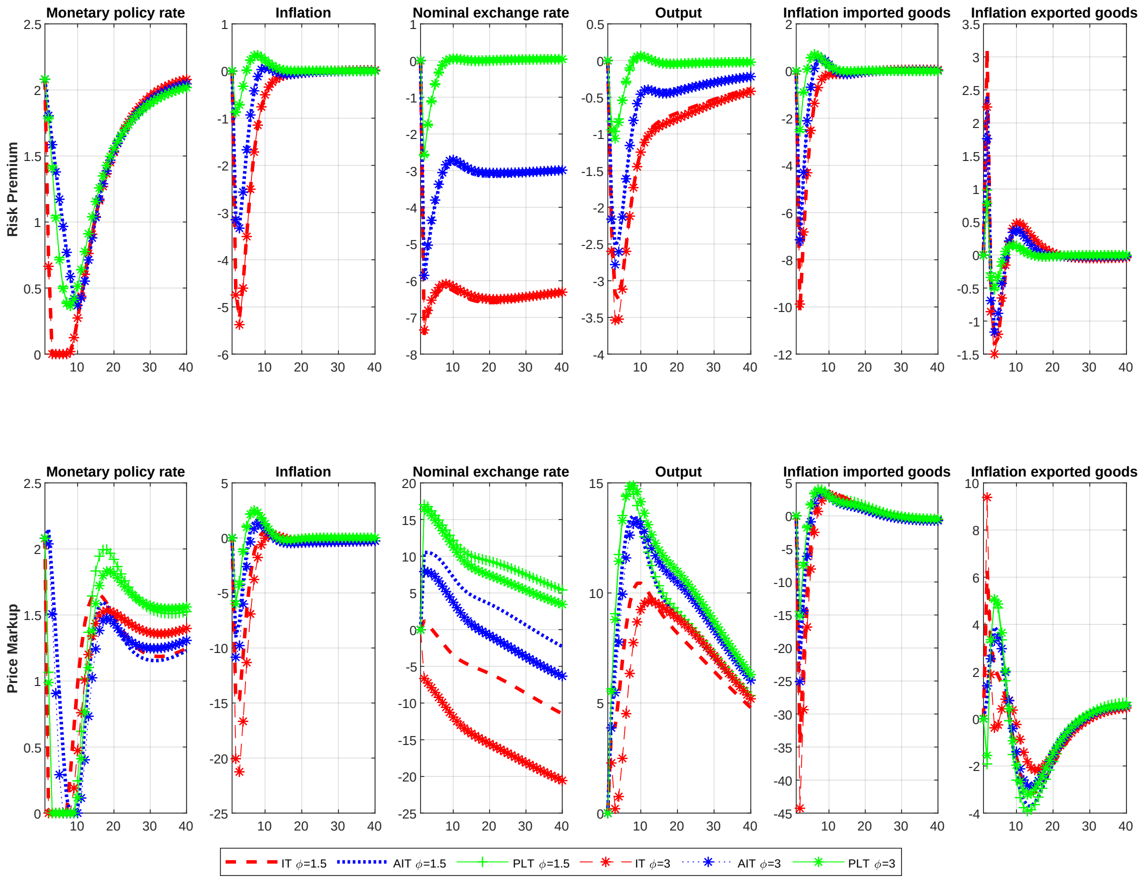
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation. Top row: high import and export price nominal rigidities. Bottom row: low import and export price nominal rigidities.

Figure 4: Negative EA price markup shock: high vs. low import and export price stickiness



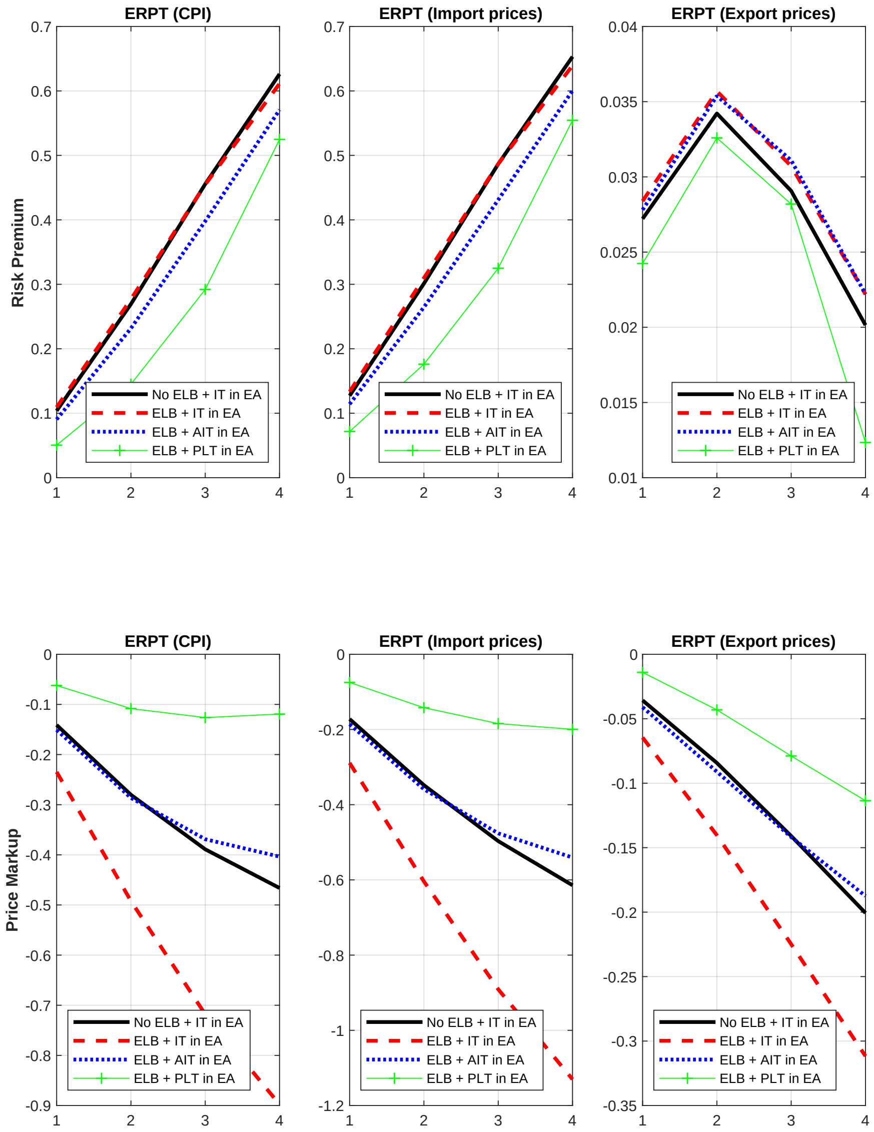
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation. Top row: high import and export price nominal rigidities. Bottom row: low import and export price nominal rigidities.

Figure 5: EA risk premium shock, price markup shock and ELB - low import and export price stickiness: baseline vs higher intratemporal elasticity of substitution between traded goods.



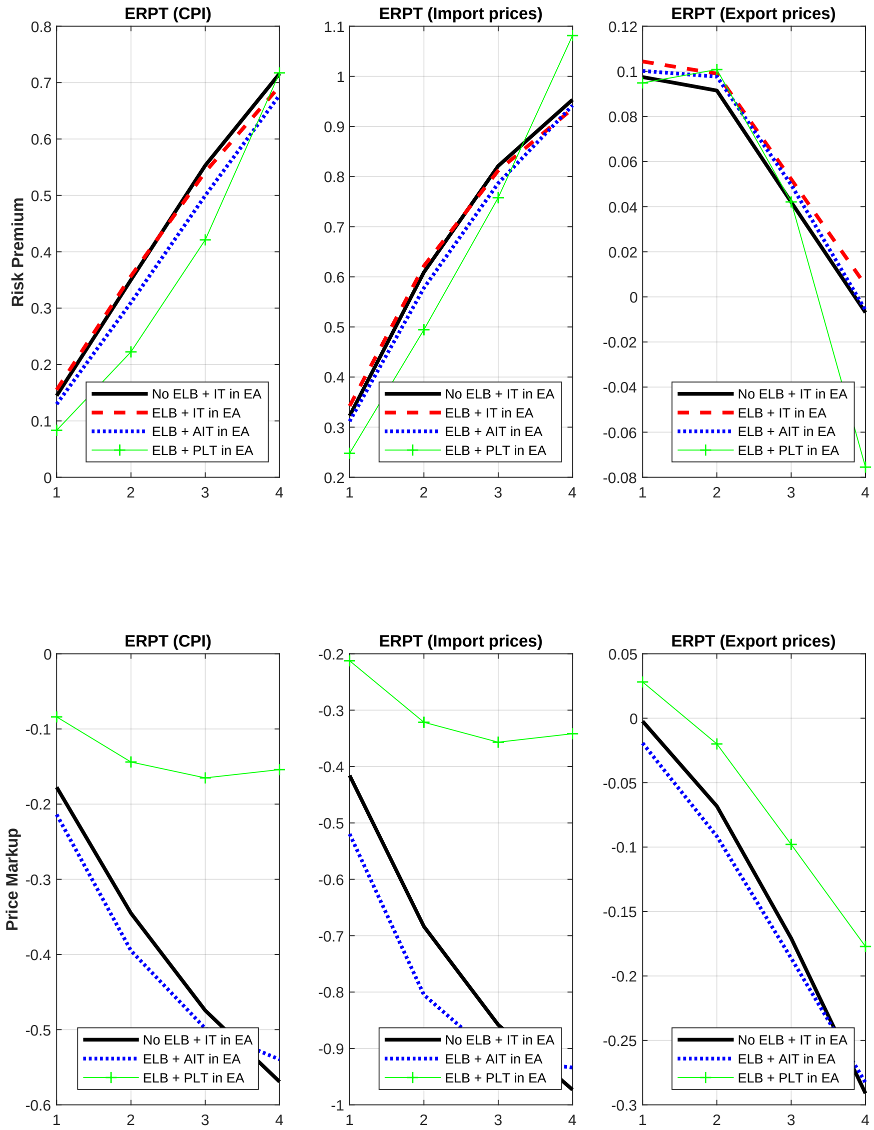
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure 6: ERPT: benchmark calibration.



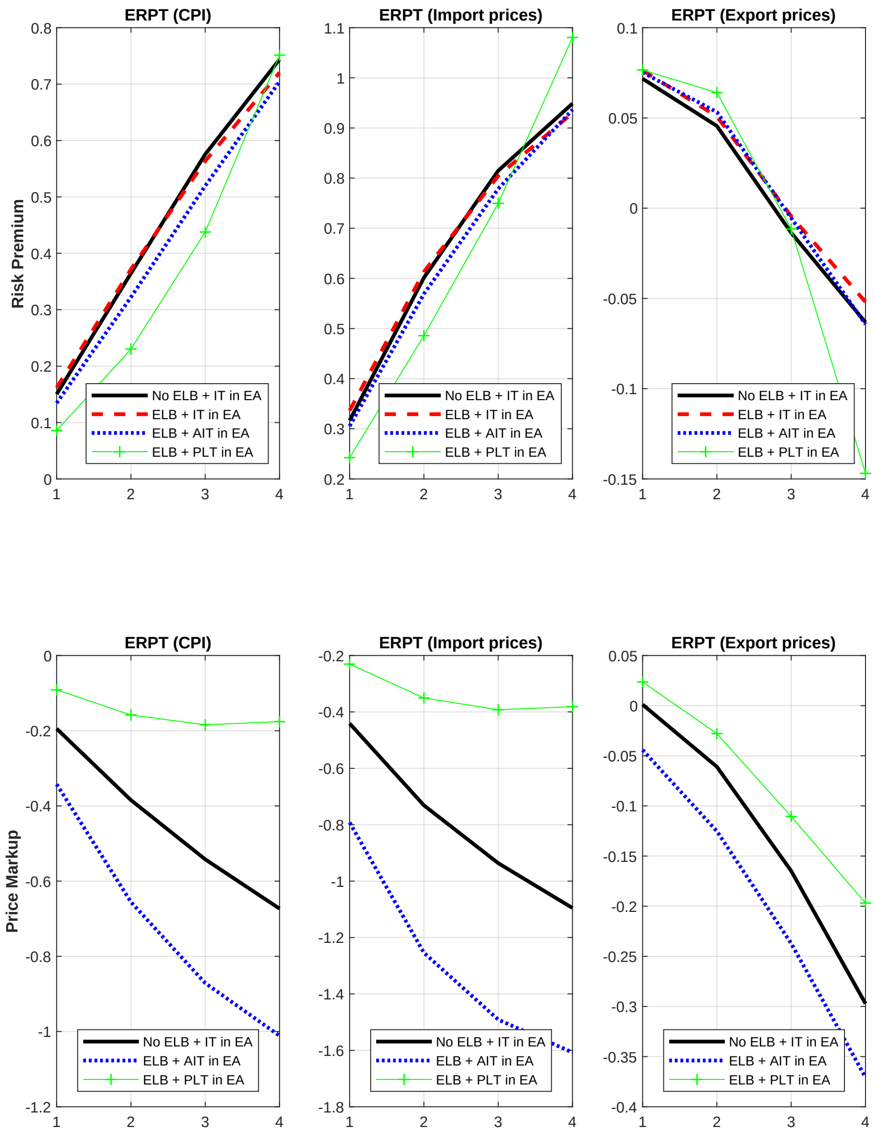
Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level.

Figure 7: ERPT with low import and export price stickiness.



Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level. For the sake of clarity and readability of the figure, the bottom row (price markup shock) does not report the case of IT with the ELB binding because responses are much larger in absolute value than in the other cases. Results are available upon request.

Figure 8: ERPT with low import and export price stickiness and higher intratemporal elasticity of substitution between traded goods.



Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level. For the sake of clarity and readability of the figure, the bottom row (price markup shock) does not report the case of IT with the ELB binding because responses are much larger in absolute value than in the other cases. Results are available upon request.

Appendix

A Model setup

The model is an open economy, New Keynesian framework. It is composed of two regions: Home (H) and Foreign (F). The size of the world economy is normalized to 1. Home and Foreign countries have sizes equal to n, and $(1-n)$, respectively, with $0 < n < 1$. For each region, the size refers to the overall households' population and to the number of firms operating in each sector (intermediate tradable, final nontradable consumption, final nontradable investment). Each region has a central bank that sets the nominal interest rate according to a standard Taylor rule, and reacts to domestic consumer price inflation and real output growth. Nominal wages are sticky.

