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Abstract

In this paper, we study domestic and foreign monetary policy transmission in a small open economy in which firms can decide to hold foreign currency loans (FCLs). In a workhorse two-country DSGE model, firms borrow in advance to cover production costs and choose the share of FCLs based on interest rate differentials and expected exchange rate movements. In this framework, we further examine how FCL holdings affect the transmission of exogenous shocks and monetary policy. The results indicate that FCLs impact the effectiveness of domestic policy depending on the shock type: they strengthen monetary policy transmission in response to domestic shocks, while weakening it in response to asymmetric foreign and exchange rate shocks. Symmetric global supply shocks reduce domestic policy efficacy, requiring higher rates to curb inflation but causing larger output losses. In contrast, global demand shocks allow for less aggressive domestic policy responses under large FCL holdings.

JEL Codes: E32, E44, E52, F41.

Keywords: Cost channel of monetary policy, dynamic stochastic general equilibrium models, foreign currency loans, small open economy.

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1. Introduction

Foreign currency loans (FCLs) have gained in significance in Central and Eastern Europe (CEE), driven by closer economic integration with the euro area. While FCLs may be attractive from the perspective of an individual firm, they alter the transmission of monetary policy and exchange rate shocks. The post-pandemic policy rate hikes in developed economies, alongside rising corporate financing costs, underscore the relevance of understanding the role of FCLs in the cost channel of monetary policy and policy spillovers.

This paper contributes to the literature by examining the impact of FCLs on monetary policy transmission and trade-offs in a two-country DSGE model inspired by Smets and Wouters (2003), with a small open economy with an independent currency (e.g., the Czech Republic) linked to a larger neighbor (e.g., the euro area). Our model is extended to include firms' working capital and FCL decisions, where the shares of FCLs respond to interest rate differentials and anticipated exchange rate movements.[1]

In the framework developed, we explore the effects of foreign, domestic, and exchange rate shocks on the small open economy for different levels of FCL holdings by varying the initial shares of FCLs in firms' portfolios. As recent years have been characterized by both global and regional turbulence caused by COVID, spiking energy prices, and geopolitical factors, we further consider the impact of global demand and supply shocks, which hit both large and small economies with the same strength. Additionally, we analyze deviations from policy rules – or "policy experiments". Under these experiments, the central bank either does not take into account the role of FCLs in monetary policy transmission, or aims to eliminate the effect of FCLs from inflation. These experiments highlight how FCL can amplify the costs of inflation and the importance of distinguishing between types of shocks.

In the New Keynesian open economy framework, the monetary policy transmission mechanism includes the standard intertemporal substitution and exchange rate channels. A policy rate hike encourages consumers to delay consumption, reducing aggregate demand, while also leading to exchange rate appreciation. The two channels work in tandem, with an increase in the policy rate lowering inflation. The speed at which inflation returns to the target and the real costs of stabilizing it depend on nominal and real frictions and the type of shock. The working capital channel introduces an additional layer. A policy hike raises firms' financing costs, creating upward pressure on prices, even if the hike is intended to reduce inflation.

We find that the FCL option modifies the working capital channel. Changes in domestic or foreign interest rates prompt firms to adjust their FCL positions, altering their exposure to foreign shocks. If only the domestic rate rises (e.g., following a domestic shock), the presence of FCLs partially mitigates the working capital channel, making domestic policy more effective than if FCLs were unavailable. However, with foreign or global shocks, where both domestic and foreign rates rise, FCLs do not provide the same mitigation. In this case, the effect of FCLs depends on the change in the rate differential, as well as on the exchange rate response. Our findings suggest that an economy with a higher share of FCLs is more prone to foreign shocks and exchange rate shocks, which require a stronger monetary policy reaction for higher FCL holdings. Spillovers from foreign monetary policy shocks are intensified under higher FCL holdings. Domestic monetary policy transmission for global symmetric inflationary shocks depends on the nature of the shocks, which determines

[1] We focus on the working capital channel of domestic and foreign monetary policy, leaving the credit channel and long-term capital investment for further research.

the exchange rate movements. A global symmetric supply shock causes currency depreciation in a small open economy. The weaker currency puts additional inflationary pressure on domestic producers with higher FCL holdings and requires a stronger domestic monetary policy response to the inflationary shock. By contrast, a global symmetric demand shock causes currency appreciation in a small open economy, reducing the cost of FCL repayments for domestic firms. Economies with higher FCL holdings thus experience lower inflation than those with smaller FCL holdings, and a smaller monetary policy response is required.[2]

The small open economy in this paper is calibrated for the Czech Republic, as we are interested in a small open economy with an independent currency and close financial and trade links to a large neighbor. Figure 1 documents recent developments in the composition of Czech corporate loans with respect to the domestic banking sector. For a long time, loans denominated in foreign currency constituted a relatively stable share of all loans and deposits. However, in recent years the share of loans in foreign currency, almost exclusively in euros, has increased substantially and currently exceeds one half of all loans. This increase has coincided with a widening interest rate differential, which may have contributed[3] to borrowing in foreign currency. The other panel indicates that this share is quite high – currently the highest among EU Member States outside the euro area. As discussed by Zamrazilová and Holas (2023), such a high degree of foreign-denominated corporate debt can present challenges for the effectiveness of monetary policy, as well as imply additional distributional impacts.[4]

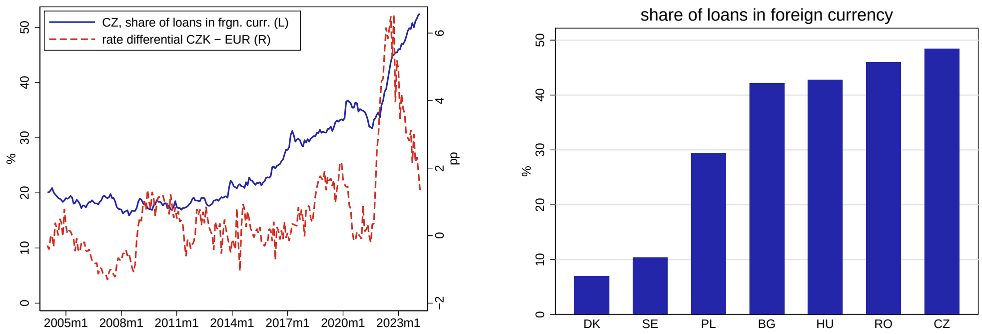
Our paper relates to several strands of literature. The first is the literature on the cost channel of monetary policy. The seminal contributions by Christiano et al. (2005), Ravenna and Walsh (2006), and Fiore et al. (2011) consider a model framework in which firms have to finance their factors of production in advance. As such, monetary policy contractions increase firms' costs and create inflationary pressure on prices. If a cost channel is strong, there is a risk that a rapid increase in interest rates in response to rising inflation expectations will make inflation expectations self-confirming (Smith 2016 and Llosa and Tuesta 2009). Some empirical studies do not find enough support for the cost channel (Choi et al. 2024 on industry-level data) or find mixed evidence: Chowdhury et al. (2006), using macro series, find it for some countries (France and the US) but not for others (Germany and Japan). Firm-level data for Sweden (Suveg 2023) suggest that firms need to finance two thirds of their working capital externally on average. A similar figure is obtained by Galindo Gil (2024) for North America, though there is significant heterogeneity across industries, while Gabriel and Martins (2010) highlight poor identification of the cost channel and challenges to its empirical assessment. The literature has further studied whether this cost channel of monetary policy contraction can dominate the demand side effect and generate a price puzzle. Rabanal (2007) con-

[2] In this paper, we do not incorporate hedging into firms' financing decisions, as empirical evidence on the *degree* of hedging is not available. In the model, hedging will weaken the impact of exchange rate movements.

[3] The increase in foreign currency corporate loans is likely driven by multiple factors. Part of this development is cyclical in nature, primarily related to interest rate differentials. Another component appears to reflect a structural trend, potentially influenced by expectations surrounding future euro adoption, recent legal changes (e.g., Czech companies have been permitted to maintain euro-denominated accounts since 2024), and/or anticipated regulatory developments (such as recurrent discussions about the possibility of paying wages in euros), all of which contribute to facilitating financial transactions in foreign currencies. This paper focuses exclusively on the cyclical dimension of this phenomenon. The trend in foreign currency lending is regularly monitored using the CNB's Inflation and Monetary Policy Risks Scoreboard.

[4] From the perspective of maturity structure, foreign currency loans in the Czech economy are distributed across the entire maturity spectrum. In 2024, the share of FCLs was approximately 50% for both short-term maturities (up to one year) and long-term maturities (over five years), while medium-term maturities exhibited a slightly higher share at around 60%. This relatively even distribution across maturities has been a consistent feature in previous years as well. The share of FCLs in short-run maturities has been close to the share of overall FCLs.

Figure 1: Composition of Loans to Non-Financial Corporations from Domestic Banks



Note: Left: time series for the share of FCLs to Czech non-financial corporations from domestic banks, and the interest rate differential on new bank loans in CZK vs. EUR. Right: international comparison of FCL shares, average for 2023. Sources: CNB ARAD, ECB.

structs and estimates a model with working capital to show that the cost channel is dominated by the demand channel after a monetary policy shock, while Henzel et al. (2009), when accounting for incomplete interest rate pass-through by banks, show that the price puzzle can be generated for very rigid nominal wages or for more flexible prices. Patel (2021) estimates a DSGE model with trade credit and finds that the presence of trade credit in the model amplifies the economy's reaction to foreign monetary policy shocks; the strength of the amplification depends on nominal rigidities. The relevance of the working capital channel of foreign monetary policy for a small open economy such as the Czech Republic has not yet been addressed empirically.

Our study relates to the literature on monetary policy spillovers. There is a body of literature focusing on monetary spillovers through either trade or domestic financial conditions – changes in domestic interest rates or lending volumes, with the exchange rate contributing to, or offsetting, some of these channels. Examples include Arbatli-Saxegaard et al. (2024) for US monetary policy and Potjagailo (2017) for euro area monetary policy. In our paper, besides the trade channel and co-movement with domestic interest rates, we consider the additional dimension of international monetary policy spillovers – firms' costs through their FCL holdings.

The paper is further related to a body of literature that studies foreign currency credit in CEE and Southern European countries. On the empirical side, Brzoza-Brzezina et al. (2010) document partial substitutability between loans in domestic and foreign currency in response to the interest rate differential. Moder (2023) shows that in the long run, one third of euro-denominated retail interest rates are linked to euro area shadow rates, limiting the domestic monetary authority's control over the interest rate channel. Ongena et al. (2021) use firm-level micro data to assess similar pass-through to loan supply. In terms of the determinants of foreign loan adoption, Luca and Petrova (2008) discuss the role of the banking sector and its desire for currency-matched portfolios, and Basso et al. (2011) find that the extent of FCLs is linked to the presence of foreign-owned banks and credit in the economy, as well as the interest rate differential. Tkalec (2013), Uroevic and Rajkovic (2016), and Mile et al. (2018), studying foreign currency loans in selected CEE economies, find that the share of FCLs is affected by the interest rate differential in the short term, while in the long term, the trade balance and the relative volatility of inflation and the nominal exchange rate become the important factors. Papers that study the issue through the lens of structural models include Céspedes et al. (2004), who incorporate entrepreneurs with foreign liabilities into a sticky-wage open-economy model with financial frictions, while Djukic et al. (2017) and Copaciu et al.

