BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Exchange rate pass-through into euro area inflation. An estimated structural model

by Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani

September 2018

Number 1192

BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Exchange rate pass-through into euro area inflation. An estimated structural model

by Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani

Number 1192 - September 2018

ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

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

EXCHANGE RATE PASS-THROUGH INTO EURO AREA INFLATION. AN ESTIMATED STRUCTURAL MODEL

by Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani*

Abstract

We evaluate the exchange rate pass-through (ERPT) into euro area (EA) inflation by estimating an open economy New Keynesian model using Bayesian methods. In the model, the ERPT is incomplete because of local currency pricing and distribution services, with the latter allowing us to distinguish between ERPT at the border and ERPT at the consumer level. Our main results are: first, the ERPT into EA prices is, in general, high; second, it is particularly high at times of exchange rate and monetary policy shocks; and third, the EA monetary stance is relevant for ERPT, which is higher if the stance is accommodative when there are expansionary demand shocks.

JEL Classification: C11, E40, E47, E52, F41.
Keywords: exchange rate, import prices, pass-through, monetary policy, euro area.

Contents

1. Introduction 5
2. The model 7
   2.1 Overview 7
   2.2 Sources of ERPT incompleteness 9
      2.2.1 LCP 9
      2.2.2 Distribution sector 10
   2.3 Equilibrium 10
   2.4 ERPT 11
      2.4.1 ERPT in the shock-invariant approach 11
      2.4.2 ERPT in the shock-dependent approach 13
3. Data 13
4. Calibration 14
5. Results 16
   5.1 Shock-invariant ERPT 16
   5.2 Shock-dependent ERPT 17
   5.3 ERPT and monetary policy stance 19
   5.4 Decomposing EA inflation: the role of ERPT 21
6. Conclusions 22
References 23
Tables and figures 26
Appendix: the model 43

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

1 Introduction[1]

The exchange rate pass-through (ERPT) is commonly defined as the degree to which the changes in the exchange rate are transmitted to import prices and to final consumer prices. If ERPT at a given horizon is complete, than its value is equal to 1 (i.e., 100%).

Evaluating ERPT is essential for monitoring inflation and, thus, for calibrating the monetary policy stance. To the extent that ERPT into import prices is high, currency fluctuations will be accompanied by significant changes in import prices with a potentially large impact on consumer price inflation. Thus, ERPT is particularly relevant for monetary policymakers interested in preserving price stability.

This paper evaluates ERPT into euro area (EA) inflation by estimating with Bayesian methods a New Keynesian open economy model of the EA and the world economy. The EA is modeled as a whole (and not as a monetary union). There are two other regions outside the EA, i.e., the U.S.A. (US) and a residual region labelled 'rest of the world' (RW).

As the model is structural and estimated we can provide estimates of ERPT according to two widely used approaches in the literature.

One approach to measuring ERPT focuses on the coefficient that multiplies the exchange rate in the import pricing equation. It is the percentage change in import prices denominated in local currency resulting from a 1% change in the bilateral exchange rate between the exporting and the importing country, *other things equal* (including current values of other variables and expected values of all variables).[2] Within this approach, the shocks affecting the economy do not matter for the ERPT.

The other approach to measuring ERPT considers the ratio of the impulse response of import prices (or other relevant price index) to the response of the exchange rate, conditional on a given shock. It considers the response of prices to the (endogenous) changes in marginal costs and in current and expected values of all relevant variables.[3] Thus, the approach does not isolate the contribution of the exchange rate to changes in import prices, and builds on the general equilibrium properties of the model.

Starting with the first (shock-invariant) measure, in the model ERPT is incomplete because of two structural features. First, it is assumed that international markets are exogenously segmented and that the nominal prices of exported goods are invoiced and sticky in the currency of the destination markets (local currency pricing assumption, LCP). Second, the model features a distribution sector intensive in local non-tradables, which introduces a wedge between prices of imports at the border (wholesale) and consumer (retail) level.[4] Exporting firms, when setting

[1]We thank Anna Bartocci, Fabio Busetti, and Stefano Neri for useful comments. All errors are ours. 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.

[2]See Corsetti et al. (2008).

[3]See Forbes et al. (2018).

[4]See Corsetti et al. (2008).

the price of their good, take into account the presence of the distribution sector in the importing country. Distribution services induce differences in demand elasticity across countries. As a result of these two assumptions, monopolistically competitive producers charge different wholesale prices in the domestic and foreign markets, and do not move prices one-to-one with exchange rate movements (even when prices are fully flexible).

Concerning the second (shock-dependent) approach, we incorporate and estimate multiple structural shocks and assess the responses, determined by the general equilibrium solution of the model, of prices and exchange rate to a given shock (in particular, shocks to the uncovered interest parity condition, to monetary policy, and to aggregate demand).

Finally, the model incorporates, consistent with the New Keynesian literature, a number of nominal and real frictions such as sticky prices, sticky wages, investment adjustment costs, and habit persistence. The model also features an international market for crude oil, which is produced in the RW. The oil price is invoiced in US dollars and is fully flexible. Fluctuations in the euro vis-à-vis the US dollar induce changes in the price of oil imports and, thus, in consumer prices. In line with the empirical evidence, it is assumed that the international law of one price holds for oil (the international price of oil is the same everywhere when evaluated in the same currency; thus, ERPT into the euro-denominated price of oil is complete).

The model is estimated using EA quarterly data from 1999:1 to 2017:2. In particular, among the observables, we use data on the euro nominal effective exchange rate, the bilateral exchange rate of the euro vis-à-vis the US dollar, the import price deflator, the oil price (in US dollar), the consumer price deflator, its energy and non-energy components, the services deflator. These data allow us to accurately pin down the estimates of parameters regulating nominal rigidities of imported goods and, thus, the degree of ERPT.

Our main results are the following. First, EA ERPT is, in general, high. Second, it is particularly high in correspondence of exchange rate and monetary policy shocks. Third, the EA monetary stance is relevant for ERPT. In particular, ERPT is higher if the stance is accommodative in correspondence of expansionary demand shocks.

We contribute to the literature on ERPT in the EA. The novelty of our contribution is that it is based on estimating a large-scale DSGE model of the EA and the world economy, featuring multiple sources of incomplete ERPT into import prices. Our DSGE model of the EA is open-economy, as in Adolfson et al. (2007) and Warne et al. (2008). Different from them, our model includes distribution services as a source of price discrimination other than LCP, an endogenous oil market, fully endogenous US and RW blocs. As in Forni et al. (2015), we model EA imports of oil to control for the role of oil price in the EA economy and price dynamics. Different from that contribution, we also include distribution services and fully endogenous US and RW blocs. We build on Corsetti et al. (2008), that evaluate ERPT using a DSGE model with LCP and distribution services calibrated to the US economy.[5] Bouakez and Rebei (2008)

[5]See also Corsetti and Dedola (2005).

evaluate Canadian ERPT by estimating a DSGE model featuring LCP. Different from those contributions, we estimate the model with Bayesian methods, using EA data. De Walque et al. (2017) estimate a DSGE model of the EA featuring imperfect ERPT. Different from them, we estimate the model using data on both the euro effective nominal exchange rate and on the euro bilateral exchange rate vis-à-vis the US dollar (they use only the latter). Moreover, our model includes intermediate nontradables (their model includes only intermediate tradable goods) and both the US and the RW (they include only the US economy). Smets and Wouters (2002) find that the estimated ERPT depends to a considerable extent on the type of shock driving the economy. Different from them, we emphasize the relevance of both shock-invariant and shock-dependent approaches to ERPT and we estimate a larger model with Bayesian methods.

A more recent contribution on estimating EA ERPT is the one by Comunale and Kunovac (2017). They build on Forbes et al. (2018) and estimate the ERPT into EA prices within a structural VAR. Different from them, we estimate a DSGE model, combining data with a theoretical model. As in their case, we do find that ERPT is high when driven by monetary policy shocks.

The paper is organized as follows. Section 2 describes the model and report the ERPT definitions. Section 3 and 4 report the data and calibration of the model, respectively. Section 5 shows the ERPT results. Finally, Section 6 concludes.

2 The model

We first report an overview of the model. Subsequently, we describe the sources of ERPT incompleteness.

2.1 Overview

The model is New Keynesian and represents a world economy composed of three regions, i.e., EA, US, and RW.[6] The size of the world economy is normalized to 1. EA, US, and RW have sizes equal to n, n^*, and $(1 - n - n^*)$, with $n > 0$, $n^* > 0$, and $n + n^* < 1$.[7] The RW is the main EA trade partner. It allows us to assess the pass-through of nominal effective exchange rate. The US allows us to assess the role of the US dollar (the key currency in the international financial markets) and, in particular, its effects on EA import and consumer prices through crude oil prices, because oil is internationally traded and its international price is invoiced in US dollars.

The crucial feature of the model is that ERPT is incomplete, i.e., there is international price discrimination. It is assumed that the markets for tradable goods are (exogenously) segmented, so that firms can set a different price for each destination market (i.e., there are deviations from the law of one price). As in Corsetti et al. (2008), we make two key assumptions. First, the LCP

[6] In the Appendix we report the problems solved by firms and households and the main equations of the model.
[7] For each region, size refers to the overall population and to the number of firms operating in each sector.

assumption holds, i.e, nominal import prices are set and sticky in the currency of the destination market. Second, international price discrimination is (also) due to a country-specific distribution sector intensive in local non-tradables. Firms, when setting the prices of their tradable good, take into account the local distribution services. The latter are not only a source of international price discrimination, but also introduce the distinction between the wholesale (dock) and the retail (consumer) prices.

Households maximize an intertemporal utility function separable in consumption and labor.[8] They consume a final good, which is a composite of intermediate non-tradable and tradable goods, for consumption and investment (in physical capital) purposes. 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 by charging a mark-up over their marginal rate of substitution between consumption and leisure.

On the production side, there are perfectly competitive firms that produce two final goods (consumption and investment goods) and monopolistic firms that produce intermediate goods. The two final goods are sold only domestically, and are produced combining all available intermediate (tradable and non-tradable) manufacturing (non-oil) goods using a constant-elasticity-of-substitution (CES) production function. In the case of consumption, the resulting basket is combined with the energy good (composed by oil) according to another CES function.

Intermediate tradable and non-tradable non-oil goods are produced combining capital, labor, and oil. Specifically, capital and labor, supplied by domestic households, are combined according to a CES function. The resulting output, i.e., the value added, is combined with oil (again, using a CES function). The factors are assumed to be mobile across sectors.

Oil is a fixed endowment owned by the RW. Thus, the EA is an oil importer. The international price of oil is invoiced in US dollars. Moreover, we assume that the international law of one price holds for oil. Thus, exchange rate fluctuations of the US dollar are immediately and fully passed-through in the oil price when the latter is denominated in euro terms.

Intermediate tradable goods can be sold domestically and abroad. Since intermediate goods are differentiated, firms have market power and restrict output to create excess profits.

In each region the monetary policy rate is determined by the central bank according to a Taylor rule that reacts to consumer price inflation and output growth. The lagged value of the policy rate is also included among the variables that the central bank responds to, to take into account of the (possible) inertial conduct of monetary policy.

In each country households trade a riskless bond denominated in domestic currency, which is in zero net supply within the country. Households in the three regions trade a US dollar-denominated riskless bond. Thus, international financial markets are incomplete and an uncovered interest parity (UIP) condition holds in both EA and RW, linking the differential between the domestic and US monetary policy rates to the expected depreciation of the corresponding

[8] Following the literature, we assume a cashless economy.

domestic currency vis-à-vis the US dollar. Thus, exchange rates are determined by both the UIP conditions and the net foreign asset positions. Equivalently, exchange rates fluctuations allow for the clearing of international goods and financial markets.

Specifically, the UIP condition that holds for the EA households, obtained by log-linearizing the model around the deterministic steady-state, is

$$\hat{i}_{EA,t} + \hat{z}_{DOMRP,t} - \left(\hat{i}_{US,t} + \hat{z}_{USRP,t} - \phi_b \times \hat{b}_t\right) = E_t \widehat{\Delta S}_{t+1} \tag{1}$$

where $\hat{i}_{EA,t}$ and $\hat{z}_{DOMRP,t}$ are the (log-linearized) EA monetary policy rate and risk premium shock on EA bonds, $\hat{i}_{US,t}$ and $\hat{z}_{USRP,t}$ are the US monetary policy rate and risk premium shock on US dollar-denominated bonds held by the EA households, and the term $E_t\widehat{\Delta S}_{t+1}$ is the expected depreciation of the euro vis-à-vis the US dollar (E_t is the expectation operator in period t). The parameter $\phi_b > 0$ multiplies the EA net foreign asset position (NFA) $\hat{b}_t$. This adjustment cost implies that the NFA is not a unit root and thus that the model is stable. A similar condition holds in the RW, where we assume a risk premium shock on US-dollar denominated bonds held by the RW households.

Finally, adjustment costs ensure that the main variables react smoothly to a shock. Specifically, 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.[9]

2.2 Sources of ERPT incompleteness

There are two sources of ERPT incompleteness (i.e., ERPT lower than 1). First, nominal prices of tradable (non-oil) goods are set and sticky in the currency of the destination market, i.e., LCP holds. Second, in each region there is a distribution sector, intensive in local non-tradables, that introduces a wedge between the wholesale and the retail prices of the tradable goods.

2.2.1 LCP

We assume that markets are segmented and each firm sets one price for each destination market.

Following Dedola and Leduc (2001), prices of tradable goods are sticky in the currency of the destination markets, because the (generic) exporter has to pay a quadratic cost, proportional to the basket $Q_{F,t}$ of all exported goods, to adjust in each (generic) period t the nominal wholesale price $\bar{p}_t(f)$ of its (exported) manufactured good f invoiced in the currency of the destination market. In the case of a generic RW firm f exporting to the EA,

$$AC_{F,t}(f) = \frac{\kappa_F^p}{2}\left(\frac{\bar{p}_t(f)/\bar{p}_{t-1}(f)}{\bar{\pi}_{F,t-1}^{\alpha_F}\pi_{target}^{1-\alpha_F}} - 1\right)^2 \bar{P}_{F,t}Q_{F,t}, \tag{2}$$

[9] See Rotemberg (1982).

where $\kappa_F^p > 0$ is a parameter measuring the degree of nominal price stickiness, $0 \leq \alpha_F \leq 1$ measures indexation of current-period prices to previous-period sector-specific inflation rate $\bar{\pi}_{F,t-1}$, π_{target} is the long-run (steady-state) inflation rate, and $\bar{P}_{F,t}$ is the aggregate wholesale price of the exported basket.[10]

2.2.2 Distribution sector

The second source of incomplete ERPT is the distribution sector. We follow Burstein et al. (2003) and assume that bringing one unit of the traded good to the consumer requires η units of the non-traded good. Consequently, the retail price of the tradable good, $p_t(f)$, reflects not only its price at the border, but also a non-traded component, since

$$p_t(f) = \bar{p}_t(f) + \eta P_{N,t}, \tag{4}$$

where $\eta > 0$ is the bundle of non-tradables used to distribute the tradable goods to the households and $P_{N,t}$ the corresponding price. Thus, distribution costs introduce a wedge between border and consumer prices. ERPT of retail prices of traded goods will be lower than for wholesale prices, because distribution services are an important component of the retail price.

The variable $p_t(f)$ is the consumer price of the tradable good, which enters the demand of households,

$$D_t(f) = \left(\frac{p_t(f)}{P_{F,t}}\right)^{-\theta_F} C_{F,t,}, \tag{5}$$

where θ_F is the elasticity of substitution among brands f.

2.3 Equilibrium

In each country the initial asset positions, preferences, technologies, and budget constraints are the same for households and firms belonging to the same sector. Profits from ownership of domestic monopolistically competitive firms are equally shared among households. Thus, we consider the representative household for each region. Moreover, we consider the representative firm for each sector (final non-tradable, intermediate tradable, and intermediate non-tradable). The implied symmetric equilibrium is a sequence of allocations and prices such that, given initial conditions and considered shocks, in each country the representative household and representative firms satisfy their corresponding first order conditions, the monetary policy rule holds, and all

[10]Similar adjustment costs are paid by the firm f to adjust the corresponding price at home and in US. US and EA firms producing intermediate tradable goods also pay the corresponding adjustment costs. Moreover, in each country a similar adjustment cost holds for the generic firm n producing the intermediate non-traded good,

$$AC_{N,t}(n) = \frac{\kappa_N^p}{2}\left(\frac{p_t(n)/p_{t-1}(n)}{\pi_{N,t-1}{}^{\alpha_N}\pi^{1-\alpha_N}} - 1\right)^2 P_{N,t}Q_{N,t}. \tag{3}$$

markets clear.

2.4 ERPT

In what follows we report two approaches to measuring ERPT widely used in the literature. The first is a shock-invariant approach that is based on estimating the coefficient of the exchange rate in the pricing equation of the imported good and that does not depend on the shocks perturbing the economy. The second is a shock-dependent approach, in which ERPT depends not only upon all the equations of the model and in particular the pricing equations, but also upon the type of shock perturbing the economy and its general equilibrium effects.

2.4.1 ERPT in the shock-invariant approach

A large empirical literature is based on the estimation of a (single) pricing equation of imported goods and measures ERPT as the percentage change in import prices denominated in local currency resulting from a 1% change in the bilateral exchange rate between the exporting and the importing country, *other things equal*.[11]

In our framework, ERPT corresponds to the coefficient that multiplies the exchange rate in the log-linearized pricing equation of imported goods. The equation corresponds to the first-order condition of the export price-setting problem solved by each country's representative producer of the tradable good.

There is one export pricing equation for each destination market because of the assumption of international goods market segmentation. For the RW good exported to the EA, the pricing equation that determines its border (dock) price, invoiced in euro, is

$$\bar{p}_{F,t} = \theta_F \left(p_{F,t} - rmc^*_{F,t} \times rer_t \right) + A_{F,t}, \tag{6}$$

where $A_{F,t}$ is defined as

$$\begin{aligned} A_{F,t} \equiv\; & p_{F,t} \kappa^p_F \frac{\bar{\pi}_{F,t}}{\bar{\pi}^{ind_F}_{F,t-1} \pi^{1-ind_F}_{target}} \left(\frac{\bar{\pi}_{F,t}}{\bar{\pi}^{ind_F}_{F,t-1} \pi^{1-ind_F}_{target}} - 1 \right) \\ & - \beta \kappa^p_F p_{F,t} E_t \frac{1}{\pi_{t+1}} \frac{1}{\Delta S_{t+1}} \frac{\lambda^*_{t+1}}{\lambda^*_t} \frac{\bar{\pi}^2_{F,t+1}}{\bar{\pi}^{ind_F}_{F,t} \pi^{1-ind_F}_{target}} \left(\frac{\bar{\pi}_{F,t+1}}{\bar{\pi}^{ind_F}_{F,t} \pi^{1-ind_F}_{target}} - 1 \right) \frac{Q_{F,t+1}}{Q_{F,t}}, \end{aligned} \tag{7}$$

where $\bar{p}_F$ and p_F are the relative prices (in EA consumption unit) of the RW good at the border and consumer levels, respectively, rmc^*_F the marginal cost of production of the imported good expressed in RW consumption units, rer the real exchange rate of the euro vis-à-vis the RW currency, $\Delta S_{t+1} \equiv \frac{S_{t+1}}{S_t}$ is the depreciation of the euro vis-à-vis the US dollar and Q_F is the basket of exported goods. The parameter $0 < \beta < 1$ is the discount factor of the RW household

[11] See Corsetti et al. (2008).

(the owner of the firm exporting to the EA), E_t is the expectation operator, λ^* is the RW household's marginal utility of consumption.

The log-linear approximation (around the steady state equilibrium) of the above pricing equation is

$$\begin{aligned}\bar{p}_{F,t}\widehat{\bar{p}}_{F,t} &= \theta_F p_F \widehat{p}_{F,t} \\ &-\theta_F rmc_F^* rer(\widehat{rmc}_{F,t}^* + \widehat{rer}_t) \\ &+\kappa_F p_F \bar{\pi}_F \widehat{\bar{\pi}}_{F,t} \\ &-\beta\kappa_F p_F \bar{\pi}_F E_t \widehat{\bar{\pi}}_{F,t+1}\end{aligned} \tag{8}$$

where variables with "hat" are % deviations from steady-state and variables without time index are evaluated at steady state.

Exploiting (i) the definition of quarterly inflation rate ($\widehat{\bar{\pi}}_{F,t} \equiv \widehat{\bar{P}}_{F,t} - \widehat{\bar{P}}_{F,t-1}$), (ii) the definition of real exchange rate ($\widehat{rer}_t \equiv \widehat{S}_t + \widehat{P}_t^* - \widehat{P}_t$), (iii) the definition of relative price ($\widehat{\bar{p}}_{F,t} \equiv \widehat{\bar{P}}_{F,t} - \widehat{P}_t$) and the relation (4) between import prices at the border and at consumer levels, in the previous equation ERPT can be defined by

$$\widehat{\bar{P}}_{F,t} = \frac{\theta_F \times rer \times rmc_F^*}{\bar{P}_F(\theta_F - 1) + \left(\bar{P}_F + \eta P_N\right)(1+\beta)\kappa_F^p \pi}\hat{S}_t \tag{9}$$

where $\hat{S}_t$ is the period-t exchange rate. The coefficient that multiplies the exchange rate, i.e., the ERPT, is a convolution of structural parameters and steady-state values of some variables. Crucially, two parameters determine the size of the ERPT in each country, i.e., the parameter measuring the import price stickiness, κ_F^p, and the parameter η measuring the role of the distribution services.[12] The higher the parameters κ_F^p and η, the lower the coefficient that multiplies the exchange rate and, thus, the lower the ERPT.

This concept of ERPT isolates the contribution of the nominal exchange rate to import prices in the considered period taking as given the current and expected values of all other variables, including the expected future values of the exchange rate and the shocks. The ERPT is invariant to the shock moving the exchange rate, as it corresponds to a coefficient that is a convolution of the structural parameters of the model.[13]

[12] The latter enters the steady-state distribution margin in EA, μ, defined as

$$\mu = \eta \frac{P_N}{P_F}, \tag{10}$$

which measures the weight of distribution in the consumer price of imported goods (P_N and P_F are evaluated in steady state).

[13] The shock-invariant ERPT does not measure the effect on current-period prices of the overall, current and expected future, exchange rate change. This effect is obtained by iterating forward the pricing equation through iterative substitutions of expected inflation term, and is measured by the coefficient multiplying the current and expected exchange rate change.