Households consume a final good, which is a composite of intermediate tradable goods. Intermediate tradables are domestically produced or imported. All households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive labor markets, as they charge a wage markup over their marginal rate of substitution between consumption and leisure.

Home households trade two bonds. One is traded domestically, and is denominated in domestic currency. The other is internationally traded, and is denominated in Foreign currency. The related first order conditions imply that an uncovered interest parity condition holds, linking the differential between Home and Foreign monetary policy rates to the expected depreciation of the exchange rate of the Home currency vis-à-vis the Foreign currency.

On the production side there are firms that, under perfect competition, produce two final manufacturing goods (consumption and investment goods), and firms that, under monopolistic competition, produce intermediate (internationally) tradable goods.

The final (consumption and investment) goods are sold domestically and are produced combining all available intermediate goods using a constant-elasticity-of-substitution (CES) production function. The two resulting bundles can have different compositions. Intermediate tradable goods are produced combining capital and labor, supplied by the domestic households.

Given the assumption of differentiated intermediate goods, firms have market power, are price-setters and restrict output to create excess profits. Intermediate tradable goods can be sold domestically and abroad. It is assumed that markets for tradable goods are segmented, so that firms can set a different price in each of the two regions.

In line with other dynamic general equilibrium models of the EA (see, among the others, Christoffel et al., 2008 and Gomes et al., 2010), we include adjustment costs on real and nominal variables, ensuring that consumption, production, wages, and prices react in a gradual way to a given shock. On the real side, habits and quadratic costs prolong the adjustment of consumption and investment, respectively. On the nominal side, quadratic costs make wages and prices sticky.[39]

A.1 Firms

In what follows, we initially show the final good sectors (private consumption good, investment good, public consumption good). Thereafter, the intermediate good sector. We report only equations for Home. Similar equations hold for Foreign. We explicitly state when this is not the case.[40]

A.1.1 Final private consumption good

There is a continuum of symmetric Home firms producing final nontradable consumption goods under perfect competition. Each firm producing the consumption good is indexed by $x \in (0, n]$, where the parameter $0 < n < 1$ measures the size of H. Firms in F are indexed by $x^* \in (n, 1-n]$. The CES production technology used by the generic firm x is

$$C_t(x) \equiv \left[\gamma_H^{\frac{1}{\phi}} C_{H,t}(x)^{\frac{\phi-1}{\phi}} + (1-\gamma_H)^{\frac{1}{\phi}} C_{F,t}(x)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \qquad (16)$$

where C_H and C_F are bundles of, respectively, intermediate tradables produced in Home and Foreign country. The parameter $\phi > 0$ is the elasticity of substitution between domestic and imported tradable goods. The parameter γ_H $(0 < \gamma_H < 1)$ is the weight of the Home tradable.

The domestically-produced manufacturing good for consumption purposes C_H is a composite basket of a continuum of differentiated intermediate goods, each supplied by a different Home firm h operating in the intermediate sector. It is produced according to the following function:

$$C_{H,t}(x) = \left[\left(\frac{1}{n}\right)^{\theta_H} \int_0^n C_{H,t}(h, x)^{\frac{\theta_H - 1}{\theta_H}} dh\right]^{\frac{\theta_H}{\theta_H - 1}}, \qquad (17)$$

where $\theta_H > 1$ being the elasticity of substitution among Home-produced intermediate brands h used as inputs by the firms x.

The basket of imported Foreign goods has a structure similar to that of Home goods, i.e.,

$$C_{F,t}(x) = \left[\left(\frac{1}{1-n}\right)^{\theta_F} \int_n^1 C_{F,t}(f, x)^{\frac{\theta_F - 1}{\theta_F}} df\right]^{\frac{\theta_F}{\theta_F - 1}}, \qquad (18)$$

where $\theta_F > 1$ is the elasticity of substitution among Foreign intermediate brands.

[39] See Rotemberg (1982).

[40] For a detailed description of the main features of the model see also Pesenti (2008), which provides a description of the GEM (the International Monetary Fund Global Economy Model).

Firm x's demand for the generic brand h is

$$C_{H,t}\left(h,x\right)=\frac{1}{n}\gamma_{H}\left(\frac{P_{H,t}(h)}{P_{H,t}}\right)^{-\theta_{H}}\left(\frac{P_{H,t}}{P_{t}}\right)^{-\phi}C_{t}\left(x\right), \tag{19}$$

where

$$P_{H,t}=\left[\int_{0}^{n}P_{H,t}\left(h\right)^{1-\theta_{H}}dh\right]^{\frac{1}{1-\theta_{H}}} \tag{20}$$

$$P_{t}=\left[\gamma_{H}P_{H,t}^{1-\phi}+\left(1-\gamma_{H}\right)P_{F,t}^{1-\phi}\right]^{\frac{1}{1-\phi}}, \tag{21}$$

are the price deflators of Home goods consumption bundle and overall consumption bundle, respectively. An equation similar to the price deflator of the H goods consumption bundle holds for the price deflator of the imported (i.e., Foreign) goods.

A.1.2 Final investment good

The production of the investment good is similar to that of the consumption bundle. There are symmetric Home firms under perfect competition indexed by $i\in(0,n]$. Output of the generic Home firm i is

$$I_{t}\left(i\right)\equiv\left[\gamma_{H,I}^{\frac{1}{\phi}}I_{H,t}\left(i\right)^{\frac{\phi-1}{\phi}}+\left(1-\gamma_{H,I}\right)^{\frac{1}{\phi}}I_{F,t}\left(i\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \tag{22}$$

where I_H and I_F are bundles of intermediate tradables produced in Home and F, respectively. The parameter $\phi>0$ is the elasticity of substitution among tradable goods. The parameter $\gamma_{H,I}$ $(0<\gamma_{H,I}<1)$ is the weight of the Home tradables.

The investment good I_H is a composite basket of a continuum of differentiated domestic intermediate goods, each supplied by a different Home firm h. It is produced according to the following function:

$$I_{H,t}\left(i\right)=\left[\left(\frac{1}{n}\right)\int_{0}^{n}I_{H}\left(h,i\right)^{\frac{\theta_{H}-1}{\theta_{H}}}dh\right]^{\frac{\theta_{H}}{\theta_{H}-1}}. \tag{23}$$

The investment good I_F is a composite basket of a continuum of differentiated domestic intermediate goods, each supplied by a different Foreign firm f. It is produced according to the following function:

$$I_{F,t}\left(i\right)=\left[\left(\frac{1}{1-n}\right)\int_{n}^{1}I_{F,t}\left(f,i\right)^{\frac{\theta_{F}-1}{\theta_{F}}}df\right]^{\frac{\theta_{F}}{\theta_{F}-1}}. \tag{24}$$

Implied demand equations for generic brands and implied deflators are similar to corresponding equations for private consumption goods.

A.1.3 Public consumption good

The public consumption good $C^g_{H,t}$, produced by the generic firm g under perfect competition, is fully biased towards the intermediate domestic brands, i.e.,

$$C^g_{H,t}(g) = \left[\left(\frac{1}{n} \right)^{\theta_H} \int_0^n C^g_{H,t}(h,g)^{\frac{\theta_H - 1}{\theta_H}} dg \right]^{\frac{\theta_H}{\theta_H - 1}}. \tag{25}$$

Implied demand equations for generic brands and implied deflators are similar to the corresponding equations for private consumption goods.[41]

The Home aggregate demand curve for the generic domestic intermediate good h is

$$\begin{aligned} Y_{H,t}(h) &= \left(\frac{1}{n} \right) (\gamma_H) \left(\frac{P_{H,t}(h)}{P_{H,t}} \right)^{-\theta_H} \left(\frac{P_{H,t}}{P_t} \right)^{-\phi} nC_t \\ &+ \left(\frac{1}{n} \right) (\gamma_{H,I}) \left(\frac{P_{H,t}(h)}{P_{H,t}} \right)^{-\theta_H} \left(\frac{P_{H,t}}{P_{I,t}} \right)^{-\phi} nI_t \\ &+ \left(\frac{1}{n} \right) (\gamma_{H,I}) \left(\frac{P_{H,t}(h)}{P_{H,t}} \right)^{-\theta_H} C^g_{H,t}. \end{aligned} \tag{26}$$

Similarly, the Home aggregate demand curve for the generic imported intermediate good f is

$$\begin{aligned} Y_{F,t}(f) &= \left(\frac{1}{1-n} \right) (1 - \gamma_H) \left(\frac{P_{F,t}(f)}{P_{F,t}} \right)^{-\theta_F} \left(\frac{P_{F,t}}{P_t} \right)^{-\phi} nC_t \\ &+ \left(\frac{1}{1-n} \right) (1 - \gamma_{H,I}) \left(\frac{P_{F,t}(f)}{P_{F,t}} \right)^{-\theta_F} \left(\frac{P_{F,t}}{P_{I,t}} \right)^{-\phi} nI_t. \end{aligned} \tag{27}$$

A.2 Intermediate goods

We report the production function and the implied first-order conditions. Finally, we show the labor bundle.

Production function The supply of each Home intermediate good h is denoted by $Y(h)$:

$$Y_t(h) = K_t(h)^{\alpha} L_t(h)^{1-\alpha}, \tag{28}$$

Firm h uses labor $L_t(h)$ and capital $K_t(h)$ supplied by domestic households. The parameter $0 < \alpha < 1$ is the share of capital in production. Firms producing intermediate goods take the prices of labor and capital as given when minimizing their costs.

[41]Public consumption is financed by lump-sum taxes paid on a period-by-period basis by domestic households and it is always kept constant at its steady-state value.

FOCs: demand for inputs Denoting W_t the nominal wage index and R_t^K the nominal rental rate of capital, cost minimization implies that

$$L_t\left(h\right) = \left(1-\alpha\right)\left(\frac{W_t}{MC_t\left(h\right)}\right)^{-1} Y_t(h), \tag{29}$$

and

$$K_t\left(h\right) = \alpha\left(\frac{R_t^K}{MC_t\left(h\right)}\right)^{-1} Y_t(h), \tag{30}$$

where $MC_t\left(h\right)$ is the nominal marginal cost.

FOCs: supply of intermediate tradables We assume that there is market segmentation because nominal prices are invoiced and sticky in the currency of the destination market (local currency pricing). The (generic) Home firm producing the brand h chooses the optimal prices $P_t\left(h\right)$ in the Home market and $P_t^*\left(h\right)$ in the Foreign market to maximize the expected flow of profits (in terms of domestic consumption units),

$$E_t \sum_{\tau=t}^{\infty} D_{t,\tau}\left[\begin{array}{c} \frac{P_\tau(h)}{P_\tau} Y_\tau\left(h\right) + \frac{S_\tau P_\tau^*(h)}{P_\tau} Y_\tau^*\left(h\right) \\ -\frac{MC_\tau(h)}{P_\tau}\left(Y_\tau\left(h\right) + Y_\tau^*\left(h\right)\right) \end{array}\right], \tag{31}$$

where the term E_t denotes the expectation operator conditional on the information set at time t, $D_{t,\tau}$ is the appropriate discount rate, S is the nominal exchange rates of the Home currency vis-à-vis the Foreign currency, respectively.

The maximization is subject to the demand of the destination market and (destination-specific) quadratic price adjustment costs.

The country-specific adjustment costs paid by the generic firm h are

$$AC_{H,\tau}^{p}\left(h\right) \equiv \frac{\kappa_H^p}{2}\left(\frac{P_{H,\tau}\left(h\right)/P_{H,\tau-1}\left(h\right)}{\pi_{H,\tau-1}^{\alpha_H}\pi_{target}^{1-\alpha_H}} - 1\right)^2 \frac{P_{H,\tau}}{P_\tau} Y_{H,\tau}, \tag{32}$$

$$AC_{H,\tau}^{p*}\left(h\right) \equiv \frac{\kappa_H^{p*}}{2}\left(\frac{P_{H,\tau}^*\left(h\right)/P_{H,\tau-1}^*\left(h\right)}{\left(\pi_{H,\tau-1}^*\right)^{\alpha_H^*}\pi_{target^*}^{1-\alpha_H^*}} - 1\right)^2 \frac{S_\tau^* P_{H,\tau}^*}{P_\tau^*} Y_{H,\tau}^*, \tag{33}$$

in the Home and Foreign markets, respectively. The parameters κ_H^p, ${\kappa_H^p}^* > 0$ measure the degree of nominal rigidity in the Home and in Foreign, respectively, whereas α_H, α_H^* are the corresponding indexation parameters. Moreover, π_{target} and π_{target^*} denote the (consumer-price) inflation targets of Home and Foreign central banks, respectively (which are assumed to be equal to the steady-state inflation rate, i.e., $\pi_{target} = \pi_{target^*} = \overline{\pi}$. The terms Y_H and Y_H^* represent the sector-specific Home and Foreign output, respectively, while P_H and P_H^* the corresponding price deflators.

The first order condition with respect to the Home price set in the domestic market, $P_t(h)$, is (expressed in real terms):

$$(1-\theta_{H,t})p_{H,t}(h)+\theta_{H,t}mc_{H,t}(h)=\kappa_H^P\left(\frac{P_{H,t}(h)/P_{H,t-1}(h)}{\pi_{H,t-1}^{\alpha_H}\pi_{target}^{1-\alpha_H}}-1\right)\frac{P_{H,t}/P_{H,t-1}(h)}{\pi_{H,t-1}^{\alpha_H}\pi_{target}^{1-\alpha_H}}$$
$$-\beta\frac{\lambda_{t+1}(j)\pi_{t+1}^{-1}}{\lambda_t(j)}\kappa_H^P\left(\frac{P_{H,t+1}(h)/P_{H,t}(h)}{\pi_{H,t}^{\alpha_H}\pi_{target}^{1-\alpha_H}}-1\right)\frac{P_{H,t+1}P_{H,t+1}(h)/P_{H,t}(h)^2Y_{H,t+1}}{\pi_{H,t}^{\alpha_H}\pi_{target}^{1-\alpha_H}Y_{H,t}} \quad (34)$$

where the terms multiplied by κ_H^p are related to the presence of price adjustment costs.