(2021) include fixed shares of foreign debt holdings within larger-scale forecasting models for Serbia and Macedonia, respectively. The studies illustrate the caveats of monetary policy transmission and exchange rate interventions in an economy with a large presence of household debt in foreign currency. The adoption of foreign currency mortgages by households is analyzed by Kolasa (2022) and Brzoza-Brzezina et al. (2017). Viziniuc (2021) analyzes foreign currency loans in the context of central bank foreign exchange interventions. From a more microeconomic perspective, Salomao and Varela (2021) use a model with heterogeneous firms to link the adoption of foreign-denominated loans to productivity, and Eren et al. (2023) propose that these loans serve as a signaling mechanism to investors. We contribute to this literature by studying the role of FCLs in firms' portfolios for monetary policy transmission in a structural model with working capital.

Our paper further relates to the debate on the role of exchange rate fluctuations in a small open economy. Our framework accounts for both competitiveness and terms of trade channels, making the overall effect of exchange rate movements ambiguous. Examples of studies finding appreciation expansionary include Lane and Stracca (2018) for the euro area, Beckmann and Comunale (2021) for a selection of emerging markets (with expansionary effects at least in the short term), and de Walque et al. (2017) using a structural model for a small open economy.

The rest of the paper is structured as follows. We start by describing our model in Section 2 and discuss our calibration choices in Section 3. Section 4 provides impulse responses to demonstrate how FCLs and the cost channel alter the transmission of monetary policy. Section 5 studies the effects of global shocks. The last section concludes.

2. The Model

To study the cost channel of monetary policy with FCLs in a small open economy, we use a model developed by de Walque et al. (2017) and further developed by Audzei and Brůha (2022) and Audzei (2023). The model consists of two fully fledged economies – a small open home economy and a large foreign economy. Each country resembles the Smets and Wouters (2003) model economy, but with foreign goods and oil products entering both the consumption basket and the intermediate goods production function. Oil represents energy and fuel inputs and is exogenous for both countries. The exogenous rest of the world (RoW) is introduced to account for demand from the rest of the world. A set of frictions standard to New Keynesian models is present, and the countries are linked through trade in intermediate goods and international bonds. Some foreign intermediate goods are used in producing domestic intermediate goods, while others are consumption goods. The main sources of spillovers are international trade and the exchange rate, though a distribution sector limits the pass-through to prices. As such, the underlying framework is well known and well studied in the literature. For a detailed description and the microfoundations of the underlying model, we refer the reader to de Walque et al. (2017) and Smets and Wouters (2003).

We modify the model so that intermediate goods producers in the domestic economy need external financing via the working capital channel in the spirit of Ravenna and Walsh (2006) and Christiano et al. (2005). We further let firms optimize their loans by choosing the share of domestic and foreign currency loans depending on the interest rate differential and expected exchange rate movements. Below, we first describe households' problem and firms' financial decisions, then we briefly sketch the rest of the model. Appendix A presents the list of model equations not described below.

2.1 Households

Households are risk-averse, and each maximizes an infinite sum of expected discounted utility. They extract utility from the consumption of combined domestic and foreign goods and oil products and have disutility from labor. Their utility features external habit in the combined consumption good. Households are monopolistic competitors in supplying a differentiated labor type, and unions represent households with the same type of labor in negotiating wages. Nominal wages demonstrate rigidity à la Calvo, with only a fraction of unions able to renegotiate. The wages that are not renegotiated are updated by consumer price inflation, trend inflation, and the economy's deterministic growth rate. Households have access to a complete set of securities, and perfect risk-sharing is assumed between the labor types. Thus, household labor income does not depend on the labor type, and we can treat households as a representative agent. Households invest in domestic and foreign investment goods, and each investment has its adjustment costs. There are also adjustment costs for imported products, so changing the consumption of imported goods is costly. Households own all the capital in the economy, pay utilization costs, and rent it to the producers for a rental price.

Households can issue and buy international bonds. In accordance with the literature, we allow only foreign households to issue international bonds and assume that those bonds pay the foreign interest rate adjusted for a wedge for foreign buyers. The demand for bonds pins the exchange rate as the UIRP condition. Denoting foreign with superscript 'f', the domestic interest rate with R, and the foreign interest rate with R^f, we can determine the nominal exchange rate as a unit of domestic currency per unit of foreign currency S. As such, a positive change in the exchange rate means depreciation of the domestic currency against the foreign currency, while a negative change means appreciation of the domestic currency:

$$E_t\left[\frac{S_{t+1}}{S_t}\right] = \frac{R_t}{R_t^{*f}} = \frac{R_t}{R_t^f\Theta_t}. \tag{1}$$

The wedge over the foreign interest rate Θ_t depends on total bond holdings in the economy and on exchange rate movements in (A6), and is not endogenized by the households.

2.2 Intermediate Goods Producers and Their Financing Decisions

Monopolistically competitive intermediate goods producers use the Cobb–Douglas production function to combine domestic labor and capital. The output from the Cobb–Douglas production function is combined with oil and foreign production goods in fixed proportions.[5] The producers set their prices in the destination currency and use the destination country's rigidities. Each differentiated good can be sold at home, exported as a consumption good, or exported as a production good. The producers take into account that consumer goods are processed through the distribution sector and price production and consumption goods differently. Nominal prices demonstrate rigidity à la Calvo, with only a fraction of producers able to reset their prices. The prices that are not reset are indexed using the inflation rate; producers export their consumption and production goods to foreign homogeneous goods assemblers and sell the consumption goods to domestic goods assemblers.

In particular, producer i uses Leontief technology:

$$\begin{aligned} Y_t(i) &= \min\left[\frac{1}{1-\rho_m-\rho_o}J_t(i); \frac{1}{\rho_m}Y^p_{F,t}(i); \frac{1}{\rho_o}O^p_t(i)\right] - \Phi, & (2)\\ J_t(i) &= \tilde{K}_t^{\alpha}\,[L_t(i)]^{1-\alpha}\, exp(\varepsilon_t^{\alpha}), & (3) \end{aligned}$$

[5] We choose to use the Leontief function for foreign materials and oil products to account for the limited substitution between foreign materials and oil inputs with the rest of the inputs when input prices change.

where O_t^p is oil used in production and $Y_{F,t}^p$ denotes foreign production goods; ρ_m and ρ_o are the respective shares in production, and Φ is a fixed cost of production. $L_t(i)$ is the aggregate labor input of the different types of labor used by the producer, and $\tilde{K}_t^\alpha$ are the effective capital services. ε_t^a is an AR(1) process with i.i.d. normal errors. The Leontief production function implies the following relationships:

$$\frac{J_t(i)}{O_t^p(i)} = \frac{1-\rho_m-\rho_o}{\rho_o}, \tag{4}$$

$$\frac{J_t(i)}{Y_{F,t}^p(i)} = \frac{1-\rho_m-\rho_o}{\rho_m}, \tag{5}$$

$$\frac{W_t L_t(i)}{\tilde{R}_t^k \tilde{K}_t(i)} = \frac{1-\alpha}{\alpha}. \tag{6}$$

Firms' marginal costs are similar to de Walque et al. (2017) and Smets and Wouters (2003):

$$MC_t(i) = (1-\rho_m)\frac{W_t^{1-\alpha}(R_t^k(i))^\alpha}{\alpha^\alpha(1-\alpha)^{1-\alpha}\varepsilon_t^\alpha} + \rho_m P_{F,t}^p + \rho_{oil} P_t^{oil}. \tag{7}$$

In line with the literature on the cost channel of monetary policy and working capital, we extend the model by assuming that firms have to borrow to pay for the factors of production. In Christiano et al. (2005) and Ravenna and Walsh (2006), firms borrow to pay for the cost of labor, while in Chowdhury et al. (2006), they borrow to pay for both materials and labor. Our production function, besides labor and rented capital, includes foreign materials and oil products. Therefore, we find it convenient to formulate firms' external financing needs as a ζ share of variable production costs.

To be able to pay in advance for the factors of production, firms borrow funds in domestic and foreign currency from domestic intermediaries. The firms decide on the share of FCLs in their portfolio, $\kappa_t(i)$. The firms pay R_t for their loans in domestic currency. The interest rate on foreign currency credit is R_t^f. Note the timing of the variables. As the interest rate is a risk-free rate set one period ahead, the interest rate R_t is the rate effective in period $t+1$. Firms decide on their share of FCLs κ_t at the end of period t, and will pay the costs of credit in period $t+1$.

We assume a wedge for accessing financing in foreign currency Ξ_t. Firms then pay $\tilde{R}_t^f = R_t^f \Xi_t$ for loans in foreign currency. The wedge represents the real costs of foreign financing, which are decreasing in the country's trade balance TB_t relative to the steady state and in the current aggregate holdings of FCLs κ_t. The wedge also includes adjustment costs η_{sg} to smooth the financing choices:

$$\Xi_t = exp\left[\alpha - \eta_a(TB_t/\bar{TB}) - \eta_s\kappa_t + \eta_{sg}\left(\frac{E_t\kappa_{t+1}}{\kappa_{t-1}} - 1\right) + \varepsilon_t^\kappa\right]. \tag{8}$$

The agents take Ξ_t as given and do not endogenize their contribution to it.

As the firms pay for the factors of production in domestic currency, they convert credit in foreign currency to domestic currency at the beginning of the period and do the opposite at the end of the current period. Denoting the change in the nominal exchange rate as $\Delta S_{t,t-1}$, one can write firms' cost of external financing as:

$$(1-\kappa_{t-1}(i))R_{t-1} + \kappa_{t-1}(i)\tilde{R}_{t-1}^f \Delta S_{t,t-1}. \tag{9}$$

The costs of financing then depend on the share of external financing needs ζ and the firm's credit portfolio:

$$F_t^c(i) = \zeta\left[(1-\kappa_{t-1}(i))R_{t-1} + \kappa_{t-1}(i)\tilde{R}_{t-1}^f \Delta S_{t,t-1}\right] + (1-\zeta). \tag{10}$$

When the share of external financing $\zeta = 0$, firms do not need credit and the model is a standard DSGE model without working capital. When $\zeta = 1$, firms have to fully finance their production costs by external credit in advance.

With the need for external financing, the above expression for marginal costs is modified to include the costs of financing $F_t^c(i)$:

$$MC_t(i) = F_t^c(i)\left[(1-\rho_m)\frac{W_t^{1-\alpha}(R_t^k(i))^\alpha}{\alpha^\alpha(1-\alpha)^{1-\alpha}\varepsilon_t^\alpha} + \rho_m P_{F,t}^p + \rho_{oil} P_t^{oil}\right]. \tag{11}$$

The producer's pricing decisions further result in Phillips curves for domestic and exported goods. As pricing decisions are standard in the literature, we report the respective Phillips curves in Appendix A.