2.4.2 ERPT in the shock-dependent approach

Another definition of ERPT, used in many empirical analyses, is the response of import prices (or other relevant price index) to the exchange rate conditional on a given shock. The response of prices is due not only to changes in exchange rate but also to the (endogenous) changes in marginal costs and in current and expected values of all relevant variables. Thus, it does not isolate the contribution of the exchange rate to changes in import prices. According to this definition, ERPT does not correspond to the coefficient that multiplies the exchange rate in the pricing equation because, different from the shock-invariant approach, the *other things equal* assumption does not hold. Specifically, *all* variables in the pricing equation are allowed to change according to the shock perturbing the economy, and the dynamics of import prices and exchange rate (and, thus, the ERPT) would be determined in general equilibrium.[14]

We stress that the shock-dependent ERPT builds upon the shock-invariant approach in structural models like ours. The effects of shocks on exchange rate and prices are determined by the general equilibrium solution of the model, but crucially depend upon the specification of the pricing equations and the values of their calibrated or estimated parameters, in particular the coefficient that multiplies the exchange rate. The size of ERPT associated with a shock perturbing the economy is higher if that coefficient is large. This happens if the structural sources of ERPT incompleteness in the pricing equations are not relevant, i.e., if the parameters measuring nominal price rigidities of imports (κ_F in the pricing equation of EA imports from the RW, and the corresponding parameter for all other import pricing equations) and the weight of local nontradable distribution services in the consumer prices (parameter η) are small.

3 Data

To estimate the model, we use quarterly data for the period 1999:1-2017:2 and match the following EA variables: GDP, consumption, investment, exports, imports, hours worked, consumption deflator, services deflator, non-energy and energy consumption deflators, export deflator, import deflator, nominal wage, three-month interest rate, long-term interest rate, nominal effective exchange rate, bilateral exchange rate vis-à-vis the US dollar, oil price (in US dollars), foreign aggregate demand.[15]

The use of a relatively large number of observables allows us to improve the identification of the estimated parameters.

We assume a worldwide non-stationary labor-augmenting technology that induces a common trend in the real variables of the model. We make them stationary by using first differences. Interest rates, exchange rates, and hours worked are demeaned. Similarly, we take first differences

[14] As emphasized by Corsetti and Dedola (2005) and more recently by Forbes et al. (2018), according to this approach, what ultimately matters for ERPT is the type of shock that is hitting the economy.

[15] GDP and its components and foreign aggregate demand are in real terms. In the model, they are evaluated at steady-state (constant) prices.

of deflators.

We estimate AR(1) processes for a large set of EA-based shocks: consumption preference, investment-specific, unit-root technology, total factor productivity, risk premium on euro-denominated bonds (which are held only the the EA households), risk premium on US dollar-denominated bonds held by the EA households, domestic tradables cost-push, import from RW cost-push, export to RW cost-push, nontradable cost-push, labor cost-push. The EA monetary policy shock follows an i.i.d process.[16] We also estimate AR(1) processes for shocks to RW consumption preference, RW crude oil supply, risk premium on US dollar-denominated bonds held by the RW households.

In the model, the EA long-term is equal to the short-term (risk-free) EA interest rate and the shock to the risk premium on EA bonds via expectations hypothesis.[17] Including the EA long-term interest rate among the observables should provide information about the effects on exchange rate and prices of non-standard monetary policy measures implemented by the ECB.

We also add measurement errors into the measurement equations of all observables but those of interest rates and exchange rates. The standard deviations of the measurement errors are calibrated to relatively small values.

The model's parameters that are not calibrated are estimated with Bayesian methods. Bayesian inference updates the prior distribution to the posterior distribution of the model's parameters using the observed data. Specifically, and following common practice in the literature, the joint posterior distribution of all estimated parameters is based on the log-linear state-space representation of the model. It is obtained as follows.[18] First, the posterior mode and an approximate covariance matrix, based on the inverse Hessian matrix evaluated at the mode, is obtained by numerical optimization on the log posterior density (the optimization is based on the Kalman filter). Second, the posterior distribution is explored by generating draws using the Metropolis-Hastings algorithm. The proposal distribution is taken to be the multivariate normal density centered at the previous draw with a covariance matrix proportional to the inverse Hessian at the posterior mode.

4 Calibration

We calibrate parameters affecting the (deterministic) steady-state equilibrium of the model. Specifically, parameters are set in line with the existing literature and to match (empirical) great ratios over the sample period.[19]

The matched great ratios are reported in Table 1. They are private consumption, government

[16]The persistence is provided by the coefficient of the lagged value of the policy rate in the Taylor rule.

[17]Iterating forward the Euler equation on the domestic bond and taking into account the domestic risk premium shock provides the definition of the long-term interest rate.

[18]See Schorfheide (2000) and An and Schorfheide (2007).

[19]See Warne et al. (2008) and Burlon et al. (2017).

consumption, total investment, and imports (all are ratios to GDP). The export-to-GDP ratio is set to the same value as import-to-GDP ratio, because we assume that the trade balance is equal to zero in steady state.

The implied parameter values are reported in Table 2.

All real variables are assumed to evolve along a balanced-growth path with a trend growth rate of 1.4% per annum, which roughly matches average real GDP growth in our estimation sample. Given the steady-state growth rate, the discount factor β is set consistently with an annualized nominal interest rate of 3.5%. The intertemporal elasticity of consumption is set to 1 (log utility of consumption).

The parameter η is equal to 1.2, so that the distribution margin is equal to 0.5 (i.e., 50% of the consumer price of imports). This value is in line with Corsetti et al. (2008) and de Walque et al. (2017). The latter contribution sets the share of the distribution sector required to make imported goods available for final demand purposes in the EA to 40%.

Nominal (wage and price) rigidities in the US and RW are determined according to calibrated Rotemberg parameters. US export prices are assumed to adjust once every quarter on average when converted in Calvo (1983) terms. US import prices are assumed to be relatively sticky and to adjust once every one-two quarters, while US and RW domestic prices of their domestically produced tradable good adjust once every year. For prices of non-tradables and wages, they adjust once every 4 years and every 2 years, respectively. The chosen calibration is in line with the literature, that sets or estimates nominal rigidities for non-tradable and domestically sold tradable goods larger than for exported and imported goods, and sets or estimates nominal wage rigidities to be relatively large (see Adolfson et al. 2007, Forni et al. 2015, Gomes et al. 2012, and Warne et al. 2008).

The low degree of nominal rigidities in the case of US exports is consistent with the evidence that ERPT is high for US tradables and that the latter are mainly invoiced in US dollars (see Gopinath 2016).

The elasticity of substitution between domestic and imported tradable goods is set to 1.5, between tradable and non-tradable goods to 0.8, between energy and non-energy component in the consumption bundle to 0.4.[20]

Finally, we calibrate some parameters that are difficult to identify. In line the literature (e.g., Adolfson et al. 2007 and Warne et al. 2008), the inverse of the Frish labor supply elasticity is set to 1.5. The parameter measuring the sensitivity of the external intermediation premium to net foreign asset position (ϕ_b in equation 1), is set to 0.01. This value does not greatly affect the trade balance dynamics and, at the same time, guarantees that the net foreign asset position is stable (i.e., it does not display a unit root).[21]

[20] The weights of the goods in the consumption and investment bundles are set to match the import content of consumption and investment spending.

[21] Other parameters are not reported to save on space. The long-run (net) inflation target of the central bank is assumed to equal 1.9% at an annualized rate. The depreciation rate $0 < \delta < 1$ in the capital accumulation

5 Results

Table 3 reports the estimation results. It shows the posterior mode of all the parameters along with the approximate posterior standard deviation obtained from the inverse Hessian at the posterior mode, the posterior mean along with the 5th and 95th percentiles of the marginal posterior distribution distributions. The latter are computed using the Metropolis-Hastings algorithm based on three Markov chains with 1,000,000 draws each.[22]

The chosen prior means for the EA nominal wage and price stickiness is in line with the literature, that sets or estimates nominal rigidities for non-tradable and domestically sold tradable goods larger than for exported and imported goods, and sets or estimates nominal wage rigidities to be relatively large (see Adolfson et al. 2007, Forni et al. 2015, Gomes et al. 2012, and Warne et al. 2008).

The estimated sticky price parameter for the EA imports from the RW, which is relevant for ERPT into the EA prices, is low. The posterior mean suggests two-quarter stickiness (the posterior mode suggests a similar value). The stickiness of EA export prices is estimated to be low (the posterior mean is lower than the prior). To the opposite, non-tradable price stickiness and nominal wage stickiness have a large posterior mean. Estimated indexation parameters are not very large, implying a moderate degree of inertia in inflation.

Parameters of the Taylor rule are estimated to be in line with the existing literature. The weight on inflation is estimated to be relatively large. Moreover, there is some smoothing in setting the policy rate, as suggested by the estimate of the related parameter.

Concerning estimated shocks, they are found to be not extremely autocorrelated. This result suggests that the model is able to generate an internal propagation mechanism that sufficiently fits the data.

Overall, estimated EA import price stickiness is low in absolute terms and relative to the stickiness of EA non-tradables and wages, implicitly suggesting that the ERPT into import prices can be non-negligible.

5.1 Shock-invariant ERPT

The calibrated distribution margin and non-tradables nominal rigidities joint with the estimated nominal price rigidity of EA non-oil imports from the RW provide an estimate of the corresponding shock-invariant ERPT coefficient. As said, the latter is a *ceteris paribus* concept (see equation 9). When evaluated at the posterior mean, it is estimated to be 0.083 and 0.038 at the border and at retail level, respectively (for comparison, ERPT into EA prices of US tradables

equation is equal to 0.025. The weights of physical capital in the production functions of the intermediate tradable and non-tradable goods are set to match the investment-to GDP ratio. Wage, tradable, and non-tradable price mark-ups are set to 1.30, 1.20, and 1.33, respectively (the corresponding elasticities of substitution among brands are 4.33, 6.00, 4.00, respectively).

[22]The resulting acceptance rate is around 21%.

is calibrated to roughly 0.45 and 0.19 at the border and consumer level, respectively).[23] Thus, in every quarter t, ceteris paribus, 8.3% (3.8%) of exchange rate fluctuations are passed-through into border (retail) prices of EA non-oil imports from the RW. When we evaluate the nominal price stickiness parameter of non-oil imports from RW at the 5th and 95th percentiles (and thus set it to 4.685 and 13.654, respectively, see Table 3), the corresponding range of estimated EA ERPT is between 0.058 and 0.148. Our estimates for ERPT into EA import prices are lower than the estimates reported by Özyurt (2016) using a single-equation approach, whose ERPT estimate into overall EA import prices in the first quarter is around 0.3. We get an estimate closer to this value (0.28) if we take into account that the prices of EA imports from the US and EA imports of oil have a large ERPT (close to 1) on impact, and that each of them has roughly 10% weight in overall EA imports.[24]

When (counterfactually) setting the parameter of import from RW nominal price rigidity to zero, the ERPT at the border is equal to 0.76. This suggests a relatively large role of LCP for the incompleteness of the ERPT. Similarly when setting the parameter η to zero (while keeping unchanged other parameters and steady-state values of the relevant variables), the ERPT increases to 0.16, suggesting a non-trivial role of the distribution services for the ERPT incompleteness.

ERPT is measured by the coefficient before the exchange rate $\hat{S}_t$ in equation (9). It isolates the contribution of the current change in the exchange rate to import prices, independently of the shock perturbing the economy (shock-invariant coefficient); thus, the expected values of the exchange rates and the current and expected values of the other variables and all shocks are taken as given. At the same time it is also important, according to some more recent contributions, to assess the ERPT when considering the response of import prices to a specific structural shock.[25] According to this approach, ERPT depends on the effects of the shocks on current and expected values of all variables. This assessment builds upon the shock-invariant ERPT, because the values of the parameters that enter the pricing equations affect the propagation of the shocks, in particular to prices and exchange rates. We report estimates of the ERPT according to this approach in the next section.

5.2 Shock-dependent ERPT

Figures 1-5 show the estimated shock-dependent ERPT into EA prices in correspondence of alternative EA-specific structural shocks. ERPT is measured by the ratio between the cumulated changes in price and the cumulated changes in the euro nominal effective exchange rate. The standard deviations of the shocks are normalized to get a 1% depreciation of the euro nominal

[23] In the ERPT coefficient, the steady-state variables have the following values: the real exchange rate is 0.89, the real marginal cost 0.44, the import price at the border 0.625, the import price at the consumer level 1.376, the price of nontradables 0.625, the consumer price inflation 1.004. The discount factor is calibrated to 0.9996, and the elasticity of substitution among RW brands to 6.

[24] As already noted, the degree of nominal rigidity of the price of EA import from the US is calibrated to a relatively small value, in line with the empirical evidence. Thus, the corresponding ERPT is relatively high.

[25] See Forbes et al. (2018) and Comunale and Kunovac (2017), that estimate structural VARs.

effective exchange rate on impact (first quarter). The value of the persistence of considered shocks is the estimated posterior mean. Remaining parameters are evaluated at the posterior mean.

In the case of a shock to the EA risk premium on US dollar-denominated bonds (commonly labelled in the literature as shock to the UIP condition), import prices at the border increase following the exchange rate depreciation (see Figure 1). The short-run increase in prices is not as large as the depreciation, i.e., prices do not fully and immediately adjust to the change in the exchange rate. The reason is that firms prefer to change prices in a gradual (sluggish) manner because of the adjustment costs (see eq. 2). Thus, firms adjust short-run mark-ups. The latter also reflect the distribution services, whose prices change because of the general equilibrium effects of the shock. The distribution sector is also the source of the slower increase of import prices at consumer (retail) level. It introduces a wedge between the import prices at the border and consumer level which is based on the prices of non-tradable services (see eq. 4), and these are estimated to be relatively sticky. Following the higher import prices, consumer prices increase as well. Their increase is smaller than that of import prices, because the imported goods are a relatively small share of the consumption basket and the prices of domestic (tradable and non-tradable) goods respond to a lower extent to the shock.

Figure 2 reports the corresponding ERPT. In the short run the ERPT of import prices at the border is incomplete. However, it is high, consistent with the estimated low degree of stickiness of imported goods. In the initial quarter it is equal to 0.3 and 0.2 for import prices at the border level and for import prices at the consumer level, respectively. It is equal to 0.1 for consumer prices. In the fourth quarter, to 0.7, 0.4, and 0.2, respectively. The ERPT is larger in the medium and long run than in the short run because nominal prices adjust over time and, thus, they incorporate to a larger extent the changes in the nominal exchange rate.

Our results are of the same order of magnitude and on the upper end of the range of the results reported in ECB (2016; Table 1, page 16): in correspondence of a 1% nominal effective appreciation of the euro, the range of the values of ERPT into import prices, obtained from estimating several multiple-equation macroeconomic models, is between 0.30 and 0.71 after one year. ECB (2016) also reports ERPT based on a single-equation regression model. Estimates suggest that for the EA a 1% nominal effective appreciation of the euro has, on average, resulted in a 0.51% decline in aggregate import prices after four quarters. De Walque et al. (2017) find that on impact ERPT into import prices is 0.335 at the border in correspondence of a risk premium shock. We do find a similar value.

The relatively high ERPT already in the short run is due to the degree of import price stickiness, which in the case of EA imports from the RW is estimated to be relatively low (the RW is the main EA trade partner; thus, the price of its exports to the EA is the main determinant of EA ERPT).[26] Thus, import prices adjust in a relatively quick manner to the increase in the exchange rate. This is true in particular for the ERPT into import prices at the border, while

[26] EA imports from the US are a small share of overall EA imports.

the corresponding ERPT at the consumer level is lower, because it is affected by the prices of distribution services, which are relatively sluggish. Similarly, the ERPT into consumer prices is lower than ERPT into import prices because prices of domestic goods are sticky and adjust in a gradual way to the shock.

To further clarify what mechanisms determine different ERPT across shocks, we now consider a 1% depreciation associated with a shock to the EA monetary policy rate in the initial quarter. Import prices increase for two reasons (see Figure 3). First, the exchange rate depreciates. Second, the looser monetary policy also increases EA aggregate demand for both domestic and imported goods. Foreign firms react to the higher EA aggregate demand by (endogenously) increasing the mark-ups and prices of the goods exported to the EA.

Figure 4 shows the corresponding ERPT. Relative to the case of the risk premium-dependent ERPT (Figure 2), the ERPT into import prices at the border is overall higher, reflecting the additional positive impulse on prices due to the increase in EA aggregate demand. Similarly, the ERPT into import prices is higher at the consumer level than in the case of the risk premium shock because firms increase the mark-ups in correspondence of the rise in EA consumption and investment. Four quarters after the shock the ERPT into import prices at the border and consumer level is equal to 0.8 and 0.5, respectively. ERPT into overall consumer prices is equal to 0.3.

ERPT in the case of a recessionary EA aggregate demand shock is obtained through a decrease in both EA consumption and investment due to a negative preference shock (Figure 5). The prices of domestic and imported goods tend to decrease, as firms face a persistent decrease in demand for their products and, thus, reduce their mark-up. The exchange rate depreciates on impact, because the EA central bank reduces the policy rate to stabilize the lower EA economic activity and prices. Thus, import prices, following the depreciation, decrease by less than they would have done were it not for deteriorating domestic conditions.

The net effect is that the ERPT into import prices at the border and at the retail level is negative, as prices fall despite the positive impulse from the exchange rate depreciation.[27] Similarly, ERPT into consumer prices is negative.

Overall, we find that the EA ERPT tends to be high in correspondence of shocks to monetary policy or to the risk premium (UIP), while it is negative in the case of shocks to domestic aggregate demand.[28]

5.3 ERPT and monetary policy stance

In the previous section we have measured ERPT in correspondence of different shocks that induce a depreciation of the euro nominal effective exchange rate. In this section we assess the effects

[27] To save on space we do not report the corresponding figure.

[28] Our results are similar to those, based on an estimated structural vector autoregressive model, reported by Forbes et al. (2018) for the case of UK and Comunale and Kunovac (2017) for the case of the EA.

of the monetary policy stance on ERPT and, through it, on domestic prices. One challenge that central banks will face in the near future, in a process of normalization of the policy stance, is the return to a situation where interest rates and guidance on their future developments will return to be the primary instrument for adjusting the monetary stance, while ensuring sufficiently supportive financial conditions.[29] Hence, we consider different possible decisions about the monetary policy rate by the central bank in response to a given shock.

We initially simulate a positive (i.e., expansionary) exogenous shock to EA aggregate demand that induces an appreciation of the nominal exchange rate, because the EA central bank increases the monetary policy rate to stabilize (consumer price) inflation and economic activity, as dictated by the Taylor rule. We then newly run the same demand shock under the assumption that the EA central bank reacts to a lower extent than in the benchmark case to the implied increase in consumer prices. Moreover, we also consider one type of non-standard monetary policy measure, the so-called forward guidance (FG). It is defined as a credible announcement by the EA central bank to keep the policy rate constant at its baseline level during the initial quarters instead of raising it because of the expansionary effects of the aggregate demand shock.[30]

Figure 6 reports results under a Taylor coefficient calibrated to the posterior mean, 1.7 (see Table 3). The exchange rate appreciates on impact, consistent with the larger increase in domestic interest rates and the EA excess demand of domestic goods. In the subsequent periods, the exchange rate depreciates, and, thus, returns towards the baseline and crosses it, consistent with the gradual increase in the EA policy rate.

Figure 7 reports the corresponding ERPT. Its sign is initially negative, because prices increase and the exchange rate appreciates (an appreciation has a negative sign). Thereafter, it switches sign in an abrupt way, when the nominal exchange rate crosses its baseline level (thus, its cumulative deviation becomes zero, causing the asymptotic behavior of the ERPT response) and starts to depreciate (the sign of the ERPT becomes positive).

These results should be compared to those obtained under a Taylor coefficient calibrated to 1.01.[31] Figures 8 and 9 report the corresponding results. In this case of less aggressive monetary policy stance, there is a lower increase in the policy rate relative to the foreign (US and RW) interest rates. The nominal exchange rate depreciates on impact, consistent with the relative low EA interest rate and the EA excess demand of foreign goods. Thus, import prices increase to a large extent. Moreover, given that the stance is less aggressive, domestic firms anticipate a larger improvement in macroeconomic conditions following the demand shock and, thus, raise prices to a larger extent. As a result, the ERPT into import prices at the border and consumer level and the ERPT into consumer prices are large already in the short run and increase over time to a large extent.

[29] See ECB (2018).

[30] In all scenarios, the EA aggregate demand shock is the same, and corresponds to a positive EA consumption preference shock that induces an initial 1% appreciation of the euro exchange rate under standard monetary policy.

[31] This is the lowest admissible value consistent with the equilibrium determinacy.

Finally, Figures 10 and 11 show results under the assumption of three-quarter FG. Relative to the case of standard monetary policy, and in line with the results based on the less aggressive monetary policy stance, the nominal exchange rate initially depreciates and prices increase to a larger extent. Thus, ERPT increases. After four quarters the ERPT into consumer prices is larger than one.

Overall, results suggest that the monetary policy stance and non-standard monetary policy measures like FG are relevant for the size of ERPT in correspondence of fundamental shocks.[32]

5.4 Decomposing EA inflation: the role of ERPT

The estimates reported in the previous sections allow us to measure ERPT and to disentangle the different sources of its incompleteness, associated with firms' optimal pricing behavior, affected by local currency pricing, distribution services, and shocks perturbing the economy. On the basis of these estimates we now measure the relevance of exchange rate fluctuations for recent price developments in the EA.

Figure 12, 13, and 14 report the changes in the euro nominal effective exchange rate, import prices, and consumer prices, respectively. Structural shocks are grouped as follows: demand includes consumption preference and investment-specific shocks; supply includes unit-root technology, total factor productivity, domestic tradables cost-push, export to RW cost-push, import from RW cost-push, nontradable cost-push, and labor cost-push shocks; foreign demand includes the RW consumption preference shock; oil supply includes the oil supply shock; monetary policy includes the monetary policy shock; exchange rate includes the risk premium shock on US dollar-denominated bonds held in EA and the risk premium shock on US dollar-denominated bonds held in RW; financial includes risk premium on euro-denominated bonds. We include measurement errors with calibrated variance on GDP, consumption, investment, exports, imports, hours worked, consumption deflator, services deflator, non-energy consumption deflator, export deflator, import deflator, energy deflator, nominal wage, oil price (in US dollars), foreign aggregate demand. Finally, in the figures we also include the contribution of the initial state of the economy, which dies out quite rapidly.

The nominal effective exchange rate (Figure 12) is mainly determined by risk-premium shocks entering the UIP condition (see equation 1). Those shocks most likely reflect also the effects of the non-standard monetary policy measures implemented in the EA since 2015. Consistent with this interpretation, and the decrease in EA short- and long-term interest rates, the exchange rate shows a depreciation over the 2015-16 period (the decrease in long-term interest rates, not reported to save on space, is driven by the contribution of financial shocks). Moreover, the

[32] In the literature there is a well know FG puzzle, i.e. the very large macroeconomic effects associated with a long-lasting FG. For this reason, we limit ourselves to the case of three-quarter FG. Carlstrom et al. (2012) show that a promise by the central bank to peg interest rates below the natural rate of interest for roughly two years generates explosive dynamics for inflation and output in a workhorse New Keynesian model. See also, on the FG puzzle, Del Negro et al. (2013) and McKay et al. (2016).