In a symmetric equilibrium (i.e., $P_{H,t}(h)=P_{H,t}\ \forall\ h$), after rearranging terms, the equation can be expressed as follows

$$p_{H,t}=\theta_{H,t}\left(p_{H,t}-MKP_t mc_{H,t}\right)+A_{H,t}, \quad (35)$$

where $p_{H,t}\equiv P_{H,t}/P_t$ (similar expressions hold for other relative prices) and $A_{H,t}$ is defined as

$$A_{H,t}\equiv p_{H,t}\kappa_H^p\frac{\pi_{H,t}}{\pi_{H,t-1}^{\alpha_H}\pi_{target}^{1-\alpha_H}}\left(\frac{\pi_{H,t}}{\pi_{H,t-1}^{\alpha_H}\pi_{target}^{1-\alpha_H}}-1\right)$$
$$-p_{H,t}\beta\kappa_H^pE_t\left[\frac{1}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\frac{\pi_{H,t+1}^2}{\pi_{H,t}^{\alpha_H}\pi_{target}^{1-\alpha_H}}\left(\frac{\pi_{H,t+1}}{\pi_{H,t}^{\alpha_H}\pi_{target}^{1-ind_H}}-1\right)\frac{Y_{H,t+1}}{Y_{H,t}}\right]. \quad (36)$$

with the definitions $\pi_{H,t}\equiv P_{H,t}/P_{H,t-1}$, $\pi_t\equiv P_t/P_{t-1}$. The term MKP_t represents a sector-specific mark-up shock, which follows an AR(1) process. Similar equations hold for the price of good h in the F market and for the price of good f in the H market.

Labor bundle In the case of the generic firm h operating in the intermediate sector, the labor input $L(h)$ is a CES combination of differentiated labor inputs supplied by domestic households and defined over a continuum of mass equal to the country size ($j\in[0,n]$):

$$L_t(h)\equiv\left(\frac{1}{n}\right)^{\frac{1}{\theta_w}}\left[\int_0^n L_t(h,j)^{\frac{\theta_w-1}{\theta_w}}\,dj\right]^{\frac{\theta_w}{\theta_w-1}}, \quad (37)$$

where $L(h,j)$ is the demand of the labor input of type j by the producer of good h and $\theta_w>1$ is the elasticity of substitution among labor inputs. Cost minimization implies

$$L_t(h,j)=\left(\frac{1}{n}\right)\left(\frac{W_t(j)}{W_t}\right)^{-\theta_w}L_t(h), \quad (38)$$

where $W(j)$ is the nominal wage of labor input j and the wage index W is

$$W_t=\left[\left(\frac{1}{n}\right)\int_0^n W_t(j)^{1-\theta_w}\,dj\right]^{\frac{1}{1-\theta_w}}. \quad (39)$$

Each household is the monopolistic supplier of a labor input j and sets the nominal wage subject to a downward-sloping demand obtained by aggregating demand across domestic firms.

A.3 Households

In the Home country there is a continuum of households of mass $j \in [0, n]$. Each household j maximizes its expected lifetime utility subject to the budget constraint. The lifetime utility, in consumption C and labor L, is

$$E_t \sum_{\tau=t}^{\infty} \beta_t \left(\log\left(C_t(j) - b_c C_{t-1}\right) - \frac{\kappa}{1+\zeta} L_t\left(j\right)^{1+\zeta} \right), \tag{40}$$

where $0 < \beta < 1$ is the discount factor, $b_c \in (0, 1)$ is the external habit parameter, $\zeta > 0$ is the reciprocal of the Frisch elasticity of labor supply, and L_t is the demand of the household-specific labor type by domestic firms,

$$L_t\left(j\right) = \left(\frac{1}{n}\right) \left(\frac{W_t(j)}{W_t}\right)^{-\theta_w} L_t, \tag{41}$$

where the parameter $\theta_w > 1$ measures the elasticity of substitution among different labor brands supplied by different households. The budget constraint is

$$\begin{aligned} B_{H,t}(j) + S_t B_{F,t}(j) \leq (1 + i_{t-1}) Z_{HRP,t-1} B_{H,t-1}(j) \\ +(1 + i^*_{t-1}) \left[1 - \left(1 - \Phi\left(\frac{S_{t-1} B_{F,t-1}}{P_{t-1}} - b_F\right)\right)\right] S_t B_{F,t-1}(j) + R^k_t K_{t-1}(j) + W_t(j) L_t(j) \\ -\frac{\kappa_W}{2} \left(\frac{W_t(j)/W_{t-1}(j)}{\pi^{\alpha_w}_{W,t} \pi^{1-\alpha_w}_{target}} - 1\right)^2 W_t L_t + \Pi^{prof}_t(j) - P_{C,t} C_t(j) - P_{I,t} I_t(j) - T_t(j), \end{aligned} \tag{42}$$

where the parameter $\kappa_W > 0$ measures the degree of nominal wage rigidity, $0 \leq \alpha_w \leq 1$ is the corresponding indexation parameter, and L_t is the total amount of labor in the Home economy. $B_{H,t}$ is the end-of-period t position in a nominal bond denominated in the Home currency, $B_{F,t}$ is the end-of period position in a nominal bond denominated in F currency. The two bonds respectively pay the domestic $R_t \equiv (1 + i_t)$ and foreign $R^*_t \equiv (1 + i^*_t)$ (gross nominal) policy rates at the beginning of period $t + 1$. The interest rates are known at time t (consistent with the riskless bond assumption). The variable S_t is the bilateral nominal exchange rate of the domestic currency vis-à-vis the F currency, defined as number of Home currency units per unit of F currency. The variable Z_{HRP} is a risk premium shock to the bond denominated in domestic currency held by Home households, which follows an AR(1) process.

The function Φ is an adjustment cost that ensures stationarity of the Home net foreign asset position, which would otherwise introduce a unit root in the model, that is, Φ is

$$\Phi\left(\frac{S_t B_{F,t}}{P_t} - b_F\right) \equiv \phi_{b,1} \frac{\exp\left[\phi_{b,2}\left(\frac{S_t B_{F,t}}{P_t} - b_F\right)\right] - 1}{\exp\left[\phi_{b,2}\left(\frac{S_t B_{F,t}}{P_t} - b_F\right)\right] + 1} \qquad \phi_{b,1}, \phi_{b,2} \geq 0$$

and represent the adjustment cost on aggregate foreign bond position $B_{F,t}$, expressed in domestic consumption units (it is divided by the domestic consumption deflator P_t) as a deviation from its steady-state value $\overline{b_F}$. The adjustment cost is taken as given by each household. See Schmitt-Grohe and Uribe (2003) and Benigno (2009).

The payment of this cost is rebated in a lump-sum fashion to foreign agents.

The sources of the household income are physical capital $K_t(j)$, which is rent to domestic intermediate firms at the net rate R_t^k, labor $L_t(j)$, which is supplied to domestic firms and earns the nominal wage $W_t(j)$, and $\Pi_t^{prof}(j)$, which represents profits from ownership of domestic firms (the profits are rebated in a lump-sum way to households).

The term $T_t(j) > 0$ represents lump-sum taxes paid to the domestic government to finance public consumption (the government budget constraint is assumed to be balanced in every period).

The variable $I_t(j)$ is investment in physical capital. The latter is accumulated according to the following law:

$$K_t(j) \leq (1-\delta) K_{t-1}(j) + \left[1 - \frac{}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)^2 I_t(j)\right], \tag{43}$$

where $0 < \delta < 1$ is the depreciation rate and investment is subject to a quadratic adjustment cost, captured by the parameter $\psi > 0$.

A.3.1 First-order conditions

Household maximizes the intertemporal utility with respect to consumption $C_t(j)$, $B_{H,t}(j)$, $B_{F,t}(j)$, $W_t(j)$, subject to the budget constraint, the capital accumulation law, and the adjustment costs.

The corresponding FOCs in the generic period t are:

- with respect to domestic consumption $C_t(j)$

$$\lambda_t(j) = (C_t(j) - b_c C_{t-1})^{-1}, \tag{44}$$

- with respect to Home-currency-denominated bond $B_{H,t}(j)$

$$\lambda_t(j) = \beta E_t \lambda_{t+1}(j) Z_{HRP,t}(1+i_t) \pi_{t+1}^{-1}, \tag{45}$$

- with respect to Foreign-currency-denominated bond $B_{F,t}(j)$

$$\lambda_t(j) = \beta E_t \lambda_{t+1}(j)(1+i_t^*) \left[1 - \left(1 - \Phi\left(\frac{S_{t-1}B_{F,t-1}}{P_{t-1}} - b_F\right)\right)\right] \frac{\Delta S_{t+1}}{\pi_{t+1}}, \tag{46}$$

- with respect to the end-of-period capital $K_t(j)$

$$Q_t(j) = \beta E_t \left[\lambda_{t+1} r_{t+1}^K + Q_{t+1}(j)(1-\delta)\right], \tag{47}$$

where $Q(j)$ is the Tobin's Q (i.e., the multiplier of the capital accumulation law),

- with respect to investment $I_t(j)$

$$\lambda_t(j) p_{I,t} = Q_t(j) \left[-\frac{\psi}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)^2 - \psi\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)\frac{I_t(j)}{I_{t-1}(j)}\right] + \beta E_t Q_{t+1}(j)\psi\left[\left(\frac{I_{t+1}(j)}{I_t(j)} - 1\right)\frac{I_{t+1}^2(j)}{I_t^2(j)}\right], \tag{48}$$

where $p_{I,t} \equiv P_{I,t}/P_t$,

- with respect to nominal wage $W_t(j)$

$$\kappa\theta_w \frac{W_t(j)^{-\theta_w(1+\zeta)-1}}{W_t^{-\theta_w(1+\zeta)}} L_t^{\zeta} + (1-\theta_w)\frac{W_t(j)^{-\theta_w}}{W_t^{-\theta_w}} = \lambda_t \kappa_W \left(\frac{W_t(j)/W_{t-1}(j)}{\pi_{W,t-1}^{\alpha_w}\pi_{target}^{1-\alpha_w}} - 1\right)\frac{W_t/W_{t-1}(j)}{\pi_{W,t-1}^{\alpha_w}\pi_{target}^{1-\alpha_w}} - \beta\lambda_{t+1}\kappa_W\left(\frac{W_{t+1}(j)/W_t(j)}{\pi_{W,t}^{\alpha_w}\pi_{target}^{1-\alpha_w}} - 1\right)\frac{W_{t+1}W_{t+1}(j)/W_t(j)^2 L_{t+1}}{\pi_{W,t}^{\alpha_w}\pi_{target}^{1-\alpha_w} L_t}, \tag{49}$$

A.4 Monetary policy

We assume the following specification for the benchmark (IT) monetary policy rule:

$$\frac{R_t}{\overline{R}} = max\left\{\frac{1}{\overline{R}}, \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_r}\left(\frac{\pi_t}{\overline{\pi}}\right)^{(1-\rho_r)\rho_\pi}\left(\frac{y_t}{y_{t-1}}\right)^{(1-\rho_r)\rho_y}\right\}. \tag{50}$$

The rule describes how the central bank conducts its monetary policy under a (flexible) IT strategy. The variable R_t is the gross policy rate and $\overline{R}$ its steady-state value. The parameters $0 \leq \rho_r \leq 1$, $\rho_\pi > 0$, ρ_y measure the sensitivity of the policy rate to its lagged value, to the gross inflation rate π_t (in deviation from the central bank target $\overline{\pi} \equiv \pi_{target}$), and to the gross growth rate of output y_t/y_{t-1}, respectively. The lagged interest rate ensures that the policy rate is adjusted smoothly and captures the idea that the central bank prefers to avoid large sudden changes in its policy instrument. The *max* operator takes into account the (endogenous) ELB (R is the nominal monetary policy rate in gross terms, thus it is equal to 1 at the ELB).

In the main text we analyze the properties of the alternative monetary policy strategies.

In our simulations we consider a symmetric equilibrium, i.e., in each country there is a representative household, a representative firm in the final nontradable sector, and a representative firm in the intermediate tradable sector. Each of them satisfies the corresponding first order conditions, budget and technology constraints, while the central banks follow the corresponding monetary policy rules, the government satisfies its budget constraint, and the market clearing conditions hold.

B Spillovers to the RW

Fig. A1 reports the responses of RW monetary policy rate, inflation, and output to a risk premium and a price markup shock in the EA (first and second row, respectively) under the alternative EA monetary policy strategies.[42]

In the case of the EA risk premium shock (first row), the RW central bank lowers the policy rate to offset the negative effects associated with the drop in EA aggregate demand, which in turn implies lower RW exports. After an initial drop, RW output persistently increases. The degree of accommodation needed to stabilize inflation and output is smaller if make-up strategies are implemented in the EA, because under these strategies the drop in EA aggregate demand is smaller and thus RW inflation decreases to a lower extent, following the relative improvement in RW exports. At the same time, under the EA make-up strategies, the smaller decrease in the RW policy rate induces a lower improvement in RW output in the medium run. Overall, inflation and output in the RW are stabilized more when the EA adopts make-up strategies relative to IT.

In the case of the EA price markup shock (second row), EA aggregate demand improves and, thus, EA imports of RW goods increase. RW production costs and, thus, RW CPI inflation increase, inducing the RW central bank to raise the policy rate. RW output decreases, because of the higher RW policy rate and because RW households save to finance the increase in EA aggregate demand. Make-up strategies in the EA amplify the improvement in EA aggregate demand and hence in RW exports, output, production costs and CPI inflation, especially as far as PLT is concerned. The latter EA regime induces a larger increase in RW inflation and, thus, RW policy rate. As a consequence, RW output decreases (slightly) more than under the EA IT regime.

Overall, make-up strategies in the EA, by stabilizing domestic macroeconomic conditions in response to a domestic disinflationary risk premium shock, stabilize foreign conditions as well through the trade channel. Instead, by inducing a larger positive response of EA aggregate demand to a domestic disinflationary markup shock, make-up strategies induce a larger positive response in RW inflation and policy rate and, thus, through the interest rate channel, a (slightly) larger drop in RW output. The size of the spillovers is not large, because the RW is a large and

[42] We assume that the IT monetary policy regime always holds in the RW.

closed economy relative to the EA.