2.3 Optimizing FCL κ

The firms select their FCL share by minimizing the mean-variance of their debt repayment value. This share for the next period is chosen as the solution to the following problem:

$$\max_{\kappa_t(i)} -E_t\left[(1-\kappa_t(i))R_t + \kappa_t(i)\tilde{R}_t^f \Delta S_{t+1,t}\right] - \frac{\rho}{2} Var\left[(1-\kappa_t(i))R_t + \kappa_t(i)\tilde{R}_t^f \Delta S_{t+1,t}\right]. \tag{12}$$

Because interest rates and the share of FCLs are decided one period in advance, firms only face uncertainty about exchange rate movements when choosing the share of FCLs.

Taking the first order-conditions of (12) and reorganizing, we have:

$$\kappa_t(i) = \frac{E_t\left[R_t - \tilde{R}_t^f \Delta S_{t+1,t}\right]}{\rho Var(\tilde{R}_t^f \Delta S_{t+1,t})}. \tag{13}$$

The firm's choice of the share of FCLs depends on the expected interest rate differential, exchange rate volatility, the availability of foreign credit, and how close the two economies are, with the last two factors accounted for by the wedge for accessing foreign currency credit Ξ. In this paper, we do not aim to explain the trend in FCLs, but focus on their short-term fluctuations around the trend, which are mostly driven by the interest rate differential $E_t R_t - \tilde{R}_t^f \Delta S_{t+1,t}$ and exchange rate movements $\Delta S_{t+1,t}$.

Note that $\kappa_t(i)$ depends only on aggregate variables, so all producers make identical decisions: $\kappa_t(i) = \kappa_t$.

2.4 Financial Intermediaries

Financial intermediaries are risk-neutral firms owned by the households. They have their stock of net wealth N, and use it and foreign funds to provide credit frictionlessly in domestic or foreign currency, where $R_{k,t}$ stands for the total amount of loans provided. They can convert between the currencies using the nominal exchange rate without a wedge or costs. They transfer the profit they receive to household families or save it as their net wealth. They invest the part of their net wealth that is not invested in the firms' credit in foreign bonds. Their net wealth evolves according to:

$$N_{j,t+1} = R_{k,t}[(1-\kappa_t)R_{t-1} + \kappa_t R^f_{t-1}\Delta S_{t,t-1} - 1] + (N_{j,t} - R_{k,t})R^f_{t-1}. \tag{14}$$

To avoid the financial intermediary accumulating infinite wealth, we follow Gertler and Karadi (2011) in assuming that a fraction θ of the intermediaries go bankrupt every period and send their net wealth to the households; households then start new intermediaries by sending ωN_{t-1} to the financial intermediaries sector.

2.5 Rest of the Model

Assemblers of homogeneous goods:

The differentiated intermediate goods are combined by competitive homogeneous goods assemblers, who also import differentiated consumption and production goods from abroad. A combined foreign production good is then sold to intermediate goods producers as a production input, and domestic and foreign homogeneous consumption goods are sold to the distribution sector.

Distribution sector:

Foreign consumption goods and oil products for consumption are processed by a competitive distribution sector, which combines them with final domestic goods in fixed proportions via the Leontief production function, limiting the exchange rate pass-through without the complexity of modeling a non-tradable sector.

International trade:

The RoW is represented as an exogenous demand process. A country's exports are determined by other countries' demand for imports, scaled by the presence of exogenous RoW demand. Total imports and exports are adjusted by their respective shares in the country's exports and imports, while oil supply is exogenous.

Central bank:

In each economy, there is an inflation-targeting central bank that reacts to deviations of inflation from the target and the output gap using a Taylor-like rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_r} \left[\left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\phi_\pi} \left(\frac{Y_t}{Y_t^f}\right)^{\phi_y}\right]^{1-\rho_r} \left(\frac{Y_t/Y_{t-1}}{Y_t^f/Y_{t-1}^f}\right)^{\psi_{\Delta y}} \varepsilon_t^r. \tag{15}$$

In the rule above, the central bank adjusts the policy rate relative to its steady-state value, $\bar{R}$, responding to deviations of inflation from the target, $\bar{\pi}$, and to the output gap. As in Slobodyan and Wouters (2012), we drop the flexible economy counterpart and substitute output from the flexible

Table 1: Calibrated Parameters

Parameter Name	Notation	Value
share of external financing	ζ	0.5
f fin. wedge adj. costs	η_{sg}	0.01
fin. wedge FCL feedback	η_s	0.0001
fin. wedge TB feedback	η_a	0.0001

economy with the process for productivity: $Y_t^f = \exp(\varepsilon_t^a)$. The strength of the monetary policy response to inflation and output growth is governed by parameters ϕ_π and ϕ_y. The policy maker also reacts to the growth rate of output relative to its flexible counterpart with parameter $\psi_{\Delta y}$. The rule includes a stochastic AR(1) process, ε^r, with i.i.d. shock μ_t^r and persistence ρ_r.

3. Calibration

The model contains the standard parameters used in the DSGE literature. We report these parameters in Table C2 in Appendix C. As we focus on a small open economy with an independent currency and deep financial connections with its large neighbor economy, the Czech economy is the obvious choice for calibrating the parameter values and steady-state ratios. Parameters related to firms' financing specific to our model are reported in Table 1. To illustrate the model dynamics and the role of the FCL channel in shock propagation, we chose to keep the monetary policy parameters in this section identical in both economies. Clearly the difference in the strength of monetary policy responses to inflation will affect the exchange rate and amplify or suppress the propagation of shocks. Moreover, the Czech National Bank employs a managed float – it intervenes in the foreign exchange market when exchange rate volatility is considered excessive. In the simulations below, we first abstract from the above policy differences and focus on the model dynamics with symmetric policy rules. We then consider domestic policy deviations from the above Taylor rule with the parameters in Table C2, allowing the domestic central bank to react to inflation that is weaker or stronger than foreign inflation.

To set the steady-state values for interest rates in Table 2, we used the Czech ARAD database for the provision of new loans in CZK (the home currency) and EUR (the foreign currency). For the steady-state value of the trade balance-to-GDP ratio, we used the balance of goods statistics, took the average, and divided by the standard deviation to get $\overline{TB} = 0.4$. We set risk aversion to $\rho = 2$.

We set the share of costs to be funded by external financing $\zeta = 0.5$. It is a usual assumption in the literature to set a unit share of financing for labor costs.[6] The empirical evidence is mixed and depends on the specification of the production functions. As we have a rich production function with imported materials, oil, labor, and capital, we choose to consider a baseline scenario where firms finance half of the total factor costs with external financing.

4. Simulation

In this section, we present responses to shocks related to firms' financing – including real exchange rate shocks, domestic and foreign monetary policy shocks, and cost-push shocks – in Figures 2–11.

[6] Examples include Christiano et al. (2005) and Ravenna and Walsh (2006).

Table 2: Steady-State Values

Parameter Name	Notation	Value
domestic rate	$\bar{R}$	3
foreign rate	$\bar{R}^f$	2
trade balance to GDP ratio	$\overline{TB}$	0.4

Other impulse responses are available on request. In all the simulations, we consider a stylized shock of 1 percent magnitude and persistence 0.85.

We simulate the model under several FCL regimes. The first, baseline regime, FCL=0, corresponds to the case in which firms can only have credit in the domestic currency with $\bar{\kappa} = 0$. In this case, firms' costs respond to the domestic interest rate in the standard New Keynesian way. The next two regimes are those in which the agents have either a medium (0.3) or a high (0.7) share of FCLs in the steady state. Outside the steady state, they adjust their shares in response to the shocks according to equation (13). The last regime, FCL=1, is one in which firms only have credit in foreign currency $\bar{\kappa} = 1$. In the two "limiting" regimes (only domestic and only foreign currency credit), firms do not adjust their shares of FCLs. To achieve the steady-state value of FCLs in the domestic economy, we vary the costs of external funding Ξ.[7]

4.1 Foreign Interest Rate Shock

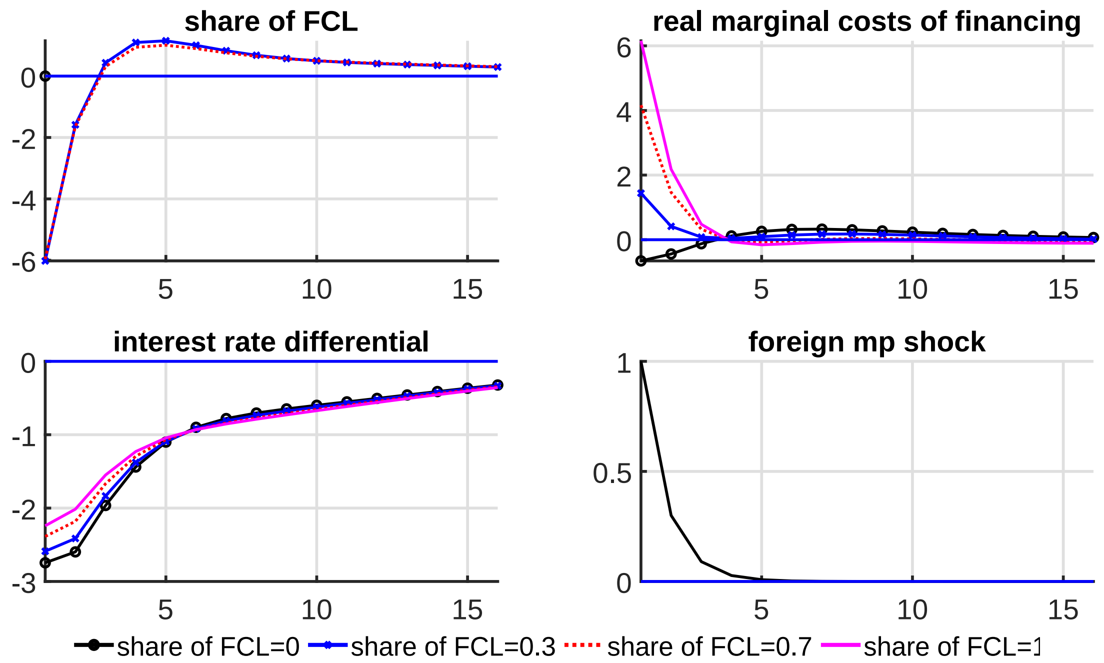
A foreign interest rate shock affects the small open domestic economy through several channels. The first one is the trade channel, present in all the economies considered even without FCLs. A foreign hike leads to a drop in foreign aggregate demand and hence also in foreign demand for inputs and consumption goods from the domestic economy. This results in a decline in domestic output. A negative interest rate differential puts depreciation pressure on the domestic exchange rate. The depreciation revives exports but suppresses imports through rising import prices. Both the imported inflation and the rising input costs result in higher consumer price inflation, and the domestic central bank needs to raise policy rates.

To study the impact of FCLs on the domestic economy, we start with firms' costs in Figure 2. The increased foreign interest rate together with the depreciation of the currency raises the marginal costs of financing for domestic firms with FCLs and motivates firms to immediately reduce their FCL holdings, but the changes in the portfolio apply to the next-period costs. By construction, the current policy rate is applied to loans in the next period, but the effect of the exchange rate change is immediate. The higher the share of FCLs, the stronger the impact of a foreign monetary policy shock on firms' costs of financing and the larger the monetary policy spillovers from the foreign economy.