(standard) 'monetary policy' contributions to the exchange rate, due to shocks to the Taylor rule, are mainly negative. This is consistent with the accommodative monetary policy in the EA (whose aim was to favor price stability).

Consistent with the relatively high ERPT, shocks to the exchange rate also provided a non-trivial contribution to import price inflation (Figure 13), joint with shocks to the supply of crude oil (labelled 'oil supply') and to worldwide demand.[33] In particular, the shocks determining the exchange rate provide a positive contribution to import prices in the 2015-16 period.

Shocks that determine exchange rate fluctuations have systematically contributed to consumer price inflation dynamics (see Figure 14), even if ERPT is lower at consumer level than at the border. In particular, the exchange rate depreciation gives a positive contribution from 2014 onward. Recent weak inflation dynamics seems to be associated to EA domestic factors. In the 2016-17 period the contributions of both EA aggregate demand and supply shocks are negative, only partially compensated by the positive contribution of the monetary policy, which has sustained aggregate demand by keeping short- and long-term interest rates at a low level.[34]

Overall, the decomposition, which builds on the estimated ERPT, suggests a non-trivial role of exchange rate fluctuations for EA inflation dynamics.

6 Conclusions

Evaluating the size of the ERPT into prices is crucial for conducting monetary policy. This is particularly true for the EA, which is a relatively open economy. In this paper we have provided some evidence for EA ERPT, based on estimating a DSGE model featuring the EA, US, and RW and, crucially, LCP and distribution services as sources of ERPT incompleteness. Our results suggest that ERPT is relatively high in the EA. Crucially, we have shown that the monetary policy stance matters for the size of ERPT.

Structural sources of pass-through incompleteness other than LCP and distribution sector can be considered. For example, inventory management of imported goods.[35] Moreover, we have not (explicitly) assessed the impact on ERPT of the asset purchases programme, a non-standard monetary policy measure implemented in the EA to favor a sustained adjustment in the path of inflation towards the objective.[36] We leave these issues for future research.

[33]Oil prices are found to be mainly driven by oil supply shocks and, to a lower extent, by shocks to aggregate world demand.

[34]Crude oil shocks are also relevant, in particular in 2009 and 2015 they contribute to the fall in inflation. The oil price determines the development of the energy component of the consumption basket, with the former being around 10% of the latter.

[35]See the survey in Burstein and Gopinath (2014).

[36]For a DSGE-based assessment of the macroeconomic effects of the EA asset purchases programme, see Burlon et al. (2017) and Cova et al. (2015).

References

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

[2] An, S. and F. Schorfheide, 2007. Bayesian analysis of DSGE Models. *Econometric Reviews*. 26, pages 113–172.

[3] Bouakez, H. and N. Rebei, 2008. Has exchange rate pass-through really declined? Evidence from Canada. *Journal of International Economics*, 75(2), pages 249–267.

[4] Burlon, L., A. Gerali, A. Notarpietro, and M. Pisani, 2017. Macroeconomic effectiveness of non-standard monetary policy and early exit. A model-based evaluation. *International Finance*, 20(2), pages 155–173, June.

[5] Burstein, A. T., and G. Gopinath, 2014. International prices and exchange rates. Handbook of International Economics, 4th ed., pages 391–451, Elsevier.

[6] Burstein, A. T., J. Neves, and S. Rebelo, 2003. Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations. *Journal of Monetary Economics*, 70, pages 1189–214.

[7] Calvo, G. A., 1983. Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12, pages 383–398.

[8] Carlstrom, C. T., T. S. Fuerst, and M.Paustian, 2012. Inflation and output in New Keynesian models with a transient interest rate peg. Federal Reserve Bank of Cleveland Working Paper 1234.

[9] Comunale, M. and D. Kunovac, 2017. Exchange rate pass-through in the euro area. ECB Working Paper Series 2003.

[10] Corsetti, G. and L. Dedola, 2005. A macroeconomic model of international price discrimination. *Journal of International Economics*, 67(1), pages 129–155.

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

[12] Cova, P., P. Pagano, and M. Pisani, 2015. Domestic and international macroeconomic effects of the Eurosystem expanded asset purchase programme. Temi di discussione (Economic working papers) 1036, Bank of Italy, DG Economics, Statistics and Research.

[13] Dedola, L. and S. Leduc, 2001. Why is the business-cycle behaviour of fundamentals alike across exchange-rate regimes?. *International Journal of Finance and Economics*, 6, pages 401–419.

[14] De Walque, G., Jeanfils, P., Lejeune, T., Y. Rychalovska, and R. Wouters, 2017. An estimated two-country EA-US model with limited exchange rate pass-through. National Bank of Belgium Working Paper Research, March, 317.

[15] Del Negro, M., M. Giannoni, and C. Patterson, 2013. The Forward Guidance Puzzle. Federal Reserve Bank of New York Staff Report 574.

[16] ECB 2016. Exchange rate pass-through into euro area inflation. Economic Bulletin, July.

[17] ECB 2018. Assessment of quantitative easing and challenges of policy normalisation. Speech by Peter Praet, Member of the Executive Board of the ECB, at The ECB and Its Watchers XIX Conference, Frankfurt am Main, 14 March 2018

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

[19] Forni, L., A. Gerali, A. Notarpietro, and M. Pisani, 2015. Euro area, oil and global shocks: An empirical model-based analysis, *Journal of Macroeconomics*, 46, pages 295–314

[20] 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.

[21] Gomes, S., P. Jacquinot, and M. Pisani, 2012. The EAGLE. A model for policy analysis of macroeconomic interdependence in the euro area. *Economic Modelling*, 29(5), pages 1686–1714.

[22] Gopinath, G., 2016. The International Price System. Jackson Hole Symposium Proceedings.

[23] McKay, A., E. Nakamura, and J. Steinsson, 2016. The power of forward guidance revisited. *American Economic Review*, 106(10), pages 3133–3158.

[24] Özyurt, S., 2016. Has the exchange rate pass through recently declined in the euro area? ECB Working Paper Series 1955.

[25] Pesenti, P., 2008. The Global Economy Model (GEM): Theoretical framework, IMF Staff Papers 55 (2), pp.243-284

[26] Rotemberg, J. J., 1982. Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, 49, pages 517–531.

[27] Schorfheide, F., 2000. Loss-function-based evaluation of DSGE Models. *Journal of Applied Econometrics*, 15, pages 645–670.

[28] Smets, F., and R. Wouters, 2002. Openness, imperfect exchange rate pass-through and monetary policy. *Journal of Monetary Economics*, 49(5), pages 947–981.

[29] Warne, A., K. Christoffel, and G. Coenen, 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.

Table 1: EA great ratios

	EA	US	RW
Private consumption	60.0	57.2	59.3
Public consumption	20.0	20.0	20.0
Total investment	20.0	22.8	21.7
Total import	19.6	16.7	9.1
Oil import	3.0	3.1	–
World GDP share	19.9	23.3	56.8

Note: EA = euro area; US = U.S.A.; RW = rest of the world. Variables reported as % of corresponding GDP.

Table 2: Calibrated parameters

	EA	US	RW
Elasticity of intertemporal substitution	1.0	1.0	1.0
Inverse of Frisch elasticity	1.5	1.5	1.5
Elasticity of substitution among non-oil tradables	1.5	1.5	1.5
Elasticity of substitution between non-oil tradables and non-tradables	0.8	0.8	0.8
Elasticity of substitution between oil and non-oil goods	0.4	0.4	0.4
Distribution services	1.2	1.2	1.2
Nominal rigidities (Rotemberg)			
Imports from US	1.0	–	1.0
Imports from RW	–	10.0	–
Imports from EA	–	10.0	–
Domestic tradables	–	60.0	60.0
Domestic non-tradables	–	800.0	800.0
Net foreign asset position	0.01	–	0.01

Note: EA = euro area; US = U.S.A.; RW = rest of the world.

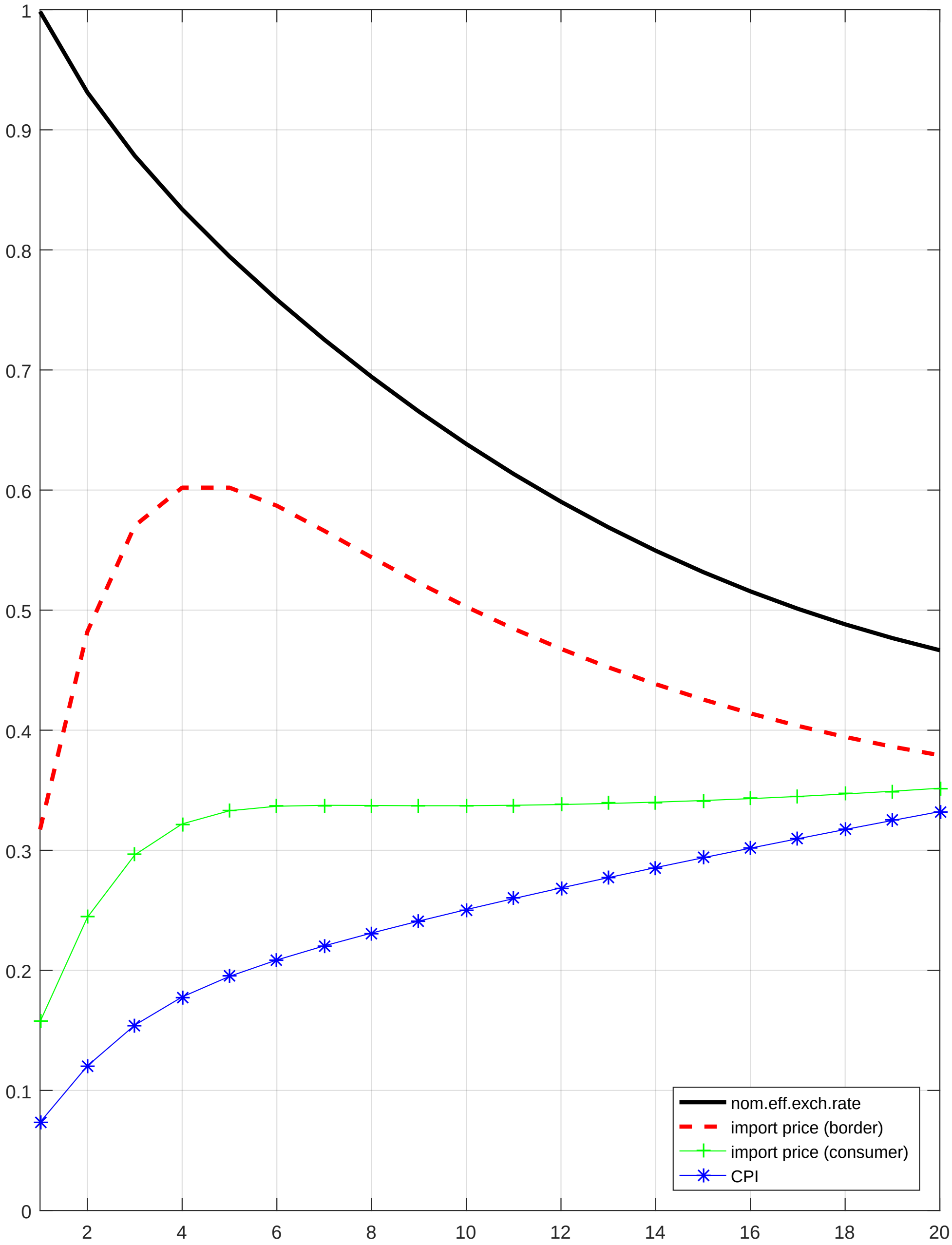
Table 3: Prior and posterior distributions

	Prior					Posterior		
Parameter	Type	Mean	S.D.	Mode	S.D. (Hessian)	Mean	5%	95%
Preferences, nominal rigidities and mon. policy								
Habit	beta	0.7	0.05	0.813	0.041	0.803	0.742	0.865
Invest. adj. cost	gamma	4	0.5	4.076	0.471	4.158	3.373	4.949
Domestic tradables price stickiness	gamma	60	6	56.491	5.824	57.725	48.163	67.347
Import from RW price stickiness	gamma	6	3	6.982	2.242	9.292	4.685	13.654
Export to RW price stickiness	gamma	6	3	0.622	0.200	0.665	0.318	1.012
Nontradables price stickiness	gamma	600	30	626.751	29.777	634.254	583.617	682.662
Nominal wage stickiness	gamma	300	150	301.397	77.656	405.737	223.084	581.889
Import from RW price indexation	beta	0.5	0.05	0.472	0.051	0.475	0.394	0.556
Export to RW price indexation	beta	0.5	0.05	0.487	0.051	0.483	0.400	0.567
Nominal wage indexation	beta	0.5	0.05	0.462	0.049	0.469	0.389	0.547
Interest rate smoothing	beta	0.75	0.1	0.858	0.016	0.856	0.830	0.884
Response to inflation	norm	1.7	0.05	1.750	0.048	1.748	1.669	1.827
Response to output growth	norm	0.062	0.05	0.099	0.049	0.093	0.013	0.173
Shock persistence								
Consumption preference	beta	0.75	0.1	0.637	0.148	0.657	0.457	0.855
Investment-specific	beta	0.75	0.1	0.613	0.094	0.594	0.446	0.747
Risk premium on euro-denominated bonds	beta	0.75	0.1	0.893	0.019	0.893	0.862	0.925
Risk premium on US dollar-denom. bonds held in EA	beta	0.75	0.1	0.951	0.011	0.938	0.917	0.960
Risk premium on US dollar-denom. bonds held in RW	beta	0.75	0.1	0.949	0.011	0.937	0.915	0.961
Total factor productivity	beta	0.75	0.1	0.889	0.039	0.877	0.812	0.944
Domestic tradables cost-push	beta	0.75	0.1	0.355	0.094	0.384	0.227	0.540
Export to RW cost-push	beta	0.75	0.1	0.920	0.029	0.919	0.871	0.967
Import from RW cost-push	beta	0.75	0.1	0.795	0.049	0.753	0.665	0.843
Nontradable cost-push	beta	0.75	0.1	0.333	0.063	0.335	0.235	0.434
Labor cost-push	beta	0.75	0.1	0.605	0.079	0.588	0.454	0.721
Unit-root technology	beta	0.75	0.1	0.717	0.085	0.716	0.562	0.876
RW consumption preference	beta	0.75	0.1	0.855	0.028	0.831	0.776	0.888
Oil supply	beta	0.75	0.08	0.972	0.011	0.966	0.945	0.987

Table 4: Prior and posterior distributions

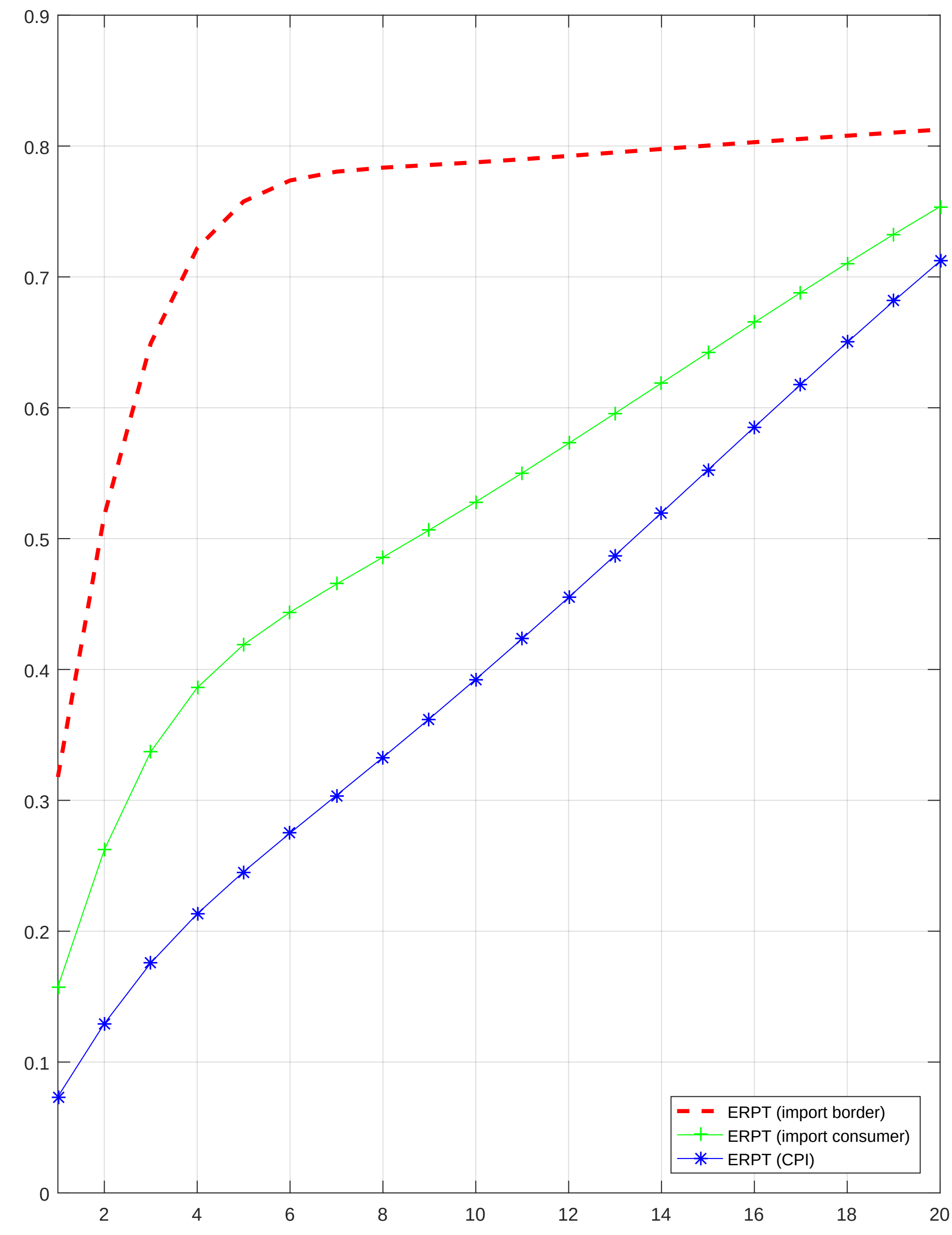
	Prior					Posterior		
Parameter	Type	Mean	S.D.	Mode	S.D. (Hessian)	Mean	5%	95%
Shock st. dev.								
Consumption preference	invg	1	Inf	1.4379	0.3141	1.4332	0.8832	1.9855
Investment-specific	invg	1	Inf	4.1126	0.8176	4.4261	2.9939	5.8116
Monetary policy shock	invg	1	Inf	0.1341	0.0115	0.1382	0.1188	0.1546
Risk premium on euro-denominated bonds	invg	1	Inf	0.1372	0.0114	0.1401	0.1206	0.1573
Risk premium on US dollar-denom. bonds held in EA	invg	1	Inf	0.3046	0.0524	0.3639	0.2525	0.4701
Risk premium on US dollar-denom. bonds held in RW	invg	1	Inf	0.4714	0.0727	0.5403	0.3843	0.6906
Total factor productivity	invg	1	Inf	0.5163	0.0547	0.5384	0.4434	0.6305
Domestic tradables cost-push	invg	1	Inf	2.5082	0.3341	2.5715	1.9923	3.1285
Export to RW cost-push	invg	1	Inf	0.1547	0.0164	0.1599	0.1297	0.1885
Import from RW cost-push	invg	1	Inf	0.2518	0.0486	0.3073	0.2038	0.4087
Nontradable cost-push	invg	1	Inf	0.1526	0.0162	0.1576	0.1296	0.1841
Labor cost-push	invg	1	Inf	0.325	0.0769	0.4153	0.2364	0.5851
Unit-root technology	invg	1	Inf	0.2519	0.0405	0.265	0.1955	0.3329
RW consumption preference	invg	1	Inf	14.6757	1.3037	14.252	12.1466	16.2261
Oil supply	invg	1	Inf	7.0778	0.5809	6.9385	5.969	7.8764

Figure 1: Risk premium shock on US dollar-denominated bonds held by EA households. Exchange rate and price responses



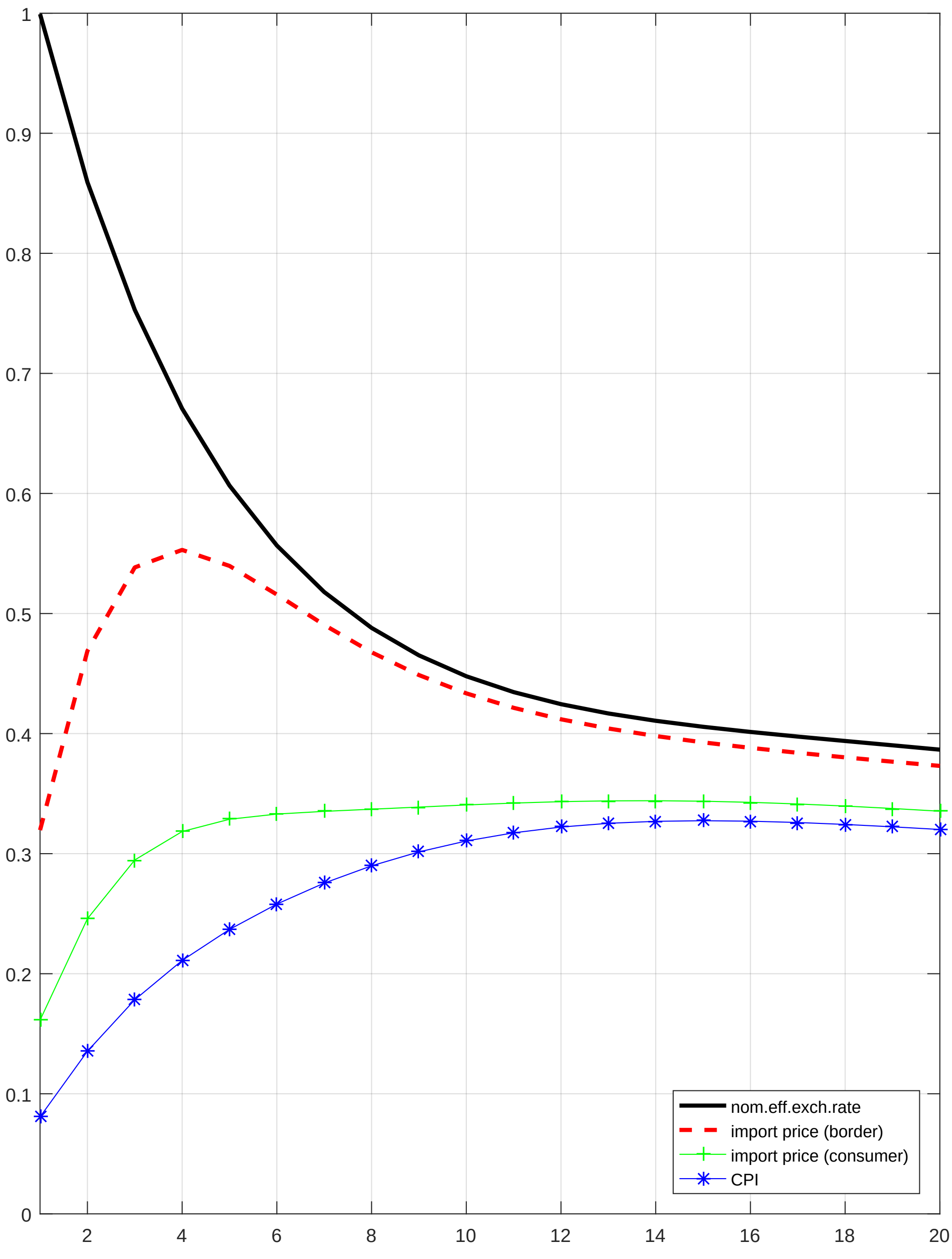
Notes: quarters on the horizontal axis; on the vertical axis, cumulated % deviations from the baseline; for exchange rate, increase = depreciation.