C Make-up strategies and hybrid inflation expectations

C.1 Positive EA risk premium shock

Fig. A2 reports the impulse responses of the policy rate, CPI inflation, nominal exchange rate, output, and import and export deflator inflation rates to the positive risk premium shock in the EA (Fig. A3 reports the impulse responses to the full set of macroeconomic variables under hybrid expectations and the three monetary policy strategies at study). The top row shows the dynamics under rational expectations (the same as in Fig. 1 in the main text), while the bottom row reports the responses when model-consistent expectations on inflation are replaced by hybrid expectations in both EA and RW.

In general, the responses are qualitatively similar to the case of model-consistent expectations, especially under make-up strategies, while the main differences arise under IT. Households and firms only partially anticipate the future inflation improvement, while they fully anticipate the policy rate path. Under IT, the central bank does not make up for past inflation misses, while it does under AIT and PLT. Thus, if the ELB holds, the ex-ante real interest rate is higher under IT than under make-up strategies and under IT with model-consistent expectations. The fall in inflation and output is therefore larger under IT when inflation expectations are hybrid.

The limited fall in the Home policy rate and the larger fall in inflation induce the nominal exchange rate of the Home currency vis-à-vis the Foreign currency to further appreciate under IT and hybrid expectations, favoring further disinflationary pressures on EA inflation through the lower import price inflation rate and the additional reduction in EA exports. AIT and PLT do not generate these additional disinflationary pressures because of the promise to keep the policy rate low for longer, which favors the lower appreciation of the nominal exchange rate.

Summing up, make-up strategies, by favoring a lower appreciation of the nominal exchange rate, continue to be more effective than IT at stabilizing inflation and output after a disinflationary risk premium shock, also under the assumption of hybrid inflation expectations. Moreover, the performance of IT deteriorates under hybrid inflation expectations.

C.2 Negative EA price markup shock

Fig. A4 reports the impulse responses of the policy rate, CPI inflation, nominal exchange rate, and import and export deflator inflation to a disinflationary markup shock in the EA, both under rational and hybrid inflation expectations in the upper and lower panel, respectively. Thus, those in the top row are the same as in Fig. 2 in the main text (Fig. A5 reports the impulse responses to the full set of macroeconomic variables under hybrid expectations and the three monetary policy strategies at study).

The responses to a price markup shock that lowers CPI inflation and increases output are qualitatively similar across the two cases of model-consistent and hybrid inflation expectations.

Under IT, the negative inflation response is (in absolute value) larger under hybrid expectations than under model-consistent expectations, consistent with the smaller nominal exchange rate depreciation. Under the make-up strategies, the central bank has to decrease the policy rate relatively more if hybrid expectations hold, given that households do not foresee the future rise in inflation and, thus, do not anticipate the lower future real interest rate. There is a (in absolute value) larger negative response of inflation than in the case of model-consistent inflation expectation. The lower policy rate induces a larger positive response of output.

Overall, also under hybrid inflation expectations, make-up strategies are more effective than IT at stabilizing inflation in response to a supply shock. Their effectiveness in stabilizing inflation and output appears to be somewhat smaller than in the case of model-consistent inflation.

C.3 Spillovers to the RW

Fig. A6 shows the spillovers to the RW of the EA risk premium and price markup shocks with hybrid expectations under the three monetary policy strategies in the EA.

Results are similar to those obtained under model-consistent expectations (see Fig. A1).

Spillovers to the RW are smaller if make-up strategies are adopted in the EA and the latter is hit by a risk premium shock. In particular, recessionary spillovers are larger in absolute value under hybrid expectations and IT strategy in the EA than under model-consistent expectations, consistent with the larger fall in EA economic activity, which drives RW exports further down.

In the case of a EA markup shock, make-up strategies entail larger spikes in RW inflation while inducing a larger drop in RW output, consistent with the larger procyclical effects of the strategies on EA aggregate demand and output. The larger increase in RW exports further stimulates RW inflation, inducing RW central bank to raise the policy rate relatively more, inducing an additional drop in domestic output.

C.4 Hybrid expectations with low import and export price stickiness

We next study the role of hybrid inflation expectations under the assumption of low import and export price stickiness.

Fig. A7 reports the impulse responses to the risk premium shock. Under IT, the policy rate spends more time at the ELB than under high import and export price rigidities and hybrid inflation expectations (see bottom row Fig. A2).

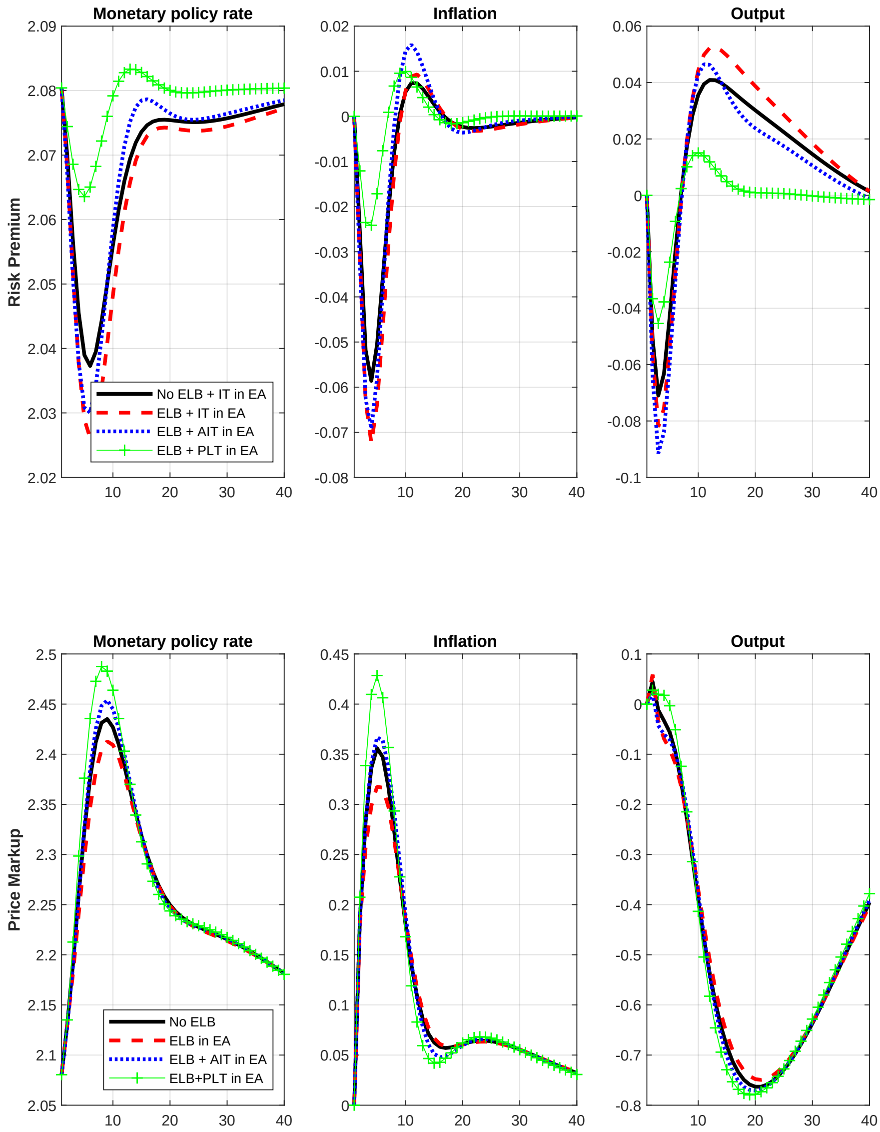
The nominal exchange rate appreciation is magnified under IT when the price stickiness is low, while under AIT the EA currency appreciation is almost unaffected by the change in the degree of nominal rigidities. Current import price inflation responds more to the exchange rate appreciation under hybrid expectations than under the model-consistent ones, because it only partially incorporates the anticipation of future higher inflation under the assumption of partially backward-looking inflation expectations. Overall, CPI inflation falls to a larger extent than in the case of model-consistent expectations and low price stickiness.

Also under low import and export price stickiness the two make-up strategies have better stabilization properties than IT. The reason is the promise to keep the policy rate lower for longer to make up for past inflation misses, which stabilizes inflation and economic activity. The very same promise induces a smaller appreciation of the nominal exchange rate than under IT, favoring import price inflation and, thus, sustaining CPI inflation. This is true for PLT and, to a lesser extent, for AIT.

Fig. A8 reports the impulse responses to the price markup shock. Also in this case, make-up strategies stabilize inflation relatively more than IT compared to the benchmark case of high import and export price stickiness and hybrid inflation expectations (see bottom row Fig. A4). The nominal exchange rate further appreciates under IT, adding disinflationary pressures through the lower import price inflation. Under IT and hybrid expectations the nominal exchange rate appreciates to a much larger extent because of (i) the larger drop in EA inflation and the implied gain in international competitiveness of EA products and (ii) the relatively higher EA interest rate level in the medium term. Make-up strategies, instead, favor the exchange rate depreciation and, thus, inflation dynamics.

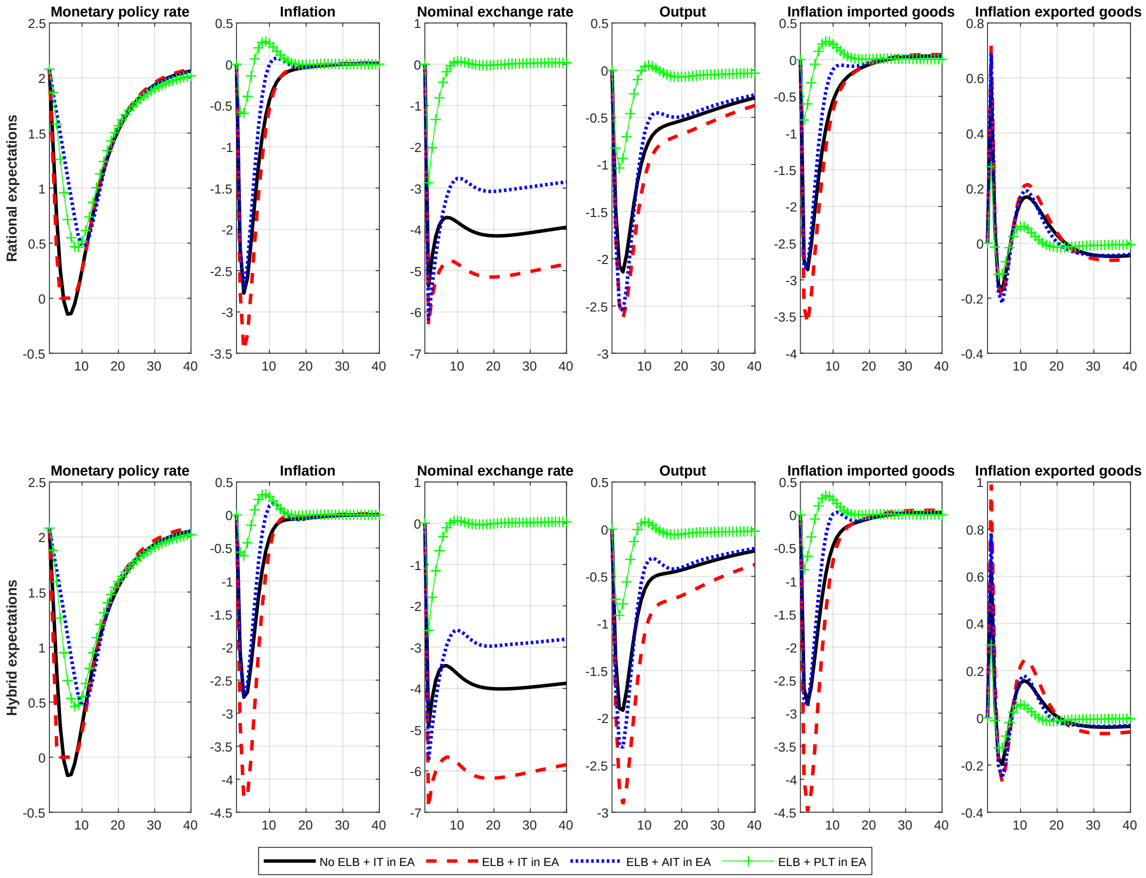
Summing up, make-up strategies' effectiveness in stabilizing inflation and macroeconomic conditions further improves relative to IT in the case of low import and export price stickiness and hybrid inflation expectations.

Figure A1: EA risk premium and price markup shocks - Spillovers to RW.



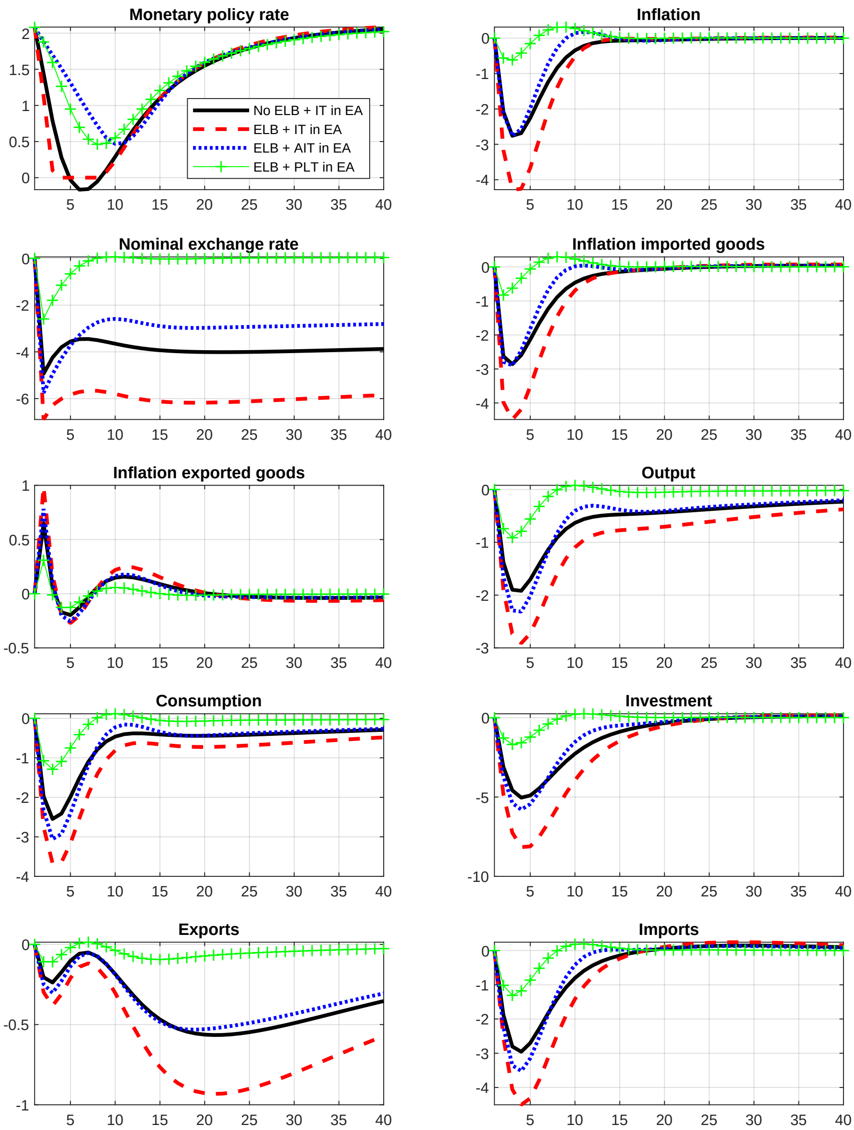
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels.