With higher FCLs, the higher marginal costs of financing increase domestic consumer price inflation further in Figure 3. With a higher share of FCLs, the domestic monetary authority has to increase its policy rate more. After the foreign monetary policy rate starts falling, domestic inflation and monetary policy and the exchange rate all converge to the steady state. The convergence is quicker for an economy with higher FCL holdings, as it is more sensitive to exchange rate movements.

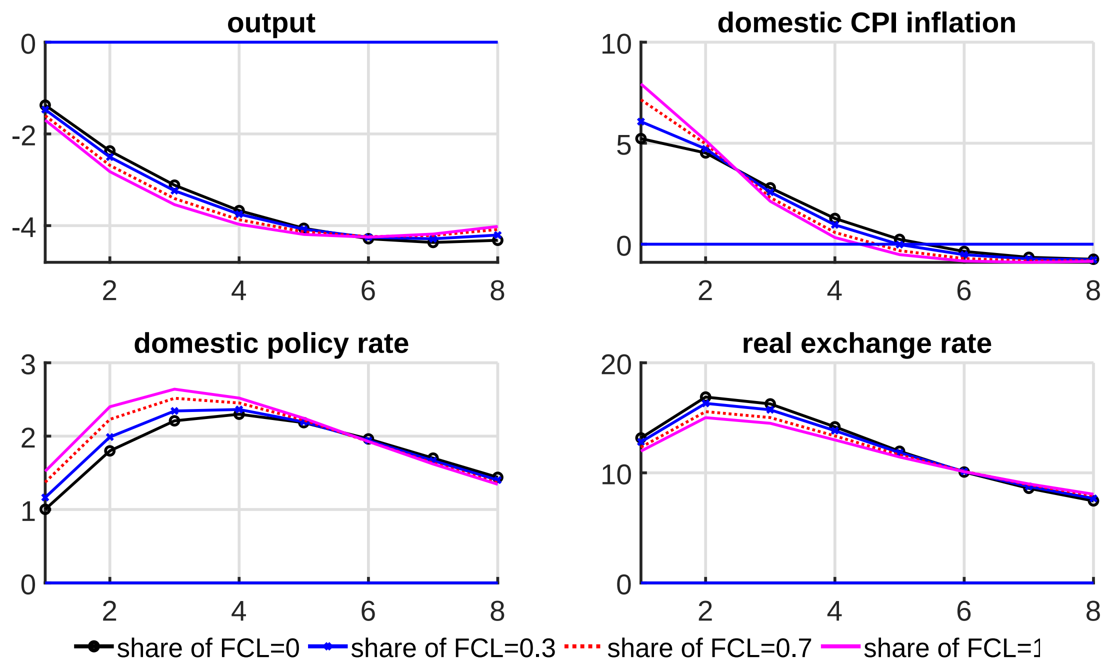
[7] Changing the steady-state value of Ξ means changing constant α in (8). An alternative way to change the steady-state value of κ is to vary the interest rate differential in (13). Note that because $NFA = 0$ in the steady state, other steady-state values are not affected.

Figure 2: Impulse Responses, 1% Foreign Interest Rate Shock



Note: All responses are reported as percentage deviations from the steady state. The interest rate differential is defined in percentage points as the domestic policy rate minus the foreign policy rate.

Figure 3: Impulse Responses, 1% Foreign Interest Rate Shock



Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized percentage point deviations. A rising exchange rate corresponds to depreciation of the domestic currency against the foreign currency.

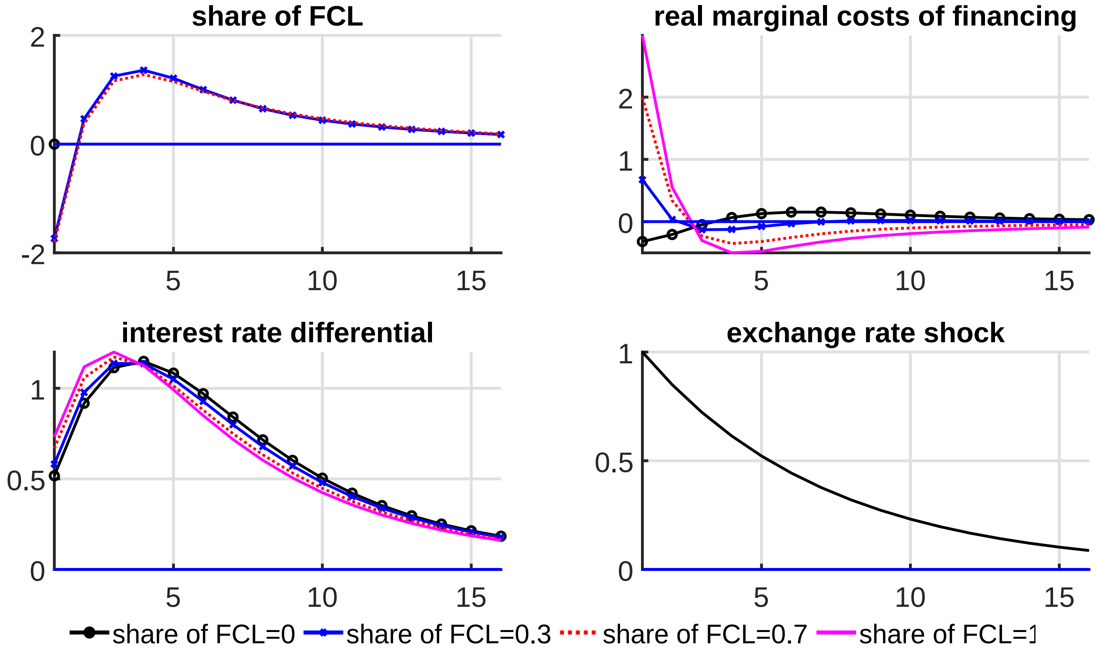
4.2 Real Exchange Rate Shock

A rising exchange rate, i.e., a weakening of the domestic currency against the foreign currency, increases the prices of imported inputs and oil, as well as imported consumption goods. As imported goods have limited substitution with domestic ones, the lower demand for them reduces demand from the distribution sector (services) and contributes to falling demand for domestic goods at home. The weaker domestic exchange rate makes exports more profitable to exporters, who price their goods in price-to-market fashion, while the rising prices of imported inputs put some upward pressure on firms' production costs.

When comparing the economies under the different scenarios in Figure 4, the largest initial increase in firms' costs of financing is in the economy with higher FCL financing. The depreciation makes firms' foreign financing more costly initially, but a strong domestic policy response increases the interest rate differential in subsequent periods. Firms initially reduce their FCLs under scenarios "FCL=0.3" and "FCL=0.7" but reverse the shares in later periods, when the fall in the real exchange rate is faster.

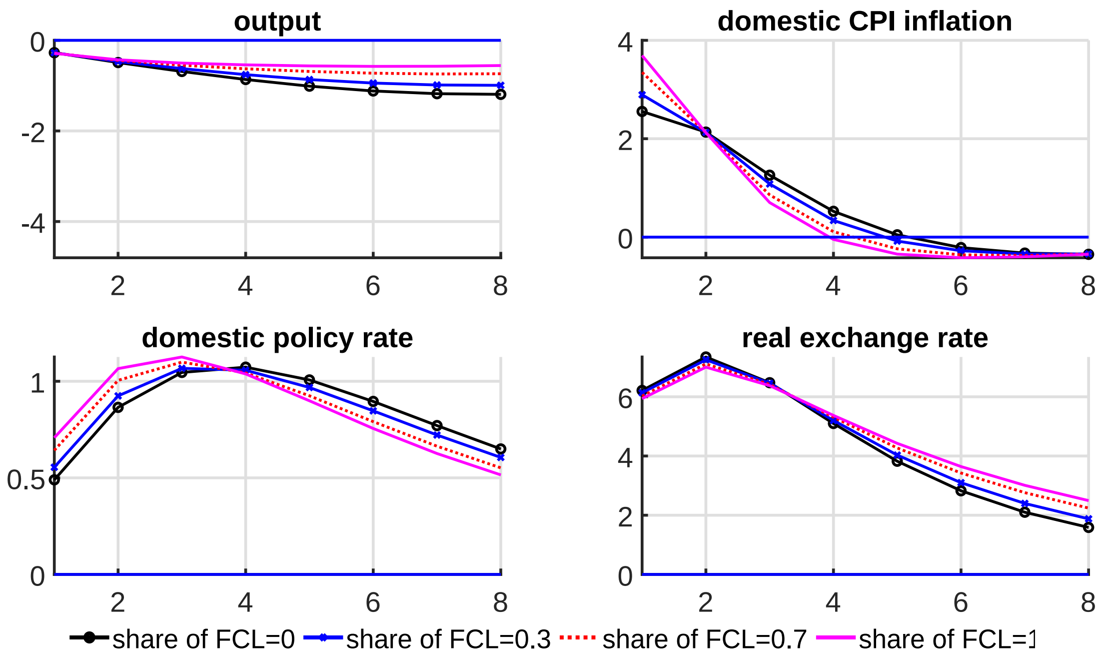
Figure 5 illustrates how firms' rising costs of financing propagate to the domestic economy. Imported consumer price inflation drives domestic CPI inflation up. The increase is higher in economies with higher FCLs due to higher costs of financing. With inflation rising more in economies with higher FCL holdings, the monetary authority reacts more strongly initially. The rising policy rate has a contractionary effect on output and consumption. With a weaker cost channel of domestic monetary policy in more euroized economies, inflation falls more quickly, followed by a faster decline in the policy rate. As inflation and the interest rate return to the steady state faster in economies with large FCL holdings in response to the exchange rate shock, these economies experience a smaller fall in output.

Figure 4: Impulse Responses, 1% Real Exchange Rate Shock



Note: All responses are reported as percentage deviations from the steady state. The interest rate differential is defined in percentage points as the domestic policy rate minus the foreign policy rate.

Figure 5: Impulse Responses, 1% Real Exchange Rate Shock



Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized percentage point deviations. The interest differential is defined as the domestic policy rate minus the foreign policy rate. A rising exchange rate corresponds to depreciation of the domestic currency against the foreign currency.