Figure 2: Risk premium shock on US dollar-denominated bonds held by EA households. ERPT



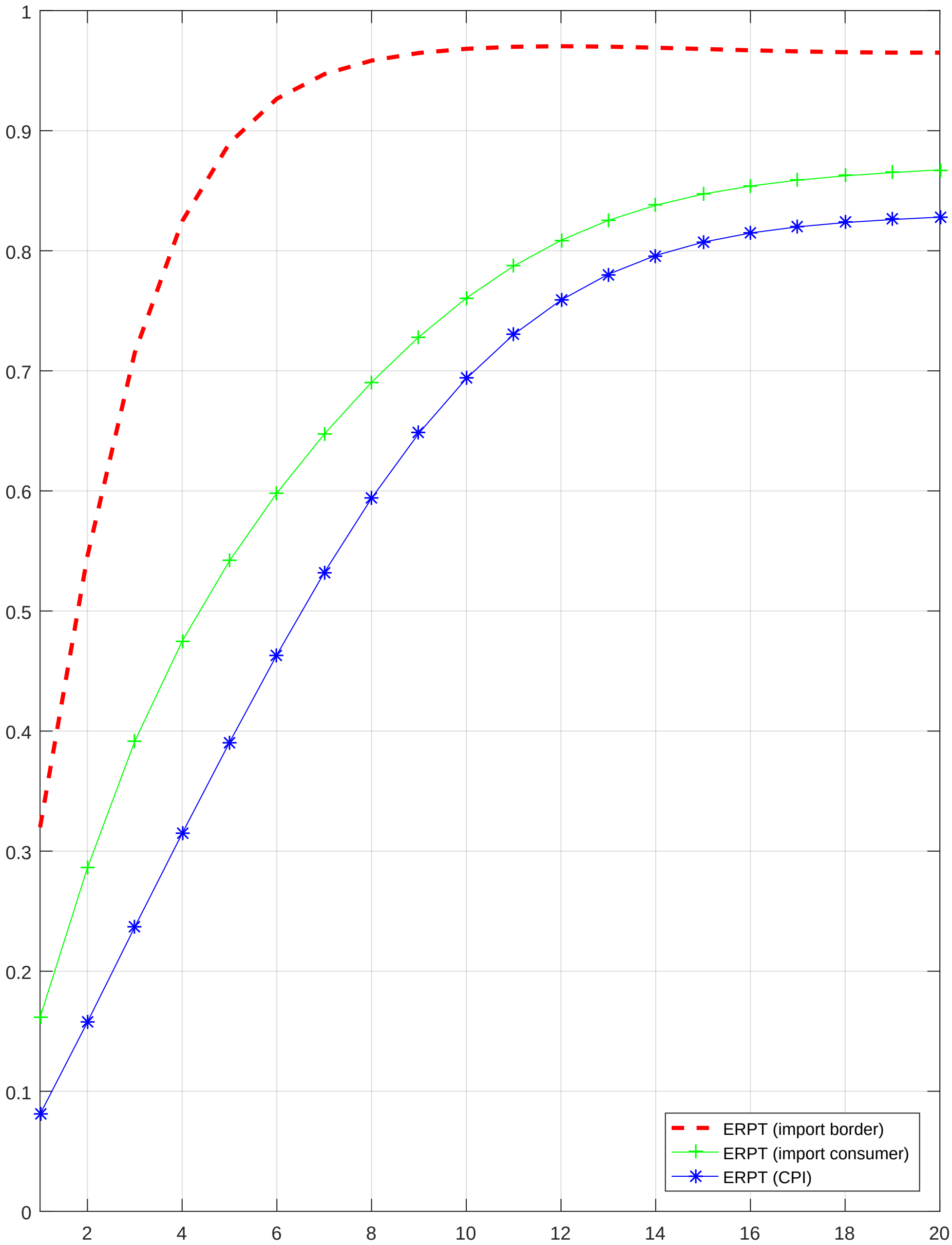
Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level.

Figure 3: EA expansionary monetary policy shock. Exchange rate and price responses



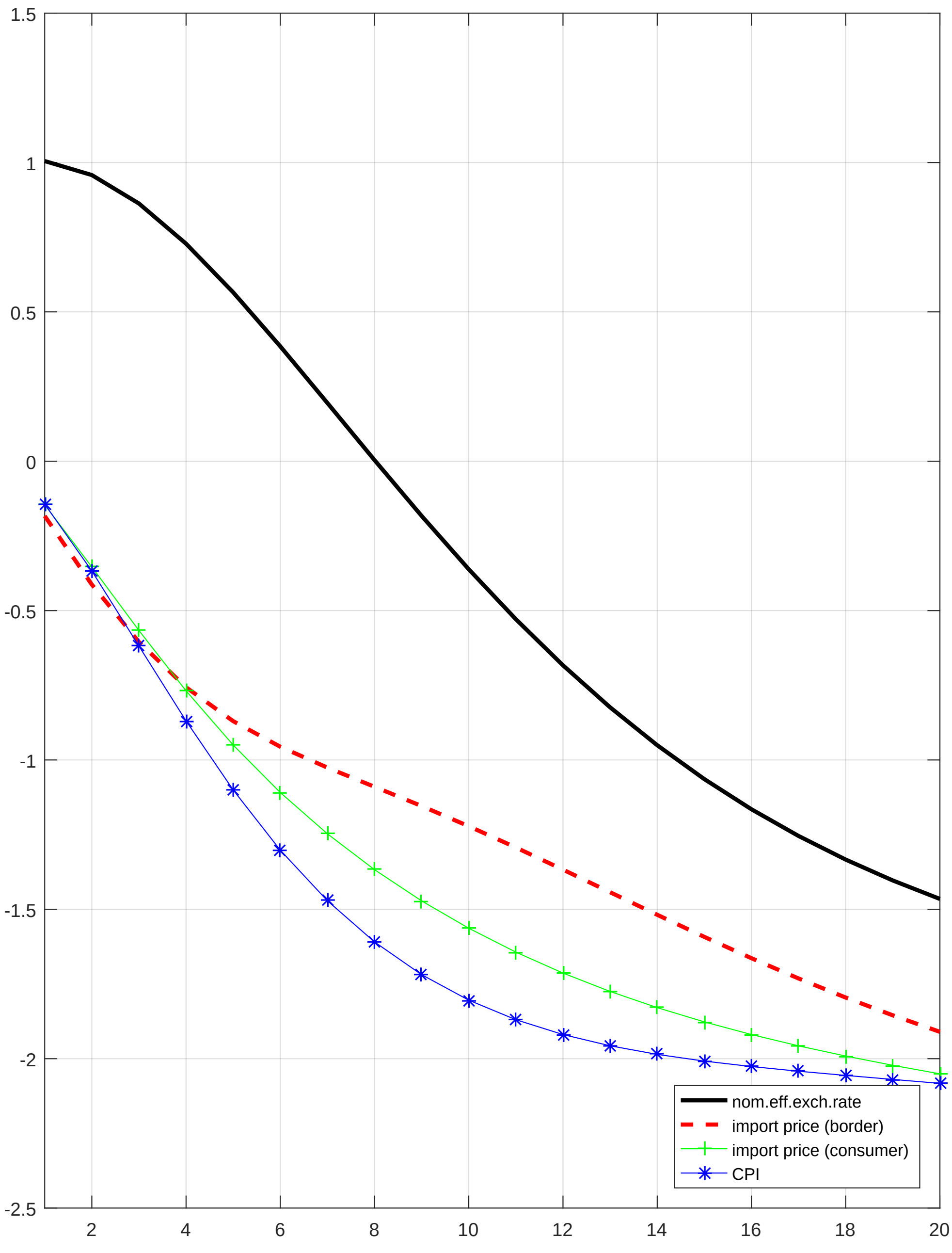
Notes: quarters on the horizontal axis; on the vertical axis, cumulated % deviations from the baseline; for exchange rate, increase = depreciation.

Figure 4: EA expansionary monetary policy shock. ERPT



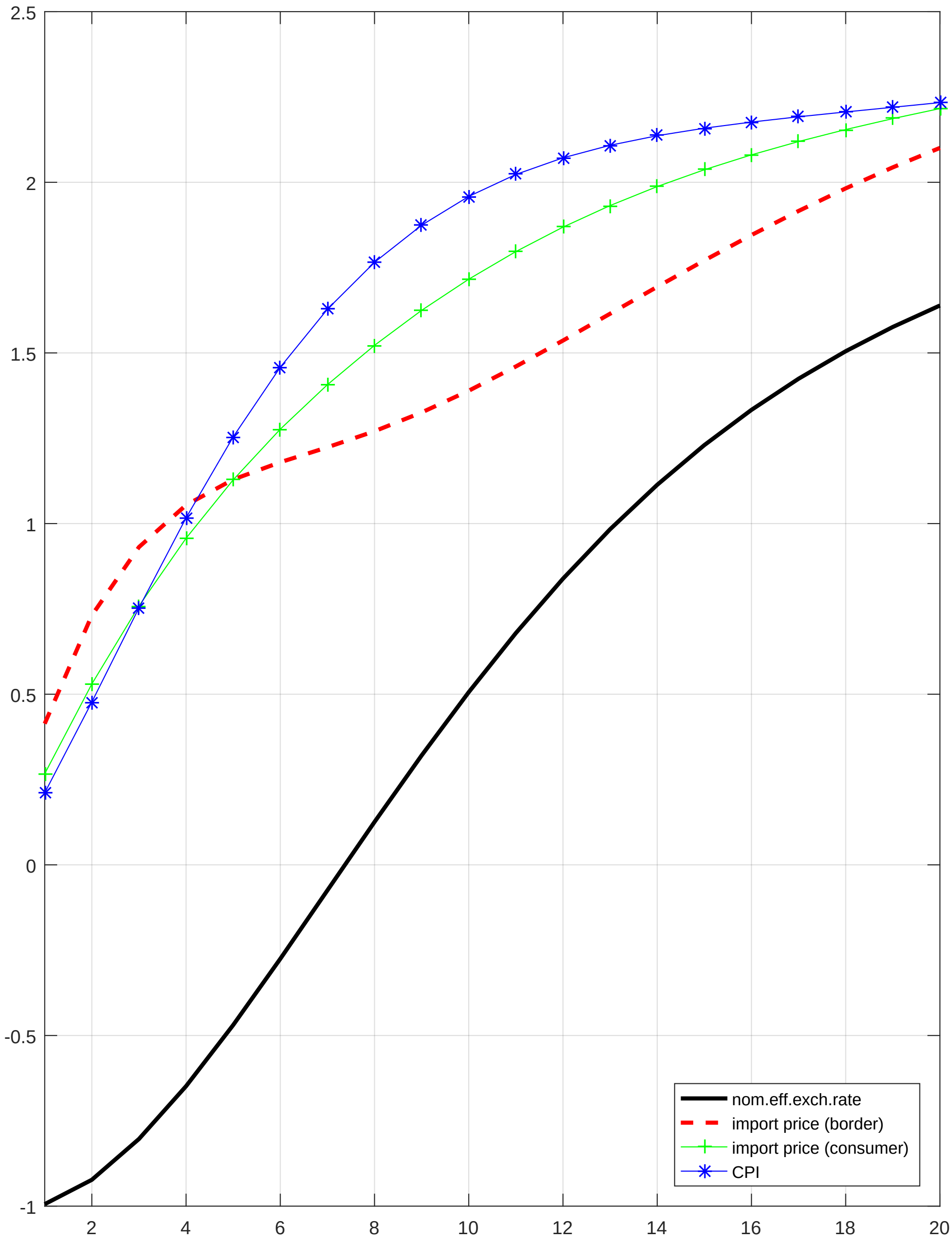
Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level.

Figure 5: EA recessionary preference shock. Exchange rate and price responses



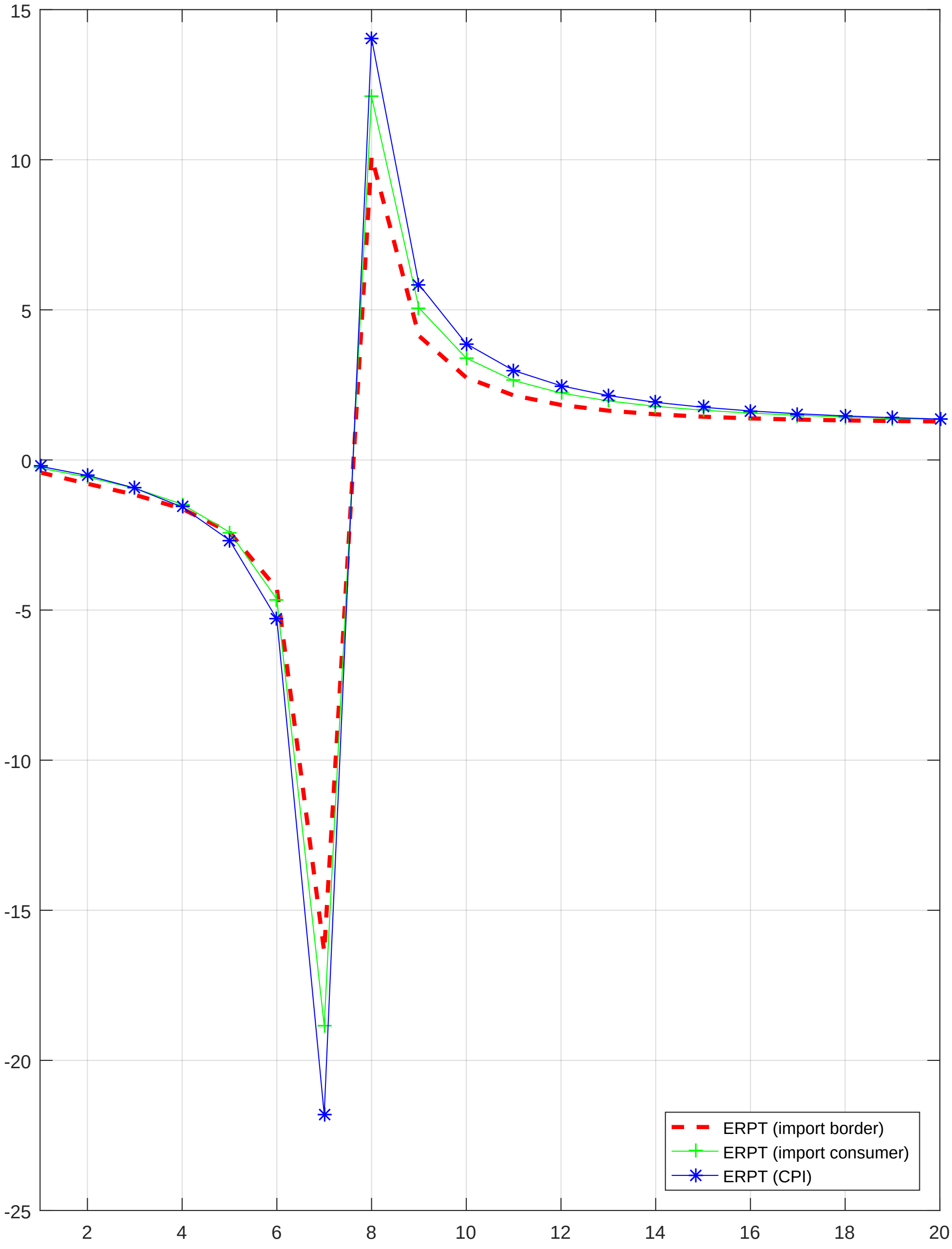
Notes: quarters on the horizontal axis; on the vertical axis, cumulated % deviations from the baseline; for exchange rate, increase = depreciation.

Figure 6: EA expansionary preference shock and standard monetary policy. Exchange rate and price responses



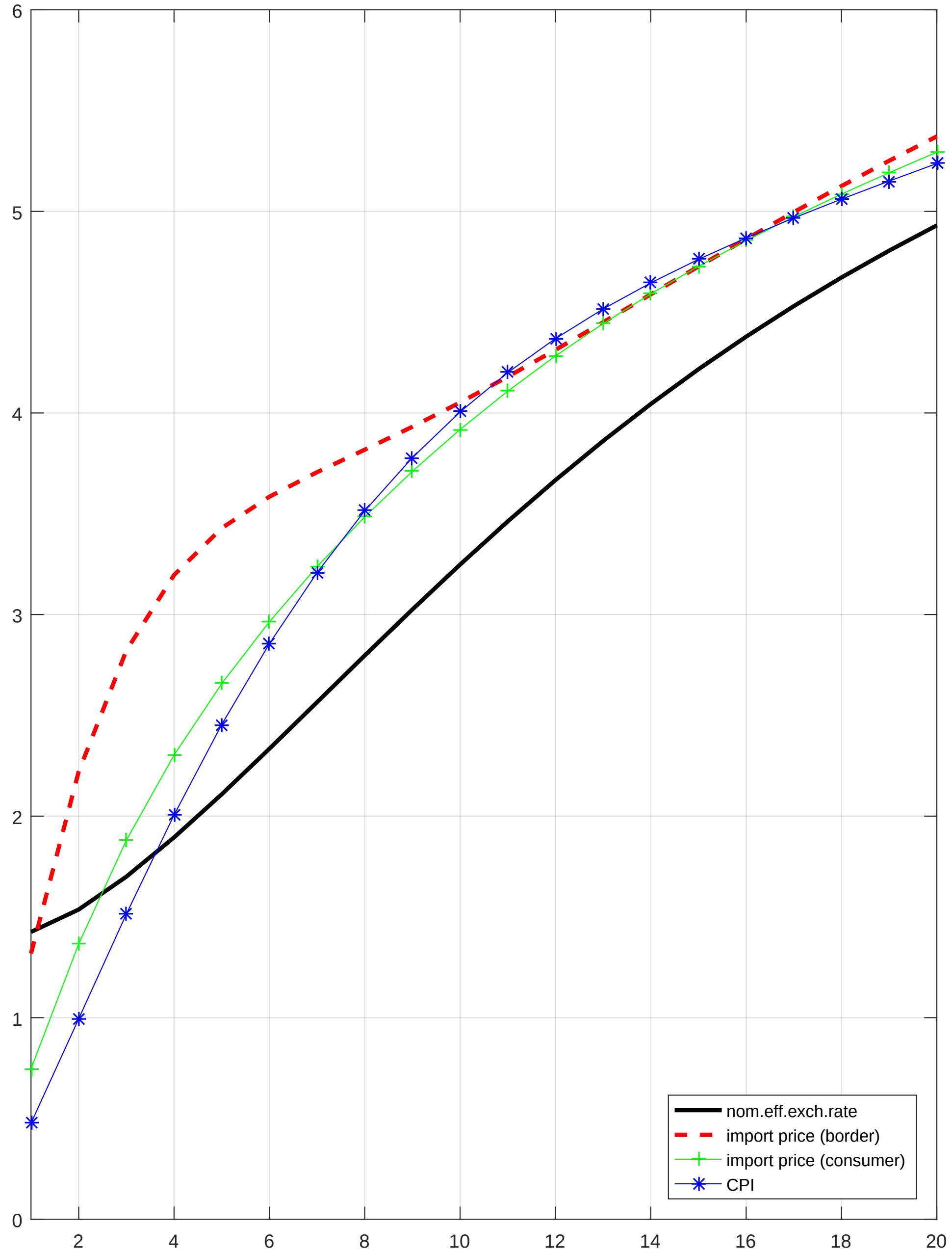
Notes: quarters on the horizontal axis; on the vertical axis, cumulated % deviations from the baseline; for exchange rate, increase = depreciation.