Figure A2: Positive EA risk premium shock: Rational vs hybrid expectations.



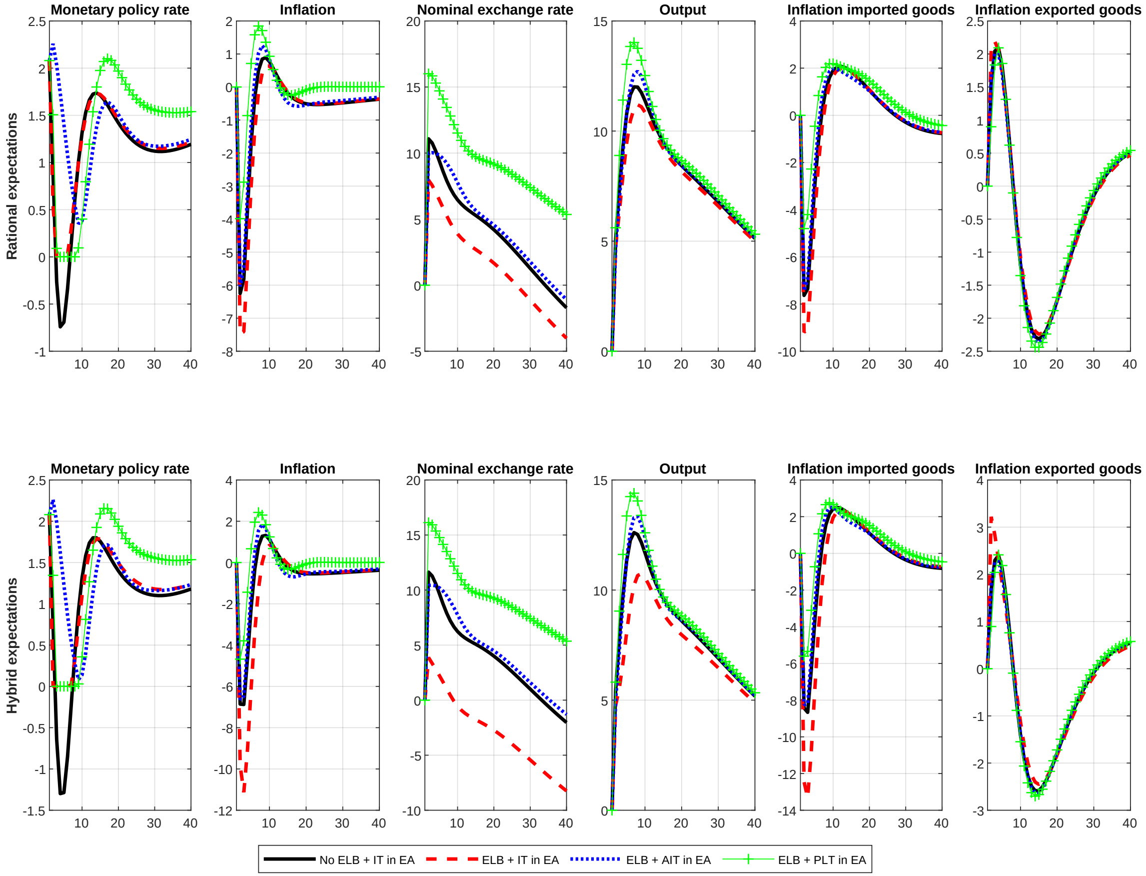
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation. Top row: rational expectations. Bottom row: hybrid expectations.

Figure A3: Hybrid expectations: positive EA risk premium shock.



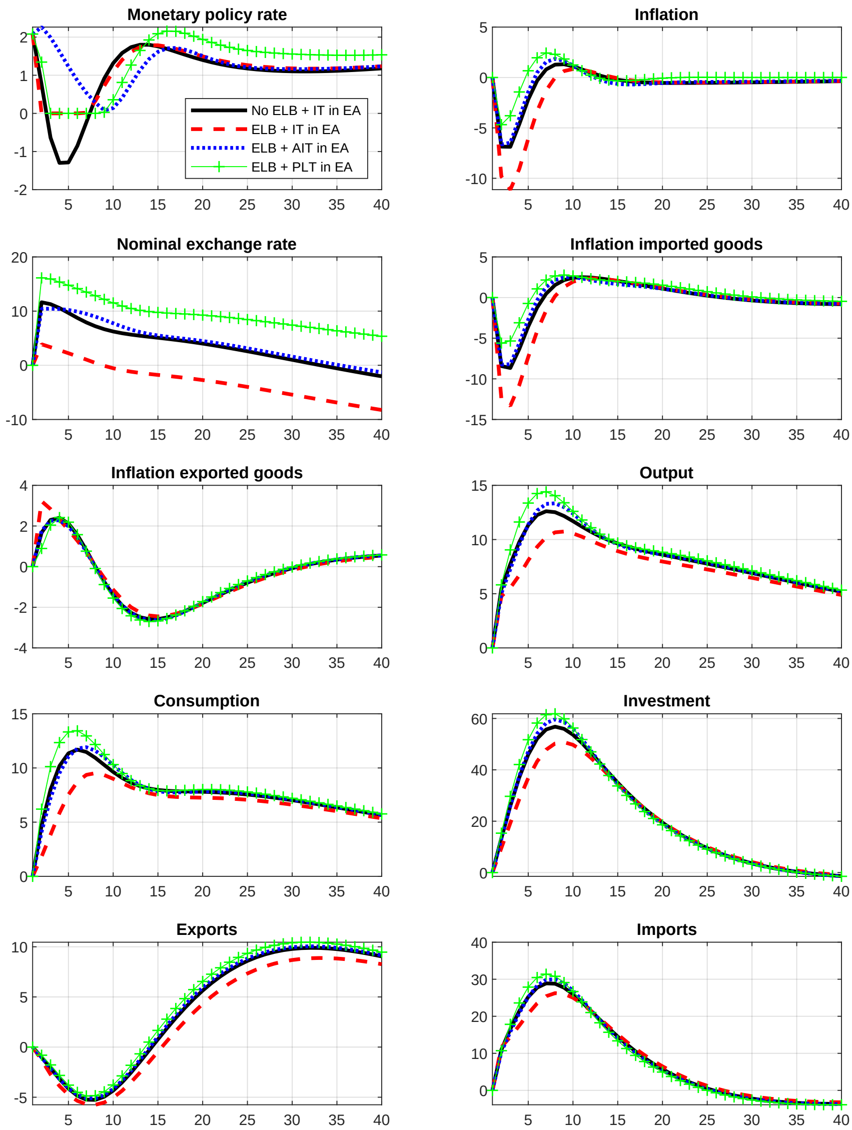
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A4: Negative EA price markup shock: Rational vs hybrid expectations.



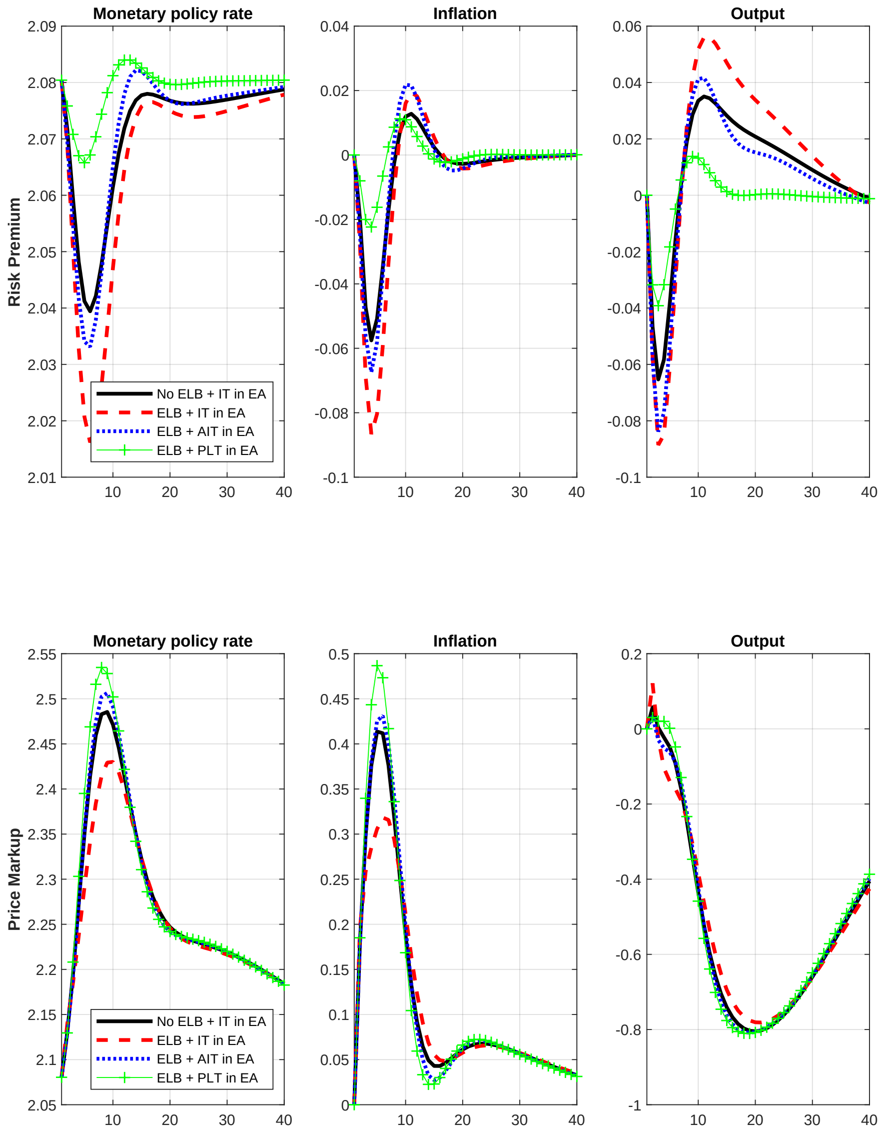
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation. Top row: rational expectations. Bottom row: hybrid expectations.

Figure A5: Hybrid expectations: negative EA price markup shock.



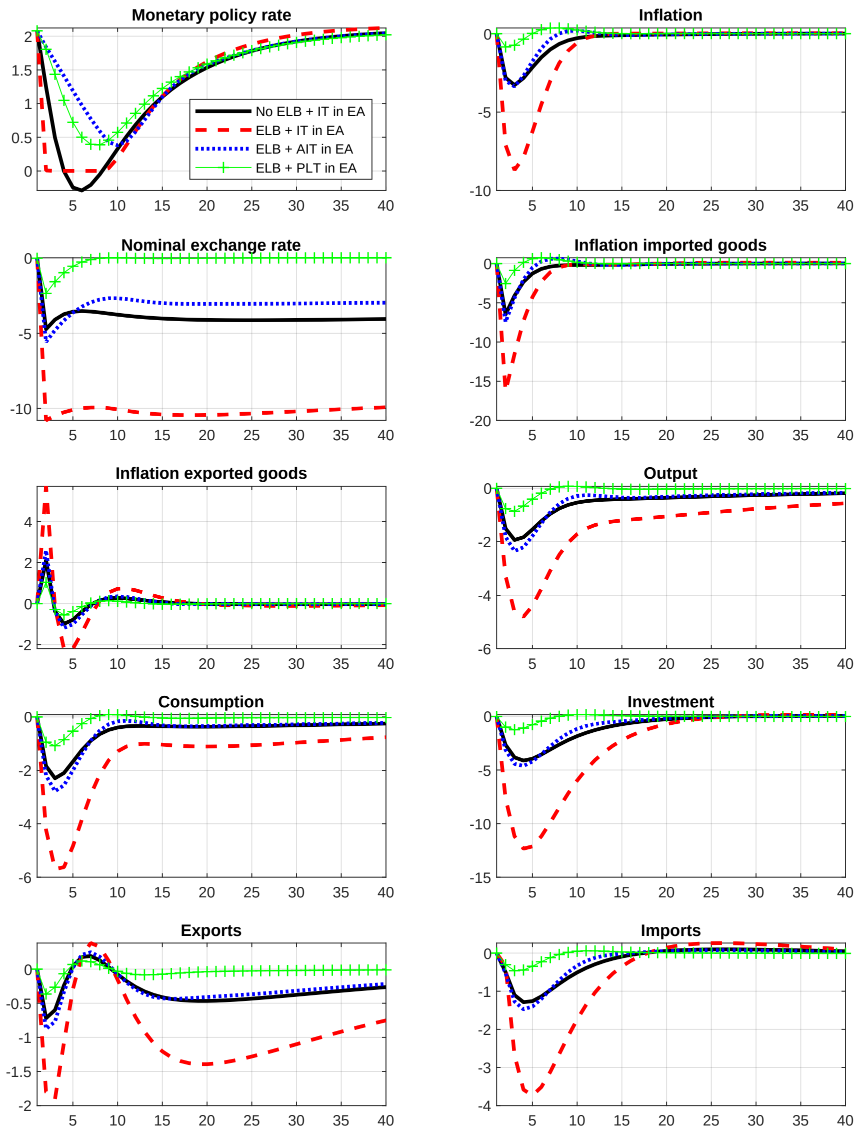
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A6: Hybrid expectations: EA risk premium and price markup shocks - Spillovers to RW.