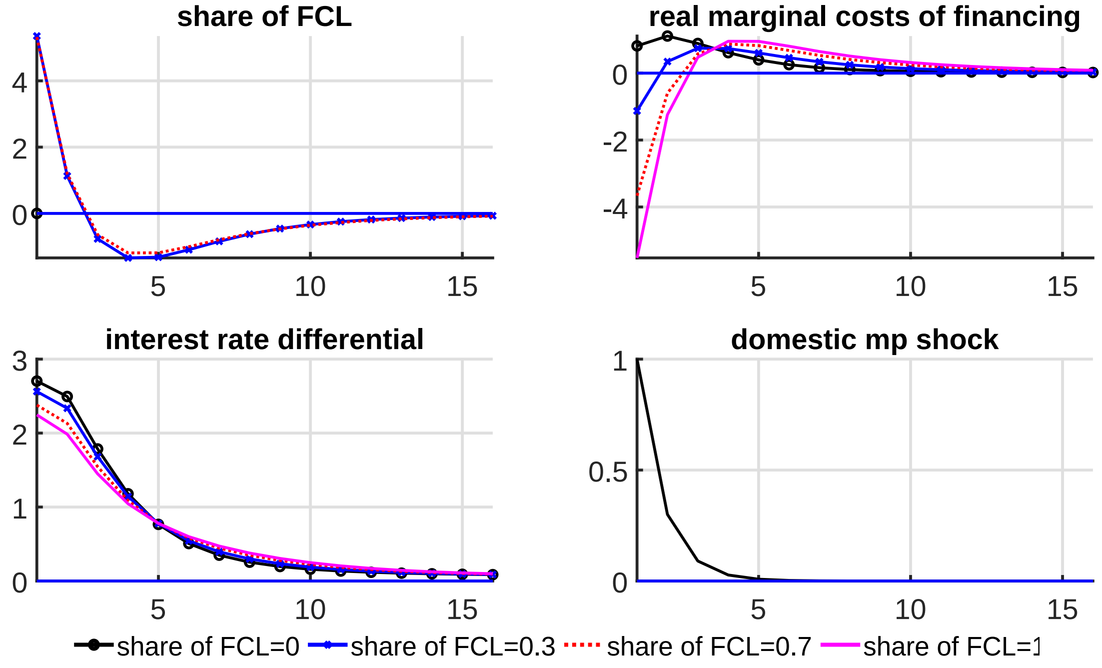
4.3 Domestic Monetary Policy Shock

A restrictive domestic monetary policy shock suppresses domestic output, investment, and inflation, and causes the domestic currency to appreciate. By suppressing aggregate demand, a restrictive domestic monetary policy shock reduces the real costs of labor and capital inputs, and imported production inputs become cheaper due to the stronger currency. This puts downward pressure on firms' real marginal costs, which consist of the real costs of the factors of production and the real costs of financing. The dynamics of the real marginal costs of financing in Figure 6 would depend on firms' exposure to credit in the domestic currency. Firms with domestic currency credit only experience a rise in real financing costs, in line with the cost channel of monetary policy. For firms with some FCLs, the costs of financing fall due to the stronger currency. The largest drop in the costs of financing is experienced by economies with FCL=1. In the economies with higher FCLs, the fall in real marginal costs is larger. A larger interest rate differential additionally results in higher FCL holdings.

A fall in the real marginal costs of financing in economies where firms are at least partially financed by foreign credit in Figure 7 results in a deeper drop in inflation compared to that implied by the standard New Keynesian mechanism. On the other hand, the output loss would be shallower in an economy with FCLs. This means that in such an economy, monetary policy shocks have a greater effect on inflation and a smaller effect on output.

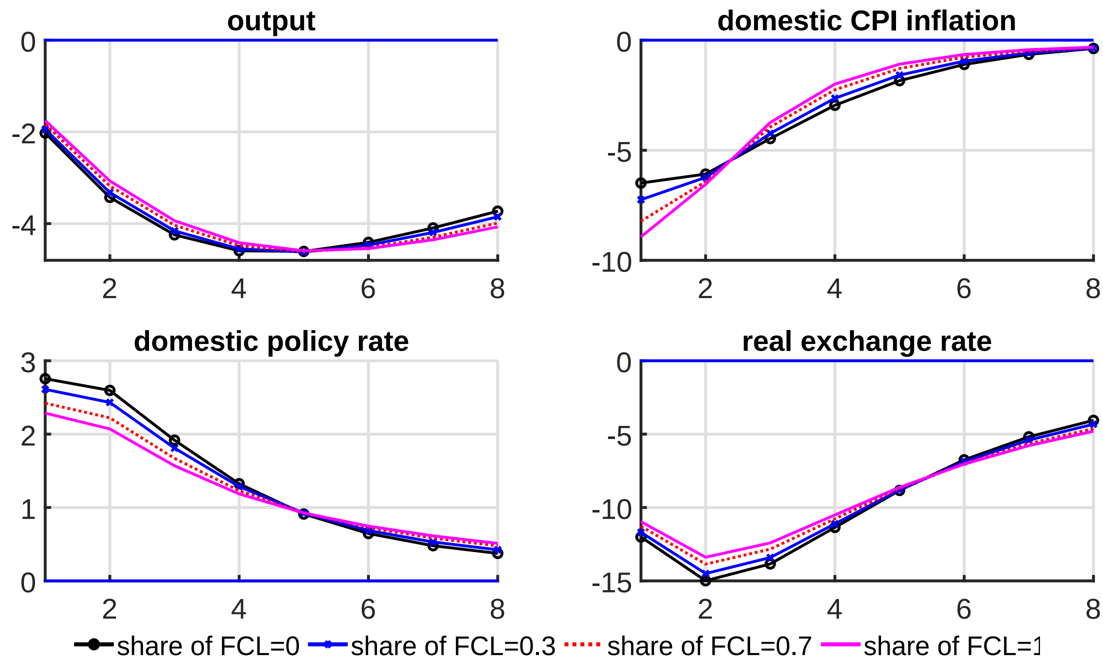
Note that in an economy with credit in domestic currency only, despite a rise in the costs of financing in Figure 6, the cost channel is not strong enough to generate an **increase** in inflation after a monetary policy shock. This is in line with previous studies (Rabanal 2007, Henzel et al. 2009), which find that an increase in real financing costs is offset by a fall in the real costs of the factors of production.

Figure 6: Impulse Responses, 1% Domestic MP Shock



Note: All responses are reported as percentage deviations from the steady state. The interest rate differential is defined in percentage points as the domestic policy rate minus the foreign policy rate.

Figure 7: Impulse Responses, 1% Domestic MP Shock



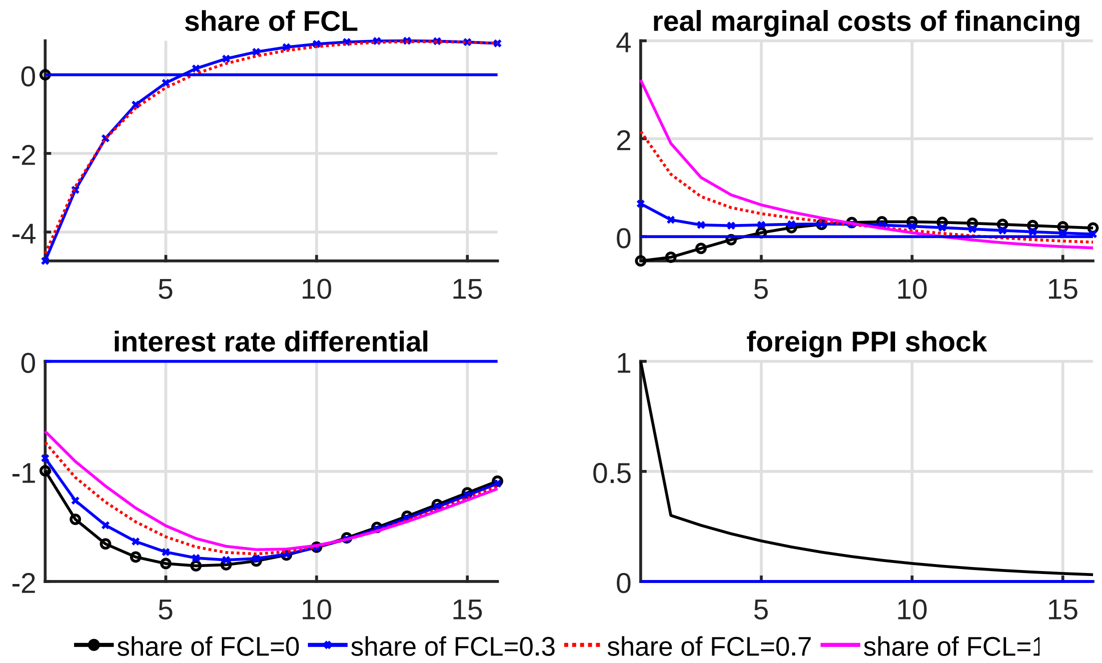
Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized. A rising exchange rate corresponds to depreciation of the domestic currency against the foreign currency.

4.4 Foreign Cost-Push Shock

A foreign cost-push shock – a shock to producers' Phillips curve in the foreign economy – results in higher foreign inflation and hence a higher foreign policy rate. It further suppresses foreign demand for foreign and domestic goods. In Figure 8, a negative interest rate differential gives domestic firms an incentive to switch from foreign currency loans to loans in domestic currency. The dynamics of firms' real financing costs reflect the changes in the real exchange rate. Strong depreciation of the domestic currency results in a rise in domestic CPI inflation and a response from the domestic monetary policy authority. While the domestic policy rate rises, the hike is not enough to offset the fall in the real interest rate. This is why the real costs of financing fall for firms with credit in the domestic currency. Firms with credit in foreign currency experience an increase in financing costs due to the weaker domestic currency.

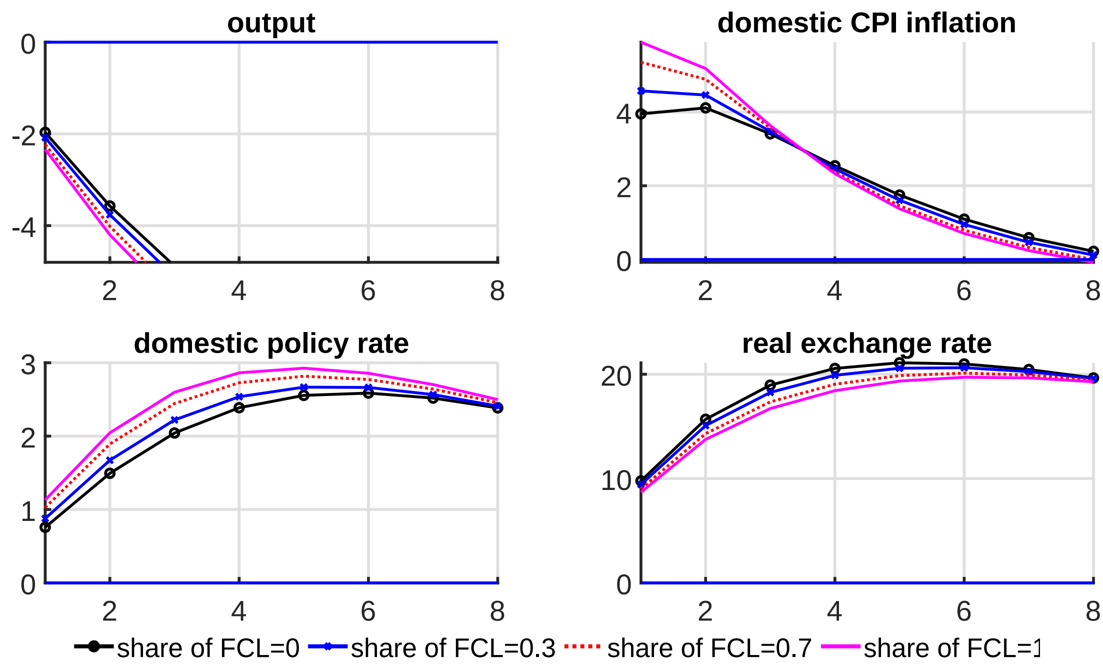
Higher firms costs result in higher domestic inflation and a higher domestic policy rate for economies with higher FCLs in Figure 9. Furthermore, there is a greater decline in domestic output with higher FCLs.