Figure 7: EA expansionary preference shock and standard monetary policy. ERPT



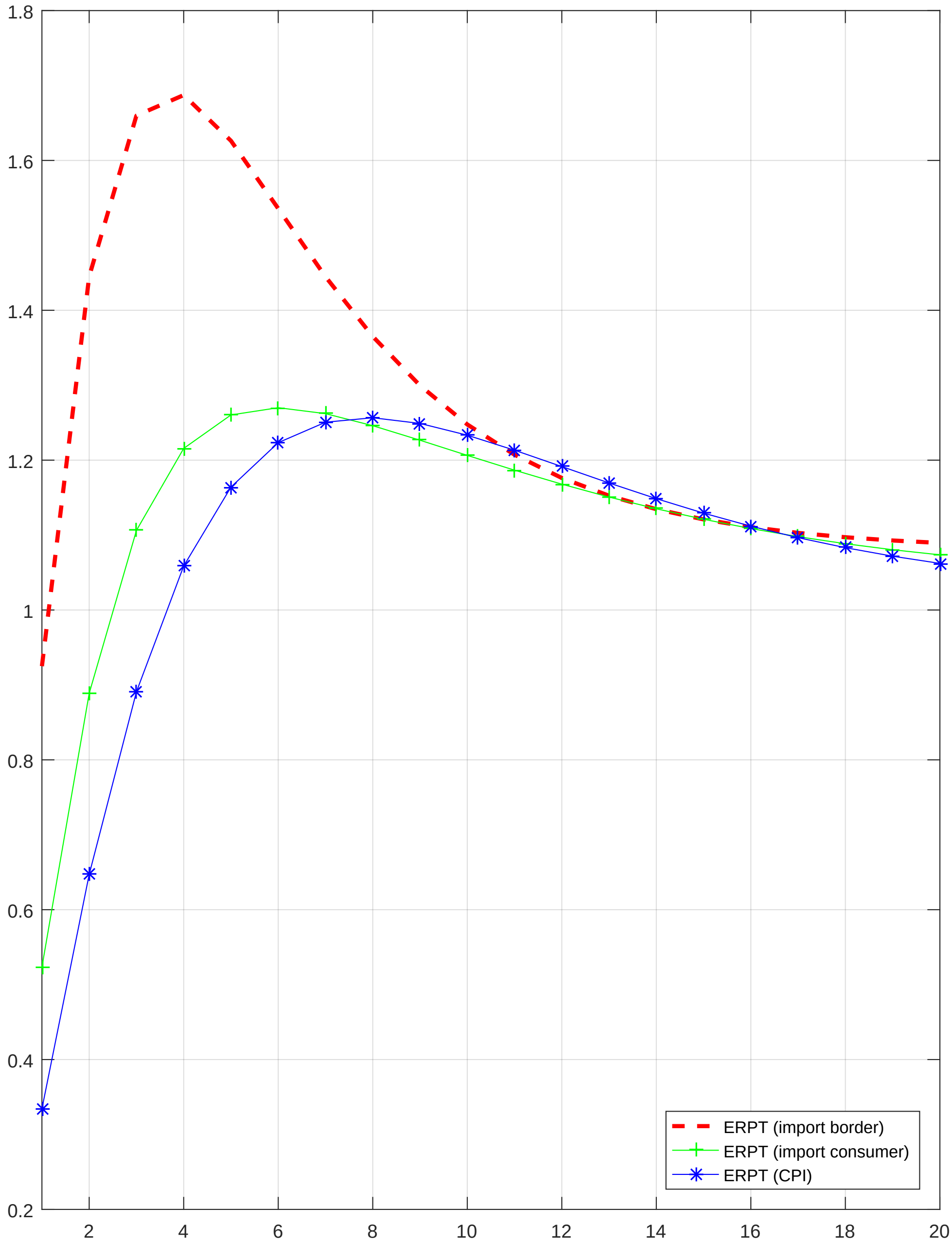
Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level.

Figure 8: EA expansionary preference shock and less aggressive monetary policy. Exchange rate and price responses



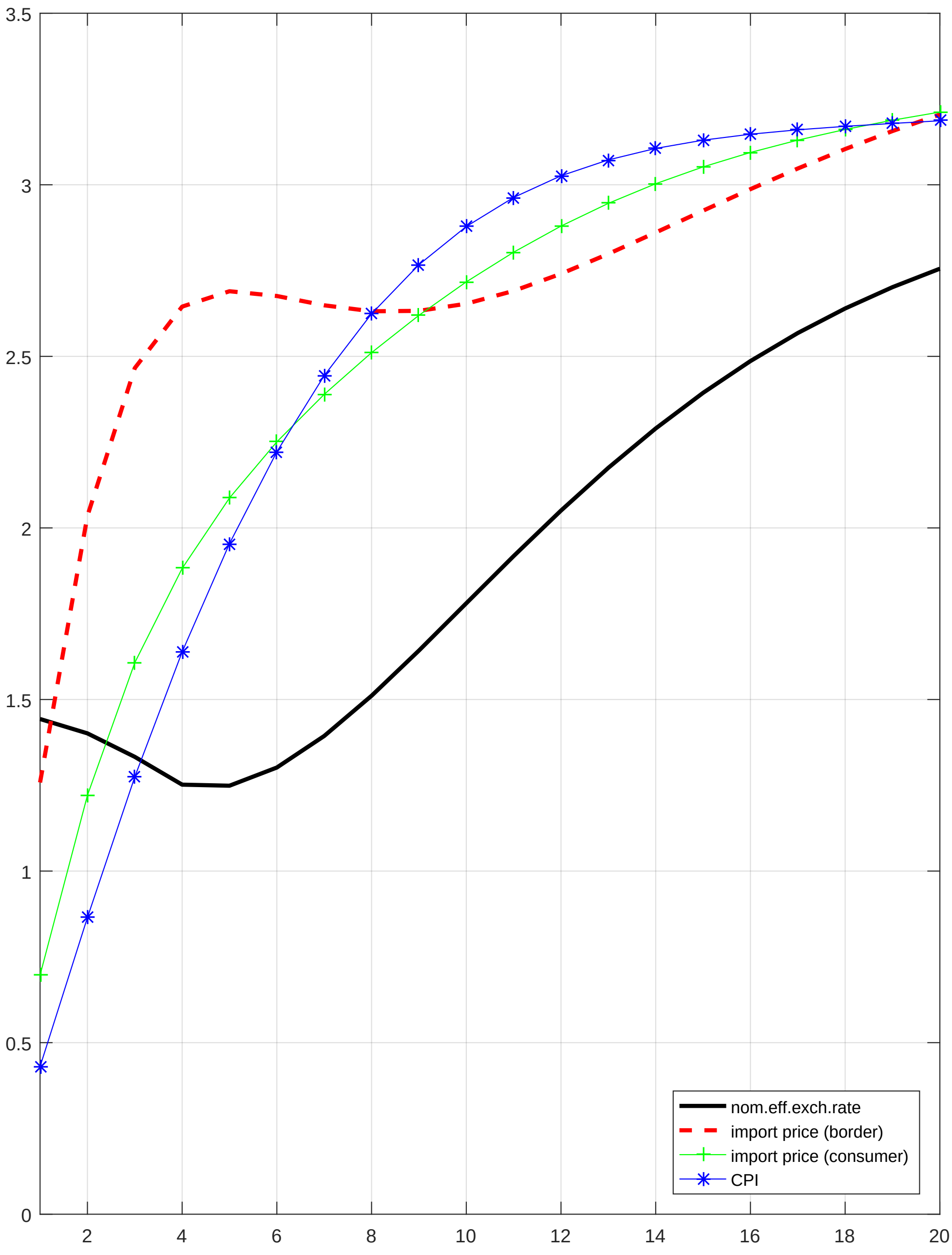
Notes: quarters on the horizontal axis; on the vertical axis, cumulated % deviations from the baseline; for exchange rate, increase = depreciation.

Figure 9: EA expansionary preference shock and less aggressive monetary policy. ERPT



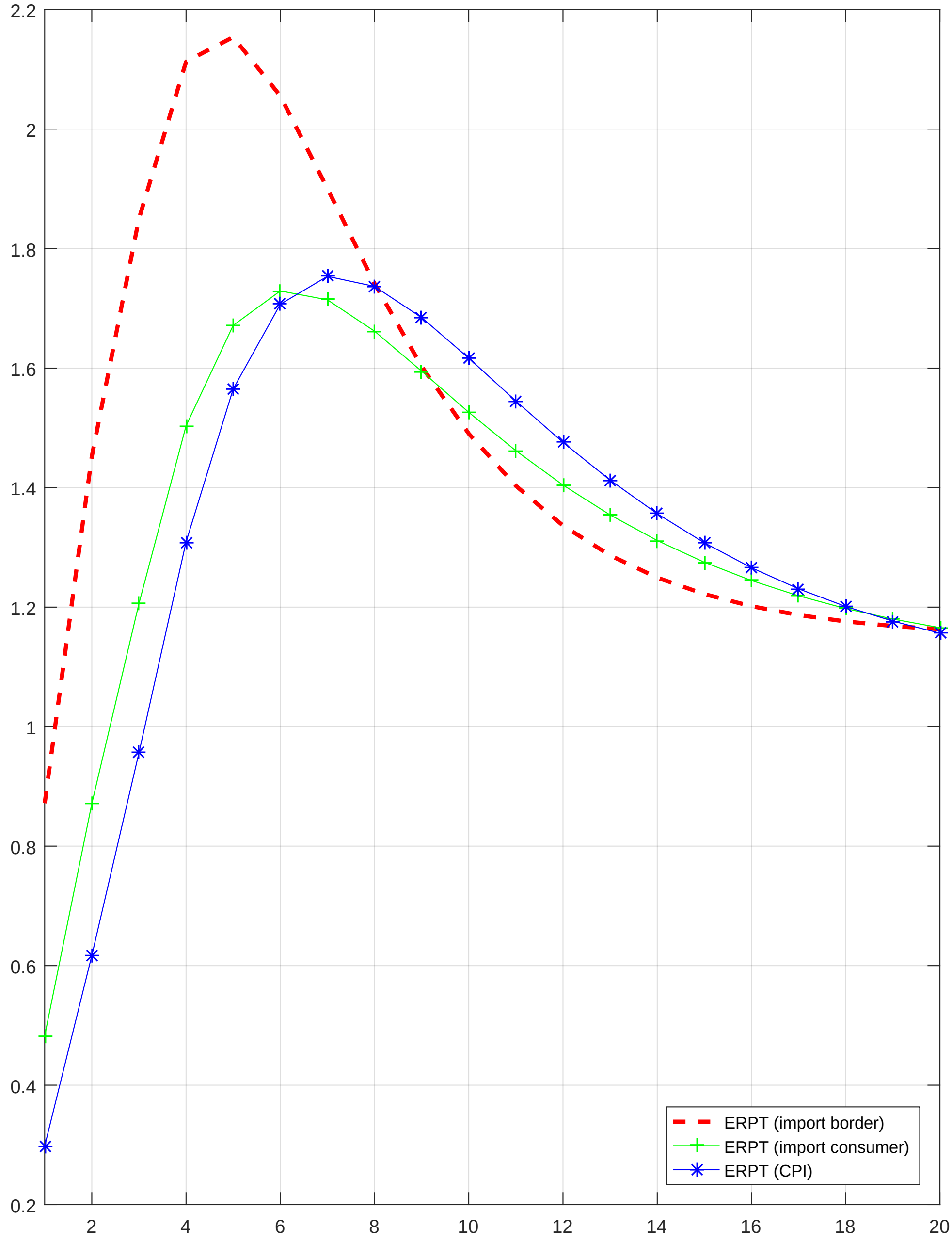
Notes: quarters on the horizontal axis; on the vertical axis, ratio of the considered price level-to-exchange rate level.

Figure 10: EA expansionary preference shock and FG. Exchange rate and price responses



Notes: quarters on the horizontal axis; on the vertical axis, cumulated % deviations from the baseline; for exchange rate, increase = depreciation.

Figure 11: EA expansionary preference shock and FG. ERPT



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

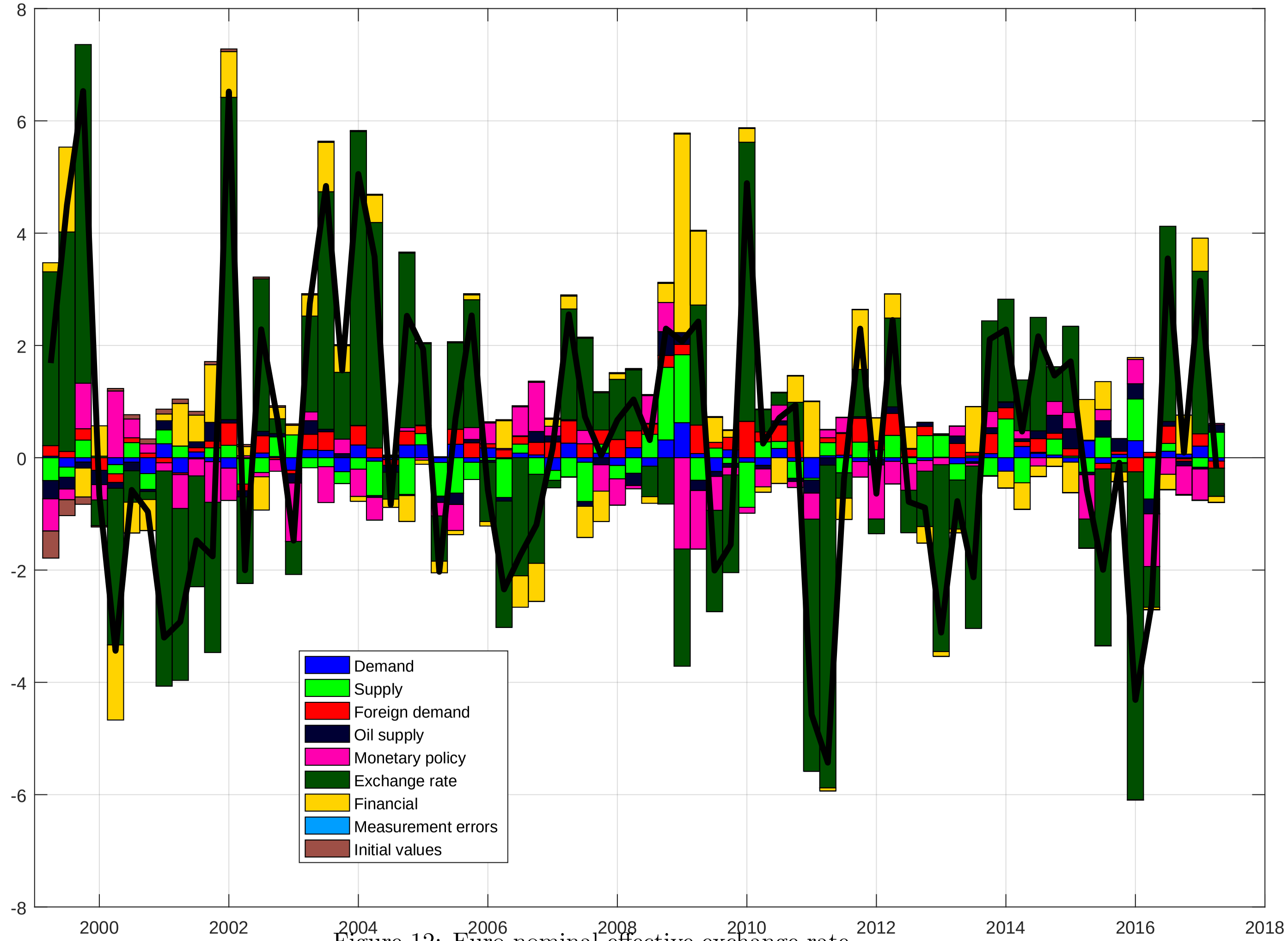


Figure 12: Euro nominal effective exchange rate

Notes: on the vertical axis, quarter-on-quarter rate of change; +=appreciation.

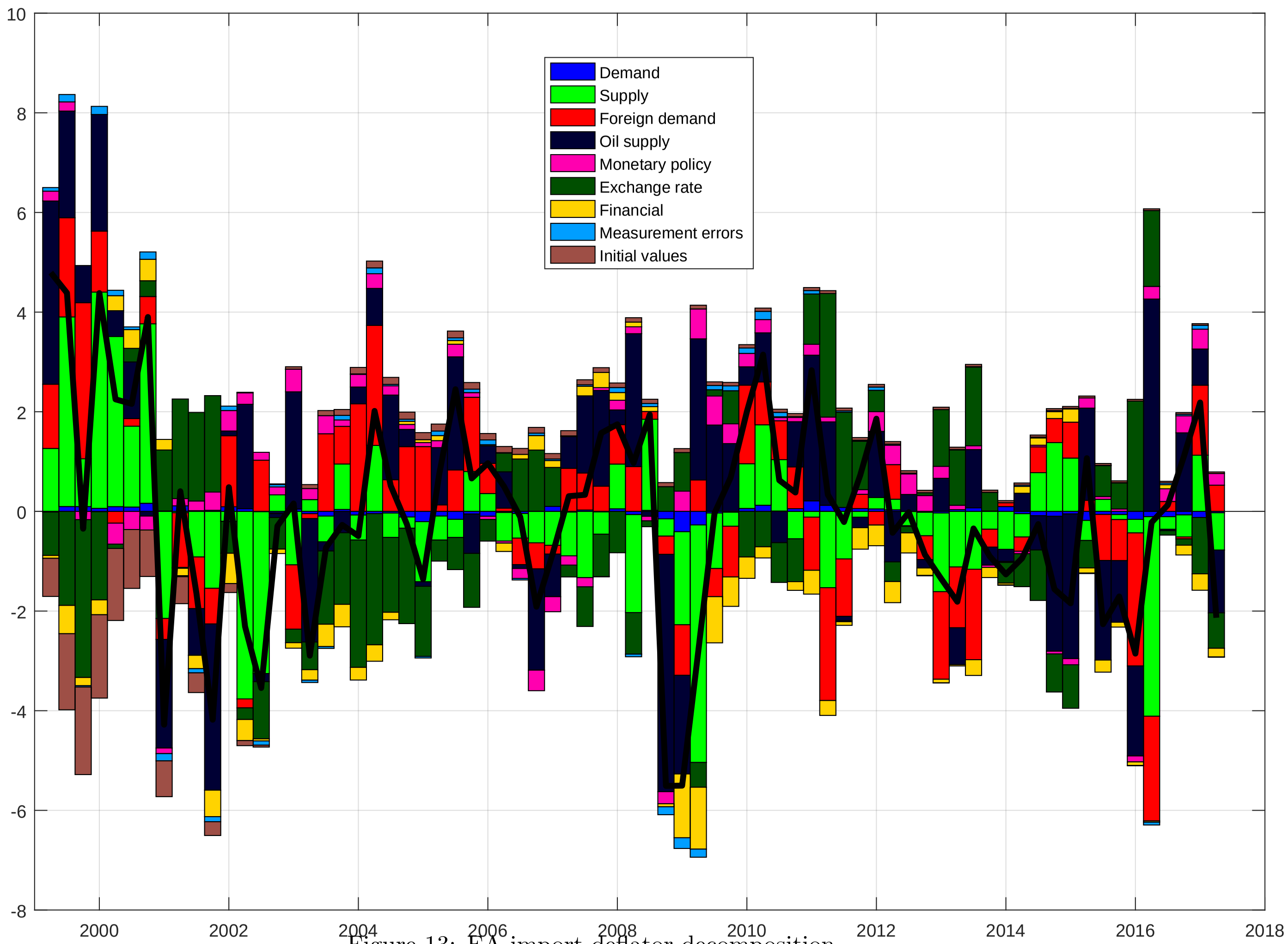


Figure 13: EA import deflator decomposition

Notes: on the vertical axis, quarterly inflation rate, pp dev. from the baseline.

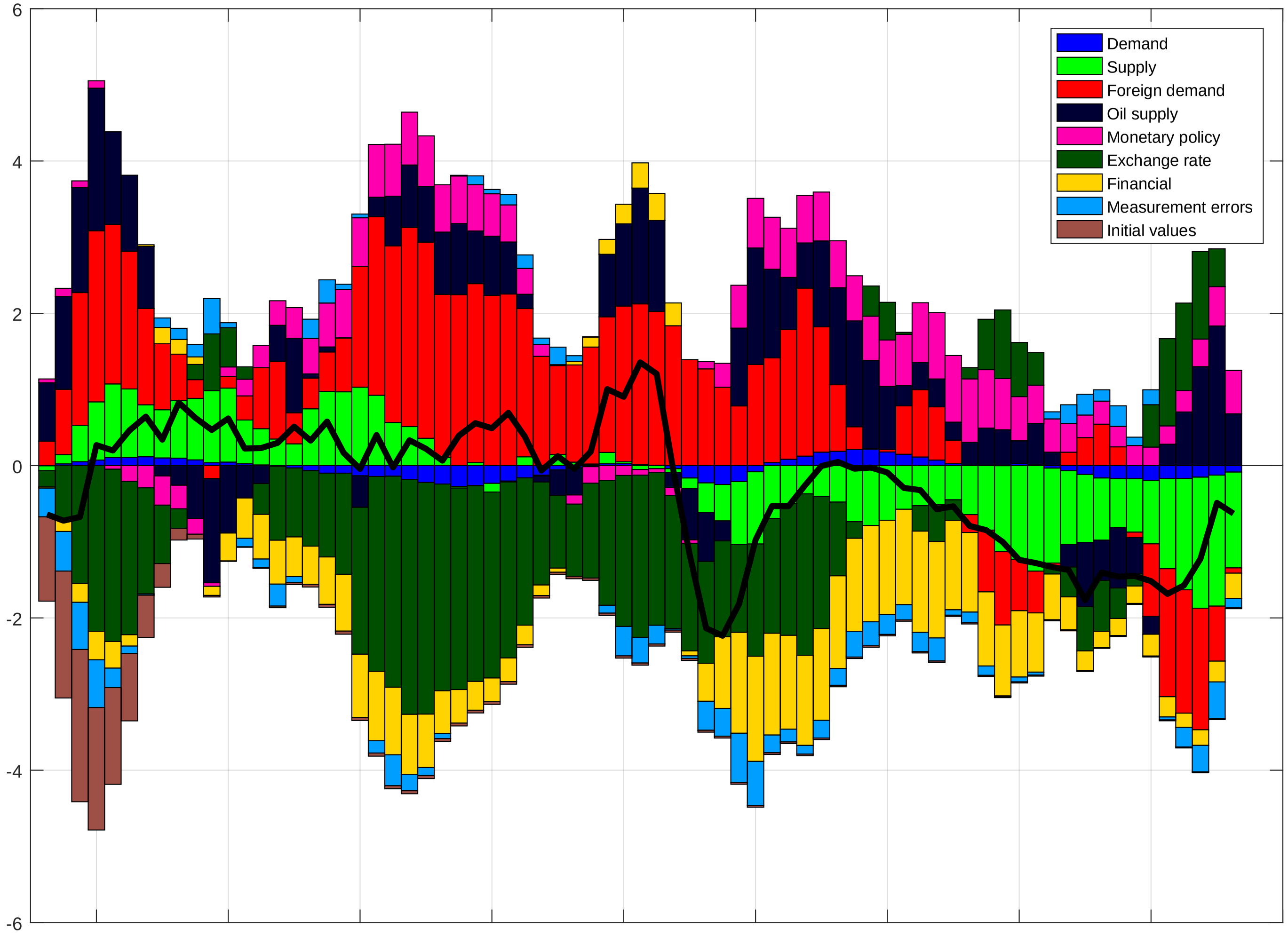


Figure 14: EA consumer price decomposition

Notes: on the vertical axis, year-on-year inflation rate, pp dev. from the baseline.

A Appendix: The model

The model is an open economy, New Keynesian framework. It represents the world economy, composed of three regions: EA, US, and RW. The size of the world economy is normalized to 1. EA, US, and RW have sizes equal to n, n^*, and $(1 - n - n^*)$, respectively, with $n, n^* > 0$, and $n + n^* < 1$. For each region, the size refers to the overall households' population and to the number of firms operating in each sector (intermediate tradable, intermediate nontradable, 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 prices and GDP growth.[37]

Households consume a final good, which is a composite of intermediate nontradable goods, intermediate tradable goods, and energy services. 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 mark-up over their marginal rate of substitution between consumption and leisure.

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

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

The final manufacturing 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 composition. Intermediate tradable and nontradable goods are produced combining capital and labor, supplied by the domestic households, and oil. Capital and labor are assumed to be mobile across the two intermediate sectors.