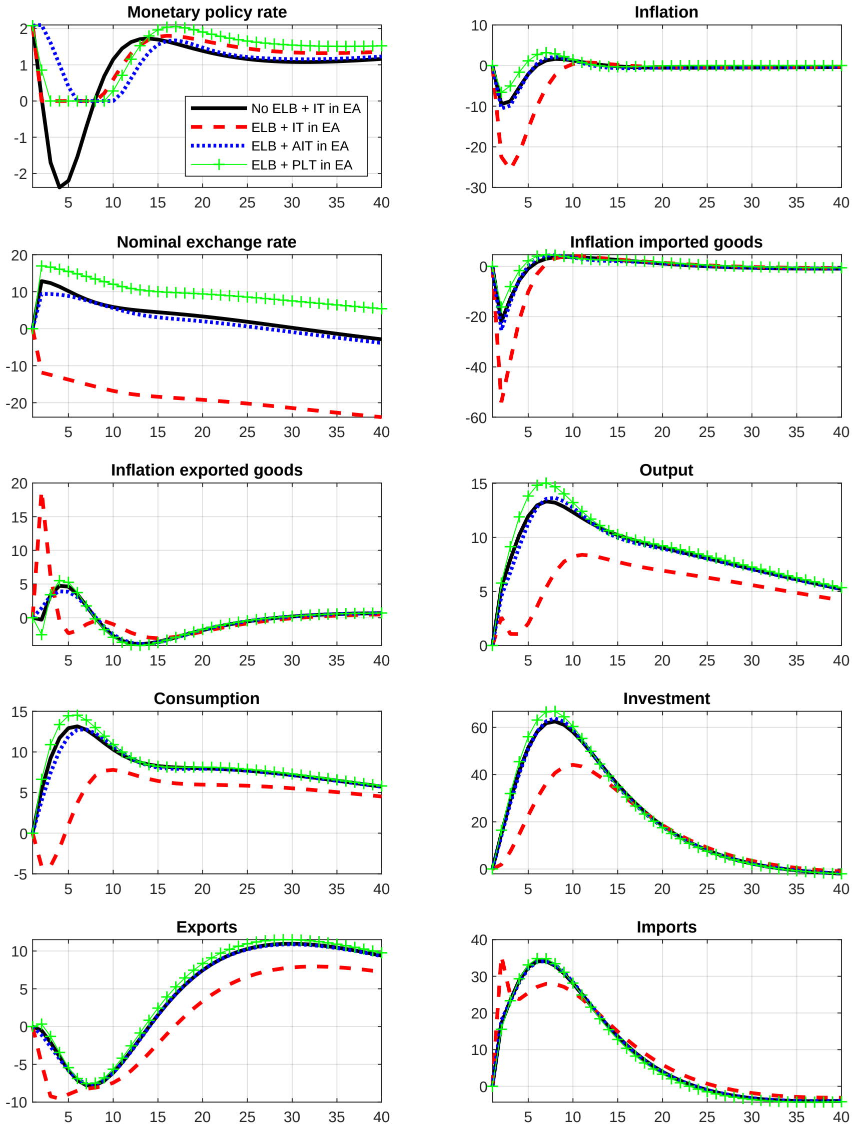
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels.

Figure A7: Hybrid expectations: positive EA risk premium shock - Low import and export price stickiness.



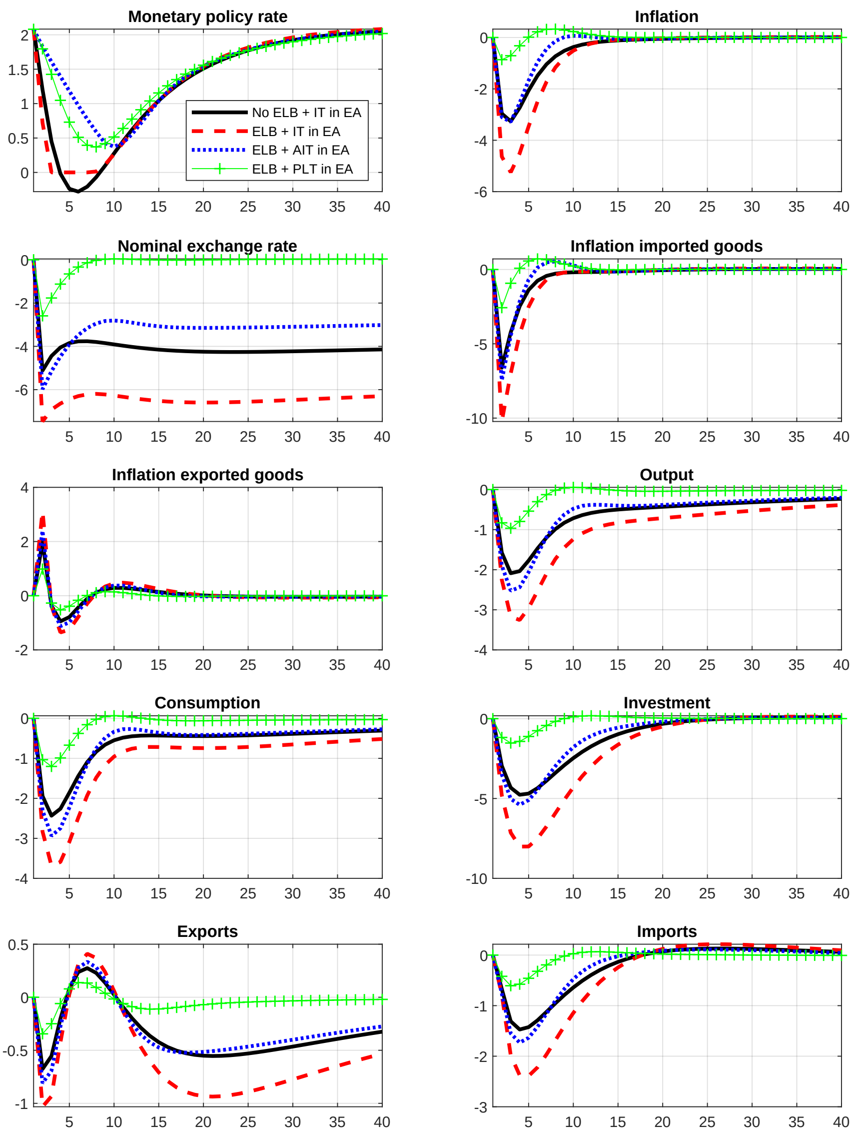
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A8: Hybrid expectations: negative EA price markup shock - Low import and export price stickiness.



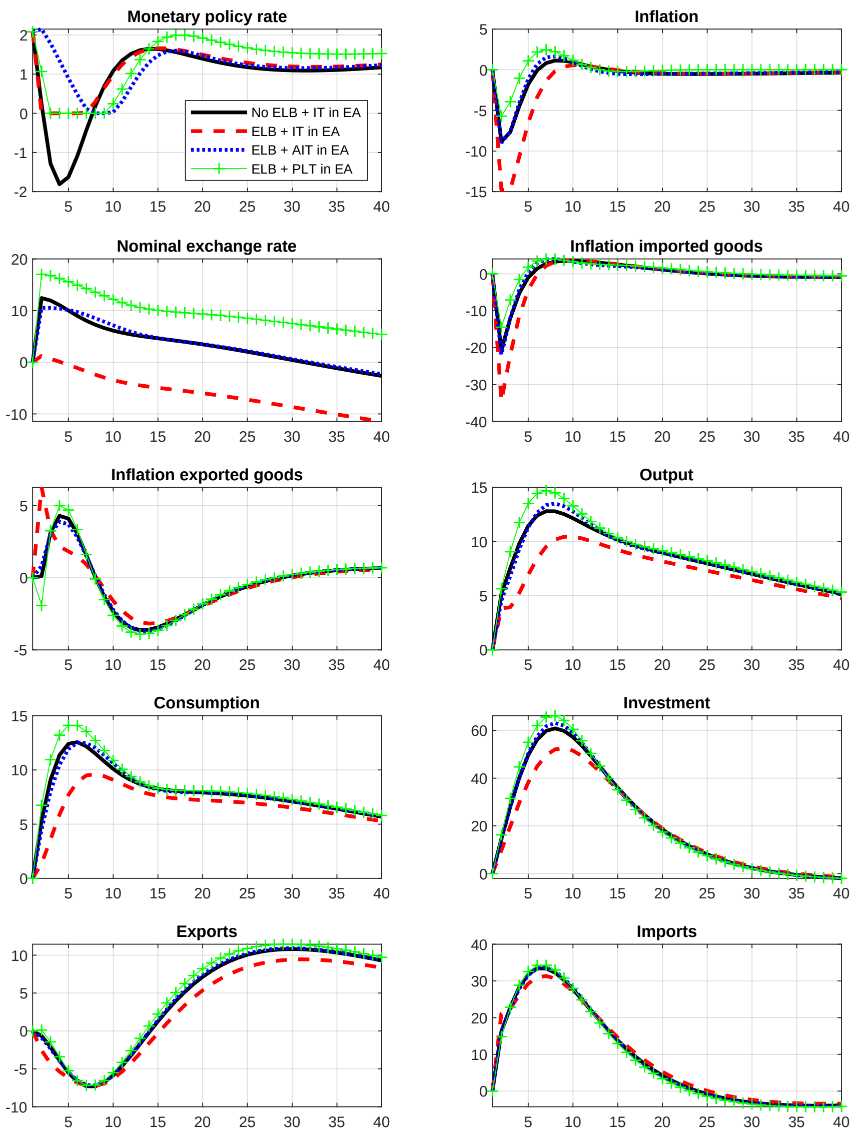
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A9: Positive EA risk premium shock - low import and export price stickiness.



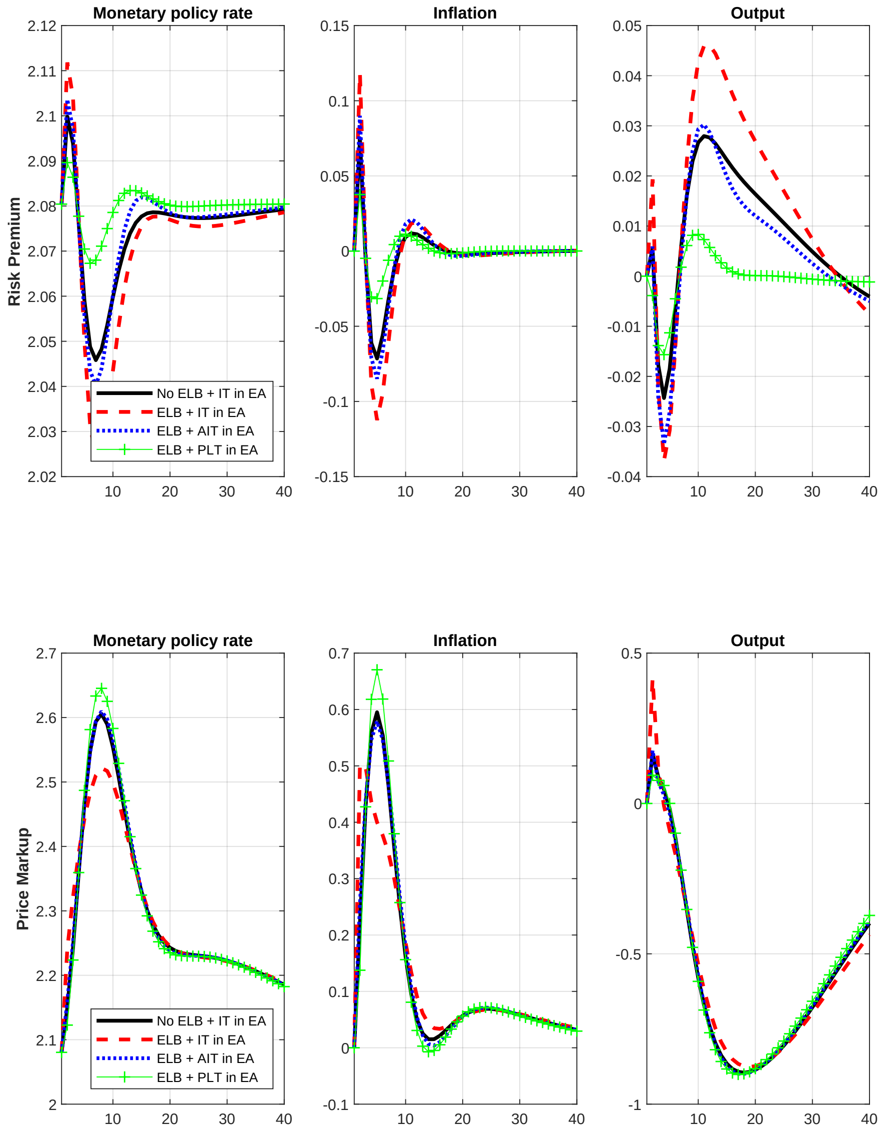
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A10: Negative EA price markup shock - low import and export price stickiness.