Figure 8: Impulse Responses, 1% Foreign Cost-Push Shock



Note: All responses are reported as percentage deviations from the steady state. The interest rate differential is defined in percentage points as the domestic policy rate minus the foreign policy rate.

Figure 9: Impulse Responses, 1% Foreign Cost-Push Shock



Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized. A rising exchange rate corresponds to depreciation of the domestic currency against the foreign currency.

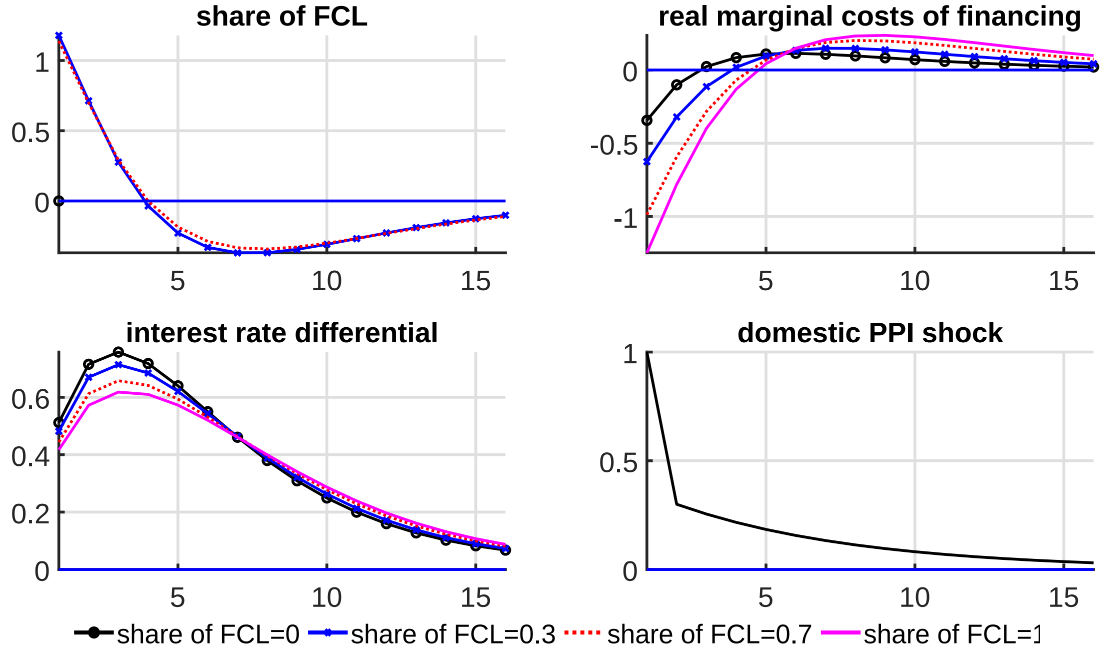
4.5 Domestic Cost-Push Shock

A domestic cost-push shock – a shock to producers' Phillips curve in the home economy – results in rising domestic PPI inflation and consequently a rising domestic policy rate and a widening interest rate differential. Firms therefore have an incentive to increase their share of FCLs. Together with the stronger currency, this leads to a fall in the real marginal costs of financing, thus partially counterbalancing the effect of the cost-push shock on inflation – see Figure 10.

Therefore, with a high share of FCLs, the increase in inflation is lower, as is the policy-rate increase consistent with the policy rule. The output loss is smaller, although the differences in the output responses are very small – see Figure 11.

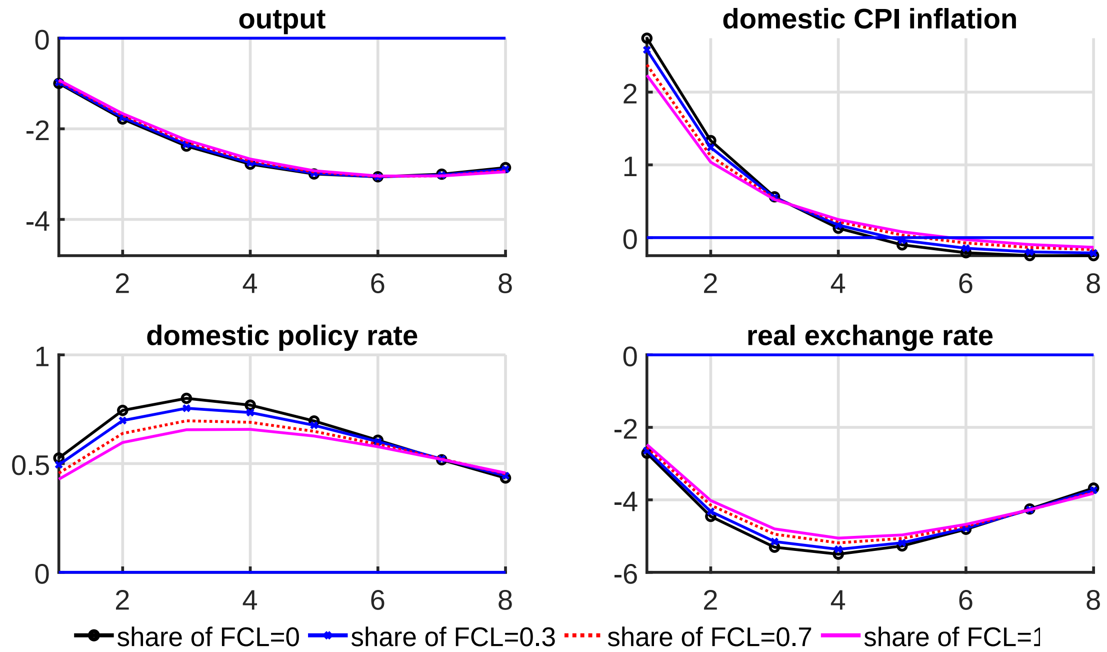
To sum up, the presence of FCLs increases the role of exchange rate movements in the propagation of domestic and foreign shocks to the domestic economy. While firms adjust their FCL holdings in response to the real interest rate differential, exchange rate movements define whether firms' financing costs rise or fall.

Figure 10: Impulse Responses, 1% Domestic Cost-Push Shock



Note: All responses are reported as percentage deviations from the steady state. The interest rate differential is defined in percentage points as the domestic policy rate minus the foreign policy rate.

Figure 11: Impulse Responses, 1% Domestic Cost-Push Shock



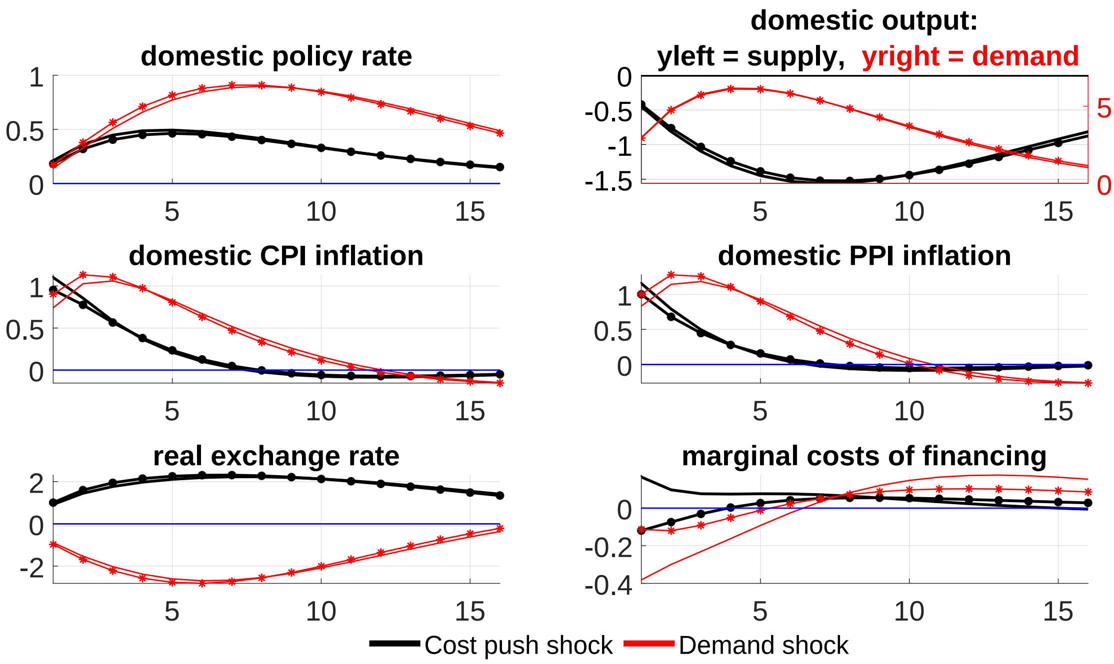
Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized. A rising exchange rate corresponds to depreciation of the domestic currency against the foreign currency.

5. Global Inflation Shocks

Various domestic and foreign shocks interact in complex ways with the working capital channel under FCLs. Economies have recently experienced common shocks, notably the COVID-19 pandemic and the energy price surge, both of which ultimately proved inflationary.[8] The inflationary pressures from these shocks eventually led central banks to tighten monetary policy, though the timing and extent of this tightening has varied, widening the interest rate differentials across countries. In this environment, FCLs have begun to play a significant role, one that should be investigated.

We therefore provide a set of stylized experiments involving global inflation shocks. We consider two kinds of shocks: (i) a global supply shock – a symmetric domestic PPI mark-up shock that moves output and inflation in opposite directions, and (ii) a global demand shock – a negative symmetric risk-premium shock that moves the two variables in the same direction. We consider simulations with a large presence of FCLs ($\kappa = 0.7$) and with domestic currency credit only ($\kappa = 0$). In Figure 12, these shocks are normalized so that in the first quarter they increase domestic CPI inflation under the scenario with $\kappa = 0$ by 1 p.p. (in annualized terms).[9]

Figure 12: Effect of the FCL Channel Under Global Inflation Shocks



Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized percentage point deviations. A rising exchange rate corresponds to depreciation of the domestic currency. The straight lines correspond to the scenario with "FCL=0.7", while the lines with asterisks "*" correspond to "FCL=0".

A symmetric global cost-push shock raises PPI inflation and suppresses output in both countries. The higher producer prices translate to higher CPI inflation. The global cost shock affects the for-

[8] Although the COVID-19 shock initially resembled a negative sentiment shock reducing output and consumption, subsequent monetary and fiscal easing around the globe transformed it into a shock with inflationary consequences (Babecká Kucharčuková et al., 2022).

[9] Note that we do not intend to replicate a particular inflationary episode, but rather to provide impulse responses to a global inflationary shock.