The final energy bundle is produced using crude oil. The latter is produced by the RW and sold in the international (oil) market. In each region crude oil is transformed into energy according to a linear production function.

Given the assumption of differentiated intermediate goods, firms have market power, are price-setter 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 three regions.

For crude oil, it is assumed that the international law of one price holds, i.e., the same US

[37] We make the assumption of cashless economy.

dollar-invoiced price holds everywhere. The price of the EA energy bundle includes not only the price of crude oil, but also local taxes and accises, consistent with the empirical evidence.

In line with other dynamic general equilibrium models of the EA (see, among the others, Christoffel, Coenen, and Warne 2008 and Gomes, Jacquinot, and Pisani 2010), we include adjustment costs on real and nominal variables, ensuring that consumption, production, 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.[38]

In what follows, we report the main new equations for the Home country. Similar equations hold in the REA and in the RW (if not so, we report the differences).

A.1 Firms

We initially show the final good sectors (private consumption good, investment good, public consumption good). Thereafter, the intermediate good sectors (intermediate nontradable goods, and intermediate tradable goods). We report only equations of the EA economy, that we call Home. Similar equations hold for the RW and US. We explicitly state when this is not the case.[39]

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 Home region. Firms in the US and in the RW are indexed by $x^* \in (n, n + n^*]$ and $x^{**} \in (n + n^*, 1]$, respectively. The CES production technology used by the generic firm x is

$$A_t(x)^{\frac{\psi_A - 1}{\psi_A}} \equiv (1 - a_{EN})^{\frac{1}{\psi_A}} \left(\begin{array}{c} a_T^{\frac{1}{\phi_A}} \left(\begin{array}{c} a_H^{\frac{1}{\rho_A}} Q_{HA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} + \\ a_G^{\frac{1}{\rho_A}} Q_{GA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \\ + (1 - a_H - a_G)^{\frac{1}{\rho_A}} Q_{FA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \end{array} \right)^{\frac{\rho_A}{\rho_A - 1} \frac{\phi_A - 1}{\phi_A}} \\ + (1 - a_T)^{\frac{1}{\phi_A}} Q_{NA,t}(x)^{\frac{\phi_A - 1}{\phi_A}} \end{array} \right)^{\frac{\phi_A - 1}{\phi_A} \frac{\psi_A}{\psi_A - 1}} + a_{EN}^{\frac{1}{\psi_A}} EN_t(x)^{\frac{\psi_A}{\psi_A - 1}} \tag{A.1}$$

where Q_{HA}, Q_{GA}, Q_{FA}, and Q_{NA} are bundles of, respectively, intermediate tradables produced in Home, US, RW, and intermediate nontradables produced in the Home country, and EN is the energy good. The parameter $\rho_A > 0$ is the elasticity of substitution among tradables, $\phi_A > 0$ is the elasticity of substitution between tradable and nontradable goods, $\psi_A > 0$ is the elasticity

[38] See Rotemberg (1982).

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

of substitution between the energy and non-energy goods.

The parameter a_H ($a_H > 0$) is the weight of the Home tradable, the parameter a_G ($a_G > 0$, $1 - a_H - a_G < 1$) the weight of tradables imported from the REA, and the parameter a_T ($0 < a_T < 1$) the weight of the tradable manufacturing goods, the parameter a_{EN} ($0 < a_{EN} < 1$) the weight of energy.

A.1.2 Final investment good

The production of the investment good is similar to that of the consumption bundle. The investment bundle does not include energy. There are symmetric Home firms under perfect competition indexed by $y \in (0, n]$. Firms in the REA and in the RW are indexed by $y^* \in (n, n + n^*]$ and $y^{**} \in (n + n^*, 1]$. Output of the generic Home firm y is

$$E_t(y) \equiv \left(\begin{array}{c} v_T^{\frac{1}{\phi_E}} \left(\begin{array}{c} v_H^{\frac{1}{\rho_E}} Q_{HE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + v_G^{\frac{1}{\rho_E}} Q_{GE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \\ + (1 - v_H - v_G)^{\frac{1}{\rho_E}} Q_{FE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \end{array} \right)^{\frac{\rho_E}{\rho_E - 1} \frac{\phi_E - 1}{\phi_E}} \\ + (1 - v_T)^{\frac{1}{\phi_E}} Q_{NE,t}(y)^{\frac{\phi_E - 1}{\phi_E}} \end{array} \right)^{\frac{\phi_E}{\phi_E - 1}}, \tag{A.2}$$

where Q_{HE}, Q_{GE}, Q_{FE}, and Q_{NE} are bundles of intermediate tradables produced in Home, REA, RW, and intermediate nontradables produced in the Home country, respectively. The parameter $\rho_E > 0$ is the elasticity of substitution among tradables, and $\phi_E > 0$ is the elasticity of substitution between tradable and non-tradable goods. The parameter v_H ($v_H > 0$) is the weight of the Home tradables, the parameter v_G ($v_G > 0, 1 - v_H - v_G < 1$) the weight of tradables imported from the REA, and the parameter v_T ($0 < v_T, 1 - v_T < 1$) the weight of the overall tradable goods.

A.1.3 Final public consumption good

The public consumption good is fully biased towards the intermediate non-tradable good

$$Q_{NA,t}(x) \equiv \left[\left(\frac{1}{n} \right)^{\theta_N} \int_0^n Q_t(i, x)^{\frac{\theta_N - 1}{\theta_N}} di \right]^{\frac{\theta_N}{\theta_N - 1}}, \tag{A.3}$$

where $\theta_N > 1$ is the elasticity of substitution among brands in the non-tradable sector.

FOCs: demands of inputs Final consumption goods are composed by CES bundles of differentiated intermediate goods, each produced by a single firm under conditions of monopolistic competition,

$$Q_{HA,t}(x) \equiv \left[\left(\frac{1}{n}\right)^{\theta_T}\int_0^n Q_t(h,x)^{\frac{\theta_T-1}{\theta_T}}\,dh\right]^{\frac{\theta_T}{\theta_T-1}}, \tag{A.4}$$

$$Q_{GA,t}(x) \equiv \left[\left(\frac{1}{n^*}\right)^{\theta_T}\int_n^{n+n^*} Q_t(g,x)^{\frac{\theta_T-1}{\theta_T}}\,dg\right]^{\frac{\theta_T}{\theta_T-1}}, \tag{A.5}$$

$$Q_{FA,t}(x) \equiv \left[\left(\frac{1}{1-n-n^*}\right)^{\theta_T}\int_{n+n^*}^{1} Q_t(f,x)^{\frac{\theta_T-1}{\theta_T}}\,df\right]^{\frac{\theta_T}{\theta_T-1}}, \tag{A.6}$$

$$Q_{NA,t}(x) \equiv \left[\left(\frac{1}{n}\right)^{\theta_N}\int_0^n Q_t(i,x)^{\frac{\theta_N-1}{\theta_N}}\,di\right]^{\frac{\theta_N}{\theta_N-1}}, \tag{A.7}$$

where firms in the Home intermediate tradable and nontradable sectors are respectively indexed by $h \in (0,n]$ and $n \in (0,n]$, firms in the US by $g \in (n, n+n^*]$, and firms in the RW by $f \in (n+n^*, 1]$. Parameters θ_T, $\theta_N > 1$ are respectively the elasticity of substitution among brands in the tradable and nontradable sector. The prices of the intermediate nontradable goods are denoted $p(i)$. Each firm x producing the final consumption good takes these prices as given when minimizing production costs. The resulting demand for intermediate nontradable input i is

$$Q_{A,t}(i,x) = \left(\frac{1}{n}\right)\left(\frac{P_t(i)}{P_{N,t}}\right)^{-\theta_N} Q_{NA,t}(x), \tag{A.8}$$

where $P_{N,t}$ is the cost-minimizing price of one basket of local nontradable intermediates,

$$P_{N,t} = \left[\int_0^n P_t(i)^{1-\theta_N}\,di\right]^{\frac{1}{1-\theta_N}}. \tag{A.9}$$

Firms y producing the final investment goods have similar demand curves. Aggregating over x and y, it can be shown that total demand for intermediate nontradable good i by firms in the final consumption and investment sectors is

$$\int_0^n Q_{A,t}(i,x)\,dx + \int_0^n Q_{E,t}(i,y)\,dy + \int_0^n C^g_{N,t}(i,x)\,dx = \left(\frac{P_t(i)}{P_{N,t}}\right)^{-\theta_N}\left(Q_{NA,t} + Q_{NE,t} + C^g_{N,t}\right), \tag{A.10}$$

where C^g_N is public sector consumption.

Home demands for (intermediate) domestic and imported tradable goods – $Q_A(h,x)$, $Q_A(f,x)$, $Q_A(g,x)$ – and the cost-minimizing prices of the corresponding baskets – P_H, P_F, and P_G – can be derived in a similar way.

A.1.4 Distribution sector

Following Corsetti and Dedola (2005), we assume that firms producing tradables need distribution services intensive in local nontradables to deliver their products to final consumers. This implies that the elasticity of demand for any brand is not necessarily the same across markets and, as a consequence, it is optimal to price discriminate markets. Firms in the distribution sector are perfectly competitive. They purchase domestic and foreign tradeable goods and distribute them in the home country using $\eta \geq 0$ units of the constant-elasticity-of-substitution basket η of nontradable brands n, which in the case of the Home economy is

$$\eta \equiv \left[\int_0^n \eta\left(n\right)^{\frac{\theta_N-1}{\theta_N}} dn\right]^{\frac{\theta_N}{\theta_N-1}} \quad \theta_N > 1. \tag{A.11}$$

The parameter θ_N measures the elasticity of substitution among the different brands.

The distribution sector introduces a wedge η between wholesale and consumer prices. Denoting with $\bar{p}\left(h\right)$ and with $\bar{p}^*\left(h\right)$, $\bar{p}^{**}\left(h\right)$ the wholesale prices of the generic home brand respectively in the home and foreign markets and assuming $\eta = \eta^* = \eta^{**}$ we get the consumer prices:

$$p_t(h) = \bar{p}_t(h) + \eta P_{N,t} \quad , \quad p_t^*(h) = \bar{p}_t^*(h) + \eta P_{N,t}^*, \quad p_t^{**}(h) = \bar{p}_t^{**}(h) + \eta P_{N,t}^{**}, \tag{A.12}$$

where P_N, P_N^*, P_N^{**} are the prices of the Home, US, RW composite basket η, respectively. The price index P_N

$$P_N = \left[\int_0^n p\left(n\right)^{1-\theta_N} dn\right]^{\frac{1}{\theta_N-1}} \tag{A.13}$$

is defined as the minimum expenditure necessary to buy one unit of the basket η. Prices in the US and RW are similarly defined.

A.1.5 World oil market and local energy sectors

The RW has an exogenous oil endowment, O^*, governed by a stochastic AR(1) process. There is only one international price of crude oil, P_t^{O*}, invoiced in US dollars, and determined in the world oil market.

Thus, the implied crude oil price in Home currency is

$$P_t^O = S_t P_t^{O*}, \tag{A.14}$$

where S is the nominal exchange rate of the domestic currency vis-à-vis the US dollar (number of Home currency units per US dollar).

In each country there is an energy sector that acts under perfect competition. Home firms import crude oil O_t and transform it into energy EN_t according to a simple linear technology ($EN_t = O_t$).

Energy is made available to domestic households (it enters the consumption basket) and to domestic firms producing the (nonfuel) intermediate goods.[40] For Home firms, there is a time-varying wedge η_t^{EN} between the border price of crude oil, P_t^O, and the retail price of energy P_t^{EN}:

$$P_t^{EN} = P_t^O + \eta^{EN}. \tag{A.15}$$

The wedge η^{EN} is a proxy that captures the presence of taxes, refinement and distribution margins in the (retail) price of fuel.

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 nontradable good i is denoted by $N^S(i)$:

$$N_t^S(i) = Z_{TECH,t}\left((1-\alpha_N)^{\frac{1}{\xi_N}} VA_{N,t}(i)^{\frac{\xi_N-1}{\xi_N}} + \alpha_N^{\frac{1}{\xi_N}} EN_{N,t}(i)^{\frac{\xi_N-1}{\xi_N}}\right)^{\frac{\xi_N}{\xi_N-1}}, \tag{A.16}$$

where $Z_{TECH,t}$ is the technology shock, which is assumed to be common to both intermediate tradable and nontradable sectors. The variable VA_t is the value added produced by the sector, which corresponds to

$$VA_t(i) = \left((1-\alpha_{K_N})^{\frac{1}{\xi_{VA_N}}} Z_{L,t}L_{N,t}(i)^{\frac{\xi_{VA_N}-1}{\xi_{VA_N}}} + \alpha_{K_N}^{\frac{1}{\xi_{VA_N}}} K_{N,t}(i)^{\frac{\xi_{VA_N}-1}{\xi_{VA_N}}}\right)^{\frac{\xi_{VA_N}}{\xi_{VA_N}-1}}. \tag{A.17}$$

The term $Z_{L,t}$ represents a unit-root labor-augmenting technology shock, common to all sectors producing intermediate goods and to all countries. The growth rate of the labor-augmenting technology shock, $gr_t = Z_{L,t}/Z_{L,t-1}$ follows an AR(1) process. Because of this shock, the model has a steady-state balanced-growth path, and all real variables have to be divided by the shock to be stationary. In the following we describe the model equations by assuming that all real variables are made stationary after dividing them by the productivity level.

Firm i uses labor $L_{N,t}(i)$ and capital $K_{N,t}(i)$ supplied by domestic households, and energy $EN_{N,t}(i)$ supplied by firms in the domestic energy sector. The parameter $\xi_N > 0$ $\xi_{VA_N} > 0$ measure the corresponding elasticities of substitution. The parameter $0 < \alpha_{K_N} < 1$ is the weight of capital in the value added, the parameter $0 < \alpha_N < 1$ the weight of energy. Firms producing intermediate goods take the prices of labor, capital, and energy inputs as given when minimizing their costs.

[40] So firms sell fuel only domestically.

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

$$L_{N,t}(i) = (1-\alpha_{K_N})\left(\frac{W_t}{MC_{VA_N,t}(i)}\right)^{-\xi_N} VA_t(i), \tag{A.18}$$

and

$$K_{N,t}(i) = \alpha_{K_N}\left(\frac{R_t^K}{MC_{VA_N,t}(i)}\right)^{-\xi_N} VA_t(i), \tag{A.19}$$

where $MC_{VA_N,t}(n)$ is the nominal marginal cost of the value added:

$$MC_{VA_N,t}(i) = \left((1-\alpha_{K_N})W_t^{1-\xi_N} + \alpha_{K_N}\left(R_t^K\right)^{1-\xi_N}\right)^{\frac{1}{1-\xi_N}}. \tag{A.20}$$

The demands of value added and energy inputs are respectively equal to

$$VA_{N,t}(i) = (1-\alpha_N)\left(\frac{MC_{VA_N,t}(i)}{MC_{N,t}(i)/Z_{TECH,t}}\right)^{-\xi_N} N_t^S(i)/Z_{TECH,t}, \tag{A.21}$$

$$EN_{N,t}(i) = \alpha_N\left(\frac{P_{EN,t}}{MC_{N,t}(i)/Z_{TECH,t}}\right)^{-\xi_N} N_t^S(i)/Z_{TECH,t}, \tag{A.22}$$

where $MC_{N,t}(n)$ is the nominal marginal cost of producing the intermediate non-tradable good:

$$MC_{N,t}(i) = \left((1-\alpha_N)MC_{VA_N,t}(i)^{1-\xi_N} + \alpha_N P_{EN,t}^{1-\xi_N}\right)^{\frac{1}{1-\xi_N}}. \tag{A.23}$$

The production of each Home tradable good, $T^S(h)$, is similarly characterized.

FOCs: supply of intermediate tradables Firms operating in the Home intermediate tradable sector solve a similar problem. We assume that there is market segmentation because nominal prices are invoiced and sticky in the currency of the destination market (local currency pricing) and because of local distribution services intensive in non-tradable goods of the destination markets.

The (generic) Home firm producing the brand h chooses the optimal (wholesale) prices $\bar{P}_t(h)$ in the Home market, the price $\bar{P}_t^*(h)$ in the US, and the price $\bar{P}_t^{**}(h)$ in the RW to maximize the expected flow of profits (in terms of domestic consumption units),

$$E_t \sum_{\tau=t}^{\infty} \beta^\tau \lambda_{t,\tau} \left[\begin{array}{c} \frac{\bar{P}_\tau(h)}{P_\tau} Q_\tau(h) + \frac{S_\tau^* \bar{P}_\tau^*(h)}{P_\tau} Q_\tau^*(h) + \frac{S_\tau^* \bar{P}_\tau^{**}(h)}{S_\tau^{**} P_\tau} Q_\tau^{**}(h) \\ -\frac{MC_{H,\tau}(h)}{P_\tau}\left(Q_\tau(h) + Q_\tau^*(h) + Q_\tau^{**}(h)\right) \end{array} \right], \tag{A.24}$$

where the term E_t denotes the expectation operator conditional on the information set at time t, $\lambda_{t,\tau}$ is the appropriate discount rate, and $MC_{T,t}(h)$ is the nominal marginal cost, S^* and S^{**} are the nominal exchange rates of the Home currency vis-à-vis the US dollar and of the RW currency vis-à-vis the US dollar, respectively.

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

The demand curves for the generic Home intermediate good h depend on local demand for all Home goods and on relative prices. The latter are the relative prices at consumer level (not at the border/wholesale level) and are affected by the local distribution services. Thus, the demand curves in Home country, US, and RW are

$$Q_{\tau}(h) = \left(\frac{\bar{P}_{H,\tau}(h) + \eta P_{N,\tau}}{P_{H,\tau}} \right)^{-\theta_H} Q_{H,\tau}, \tag{A.25}$$

$$Q^*_{\tau}(h) = \left(\frac{\bar{P}^*_{H,\tau}(h) + \eta P^*_{N,\tau}}{P^*_{H,\tau}} \right)^{-\theta_H} Q^*_{H,\tau}, \tag{A.26}$$

$$Q^{**}_{\tau}(h) = \left(\frac{\bar{P}^{**}_{H,\tau}(h) + \eta P^{**}_{N,\tau}}{P^{**}_{H,\tau}} \right)^{-\theta_H} Q^{**}_{H,\tau}, \tag{A.27}$$

respectively.

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

$$AC^{p}_{H,\tau}(i) \equiv \frac{\kappa^p_H}{2} \left(\frac{\bar{P}_{H,\tau}(h) / \bar{P}_{H,\tau-1}(h)}{\pi^{ind_H}_{H,\tau-1} \pi^{1-ind_H}_{target}} - 1 \right)^2 \frac{\bar{P}_{H,\tau}}{P_{\tau}} Q_{H,\tau}, \tag{A.28}$$

$$AC^{p*}_{H,\tau}(h) \equiv \frac{\kappa^{p*}_H}{2} \left(\frac{\bar{P}^*_{H,\tau}(h) / \bar{P}^*_{H,\tau-1}(h)}{\left(\pi^*_{H,\tau-1}\right)^{ind^*_H} \pi^{1-ind^*_H}_{target^*}} - 1 \right)^2 \frac{S^*_{\tau} \bar{P}^*_{H,\tau}}{P^*_{\tau}} Q^*_{H,\tau}, \tag{A.29}$$

$$AC^{p**}_{H,\tau}(i) \equiv \frac{\kappa^{p**}_H}{2} \left(\frac{\bar{P}^{**}_{H,\tau}(h) / \bar{P}^{**}_{H,\tau-1}(h)}{\left(\pi^{**}_{H,\tau-1}\right)^{ind^{**}_H} \pi^{1-ind^{**}_H}_{target^{**}}} - 1 \right)^2 \frac{S^*_{\tau} \bar{P}^{**}_{H,\tau}}{S^{**}_{\tau} P^{**}_{\tau}} Q^{**}_{H,\tau}, \tag{A.30}$$

in the domestic, US, and RW markets, respectively. The parameters κ^p_H,${\kappa^p_H}^*$,${\kappa^p_H}^{**} > 0$ measure the degree of nominal rigidity in the Home country, in the US, and in the RW, respectively, whereas ind_H, ind^*_H and ind^{**}_H are the corresponding indexation parameters. Moreover, π_{target}, π_{target^*} and $\pi_{target^{**}}$ denote the long-run (consumer-price) inflation targets set by the central bank in EA, US and RW, respectively.

First order condition with respect to the domestic wholesale price of the Home tradable good. The first order condition with respect to the Home (wholesale) price set in the domestic market, $\bar{P}_t(h)$, is:

$$
\begin{aligned}
0 &= \frac{\lambda_t}{P_t}\left(\frac{\bar{P}_{H,t}(h)+\eta P_{N,t}}{P_{H,t}}\right)^{-\theta_H} Q_{H,t} \\
&-\frac{\lambda_t}{P_t}\theta_H \frac{(\bar{P}_{H,t}(h)+\eta P_{N,t})^{-\theta_H-1}}{P_{H,t}^{-\theta_H}}\left(\bar{P}_{H,t}(h)-MC_{H,t}(h)\right) Q_{H,t} \\
&-\lambda_t \kappa_H^p \frac{1/\bar{P}_{H,t-1}(h)}{\pi_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{P}_{H,t}(h)/\bar{P}_{H,t-1}(h)}{\pi_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}}-1\right)\frac{\bar{P}_{H,t}}{P_t}Q_{H,t} \\
&+\beta\kappa_H^p E_t\left[\lambda_{t+1}\frac{\bar{P}_{H,t+1}(h)/\bar{P}_{H,t}(h)^2}{\pi_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{P}_{H,t+1}(h)/\bar{P}_{H,t}(h)}{\pi_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}-1\right)\frac{\bar{P}_{H,t+1}}{P_{t+1}}Q_{H,t+1}\right],
\end{aligned}
\tag{A.31}
$$

where $\theta_H > 1$ is the elasticity of substitution among intermediate tradable brands, is a cost-push shock, common to all Home firms, that affect their supply in the Home country, while the terms multiplied by κ_H^p are related to the presence of price adjustment costs.