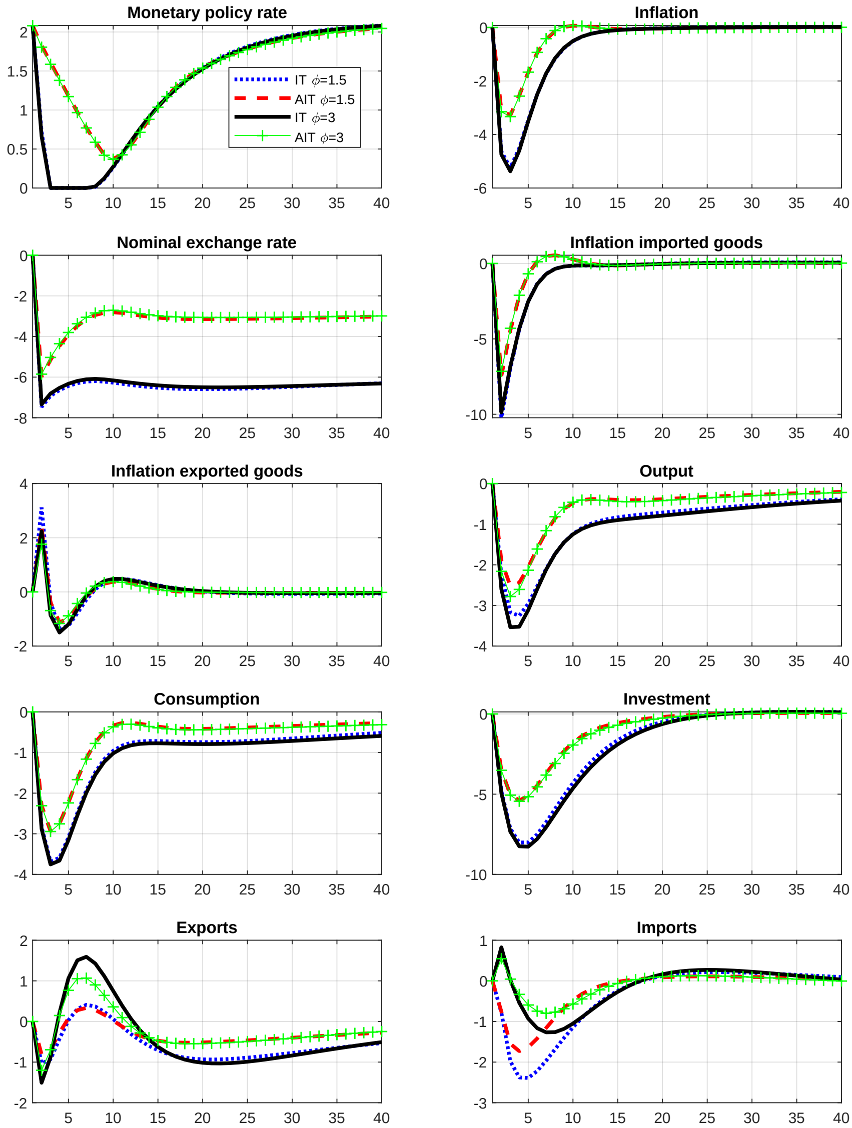
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A11: Low import and export price stickiness: EA risk premium and price markup shocks - Spillovers to RW.



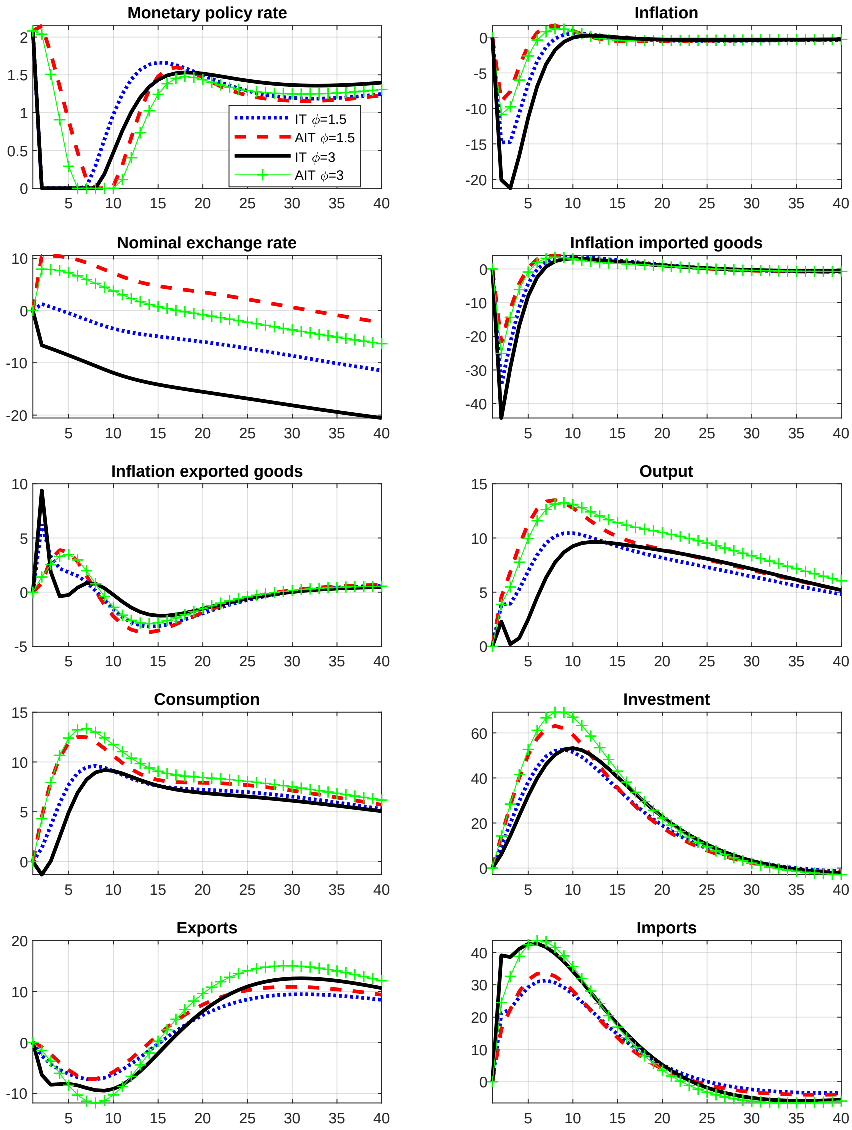
Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels.

Figure A12: Positive EA risk premium shock - low import and export price stickiness: baseline vs higher intratemporal elasticity of substitution between traded goods.



Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

Figure A13: Negative EA price markup shock - low import and export price stickiness: baseline vs higher intratemporal elasticity of substitution between traded goods.



Notes: quarters on the horizontal axis; on the vertical axis, %deviations from the steady-state; inflation rates: annualized pp deviations from the steady-state; and interest rate: %annualized levels; nominal exchange rate: level, %deviations from the steady-state, += depreciation.

References

- Christoffel, K., G. Coenen and A. Warne, (2008). The New Area-Wide Model of the euro area: A micro-founded open-economy Model for forecasting and policy analysis. ECB Working Paper Series 944.
- Gomes, S., P. Jacquinot and M. Pisani, 2010. The EAGLE. A model for policy analysis of macroeconomic interdependence in the euro area. ECB Working Paper Series 1195.
- Pesenti, P., 2008. The Global Economy Model (GEM): Theoretical framework. *IMF Staff Papers*, 55 (2), pp.243–284
- Rotemberg, J. J., 1982. Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, 49, pp. 517–31.

RECENTLY PUBLISHED "TEMI" (*)

N. 1375 – *New facts on consumer price rigidity in the Euro Area*, by Erwan Gautier, Cristina Conflitti, Riemer P. Faber, Brian Fabo, Ludmila Fadejeva, Valentin Jouvanceau, Jan-Oliver Menz, Teresa Messner, Pavlos Petroulas, Pau Roldan-Blanco, Fabio Rumler, Sergio Santork, Elisabeth Wieland and Hélène Zimmer (July 2022).

N. 1376 – *Connecting to power: political connections, innovation, and firm dynamics*, by Ufuk Akcigit, Salomé Baslandze and Francesca Lotti (July 2022).

N. 1377 – *"Green" fiscal policy measures and non-standard monetary policy in the Euro Area*, by Anna Bartocci, Alessandro Notarpietro and Massimiliano Pisani (July 2022).

N. 1378 – *Firm liquidity and the transmission of monetary policy*, by Margherita Bottero and Stefano Schiaffi (July 2022).

N. 1379 – *The impact of Covid-19 on the european short-term rental market*, by Elisa Guglielminetti, Michele Loberto and Alessandro Mistretta (July 2022).

N. 1380 – *An analysis of objective inflation expectations and inflation risk premia*, by Sara Cecchetti, Adriana Grasso and Marcello Pericoli (July 2022).

N. 1381 – *The role of central bank communication in inflation-targeting Eastern European emerging economies*, by Valerio Astuti, Alessio Ciarlone and Alberto Coco (October 2022).

N. 1382 – *The heterogeneous effects of bank mergers and acquisitions on credit to firms: evidence from Italian macro-regions*, by Silvia Del Prete, Cristina Demma, Iconio Garrì, Marco Piazza and Giovanni Soggia (October 2022).

N. 1383 – *Bank lending to small firms: metamorphosis of a financing model*, by Paolo Finaldi Russo, Valentina Nigro and Sabrina Pastorelli (October 2022).

N. 1384 – *MMacroeconomic effects of growth-enhancing measures in the euro area*, by Alessandro Cantelmo, Alessandro Notarpietro and Massimiliano Pisani (October 2022).

N. 1385 – *Revisiting the real exchange rate misalignment-economic growth nexus via the across-sector misallocation channel*, by Claire Giordano (October 2022).

N. 1386 – *Labor market spillovers of a large plant opening. Evidence from the oil industry*, by Matteo Alpino, Irene Di Marzio, Maurizio Lozzi and Vincenzo Mariani (October 2022).

N. 1387 – *Unburdening regulation: the impact of regulatory simplification on photovoltaic adoption in Italy*, by Federica Daniele, Alessandra Pasquini, Stefano Clò and Enza Maltese (October 2022).

N. 1388 – *Liberalizing the opening of new pharmacies and hospitalizations*, by Andrea Cintolesi and Andrea Riganti (November 2022).

N. 1389 – *Mediation Analysis Synthetic Control*, by Giovanni Mellace and Alessandra Pasquini (November 2022).

N. 1390 – *The effects of partial employment protection reforms: evidence from Italy*, by Diego Daruich, Sabrina Di Addario and Raffaele Saggio (November 2022).

N. 1391 – *The role of majority status in close election studies*, by Matteo Alpino and Marta Crispino (November 2022).

N. 1392 – *Issuing bonds during the Covid-19 pandemic: is there an ESG premium?*, by Fabrizio Ferriani (November 2022).

N. 1393 – *Economic fundamentals and stock market valuation: a CAPE-based approach*, by Maria Ludovica Drudi and Federico Calogero Nucera (November 2022).

(*) Requests for copies should be sent to:
Banca d'Italia – Servizio Studi di struttura economica e finanziaria – Divisione Biblioteca e Archivio storico – Via Nazionale, 91 – 00184 Rome – (fax 0039 06 47922059). They are available on the Internet www.bancaditalia.it.

2020

ALESSANDRI P. and M. BOTTERO, *Bank lending in uncertain times,* R European Economic Review, V. 128, **WP 1109 (April 2017).**

ANTUNES A. and V. ERCOLANI, *Public debt expansions and the dynamics of the household borrowing constraint,* Review of Economic Dynamics, v. 37, pp. 1-32, **WP 1268 (March 2020).**

ARDUINI T., E. PATACCHINI and E. RAINONE, *Treatment effects with heterogeneous externalities,* Journal of Business & Economic Statistics, , v. 38, 4, pp. 826-838, **WP 974 (October 2014).**

BALTRUNAITE A., C. GIORGIANTONIO, S. MOCETTI and T. ORLANDO, Discretion and supplier selection in public procurement, Journal of Law, Economics, and Organization, v. 37, 1, pp. 134-166, **WP 1178 (June 2018)**

BOLOGNA P., A. MIGLIETTA and A. SEGURA, *Contagion in the CoCos market? A case study of two stress events,* International Journal of Central Banking, v. 16, 6, pp. 137-184, **WP 1201 (November 2018).**

BOTTERO M., F. MEZZANOTTI and S. LENZU, *Sovereign debt exposure and the Bank Lending Channel: impact on credit supply and the real economy,* Journal of International Economics, v. 126, article 103328, **WP 1032 (October 2015).**

BRIPI F., D. LOSCHIAVO and D. REVELLI, *Services trade and credit frictions: evidence with matched bank – firm data,* The World Economy, v. 43, 5, pp. 1216-1252, **WP 1110 (April 2017).**

BRONZINI R., G. CARAMELLINO and S. MAGRI, *Venture capitalists at work: a Diff-in-Diff approach at late-stages of the screening process,* Journal of Business Venturing, v. 35, 3, **WP 1131 (September 2017).**

BRONZINI R., S. MOCETTI and M. MONGARDINI, *The economic effects of big events: evidence from the Great Jubilee 2000 in Rome,* Journal of Regional Science, v. 60, 4, pp. 801-822, **WP 1208 (February 2019).**

COIBION O., Y. GORODNICHENKO and T. ROPELE, *Inflation expectations and firms' decisions: new causal evidence,* Quarterly Journal of Economics, v. 135, 1, pp. 165-219, **WP 1219 (April 2019).**

CORSELLO F. and V. NISPI LANDI, *Labor market and financial shocks: a time-varying analysis,* Journal of Money, Credit and Banking, v. 52, 4, pp. 777-801, **WP 1179 (June 2018).**

COVA P. and F. NATOLI, *The risk-taking channel of international financial flows,* Journal of International Money and Finance, v. 102, **WP 1152 (December 2017).**

D'ALESSIO G., *Measurement errors in survey data and the estimation of poverty and inequality indices,* Statistica Applicata - Italian Journal of Applied Statistics, v. 32, 3, **WP 1116 (June 2017).**

DE BLASIO G., I. DE ANGELIS and L. RIZZICA, *Lost in corruption. Evidence from EU funding to Southern Italy,* Italian Economic Journal / Rivista italiana degli economisti, v. 6, 3, pp. 355–377, **WP 1180 (December 2016).**

DEL PRETE S. and S. FEDERICO, *Do links between banks matter for bilateral trade? Evidence from financial crises,* Review of World Economic, v. 156, 4, pp. 859 - 885, **WP 1217 (April 2019).**

D'IGNAZIO A. and C. MENON, *The causal effect of credit Guarantees for SMEs: evidence from Italy,* The Scandinavian Journal of Economics, v. 122, 1, pp. 191-218, **WP 900 (February 2013).**

ERCOLANI V. and F. NATOLI, *Forecasting US recessions: the role of economic uncertainty,* Economics Letters, v. 193, **WP 1299 (October 2020).**

MAKINEN T., L. SARNO and G. ZINNA, *Risky bank guarantees,* Journal of Financial Economics, v. 136, 2, pp. 490-522, **WP 1232 (July 2019).**

MODENA F., E. RETTORE and G. M. TANZI, *The effect of grants on university dropout rates: evidence from the Italian case,* Journal of Human Capital, v. 14, 3, pp. 343-370, **WP 1193 (September 2018).**

NISPI LANDI V., *Capital controls spillovers,* Journal of International Money and Finance, v. 109, **WP 1184 (July 2018).**

PERICOLI M., *On risk factors of the stock–bond correlation,* International Finance, v. 23, 3, pp. 392-416, **WP 1198 (November 2018).**