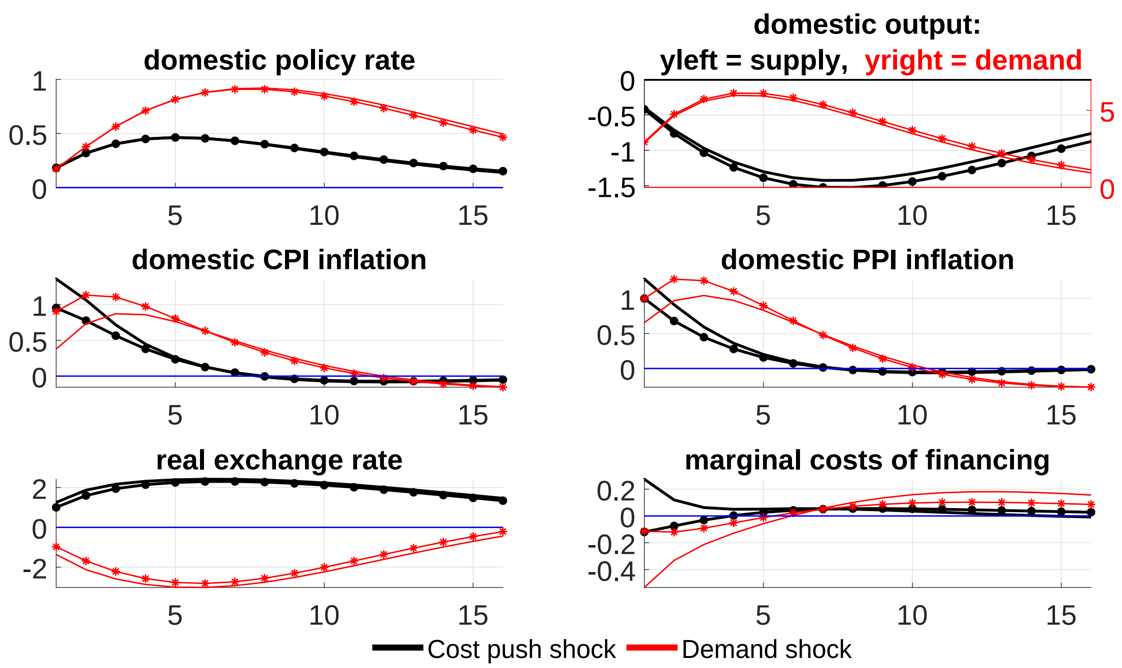
eign economy through foreign producer costs and the domestic economy through both domestic and foreign producer costs and import prices. Both the domestic and foreign central banks increase their policy rates, but lower real rates in the domestic economy put depreciation pressure on the domestic currency. The domestic economy with higher FCL holdings – the straight line – experiences higher inflation and higher policy rates compared to the situation with no FCLs – the line with asterisks. As the transmission of policy to inflation takes time, real interest rates fall at first, resulting in initially lower real company costs in the economy without FCLs. In the economy with FCLs, higher interest rates and a weaker currency push firms' financing costs up, contributing to higher inflation.

A symmetric demand shock boosts both inflation and output in the domestic and foreign economies. The domestic economy is further affected by spillovers from the foreign economy in terms of higher demand for its exports. Both the domestic and foreign monetary authorities increase interest rates, but real rates in the domestic economy are higher and result in appreciation of the domestic currency. Firms in the economy with FCL holdings enjoy lower financing costs due to the stronger currency. The economy with FCL holdings thus has lower company costs and inflation than the economy without FCLs.

Next, we design two sets of policy experiments. First, we ask what the policy outcome would be if the domestic policymaker did not take the FCL channel into account – which could be viewed as a policy mistake. The results are displayed in Figure 13. Formally, we design a set of expected monetary policy shocks so that in the first four periods, the policy rates under FCLs are the same as those implied by the model without FCLs. Domestic rates do not increase in response to a global supply shock relative to the case without FCLs, and as a result, inflation rates are even higher than in Figure 12, with minor differences in the output responses. For a global demand shock, the policy rate with FCLs is now higher than implied by the Taylor rule. Fixing the policy response at the level of the economy without FCLs leads to even stronger appreciation and lower inflation, resulting in a relative output loss, albeit a small one.

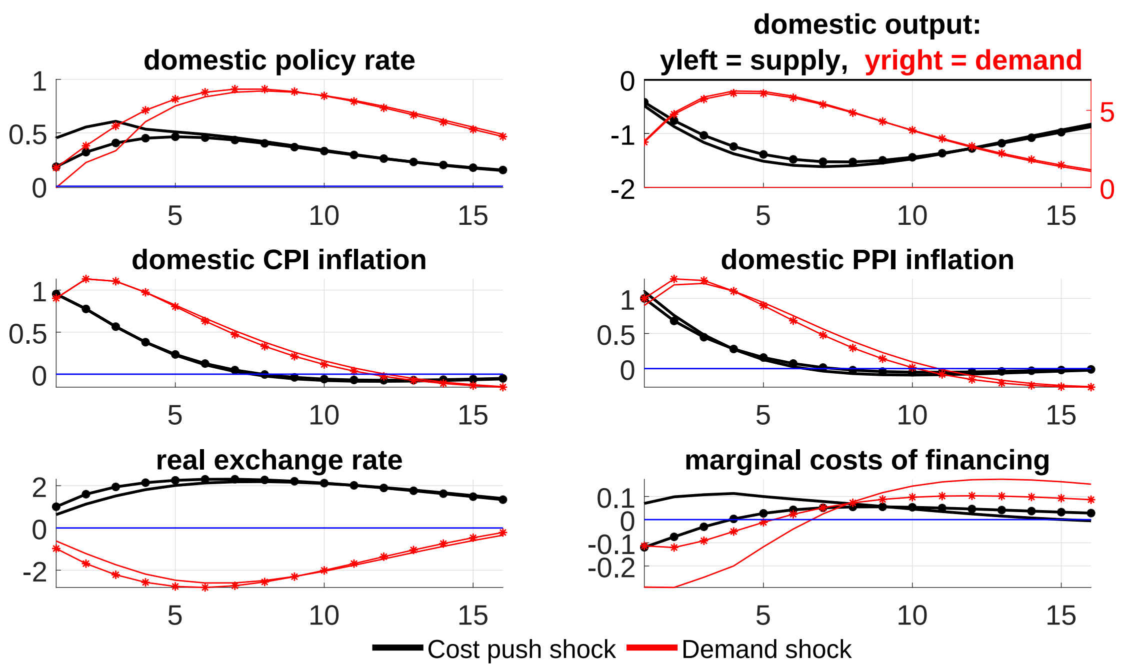
Now, consider a situation in which the policymaker wants to keep the CPI inflation response the same as in the situation without the FCL channel. To do so, we again design a sequence of expected monetary policy shocks so that the inflation response in the FCL world is the same as in the model without FCLs for the first four quarters. The results are displayed in Figure 14. For a global supply shock, the simulations imply a higher policy rate than that implied by the Taylor rule. This significantly raises costs for firms with some share of FCLs and results in small but visible output losses. As for a global demand shock, the domestic policy reaction is now weaker than implied by the Taylor rule. There is weaker currency appreciation and a smaller fall in financing costs for firms with FCLs compared to Figure 12.

Figure 13: Partial Effect of the FCL Channel Under Global Inflation Shocks and a Policy Experiment



Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized percentage point deviations. A rising exchange rate corresponds to depreciation of the domestic currency. The straight lines correspond to the scenario with "FCL=0.7", while the lines with asterisks "*" correspond to "FCL=0".

Figure 14: Partial Effect of the FCL Channel Under Global Inflation Shocks and a Strong/Weak Policy Reaction



Note: All responses are reported as percentage deviations from the steady state. Inflation and the interest rate are annualized percentage point deviations. A rising exchange rate corresponds to depreciation of the domestic currency. The straight lines correspond to the scenario with "FCL=0.7", while the lines with asterisks "*" correspond to "FCL=0".

The sets of experiments with global inflationary shocks show that the FCL channel weakens the domestic policy transmission mechanism for global inflationary supply shocks: to achieve the same level of inflation with high levels of FCLs, a central bank must increase rates more and tolerate somewhat higher output losses. The effect of FCLs on monetary transmission for global demand shocks is reversed. Due to appreciation of the domestic currency, a weaker monetary policy response is needed, as the stronger currency puts downward pressure on firms' financing costs.

6. Conclusions

In this paper, we study a small open economy with an independent currency and close trade linkages with a neighboring foreign block. We consider an economy in which firms need to borrow in advance to pay for the factors of production and can choose the share of loans to be financed in foreign currency.

We find that the presence of FCLs makes the economy more vulnerable to foreign and exchange rate shocks and weakens the monetary policy authority's control under interest rate transmission. With a larger presence of FCLs, foreign policy hikes impact domestic firms' costs via an additional channel. With an increase in foreign rates, domestic firms no longer enjoy the cost-saving benefits of having FCLs and face losses due to currency depreciation.

At the same time, a high share of FCLs weakens the cost channel of domestic monetary policy, making the latter more effective in fighting inflation after domestic inflationary shocks. The interest rate hikes implied by the policy rule are lower than in an economy without FCLs, as are the resulting output losses.

When both the domestic and foreign economies are hit by a global symmetric inflationary shock, an important role is played by exchange rate movements. A symmetric supply shock causes the domestic currency to depreciate, contributing to higher costs of financing and higher inflation from imported goods, despite stronger domestic exports. A symmetric demand shock results in appreciation of the currency. This helps monetary policy through lower costs of financing and cheaper foreign goods.

The effects of foreign currency loans on monetary policy transmission are thus shock-dependent. It is therefore important for policymakers to carefully identify the source and nature of incoming shocks in order to correctly calibrate monetary policy reactions.

References

ARBATLI-SAXEGAARD, E. C., D. FURCERI, P. G. DOMINGUEZ, J. D. OSTRY, AND S. J. PEIRIS (2024): "Spillovers from US Monetary Policy: Role of Policy Drivers and Cyclical Conditions." *Journal of International Money and Finance,* 143:103053.

AUDZEI, V. (2023): "Learning and Cross-Country Correlations in a Multi-Country DSGE Model." *Economic Modelling,* 120(C).

AUDZEI, V. AND J. BRŮHA (2022): "A Model of the Euro Area, China, and the United States: Trade Links and Trade Wars." *Economic Modelling,* 111(C).

BABECKÁ KUCHARČUKOVÁ, O., J. BRŮHA, P. KRÁL, M. MOTL, AND J. TONNER (2022): "Assessment of the Nature of the Pandemic Shock: Implications for Monetary Policy." CNB Research and Policy Notes No. 1/2022.

BASSO, H. S., O. CALVO-GONZALEZ, AND M. JURGILAS (2011): "Financial Dollarization: The Role of Foreign-Owned Banks and Interest Rates." *Journal of Banking & Finance,* 35(4): 794–806.

BECKMANN, J. AND M. COMUNALE (2021): "Exchange Rate Fluctuations and the Financial Channel in Emerging Economies." BOFIT Discussion Papers 11/2021, Bank of Finland Institute for Emerging Economies.

BRZOZA-BRZEZINA, M., T. CHMIELEWSKI, AND J. NIEDZWIEDZINSKA (2010): "Substitution between Domestic and Foreign Currency Loans in Central Europe. Do Central Banks Matter?" ECB Working Paper Series No. 1187

BRZOZA-BRZEZINA, M., M. KOLASA, AND K. MAKARSKI (2017): "Monetary and Macroprudential Policy with Foreign Currency Loans." *Journal of Macroeconomics,* 54(PB):352–372.