In symmetric equilibrium (i.e.,$\bar{P}_{H,t}(h) = \bar{P}_{H,t}$ for every h) and dividing all terms by $\lambda_t Q_{H,t}$, the FOC becomes

$$
\begin{aligned}
0 &= \frac{1}{P_t}\left(\frac{\bar{P}_{H,t}+\eta P_{N,t}}{P_{H,t}}\right)^{-\theta_H} \\
&-\frac{1}{P_t}\theta_H \frac{(\bar{P}_{H,t}+\eta P_{N,t})^{-\theta_H-1}}{P_{H,t}^{-\theta_H}}\left(\bar{P}_{H,t}(h)-MC_{H,t}\right) \\
&-\kappa_H^p \frac{1/\bar{P}_{H,t-1}}{\pi_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{P}_{H,t}/\bar{P}_{H,t-1}}{\pi_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}}-1\right)\frac{\bar{P}_{H,t}}{P_t} \\
&+\beta\kappa_H^p E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{\bar{P}_{H,t+1}/\bar{P}_{H,t}^2}{\pi_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{P}_{H,t+1}/\bar{P}_{H,t}}{\pi_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}-1\right)\frac{\bar{P}_{H,t+1}}{P_{t+1}}\frac{Q_{H,t+1}}{Q_{H,t}}\right];
\end{aligned}
\tag{A.32}
$$

using the relation $P_{H,t} = \bar{P}_{H,t} + \eta P_{N,t}$, the definition $\bar{\pi}_{H,t} \equiv \bar{P}_{H,t}/\bar{P}_{H,t-1}$ and rearranging terms we get

$$
\begin{aligned}
\frac{P_{H,t}}{P_t} &= \theta_H\left(\bar{P}_{H,t}-MC_{H,t}\right)\frac{1}{P_t} \\
&+\frac{P_{H,t}}{P_t}\kappa_F^p \frac{\bar{\pi}_{H,t}}{\bar{\pi}_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{\pi}_{H,t}}{\bar{\pi}_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}}-1\right) \\
&-\beta\kappa_H^p E_t\left[\frac{P_{H,t}}{P_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\frac{\bar{\pi}_{H,t+1}^2}{\bar{\pi}_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{\pi}_{H,t+1}}{\bar{\pi}_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}-1\right)\frac{Q_{H,t+1}}{Q_{H,t}}\right].
\end{aligned}
\tag{A.33}
$$

The equation, in real terms (i.e., in units of domestic consumption) becomes

$$
p_{H,t} = \theta_H\left(\bar{p}_{H,t}-mc_{H,t}\right) + A_{H,t} + cp_{H,t}, \tag{A.34}
$$

where $\bar{p}_{H,t} \equiv \bar{P}_{H,t}/P_t$ (similar expressions hold for other relative prices), $A_{H,t}$ is defined as

$$A_{H,t} \equiv p_{H,t}\kappa_H^p \frac{\bar{\pi}_{H,t}}{\bar{\pi}_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}} \left(\frac{\bar{\pi}_{H,t}}{\bar{\pi}_{H,t-1}^{ind_H}\pi_{target}^{1-ind_H}} - 1\right)$$
$$-p_{H,t}\beta\kappa_H^p E_t \left[\frac{1}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\frac{1}{\Delta S_{t+1}}\frac{\bar{\pi}_{H,t+1}^2}{\bar{\pi}_{H,t}^{ind_H}\pi_{target}^{1-ind_H}}\left(\frac{\bar{\pi}_{H,t+1}}{\bar{\pi}_{H,t}^{ind_H}\pi_{target}^{1-ind_H}} - 1\right)\frac{Q_{H,t+1}}{Q_{H,t}}\right]. \quad \text{(A.35)}$$

and $cp_{H,t}$ is an AR(1) cost-push shock that we add to the pricing equation when we take the model to the data.

First order condition with respect to the wholesale price of the Home tradable good in the US market. The FOC with respect to (wholesale) price of the Home good in the US $\bar{P}_t^*(h)$ is

$$0 = \frac{\lambda_t}{P_t}\left(\frac{\bar{P}_{H,t}^*(h) + \eta P_{N,t}^*}{P_{H,t}^*}\right)^{-\theta_H^*} Q_{H,t}^* S_t^*$$
$$-\frac{\lambda_t}{P_t}\theta_H^* \frac{(\bar{P}_{H,t}^*(h) + \eta P_{N,t}^*)^{-\theta_H^*-1}}{P_{H,t}^{*\ -\theta_H^*}}\left(\bar{P^*}_{H,t}(h) - MC_{H,t}^*(h)\right) Q_{H,t}^* S_t^*$$
$$-\lambda_t \kappa_H^{p\ *} \frac{1/\bar{P}_{H,t-1}^*(h)}{\pi_{H,t-1}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}}\left(\frac{\bar{P}_{H,t}^*(h)/\bar{P^*}_{H,t-1}(h)}{\pi_{H,t-1}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}} - 1\right)\frac{\bar{P}_{H,t}^*}{P_t} Q_{H,t}^* S_t^*$$
$$+\beta\kappa_H^{p\ *} E_t\left[\lambda_{t+1}\frac{\bar{P}_{H,t+1}^*(h)/\bar{P}_{H,t}^*(h)^2}{\pi_{H,t}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}}\left(\frac{\bar{P}_{H,t+1}^*(h)/\bar{P}_{H,t}^*(h)}{\pi_{H,t}^{*\ \ ind_H}\pi_{target}^{*\ \ 1-ind_H^*}} - 1\right)\frac{\bar{P}_{H,t+1}^*}{P_{t+1}^*} Q_{H,t+1}^* S_{t+1}^*\right]. \quad \text{(A.36)}$$

In symmetric equilibrium, the previous equation becomes

$$p_{H,t}^* = \theta_H^*\left(\bar{p}_{H,t}^* - mc_{H,t}^*\right) + A_{H,t}^* + cp_{H,t}^*, \quad \text{(A.37)}$$

where $A_{H,t}^*$ is

$$A_{H,t}^* \equiv p_{H,t}^*\kappa_H^{*\ p}\frac{\bar{\pi}_{H,t}^*}{\pi_{H,t-1}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}}\left(\frac{\bar{\pi}_{H,t}^*}{\pi_{H,t-1}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}} - 1\right)$$
$$-\beta\kappa_H^p E_t\left[p_{H,t}^*\frac{1}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\frac{\bar{\pi}_{H,t+1}^2}{\pi_{H,t}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}}\left(\frac{\bar{\pi}_{H,t+1}^*}{\pi_{H,t}^{*\ \ ind_H^*}\pi_{target}^{*\ \ 1-ind_H^*}} - 1\right)\frac{Q_{H,t+1}^*}{Q_{H,t}^*}\frac{S_{t+1}^*}{S_t^*}\right]. \quad \text{(A.38)}$$

First order condition with respect to the wholesale price of the Home tradable good in the RW. Similar equations hold for the price $\bar{P}_t^{**}(h)$ set in the RW market.

First order condition with respect to the price of the Home non-tradable good. Each firm i sets the price $P_{N,t}(i)$ in the Home intermediate non-tradable sector to maximize the present discounted value of profits

$$E_t \sum_{\tau=t}^{\infty} \beta^t \lambda_{t,\tau} \left[Q_{N,\tau}(i) \left(\frac{P_{N,\tau}(i)}{P_\tau} - \frac{MC_{N,\tau}(i)}{P_\tau} \right) \right], \tag{A.39}$$

where the term E_t denotes the expectation operator conditional on the information set at time t, $\lambda_{t,\tau}$ is the appropriate discount rate, and $MC_{N,t}(h)$ is the nominal marginal cost.

The maximization is subject to the demand constraint

$$Q_{N,\tau}(i) = \left(\frac{1}{n}\right) \left(\frac{P_{N,\tau}(i)}{P_{N,\tau}}\right)^{-\theta_N} Q_{N,\tau}, \tag{A.40}$$

and the quadratic adjustment cost,

$$AC^p_{N,\tau}(i) \equiv \frac{\kappa^p_N}{2} \left(\frac{P_{N,\tau}(i)/P_{N,\tau-1}(i)}{\pi^{ind_N}_{N,\tau-1} \pi^{1-ind_N}_{target}} - 1 \right)^2 \frac{P_{N,\tau}}{P_\tau} Q_{N,\tau}. \tag{A.41}$$

The adjustment cost is paid in unit of sector-specific product $Q_{N,t}$, where $\kappa^p_N \geq 0$ is a parameter that measures the degree of price stickiness, $\pi_{N,t-1}$ is the previous-period gross inflation rate of nontradable goods $(\pi_{N,t} \equiv P_{N,t}/P_{N,t-1})$, π is the long-run (consumer-price) inflation target set by the central bank, and $0 \leq ind_N \leq 1$ is a parameter that measures indexation to previous-period inflation.

The FOC with respect to $P_{N,t}(i)$ is

$$\begin{aligned} 0 = {} & \frac{\lambda_t}{P_t}(1-\theta_N)\frac{P_{N,t}(i)^{-\theta_N}}{P_{N,t}{}^{-\theta_N}} Q_{N,t} - \frac{\lambda_t}{P_t}\theta_N \frac{P_{N,t}(i)^{-\theta_N-1}}{P_{N,t}{}^{-\theta_N}} MC_{N,t}(i)\, Q_{N,t} \\ & -\lambda_t \kappa^p_N \frac{1/\bar{P}_{N,t-1}(i)}{\pi^{ind_N}_{N,t-1}\pi^{1-ind_N}_{target}} \left(\frac{\bar{P}_{N,t}(i)/\bar{P}_{N,t-1}(i)}{\pi^{ind_N}_{N,t-1}\pi^{1-ind_N}_{target}} - 1 \right) \frac{\bar{P}_{N,t}}{P_t} Q_{N,t} \\ & +\beta\kappa^p_N E_t \left[\lambda_{t+1} \frac{\bar{P}_{N,t+1}(i)/\bar{P}^2_{N,t}(i)}{\pi^{ind_N}_{N,t}\pi^{1-ind_N}_{target}} \left(\frac{\bar{P}_{N,t+1}(i)/\bar{P}_{N,t}(i)}{\pi^{ind_N}_{N,t}\pi^{1-ind_N}_{target}} - 1 \right) \frac{\bar{P}_{N,t+1}}{P_{t+1}} Q_{N,t+1} \right]; \end{aligned} \tag{A.42}$$

which becomes

$$p_{N,t} = \frac{\theta_N}{\theta_N - 1} mc_{N,t} - \frac{A_{N,t}}{\theta_N - 1} + cp_{N,t}, \tag{A.43}$$

where $cp_{N,t}$ is a sector-specific cost-push shock (thus, common to all firms in the sector) and

$A_{N,t}$ contains terms related to the presence of price adjustment costs

$$A_{N,t} \equiv p_{N,t}\kappa_N^p \frac{\bar{\pi}_{N,t}}{\bar{\pi}_{N,t-1}^{ind_N}\bar{\pi}_{target}^{1-ind_N}} \left(\frac{\bar{\pi}_{N,t}}{\bar{\pi}_{N,t-1}^{ind_N}\pi_{target}^{1-ind_N}} - 1\right)$$
$$-\beta\kappa_N^p E_t \left[p_{N,t}\frac{1}{\pi_{t+1}}\frac{\lambda_{t+1}}{\lambda_t}\frac{\bar{\pi}_{N,t+1}^2}{\bar{\pi}_{N,t}^{ind_N}\pi_{target}^{1-ind_N}}\left(\frac{\bar{\pi}_{N,t+1}}{\bar{\pi}_{N,t}^{ind_N}\pi_{target}^{1-ind_N}} - 1\right)\frac{Q_{N,t+1}}{Q_{N,t}}\right]. \quad \text{(A.44)}$$

Wholesale (dock) price of EA imports from the US The US producer of the tradable brand f solves the following profit maximization problem (similar to the one solved by the EA exporter):

$$E_t \sum_{\tau=t}^{\infty} \beta^\tau \lambda_{t,\tau} \left[\begin{array}{c} \frac{\bar{P}_\tau(f)}{P_\tau S_\tau^*} Q_\tau(f) + \frac{\bar{P}_\tau^*(f)}{P_\tau^*} Q_\tau^*(f) + \frac{\bar{P}_\tau^{**}(f)}{P_\tau^{**} S_\tau^{**}} Q_\tau^{**}(f) \\ -\frac{MC_{F,\tau}^*(f)}{P_\tau}\left(Q_\tau(f) + Q_\tau^*(f) + Q_\tau^{**}(f)\right) \end{array} \right]. \quad \text{(A.45)}$$

The demand curve in Home country for US goods is

$$Q_\tau(f) = \left(\frac{\bar{P}_{F,\tau}(f) + \eta P_{N,\tau}}{P_{F,\tau}}\right)^{-\theta_F} Q_{F,\tau}, \quad \text{(A.46)}$$

while the (country-specific) adjustment costs paid by the generic firm f in the Home country, invoiced in the currency of the Home country, are

$$AC_{F,\tau}^p(f) \equiv \frac{\kappa_F^p}{2}\left(\frac{\bar{P}_{F,\tau}(f)/\bar{P}_{F,\tau-1}(f)}{\pi_{F,\tau-1}^{ind_F}\left(\pi^{target}\right)^{1-ind_F}} - 1\right)^2 \frac{\bar{P}_{F,\tau}}{P_\tau} Q_{F,\tau}. \quad \text{(A.47)}$$

The FOC with respect to (wholesale) $\bar{P}_{F,t}(f)$ is

$$0 = \frac{\lambda_t}{P_t}\left(\frac{\bar{P}_{F,t}(f) + \eta P_{N,t}}{P_{F,t}}\right)^{-\theta_F} Q_{F,t}$$
$$-\frac{\lambda_t}{P_t}\theta_F \frac{\left(\bar{P}_{F,t}(f) + \eta P_{N,t}\right)^{-\theta_F - 1}}{P_{F,t}^{-\theta_F}}\left(\bar{P}_{F,t}(f) - MC_{F,t}^*(h) S_t\right) Q_{F,t}$$
$$-\lambda_t \kappa_F^p \frac{1/\bar{P}_{F,t-1}(f)}{\pi_{F,t-1}^{ind_F}\pi_{target}^{1-ind_F}}\left(\frac{\bar{P}_{F,t}(f)/\bar{P}_{F,t-1}(f)}{\pi_{F,t-1}^{ind_F}\pi_{target}^{1-ind_F}} - 1\right)\frac{\bar{P}_{F,t}}{P_t} Q_{F,t} S_t$$
$$+\beta\kappa_F^p E_t \left[\lambda_{t+1}\frac{\bar{P}_{F,t+1}(f)/\bar{P}_{F,t}(f)^2}{\pi_{F,t}^{ind_F}\pi_{target}^{1-ind_F}}\left(\frac{\bar{P}_{F,t+1}(f)/\bar{P}_{F,t}(f)}{\pi_{F,t}^{ind_F}\pi_{target}^{1-ind_F}} - 1\right)\frac{\bar{P}_{F,t+1}}{P_{t+1}} Q_{F,t+1} S_{t+1}\right]. \quad \text{(A.48)}$$

In the symmetric equilibrium, the previous equation becomes

$$p_{F,t} = \theta_F\left(\bar{p}_{F,t} - mc_{F,t} S_t\right) + A_{F,t} + cp_{F,t}. \quad \text{(A.49)}$$

where $cp_{F,t}$ is a sector-specific cost-push shock (thus, common to all firms in the sector) and $A_{F,t}$

contains terms related to the presence of price adjustment costs

$$
\begin{aligned}
A_{F,t} \equiv\ & p_{F,t}\kappa_F^p \frac{\bar{\pi}_{F,t}}{\bar{\pi}_{F,t-1}^{ind_F}\bar{\pi}_{target}^{1-ind_F}} \left(\frac{\bar{\pi}_{F,t}}{\bar{\pi}_{F,t-1}^{ind_F}\pi_{target}^{1-ind_F}} - 1 \right) \\
-\beta\kappa_F^p E_t & \left[p_{F,t} \frac{1}{\pi_{t+1}} \frac{\lambda_{t+1}}{\lambda_t} \frac{\bar{\pi}_{F,t+1}^2}{\bar{\pi}_{F,t}^{ind_F}\pi_{target}^{1-ind_F}} \left(\frac{\bar{\pi}_{F,t+1}}{\bar{\pi}_{F,t}^{ind_F}\pi_{target}^{1-ind_F}} - 1 \right) \frac{Q_{F,t+1}}{Q_{F,t}} \frac{S_{t+1}}{S_t} \right].
\end{aligned} \tag{A.50}
$$

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

$$
L_{N,t}(i) \equiv \left(\frac{1}{n}\right)^{\frac{1}{\sigma_L}} \left[\int_0^n L_t(i,j)^{\frac{\sigma_L - 1}{\sigma_L}} dj \right]^{\frac{\sigma_L}{\sigma_L - 1}}, \tag{A.51}
$$

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

$$
L_t(i,j) = \left(\frac{1}{n}\right) \left(\frac{W_t(j)}{W_t}\right)^{-\sigma_L} L_{N,t}(j), \tag{A.52}
$$

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

$$
W_t = \left[\left(\frac{1}{n}\right) \int_0^n W_t(j)^{1-\sigma_L} dj \right]^{\frac{1}{1-\sigma_L}}. \tag{A.53}
$$

Similar equations hold for firms producing intermediate tradable goods. Each household is the monopolistic supplier of a labor input j and sets the nominal wage facing a downward-sloping demand obtained by aggregating demand across domestic firms.

A.3 Households

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

$$
E_t \sum_{\tau=t}^{\infty} \beta_t \left(Z_{PR,t} \log\left(C_t(j) - b_c \frac{C_{t-1}}{gr_t} \right) - \frac{\kappa}{1+\zeta} L_t(j)^{1+\zeta} \right), \tag{A.54}
$$

where $Z_{PR,t}$ is a consumption preference shock following an AR(1) process, $0 < \beta < 1$ 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,

$$L_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\sigma_L} L_t, \tag{A.55}$$

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

$$\begin{aligned} B_{H,t}(j) + S_t B_{F,t}(j) &\leq (1+i_{t-1}) Z_{DOMRP,t-1} \frac{B_{H,t-1}(j)}{gr_t} \\ +(1+i^*_{t-1}) Z_{USRP,t-1} \left[1-\Gamma_{B_F,t-1}\right] S_t B_{F,t-1}(j) &+ R^k_t \frac{K_{t-1}(j)}{gr_t} + W_t(j) L_t(j) \\ -\frac{\kappa_W}{2}\left(\frac{W_t(j) gr_t / W_{t-1}(j)}{\pi_{W,t}^{ind_W} \pi_t^{1-ind_W}} - 1\right)^2 W_t L_t &+ \Pi_t^{prof}(j) - P_{C,t} C_t(j) - P_{I,t} I_t(j), \end{aligned} \tag{A.56}$$

where the parameter $\kappa_W > 0$ measures the degree of nominal wage rigidity 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 US dollars. The two bonds respectively pay the domestic $(1+i_t)$ and US $(1+i^*_t)$ (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 US dollar, defined as number of Home currency units per unit of US dollar. The variable Z_{DOMRP} is a risk premium shock to the bond denominated in euro held by Home (i.e., EA) households. The variable Z_{USRP} is a risk premium shock to the bond denominated in US dollars held by Home households. Both shocks follow an AR(1) process. A shock similar to Z_{USRP} holds in the RW.

The function $\Gamma_{B_F,t}$ captures the costs of undertaking positions in the international asset market and pins down a well-defined steady-state. It has the following functional form:

$$\Phi\left(\frac{S_t B_{F,t}}{P_t} - b\right) \equiv \exp\left(\phi_b \left(\frac{S_t B_{F,t}}{P_t} - b\right)\right) \qquad \phi_B \geq 0.$$

The parameter ϕ_B controls the speed of convergence to the non-stochastic steady state.[41] 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^k_t, 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 variable $I_t(j)$ is investment in physical capital. The latter is accumulated according to

[41] The function $\Phi(.)$ depends on real holdings of the foreign assets in the entire Home economy. Hence, domestic households take it as given when deciding on the optimal holding of the foreign bond. We require that $\Phi(0) = 1$ and that $\Phi(.) = 1$ only if $S_t B_{F,t}/P_t = b$, where b is the steady state real holdings of the foreign assets in the entire home economy. The function $\Phi(.)$ is assumed to be differentiable and decreasing at least in the neighborhood of the steady state. See Turnovsky (1985) and Schmitt-Grohé and Uribe (2003).

the following law:

$$K_t(j) \leq (1-\delta)K_{t-1}(j) + \left[1 - \frac{\psi}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - gr_t\right)^2 Z_{I,t}I_t(j)\right], \tag{A.57}$$

where $0 < \delta < 1$ is the depreciation rate and investment is subject to a quadratic adjustment cost. The variable $Z_{I,t}$ is an AR(1) investment-specific technology shock.

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 bond $C_t(j)$

$$\lambda_t(j) = Z_{PR,t}\left(C_t(j) - b_c C_{t-1}\right)^{-1}, \tag{A.58}$$

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

$$\lambda_t(j) = \beta E_t \frac{\lambda_{t+1}(j)}{gr_{t+1}} Z_{DOMRP,t}(1+i_t)\pi_{t+1}^{-1}, \tag{A.59}$$

- with respect to US-dollar bonds $B_{F,t}(j)$

$$\lambda_t(j) = \beta E_t \frac{\lambda_{t+1}(j)}{gr_{t+1}}(1+i_t^*)(1-\Gamma_{B,t})Z_{USRP,t}\frac{\Delta S_{t+1}}{\pi_{t+1}}, \tag{A.60}$$

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

$$Q_t(j) = \beta E_t \left[\lambda_{t+1}\frac{r_{t+1}^K}{gr_{t+1}} + Q_{t+1}(j)\frac{(1-\delta)}{gr_{t+1}}\right], \tag{A.61}$$

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

- with respect to investment $I_t(j)$

$$\lambda_t(j)p_{I,t} = Q_t(j)\left[Z_{I,t} - \frac{\psi}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - gr_t\right)^2 Z_{I,t} - \psi\left(\frac{I_t(j)}{I_{t-1}(j)} - gr_t\right) Z_{I,t}\frac{I_t(j)}{I_{t-1}(j)}\right]$$
$$+\beta E_t Q_{t+1}(j)\psi\left[\left(\frac{I_{t+1}(j)}{I_t(j)} - gr_{t+1}\right) Z_{I,t+1}\frac{I_{t+1}^2(j)}{I_t^2(j)}\right], \tag{A.62}$$

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

$$\kappa\sigma_L \frac{W_t(j)^{-\sigma_L(1+\zeta)-1}}{W_t^{-\sigma_L(1+\zeta)}} L_t^{\zeta} + (1-\sigma_L)\frac{W_t(j)^{-\sigma_L}}{W_t^{-\sigma_L}} = \lambda_t \kappa_W \left(\frac{W_t(j)/W_{t-1}(j)}{\pi_{W,t-1}^{ind_w}\pi^{1-ind_w}} - 1 \right) \frac{W_t/W_{t-1}(j)}{\pi_{W,t-1}^{ind_I}\pi^{1-ind_w}}$$
$$-\beta\lambda_{t+1}\kappa_W \left(\frac{W_{t+1}(j)/W_t(j)}{\pi_{W,t}^{ind_w}\pi^{1-ind_w}} - 1 \right) \frac{W_{t+1}W_{t+1}(j)/W_t(j)^2 L_{t+1}}{\pi_{W,t}^{ind_w}\pi^{1-ind_w} L_t} + cp_{L,t}, \qquad \text{(A.63)}$$

where $cp_{L,t}$ is an AR(1) cost-push shock that affects the labor supply.