PIETRUNTI M. and F. M. SIGNORETTI, *Unconventional monetary policy and household debt: the role of cash-flow effects,* Journal of Macroeconomics, v. 64, Article 103201, **WP 1142 (October 2017).**

RAINONE E., *The network nature of OTC interest rates,* Journal of Financial Markets, v.47, article 100525, **WP 1022 (July 2015).**

RAINONE E. and F. VACIRCA, *Estimating the money market microstructure with negative and zero interest rates,* Quantitative Finance, v. 20, 2, pp. 207-234, **WP 1059 (March 2016).**

RIZZICA L., *Raising aspirations and higher education. Evidence from the UK's widening participation policy,* Journal of Labor Economics, v. 38, 1, pp. 183-214, **WP 1188 (September 2018).**

RIZZICA L. and M. TONELLO, *Persuadable perceptions: the effect of media content on beliefs about* *corruption,* Economic Policy, v. 35, 104, pp. 679–737, **WP 1043 (November 2016).**

SANTIONI, R., F. SCHIANTARELLI and P. STRAHAN, *Internal capital markets in times of crisis: the benefit of group affiliation*, Review of Finance, v. 24, 4, pp. 773-811, **WP 1146 (October 2017).**

SCHIANTARELLI F., M. STACCHINI and P. STRAHAN, *Bank Quality, judicial efficiency and loan repayment delays in Italy,* Journal of Finance, v. 75, 4, pp. 2139-2178, **WP 1072 (July 2016).**

2021

ACCETTURO A., A. LAMORGESE, S. MOCETTI and D. PELLEGRINO, *Housing Price elasticity and growth: evidence from Italian cities,* Journal of Economic Geography, v. 21, 3, pp. 367-396, **WP 1267 (March 2020).**

AFFINITO M. and M. PIAZZA, *Always look on the bright side? Central counterparties and interbank markets during the financial crisis*, International Journal of Central Banking, v. 17, 1, pp. 231-283, **WP 1181 (July 2018).**

ALBANESE G., E. CIANI and G. DE BLASIO, *Anything new in town? The local effects of urban regeneration policies in Italy,* Regional Science and Urban Economics, v. 86, **WP 1214 (April 2019).**

ALBANESE G., G. DE BLASIO and A. LOCATELLI, *Does EU regional policy promote local TFP growth? Evidence from the Italian Mezzogiorno,* Papers in Regional Science, v. 100, 2, pp. 327-348, **WP 1253 (December 2019).**

ALBERTAZZI A., A. NOBILI and F. M. SIGNORETTI, *The bank lending channel of conventional and unconventional monetary policy,* Journal of Money, Credit and Banking, v. 53, 2-3, pp. 261-299, **WP 1094 (Jan 2017).**

ANZUINI A. and L. ROSSI, *Fiscal policy in the US: a new measure of uncertainty and its effects on the American economy*, Empirical Economics, v. 61, 6, pp. 2613-2634, **WP 1197 (November 2018).**

APRIGLIANO V. and D. LIBERATI, *Using credit variables to date business cycle and to estimate the probabilities of recession in real time*, The Manchester School, v. 89, 51, pp. 76-96, **WP 1229 (July 2019).**

AUER S., M. BERNARDINI and M. CECIONI, *Corporate leverage and monetary policy effectiveness in the euro area,* European Economic Review, v. 140, Article 103943, **WP 1258 (December 2019).**

BANERJEE R, L. GAMBACORTA and E. SETTE, *The real effects of relationship lending,* Journal of Financial Intermediation, v. 48, Article 100923, **WP 1133 (September 2017).**

BARONE G., F. DAVID, G. DE BLASIO and S. MOCETTI, *How do house prices respond to mortgage supply?,* Journal of Economic Geography, v. 21, 1, pp.127-140, **WP 1282 (June 2020).**

BARONE G. and S. MOCETTI, *Intergenerational mobility in the very long run: Florence 1427-2011,* Review of Economic Studies, v. 88, 4, pp. 1863–1891, **WP 1060 (April 2016).**BARTOCCI A., L. BURLON, A. NOTARPIETRO and M. PISANI, *Macroeconomic effects of non-standard monetary policy measures in the Euro Area: the role of corporate bond purchases,* The Manchester School, v. 89, S1, pp. 97-130, **WP 1241 (Oct 2019).**

BATINI N., A. CANTELMO, G. MELINA and S. VILLA, *How loose, how tight? A measure of monetary and fiscal stance for the euro area,* Oxford Economic Papers, v. 73, 4, pp. 1536-1556, **WP 1295 (September 2020).**

BENETTON M. and D. FANTINO, *Targeted monetary policy and bank lending behavior,* Journal of Financial Economics, v. 142, 1, pp. 404-429, **WP 1187 (September 2018).**

BUSETTI F., M. CAIVANO and D. DELLE MONACHE, *Domestic and global determinants of inflation: evidence from expectile regression,* Oxford Bulletin of Economics and Statistics, v. 83, 4, pp. 982-1001, **WP 1225 (June 2019).**

BUSETTI F., M. CAIVANO, D. DELLE MONACHE and C. PACELLA, *The time-varying risk of Italian GDP,* Economic Modelling, v. 101, Article 105522, **WP 1288 (July 2020).**

BUSETTI F., S. NERI, A. NOTARPIETRO and M. PISANI, *Monetary Policy strategies in the new normal: a model-based analysis for the Euro Area,* Journal of Macroeconomics, v. 70, Article 103366, **WP 1308 (December 2020).**

CAPOLONGO A. and C. PACELLA, *Forecasting inflation in the Euro Area: countries matter*, Empirical Economics, v. 61, 4, pp. 2477-2499, **WP 1224 (June 2019).**

CARMIGNANI A., G. DE BLASIO, C. DEMMA and A. D'IGNAZIO, *Urbanization and firm access to credit,* Journal of Regional Science, v. 61, 3, pp. 597-622, **WP 1222 (June 2019).**

CORNELI F., *Financial integration without financial development,* Atlantic Economic Journal, v. 49, 2, pp. 201-220, **WP 1120 (June 2017).**

COVA P., P. PAGANO, A. NOTARPIETRO and M. PISANI, *Secular stagnation, R&D, public investment and monetary policy: a global-model perspective,* Macroeconomic Dynamics, v. 25, 5, pp. 1267-1287, **WP 1156 (December 2017).**

DE PHILIPPIS M., *Multitask agents and incentives: the case of teaching and research for university professors,* Economic Journal, v. 131, 636, pp. 1643-1681, **WP 1042 (December 2015).**

DEL PRETE S. and M. L. STEFANI, *Women as "Gold Dust": gender diversity in top boards and the performance of Italian banks,* Economic Notes, Monte dei Paschi di Siena, v. 50, 2, e12183, **WP 1014 (June 2015).**

FERRERO G., M. LOBERTO and M. MICCOLI, *The assets' pledgeability channel of unconventional monetary policy,* Economic Inquiry, v. 59, 4, pp. 1547-1568, **WP 1119 (June 2017).**

FIDORA M., C. GIORDANO and M. SCHMITZ, *Real exchange rate misalignments in the Euro Area,* Open Economies Review, v. 32, 1, pp. 71-107, **WP 1162 (January 2018).**

GAMBACORTA L., G. RICOTTI, S. SUNDARESAN and Z. WANG, *Tax effects on bank liability structure,* European Economic Review, v. 138, Article 103820, **WP 1101 (February 2017).**

HERTWECK M., V. LEWIS and S. VILLA, *Going the extra mile: effort by workers and job-seekers,* Journal of Money, Credit and Banking, v. 54, 8, pp. 2099-2127, **WP 1277 (June 2020).**

LI F., A. MERCATANTI, T. MAKINEN and A. SILVESTRINI, *A regression discontinuity design for ordinal running variables: evaluating central bank purchases of corporate bonds,* The Annals of Applied Statistics, v. 15, 1, pp. 304-322, **WP 1213 (March 2019).**

LOSCHIAVO D., *Big-city life (dis)satisfaction? The effect of urban living on subjective well-being,* Journal of Economic Behavior & Organization, vol. 192, pp. 740-764, **WP 1221 (June 2019).**

LOSCHIAVO D., *Household debt and income inequality: evidence from Italian survey data,* Review of Income and Wealth. v. 67, 1, pp. 61-103, **WP 1095 (January 2017).**

METELLI L. and F. NATOLI, *The international transmission of US tax shocks: a proxy-SVAR approach,* IMF Economic Review, v. 69, 2, pp. 325-356, **WP 1223 (June 2019).**

NISPI LANDI V. and A. SCHIAVONE, *The effectiveness of capital controls,* Open Economies Review, v. 32, 1, pp. 183-211, **WP 1200 (November 2018).**

PAPETTI A., *Demographics and the natural real interest rate: historical and projected paths for the Euro Area,* Journal of Economic Dynamics and Control, v. 132, Article 04209, **WP 1306 (November 2020).**

PEREDA FERNANDEZ S., *Copula-based random effects models for clustered data,* Journal of Business & Economic Statistics, v. 39, 2, pp. 575-588, **WP 1092 (January 2017).**

2022

ANDINI M., M. BOLDRINI, E. CIANI, G. DE BLASIO, A. D'IGNAZIO and A. PALADINI, *Machine learning in the service of policy targeting: the case of public credit guarantees,* Journal of Economic Behavior & Organization, v. 198, pp. 434-475, **WP 1206 (February 2019).**

ANGELICO C., J. MARCUCCI, M. MICCOLI and F. QUARTA, *Can we measure inflation expectations using twitter?,* Journal of Econometrics, v. 228, 2, pp. 259-277, **WP 1318 (February 2021).**

BOTTERO M., C. MINOIU, J. PEYDRÒ, A. POLO, A. PRESBITERO and E. SETTE, *Expansionary yet different: credit supply and real effects of negative interest rate policy,* Journal of Financial Economics, v. 146, 2, pp. 754-778, **WP 1269 (March 2020).**

CANTELMO A., *Rare disasters, the natural interest rate and monetary policy,* Oxford Bulletin of Economics and Statistics, v. 84, 3, pp. 473-496, **WP 1309 (December 2020).**

CARRIERO A., F. CORSELLO and M. MARCELLINO, *The global component of inflation volatility,* Journal of Applied Econometrics, v. 37, 4, pp. 700-721, **WP 1170 (May 2018).**

CIAPANNA E. and G. ROVIGATTI, *The grocery trolley race in times of Covid-19. Evidence from Italy,* Italian Economic Journal / Rivista italiana degli economisti, v. 8, 2, pp. 471-498, **WP 1341 (June 2021).**

FAIELLA I. and A. MISTRETTA, *The net zero challenge for firms' competitiveness,* Environmental & Resource Economics, v. 83, pp. 85-113, **WP 1259 (February 2020).**

GUISO L., A. POZZI, A. TSOY, L. GAMBACORTA and P. E. MISTRULLI, *The cost of steering in financial markets: evidence from the mortgage market,* Journal of Financial Economics, v.143, 3, pp. 1209-1226, **WP 1252 (December 2019).**

LAMORGESE A. and D. PELLEGRINO, *Loss aversion in housing appraisal: evidence from Italian homeowners,* Journal of Housing Economics, v. 56, Article 101826, **WP 1248 (November 2019).**

LI F., T. MÄKINEN, A. MERCATANTI and A. SILVESTRINI, *Causal analysis of central bank holdings of corporate bonds under interference,* Economic Modelling, v.113, Article 105873, **WP 1300 (November 2020).**

MIRENDA L., M. SAURO and L. RIZZICA, *The economic effects of mafia: firm level evidence,* American Economic Review, vol. 112, 8, pp. 2748-2773, **WP 1235 (October 2019).**

MOCETTI S., G. ROMA and E. RUBOLINO, *Knocking on parents' doors: regulation and intergenerational mobility,* Journal of Human Resources, v. 57, 2, pp. 525-554, **WP 1182 (July 2018).**

PERICOLI M. and M. TABOGA, *Nearly exact Bayesian estimation of non-linear no-arbitrage term-structure models,* Journal of Financial Econometrics, , v. 20, 5, pp. 807-838, **WP 1189 (September 2018).**

ROSSI P. and D. SCALISE, *Financial development and growth in European regions,* Journal of Regional Science, v. 62, 2, pp. 389-411, **WP 1246 (November 2019).**

SCHIVARDI F., E. SETTE and G. TABELLINI, *Credit misallocation during the European financial crisis,* Economic Journal, v. 132, 641, pp. 391-423, **WP 1139 (September 2017).**

TABOGA M., *Cross-country differences in the size of venture capital financing rounds: a machine learning approach,* Empirical Economics, v. 62, 3, pp. 991-1012, **WP 1243 (November 2019).**

FORTHCOMING

APRIGLIANO V., S. EMILIOZZI, G. GUAITOLI, A. LUCIANI, J. MARCUCCI and L. MONTEFORTE, *The power of text-based indicators in forecasting Italian economic activity,* International Journal of Forecasting, **WP 1321 (March 2021).**

BRONZINI R., A. D'IGNAZIO and D. REVELLI, *Financial structure and bank relationships of Italian multinational firms,* Journal of Multinational Financial Management, **WP 1326 (March 2021).**

DI ADDARIO S., P. KLINE, R. SAGGIO and M. SØLVSTEN, *It ain't where you're from, it's where you're at: hiring origins, firm heterogeneity, and Wages,* Journal of Econometrics, **WP 1374 (June 2022).**

FERRARI A. and V. NISPI LANDI, *Toward a green economy: the role of central bank's asset purchases,* International Journal of Central Banking, **WP 1358 (February 2022).**

LILLA F., *Volatility bursts: a discrete-time option model with multiple volatility components,* Journal of Financial Econometrics, **WP 1336 (June 2021).**

LOBERTO M, *Foreclosures and house prices,* Italian Economic Journal / Rivista italiana degli economisti, **WP 1325 (March 2021).**

LOBERTO M, A. LUCIANI and M. PANGALLO, *What do online listings tell us about the housing market?,* International Journal of Central Banking, **WP 1171 (April 2018).**

RIZZICA L., G. ROMA and G. ROVIGATTI, *The effects of shop opening hours deregulation: evidence from Italy,* The Journal of Law and Economics, **WP 1281 (June 2020).**

TANZI G. M., *Scars of youth non-employment and labour market conditions,* Italian Economic Journal / Rivista italiana degli economisti, **WP 1312 (December 2020).**