A.4 Monetary policy

The Home central bank set the policy rate according to the following Taylor rule:

$$\frac{1+i_t}{1+\bar{i}} = \left(\frac{1+_{t-1}}{1+\bar{i}} \right)^{\rho_{1+i}} \left(\frac{\pi_t}{\bar{\pi}} \right)^{(1-\rho_{1+i})\rho_\pi} \left(\frac{GDP_t}{GDP_{t-1}} \right)^{(1-\rho_{1+i})\rho_{GDP}} (1+Z_{1+i}), \qquad \text{(A.64)}$$

where $1+i_t$ is the gross monetary policy rate (i_t is the net policy rate). The parameter ρ_{1+i} ($0 < \rho_{1+i} < 1$) captures inertia in interest rate setting, while the parameter $\bar{R}$ represents the steady-state gross nominal policy rate. The parameters ρ_π and ρ_{GDP} are respectively the weights of Home consumer price index (CPI) inflation rate (π_t) (taken as a deviation from its long-run constant target $\bar{\pi}$) and GDP (GDP_t). The term Z_{1+i} is an i.i.d. monetary policy shock.

RECENTLY PUBLISHED "TEMI" (*)

N. 1163 – *What will Brexit mean for the British and euro-area economies? A model-based assessment of trade regimes*, by Massimiliano Pisani and Filippo Vergara Caffarelli (January 2018).

N. 1164 – *Are lenders using risk-based pricing in the consumer loan market? The effects of the 2008 crisis*, by Silvia Magri (January 2018).

N. 1165 – *Listening to the buzz: social media sentiment and retail depositors' trust* by Matteo Accornero and Mirko Moscatelli (February 2018)

N. 1166 – *Banks' holdings of and trading in government bonds*, by Michele Manna and Stefano Nobili (March 2018).

N. 1167 – *Firms' and households' investment in Italy: the role of credit constraints and other macro factors*, by Claire Giordano, Marco Marinucci and Andrea Silvestrini (March 2018).

N. 1168 – *Credit supply and productivity growth*, by Francesco Manaresi and Nicola Pierri (March 2018).

N. 1169 – *Consumption volatility risk and the inversion of the yield curve*, by Adriana Grasso and Filippo Natoli (March 2018).

N. 1170 – *The global component of inflation volatility*, by Andrea Carriero, Francesco Corsello and Massimiliano Marcellino (April 2018).

N. 1171 – *The potential of big housing data: an application to the Italian real-estate market*, by Michele Loberto, Andrea Luciani and Marco Pangallo (April 2018).

N. 1172 – *ECB monetary policy and the euro exchange rate*, by Martina Cecioni (April 2018).

N. 1173 – *Firms' investments during two crises*, by Antonio De Socio and Enrico Sette (April 2018).

N. 1174 – *How can the government spending multiplier be small at the zero lower bound?*, by Valerio Ercolani and João Valle e Azevedo (April 2018).

N. 1175 – *Asset price volatility in EU-6 economies: how large is the role played by the ECB?*, by Alessio Ciarlone and Andrea Colabella (June 2018).

N.1176 – *Fixed rate versus adjustable rate mortgages: evidence from euro area banks*, by Ugo Albertazzi, Fulvia Fringuellotti and Steven Ongena (June 2018).

N. 1177 – *Short term forecasts of economic activity: are fortnightly factors useful?*, by Libero Monteforte and Valentina Raponi (June 2018).

N. 1178 – *Discretion and supplier selection in public procurement*, by Audinga Baltrunaite, Cristina Giorgiantonio, Sauro Mocetti and Tommaso Orlando (June 2018).

N. 1179 – *Labor market and financial shocks: a time varying analysis*, by Francesco Corsello and Valerio Nispi Landi (June 2018).

N. 1180 – *On the unintended effects of public transfers: evidence from EU funding to Southern Italy*, by Ilaria De Angelis, Guido de Blasio and Lucia Rizzica (June 2018).

N. 1181 – *Always look on the bright side? Central counterparties and interbank markets during the financial crisis*, by Massimiliano Affinito and Matteo Piazza (July 2018).

N. 1182 – *Knocking on parents' doors: regulation and intergenerational mobility*, by Sauro Mocetti, Giacomo Roma and Enrico Rubolino (July 2018).

N. 1183 – *Why do banks securitise their assets? Bank-level evidence from over one hundred countries in the pre-crisis period,* by Fabio Panetta and Alberto Franco Pozzolo.

N. 1184 – *Capital controls spillovers*, by Valerio Nispi Landi (July 2018).

N.1185 – *The macroeconomic effects of an open-ended asset purchase programme*, by Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani (July 2018).

N.1186 – *Fiscal buffers, private debt and recession: the good, the bad and the ugly*, by Nicoletta Batini, Giovanni Melina and Stefania Villa (July 2018).

(*) 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.

2016

ALBANESE G., G. DE BLASIO and P. SESTITO, *My parents taught me. evidence on the family transmission of values,* Journal of Population Economics, v. 29, 2, pp. 571-592, **TD No. 955 (March 2014).**

ANDINI M. and G. DE BLASIO, *Local development that money cannot buy: Italy's Contratti di Programma,* Journal of Economic Geography, v. 16, 2, pp. 365-393, **TD No. 915 (June 2013).**

BARONE G. and S. MOCETTI, *Inequality and trust: new evidence from panel data,* Economic Inquiry, v. 54, pp. 794-809, **TD No. 973 (October 2014).**

BELTRATTI A., B. BORTOLOTTI and M. CACCAVAIO, *Stock market efficiency in China: evidence from the split-share reform,* Quarterly Review of Economics and Finance, v. 60, pp. 125-137, **TD No. 969 (October 2014).**

BOLATTO S. and M. SBRACIA, *Deconstructing the gains from trade: selection of industries vs reallocation of workers,* Review of International Economics, v. 24, 2, pp. 344-363, **TD No. 1037 (November 2015).**

BOLTON P., X. FREIXAS, L. GAMBACORTA and P. E. MISTRULLI, *Relationship and transaction lending in a crisis*, Review of Financial Studies, v. 29, 10, pp. 2643-2676, **TD No. 917 (July 2013).**

BONACCORSI DI PATTI E. and E. SETTE, *Did the securitization market freeze affect bank lending during the financial crisis? Evidence from a credit register,* Journal of Financial Intermediation , v. 25, 1, pp. 54-76, **TD No. 848 (February 2012).**

BORIN A. and M. MANCINI, *Foreign direct investment and firm performance: an empirical analysis of Italian firms,* Review of World Economics, v. 152, 4, pp. 705-732, **TD No. 1011 (June 2015).**

BRAGOLI D., M. RIGON and F. ZANETTI, *Optimal inflation weights in the euro area,* International Journal of Central Banking, v. 12, 2, pp. 357-383, **TD No. 1045 (January 2016).**

BRANDOLINI A. and E. VIVIANO, *Behind and beyond the (headcount) employment rate,* Journal of the Royal Statistical Society: Series A, v. 179, 3, pp. 657-681, **TD No. 965 (July 2015).**

BRIPI F., *The role of regulation on entry: evidence from the Italian provinces,* World Bank Economic Review, v. 30, 2, pp. 383-411, **TD No. 932 (September 2013).**

BRONZINI R. and P. PISELLI, *The impact of R&D subsidies on firm innovation,* Research Policy, v. 45, 2, pp. 442-457, **TD No. 960 (April 2014).**

BURLON L. and M. VILALTA-BUFI, *A new look at technical progress and early retirement,* IZA Journal of Labor Policy, v. 5, **TD No. 963 (June 2014).**

BUSETTI F. and M. CAIVANO, *The trend–cycle decomposition of output and the Phillips Curve: bayesian estimates for Italy and the Euro Area,* Empirical Economics, V. 50, 4, pp. 1565-1587, **TD No. 941 (November 2013).**

CAIVANO M. and A. HARVEY, *Time-series models with an EGB2 conditional distribution,* Journal of Time Series Analysis, v. 35, 6, pp. 558-571, **TD No. 947 (January 2014).**

CALZA A. and A. ZAGHINI, *Shoe-leather costs in the euro area and the foreign demand for euro banknotes,* International Journal of Central Banking, v. 12, 1, pp. 231-246, **TD No. 1039 (December 2015).**

CESARONI T. and R. DE SANTIS, *Current account "core-periphery dualism" in the EMU,* The World Economy, v. 39, 10, pp. 1514-1538, **TD No. 996 (December 2014).**

CIANI E., *Retirement, Pension eligibility and home production,* Labour Economics, v. 38, pp. 106-120, **TD No. 1056 (March 2016).**

CIARLONE A. and V. MICELI, *Escaping financial crises? Macro evidence from sovereign wealth funds' investment behaviour,* Emerging Markets Review, v. 27, 2, pp. 169-196, **TD No. 972 (October 2014).**

CORNELI F. and E. TARANTINO, *Sovereign debt and reserves with liquidity and productivity crises,* Journal of International Money and Finance, v. 65, pp. 166-194, **TD No. 1012 (June 2015).**

D'AURIZIO L. and D. DEPALO, *An evaluation of the policies on repayment of government's trade debt in Italy,* Italian Economic Journal, v. 2, 2, pp. 167-196, **TD No. 1061 (April 2016).**

DE BLASIO G., G. MAGIO and C. MENON, *Down and out in Italian towns: measuring the impact of economic downturns on crime,* Economics Letters, 146, pp. 99-102, **TD No. 925 (July 2013).**

DOTTORI D. and M. MANNA, *Strategy and tactics in public debt management,* Journal of Policy Modeling, v. 38, 1, pp. 1-25, **TD No. 1005 (March 2015).**

LIBERATI D., M. MARINUCCI and G. M. TANZI, *Science and technology parks in Italy: main features and analysis of their effects on hosted firms*, Journal of Technology Transfer, v. 41, 4, pp. 694-729, **TD No. 983 (November 2014).**

MARCELLINO M., M. PORQUEDDU and F. VENDITTI, *Short-Term GDP forecasting with a mixed frequency dynamic factor model with stochastic volatility,* Journal of Business & Economic Statistics , v. 34, 1, pp. 118-127, **TD No. 896 (January 2013).**

RODANO G., N. SERRANO-VELARDE and E. TARANTINO, *Bankruptcy law and bank financing,* Journal of Financial Economics, v. 120, 2, pp. 363-382, **TD No. 1013 (June 2015).**

ZINNA G., *Price pressures on UK real rates: an empirical investigation,* Review of Finance,v. 20, 4, pp. 1587-1630, **TD No. 968 (July 2014).**

2017

ADAMOPOULOU A. and G.M. TANZI, *Academic dropout and the great recession,* Journal of Human Capital, V. 11, 1, pp. 35–71, **TD No. 970 (October 2014).**

ALBERTAZZI U., M. BOTTERO and G. SENE, *Information externalities in the credit market and the spell of credit rationing,* Journal of Financial Intermediation, v. 30, pp. 61–70, **TD No. 980 (November 2014).**

ALESSANDRI P. and H. MUMTAZ, *Financial indicators and density forecasts for US output and inflation,* Review of Economic Dynamics, v. 24, pp. 66-78, **TD No. 977 (November 2014).**

BARBIERI G., C. ROSSETTI and P. SESTITO, *Teacher motivation and student learning,* Politica economica/Journal of Economic Policy, v. 33, 1, pp.59-72, **TD No. 761 (June 2010).**

BENTIVOGLI C. and M. LITTERIO, *Foreign ownership and performance: evidence from a panel of Italian firms,* International Journal of the Economics of Business, v. 24, 3, pp. 251-273, **TD No. 1085 (October 2016).**

BRONZINI R. and A. D'IGNAZIO, *Bank internationalisation and firm exports: evidence from matched firm-bank data,* Review of International Economics, v. 25, 3, pp. 476-499 **TD No. 1055 (March 2016).**

BRUCHE M. and A. SEGURA, *Debt maturity and the liquidity of secondary debt markets,* Journal of Financial Economics, v. 124, 3, pp. 599-613, **TD No. 1049 (January 2016).**

BURLON L., *Public expenditure distribution, voting, and growth,* Journal of Public Economic Theory,, v. 19, 4, pp. 789–810, **TD No. 961 (April 2014).**

BURLON L., A. GERALI, A. NOTARPIETRO and M. PISANI, *Macroeconomic effectiveness of non-standard monetary policy and early exit. a model-based evaluation,* International Finance, v. 20, 2, pp.155-173, **TD No. 1074 (July 2016).**

BUSETTI F., *Quantile aggregation of density forecasts,* Oxford Bulletin of Economics and Statistics, v. 79, 4, pp. 495-512, **TD No. 979 (November 2014).**

CESARONI T. and S. IEZZI, *The predictive content of business survey indicators: evidence from SIGE,* Journal of Business Cycle Research, v.13, 1, pp 75–104, **TD No. 1031 (October 2015).**

CONTI P., D. MARELLA and A. NERI, *Statistical matching and uncertainty analysis in combining household income and expenditure data,* Statistical Methods & Applications, v. 26, 3, pp 485–505, **TD No. 1018 (July 2015).**

D'AMURI F., *Monitoring and disincentives in containing paid sick leave,* Labour Economics, v. 49, pp. 74-83, **TD No. 787 (January 2011).**

D'AMURI F. and J. MARCUCCI, *The predictive power of google searches in forecasting unemployment,* International Journal of Forecasting, v. 33, 4, pp. 801-816, **TD No. 891 (November 2012).**

DE BLASIO G. and S. POY, *The impact of local minimum wages on employment: evidence from Italy in the 1950s,* Journal of Regional Science, v. 57, 1, pp. 48-74, **TD No. 953 (March 2014).**

DEL GIOVANE P., A. NOBILI and F. M. SIGNORETTI, *Assessing the sources of credit supply tightening: was the sovereign debt crisis different from Lehman?,* International Journal of Central Banking, v. 13, 2, pp. 197-234, **TD No. 942 (November 2013).**

DEL PRETE S., M. PAGNINI, P. ROSSI and V. VACCA, *Lending organization and credit supply during the 2008–2009 crisis,* Economic Notes, v. 46, 2, pp. 207–236, **TD No. 1108 (April 2017).**

DELLE MONACHE D. and I. PETRELLA, *Adaptive models and heavy tails with an application to inflation forecasting,* International Journal of Forecasting, v. 33, 2, pp. 482-501, **TD No. 1052 (March 2016).**

FEDERICO S. and E. TOSTI, *Exporters and importers of services: firm-level evidence on Italy,* The World Economy, v. 40, 10, pp. 2078-2096, **TD No. 877 (September 2012).**

GIACOMELLI S. and C. MENON, *Does weak contract enforcement affect firm size? Evidence from the neighbour's court,* Journal of Economic Geography, v. 17, 6, pp. 1251-1282, **TD No. 898 (January 2013).**

LOBERTO M. and C. PERRICONE, *Does trend inflation make a difference?,* Economic Modelling, v. 61, pp. 351–375, **TD No. 1033 (October 2015).**

MANCINI A.L., C. MONFARDINI and S. PASQUA, *Is a good example the best sermon? Children's imitation of parental reading,* Review of Economics of the Household, v. 15, 3, pp 965–993, **D No. 958 (April 2014).**

MEEKS R., B. NELSON and P. ALESSANDRI, *Shadow banks and macroeconomic instability,* Journal of Money, Credit and Banking, v. 49, 7, pp. 1483–1516, **TD No. 939 (November 2013).**

MICUCCI G. and P. ROSSI, *Debt restructuring and the role of banks' organizational structure and lending technologies,* Journal of Financial Services Research, v. 51, 3, pp 339–361, **TD No. 763 (June 2010).**

MOCETTI S., M. PAGNINI and E. SETTE, *Information technology and banking organization,* Journal of Journal of Financial Services Research, v. 51, pp. 313-338, **TD No. 752 (March 2010).**

MOCETTI S. and E. VIVIANO, *Looking behind mortgage delinquencies,* Journal of Banking & Finance, v. 75, pp. 53-63, **TD No. 999 (January 2015).**

NOBILI A. and F. ZOLLINO, *A structural model for the housing and credit market in Italy,* Journal of Housing Economics, v. 36, pp. 73-87, **TD No. 887 (October 2012).**

PALAZZO F., *Search costs and the severity of adverse selection,* Research in Economics, v. 71, 1, pp. 171-197, **TD No. 1073 (July 2016).**

PATACCHINI E. and E. RAINONE, *Social ties and the demand for financial services,* Journal of Financial Services Research, v. 52, 1–2, pp 35–88, **TD No. 1115 (June 2017).**

PATACCHINI E., E. RAINONE and Y. ZENOU, *Heterogeneous peer effects in education,* Journal of Economic Behavior & Organization, v. 134, pp. 190–227, **TD No. 1048 (January 2016).**

SBRANA G., A. SILVESTRINI and F. VENDITTI, *Short-term inflation forecasting: the M.E.T.A. approach,* International Journal of Forecasting, v. 33, 4, pp. 1065-1081, **TD No. 1016 (June 2015).**

SEGURA A. and J. SUAREZ, *How excessive is banks' maturity transformation?,* Review of Financial Studies, v. 30, 10, pp. 3538–3580, **TD No. 1065 (April 2016).**

VACCA V., *An unexpected crisis? Looking at pricing effectiveness of heterogeneous banks,* Economic Notes, v. 46, 2, pp. 171–206, **TD No. 814 (July 2011).**

VERGARA CAFFARELI F., *One-way flow networks with decreasing returns to linking,* Dynamic Games and Applications, v. 7, 2, pp. 323-345, **TD No. 734 (November 2009).**

ZAGHINI A., *A Tale of fragmentation: corporate funding in the euro-area bond market,* International Review of Financial Analysis, v. 49, pp. 59-68, **TD No. 1104 (February 2017).**

2018

ADAMOPOULOU A. and E. KAYA, *Young Adults living with their parents and the influence of peers,* Oxford Bulletin of Economics and Statistics,v. 80, pp. 689-713, **TD No. 1038 (November 2015).**

BELOTTI F. and G. ILARDI *Consistent inference in fixed-effects stochastic frontier models,* Journal of Econometrics, v. 202, 2, pp. 161-177, **TD No. 1147 (October 2017).**

BRILLI Y. and M. TONELLO, *Does increasing compulsory education reduce or displace adolescent crime? New evidence from administrative and victimization data,* CESifo Economic Studies, v. 64, 1, pp. 15–4, **TD No. 1008 (April 2015).**

BUONO I. and S. FORMAI *The heterogeneous response of domestic sales and exports to bank credit shocks,* Journal of International Economics, v. 113, pp. 55-73, **TD No. 1066 (March 2018).**

CARTA F. and M. DE PHLIPPIS, *You've Come a long way, baby. husbands' commuting time and family labour supply,* Regional Science and Urban Economics, v. 69, pp. 25-37, **TD No. 1003 (March 2015).**

CARTA F. and L. RIZZICA, *Early kindergarten, maternal labor supply and children's outcomes: evidence from Italy,* Journal of Public Economics, v. 158, pp. 79-102, **TD No. 1030 (October 2015).**

CASIRAGHI M., E. GAIOTTI, L. RODANO and A. SECCHI, *A "Reverse Robin Hood"? The distributional implications of non-standard monetary policy for Italian households,* Journal of International Money and Finance, v. 85, pp. 215-235, **TD No. 1077 (July 2016).**

CECCHETTI S., F. NATOLI and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, v. 14, 1, pp. 35-71, **TD No. 1025 (July 2015).**

CIPRIANI M., A. GUARINO, G. GUAZZAROTTI, F. TAGLIATI and S. FISHER, *Informational contagion in the laboratory,* Review of Finance, v. 22, 3, pp. 877-904, **TD No. 1063 (April 2016).**

NUCCI F. and M. RIGGI, *Labor force participation, wage rigidities, and inflation,* Journal of Macroeconomics, v. 55, 3 pp. 274-292, **TD No. 1054 (March 2016).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, v. 22, 2, pp. 661-697, **TD No. 1100 (February 2017).**

FORTHCOMING

ALBANESE G., G. DE BLASIO and P. SESTITO, *Trust, risk and time preferences: evidence from survey data,* International Review of Economics, **TD No. 911 (April 2013).**

APRIGLIANO V., G. ARDIZZI and L. MONTEFORTE, *Using the payment system data to forecast the economic activity,* International Journal of Central Banking, **TD No. 1098 (February 2017).**

BARONE G., G. DE BLASIO and S. MOCETTI, *The real effects of credit crunch in the great recession: evidence from Italian provinces,* Regional Science and Urban Economics, **TD No. 1057 (March 2016).**

BELOTTI F. and G. ILARDI, *Consistent inference in fixed-effects stochastic frontier models,* Journal of Econometrics, **TD No. 1147 (October 2017).**

BERTON F., S. MOCETTI, A. PRESBITERO and M. RICHIARDI, *Banks, firms, and jobs,* Review of Financial Studies, **TD No. 1097 (February 2017).**

BOFONDI M., L. CARPINELLI and E. SETTE, *Credit supply during a sovereign debt crisis,* Journal of the European Economic Association, **TD No. 909 (April 2013).**

CIANI E. and C. DEIANA, *No Free lunch, buddy: housing transfers and informal care later in life,* Review of Economics of the Household, **TD No. 1117 (June 2017).**

CIANI E. and P. FISHER, *Dif-in-dif estimators of multiplicative treatment effects,* Journal of Econometric Methods, **TD No. 985 (November 2014).**

D'AMURI F., *Monitoring and disincentives in containing paid sick leave,* Labour Economics, **TD No. 787 (January 2011).**

ERCOLANI V. and J. VALLE E AZEVEDO, *How can the government spending multiplier be small at the zero lower bound?,* Macroeconomic Dynamics, **TD No. 1174 (April 2018).**

FEDERICO S. and E. TOSTI, *Exporters and importers of services: firm-level evidence on Italy,* The World Economy, **TD No. 877 (September 2012).**

GERALI A. and S. NERI, *Natural rates across the atlantic,* Journal of Macroeconomics, **TD No. 1140 (September 2017).**

GIACOMELLI S. and C. MENON, *Does weak contract enforcement affect firm size? Evidence from the neighbour's court,* Journal of Economic Geography, **TD No. 898 (January 2013).**

LINARELLO A., *Direct and indirect effects of trade liberalization: evidence from Chile,* Journal of Development Economics, **TD No. 994 (December 2014).**

NATOLI F. and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, **TD No. 1025 (July 2015).**

RIGGI M., *Capital destruction, jobless recoveries, and the discipline device role of unemployment,* Macroeconomic Dynamics, **TD No. 871 (July 2012).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, **TD No. 1100 (February 2017).**