CHOI, S., T. WILLEMS, AND S. Y. YOO (2024): "Revisiting the Monetary Transmission Mechanism Through an Industry-Level Differential Approach." *Journal of Monetary Economics,* 145:103556.

CHOWDHURY, I., M. HOFFMANN, AND A. SCHABERT (2006): "Inflation Dynamics and the Cost Channel of Monetary Transmission." *European Economic Review,* 50(4):995–1016.

CHRISTIANO, L., M. EICHENBAUM, AND C. EVANS (2005): "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy,* 113(1):1–45.

COENEN, G., P. KARADI, S. SCHMIDT, AND A. WARNE (2018): "The New Area-Wide Model II: An Extended Version of the ECBs Micro-Founded Model for Forecasting and Policy Analysis with a Financial Sector." ECB Working Paper Series No 2200.

COPACIU, M., J. MADJOSKA, AND M. MITESKI (2021): "A DSGE Model with Partial Euroization: The Case of the Macedonian Economy." *Economy, Business & Development: An International Journal,* 2(2):57118.

CÉSPEDES, L. F., R. CHANG, AND A. VELASCO (2004): "Balance Sheets and Exchange Rate Policy." *American Economic Review,* 94(4):1183–1193.

DE WALQUE, G., T. LEJEUNE, 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 No 317.

DJUKIC, M., T. HLEDIK, J. POLANSKY, L. TRAJCEV, AND J. VLCEK (2017): "A DSGE Model with Financial Dollarization - the Case of Serbia." CNB Working Papers No. 02/2017.

EREN, E., S. MALAMUD, AND H. ZHOU (2023): "Signaling with Debt Currency Choice." BIS Working Papers 1067, Bank for International Settlements

FIORE, F. D., P. TELES, AND O. TRISTANI (2011): "Monetary Policy and the Financing of Firms." *American Economic Journal: Macroeconomics,* 3(4):112–142.

GABRIEL, V. J. AND L. F. MARTINS (2010): "The Cost Channel Reconsidered: A Comment Using an Identification-Robust Approach." *Journal of Money, Credit and Banking,* 42(8): 1703–1712.

GALINDO GIL, H. (2024): "Is the Working Capital Channel of the Monetary Policy Quantitatively Relevant? A Structural Estimation Approach." *Macroeconomic Dynamics,* 125.

GERTLER, M. AND P. KARADI (2011): "A Model of Unconventional Monetary Policy." *Journal of Monetary Economics,* 58(1):17–34.

HENZEL, S., O. HÜLSEWIG, E. MAYER, AND T. WOLLMERSHÄUSER (2009): "The Price Puzzle Revisited: Can the Cost Channel Explain a Rise in Inflation After a Monetary Policy Shock?." *Journal of Macroeconomics,* 31(2):268–289.

KOLASA, M. (2022): "Equilibrium Foreign Currency Mortgages." *Review of Economic Dynamics,* 45:168–186.

LANE, P. R. AND L. STRACCA (2018): "Can Appreciation Be Expansionary? Evidence from the Euro Area." *Economic Policy,* 33(94):225–264.

LLOSA, L.-G. AND V. TUESTA (2009): "Learning about Monetary Policy Rules when the Cost-Channel Matters." *Journal of Economic Dynamics and Control,* 33(11):1880–1896.

LUCA, A. AND I. PETROVA (2008): "What Drives Credit Dollarization in Transition Economies?" *Journal of Banking & Finance,* 32(5):858–869.

MILE, B., K. GORDANA, AND B. VLATKA (2018): "Determinants Of Financial Euroisation In A Small Open Economy: The Case Of Serbia." *Economic Annals,* 63(218):9–22.

MODER, I. (2023): "The Transmission of Euro Area Monetary Policy To Financially Euroized Countries." *Economics & Politics,* 35(3):718–751.

ONGENA, S., I. SCHINDELE, AND D. VONNÁK (2021): "In Lands Of Foreign Currency Credit, Bank Lending Channels Run Through?" *Journal of International Economics,* 129:103435.

PATEL, N. (2021): "International Trade Finance and the Cost Channel of Monetary Policy in Open Economies." *International Journal of Central Banking,* 17(70):1–62.

POTJAGAILO, G. (2017): "Spillover Effects From Euro Area Monetary Policy Across Europe: A Factor-Augmented VAR Approach." *Journal of International Money and Finance,* 72: 127–147.

RABANAL, P. (2007): "Does Inflation Increase After a Monetary Policy Tightening? Answers Based On an Estimated DSGE Model." *Journal of Economic Dynamics and Control,* 31(3): 906–937.

RAVENNA, F. AND C. E. WALSH (2006): "Optimal Monetary Policy With the Cost Channel." *Journal of Monetary Economics,* 53(2):199–216.

SALOMAO, J. AND L. VARELA (2021): "Exchange Rate Exposure and Firm Dynamics." *The Review of Economic Studies,* 89(1):481–514.

SLOBODYAN, S. AND R. WOUTERS (2012): "Learning In an Estimated Medium-Scale DSGE Model." *Journal of Economic Dynamics and Control,* 36(1):26–46.

SMETS, F. AND R. WOUTERS (2003): "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area." *Journal of the European Economic Association,* 1(5):1123–1175.

SMITH, A. L. (2016): "When Does the Cost Channel Pose a Challenge To Inflation Targeting Central Banks?." *European Economic Review,* 89(C):471–494.

SUVEG, M. (2023): "The Working Capital Channel." Research Institute of Industrial Economics Working Paper Series No. 1482.

TKALEC, M. (2013): "Monetary Determinants of Deposit Euroization in European Post-Transition Countries." *Panoeconomicus,* 60(1):89–101.

UROEVIC, B. AND I. RAJKOVIC (2016): "Dollarization of Deposits in the Short and Long Run: Evidence from CESE Countries." CESifo Working Paper Series No. 5745.

VIZINIUC, M. (2021): "Winners And Losers Of Central Bank Foreign Exchange Interventions." *Economic Modelling,* 94(C):748–767.

ZAMRAZILOVÁ, E. AND J. HOLAS (2023): "Struktura Financování Firem a Transmise Měnové Politiky ČNB." *Bankovnictví.*

Appendix A: Model Equations

Here we present the equations of the model not mentioned in the text. Most of them are taken from de Walque et al. (2017) and from the relevant appendixes in Audzei and Bůha (2022) and Audzei (2023), modified to consider FCLs in a small open economy.

A.1 Households

There is a continuum of households, indexed by h, with the following utility:

$$U_t(h) \equiv E_t \sum_{j=0}^{\infty} \beta^j \left(\frac{\left(\mathbb{C}_{t+j}(h) - H_{t+j}\right)^{1-\sigma_c}}{1-\sigma_c} \right) exp\left(\frac{\sigma_c - 1}{1+\sigma_l} l_{t+j}(h)^{1+\sigma_l} \right), \tag{A1}$$

where σ_c is the degree of relative risk aversion, σ_l is the inverse of the Frisch elasticity of labor supply, and H_t is the external habit variable, such that $H_t = \lambda_{hab}\mathbb{C}_{t-1}$.

The consumption composite good, $\mathbb{C}$, consists of an oil good, O^D, and a non-oil good, C. The consumption index and the corresponding price index are:

$$\mathbb{C}_t(h) = \left[(1-\phi_{oil})^{\frac{1}{\lambda_{oil}}} C_t(h)^{\frac{\lambda_{oil}-1}{\lambda_{oil}}} + \phi_{oil}^{\frac{1}{\lambda_{oil}}} O_t^D(h)^{\frac{\lambda_{oil}-1}{\lambda_{oil}}} \right]^{\frac{\lambda_{oil}}{\lambda_{oil}-1}}, \tag{A2}$$

$$P_{\mathbb{C},t} = \left[(1-\phi_{oil}) P_{c,t}^{1-\lambda_{oil}} + \phi_{oil} P_{oil,t}^{D\ \ 1-\lambda_{oil}} \right]^{\frac{1}{1-\lambda_{oil}}} exp(\varepsilon_t^p), \tag{A3}$$

where ε_t^p is the price shock, which is an AR(1) process with i.i.d. normal errors. $P_{\mathbb{C}}$, P_c, and P_{oil}^D stand for the price of the total consumption aggregate, the price of non-oil consumption, and the price of oil products for direct consumption, respectively. Superscript D denotes that the good is ready for direct consumption. λ_{oil} is the price elasticity of demand in total consumption and ϕ_{oil} is the share of oil in consumption.

Similarly, the investment good, I, combines domestic and foreign goods. We further assume that the price of the investment good equals the price of the non-oil consumption bundle, P_c, and that the same elasticity and home bias apply:

$$I_t(h) = \left[\phi_H^{\frac{1}{\lambda}} I_{H,t}(h)^{\frac{\lambda-1}{\lambda}} + (1-\phi_H)^{\frac{1}{\lambda}} (1-\Omega_{I,t}) I_{F,t}(h)^{\frac{\lambda-1}{\lambda}} \right]^{\frac{\lambda}{\lambda-1}}. \tag{A4}$$

A.2 International Bond Market and Nominal Exchange Rate

Following de Walque et al. (2017) and Audzei and Bůha (2022), we assume that all foreign bonds are denominated in foreign currency and pay the foreign country interest rate. Then, the budget constraint for a household is:

$$\begin{aligned} & P_{\mathbb{C},t}\left(\mathbb{C}_t(h) + I_t(h)\right) + \frac{B_{H,t}(h)}{exp(\varepsilon_t^b)R_t} + \frac{S_t B_{F,t}(h)}{exp(\varepsilon_t^b)\tilde{R}_t^f} \\ & \leq W_t(h) l_t(h) + B_{H,t-1}(h) + S_t B_{F,t-1}(h) \\ & + R_t^k u_t(h) K_{t-1}(h) - \psi(u_t) K_{t-1}(h) + \int Div_i(i,h) di + TN_t. \end{aligned} \tag{A5}$$

The revenue side includes labor income, $W_t(h)l_t(h)$, the return on domestic bonds, $B_{H,t-1}(h)$, and the return on foreign bonds, $B_{F,t-1}(h)$. The return enters with a negative sign if the household borrows on the bond market. S_t denotes the nominal exchange rate between the home currency and the foreign currency in indirect quotation: home currency per unit of foreign currency. The household receives a return on the capital stock, $R_t^k u_t(h)K_{t-1}(h)$, minus utilization costs, $\psi(u_t)K_{t-1}(h)$, and dividends from domestic intermediate firms, indexed by i: $\int Div_i(i,h)di$, and net transfers from financial intermediaries $TN_t \equiv (\theta-\omega)N_{t-1}$.

The expenditure side includes total consumption, including consumption of the oil good, $\mathbb{C}_t(h)$, investment in physical capital, $I_t(h)$, and the positions on the domestic and foreign bond markets. R_t and R_t^f stand for the domestic and foreign gross interest rate, and ε^b resembles the risk premium shock from Smets and Wouters (2003). Following de Walque et al. (2017), we assume that households pay a premium over the foreign bond return to participate in the international bond market; thus, the return on foreign bonds equals $R_t^{*f} = R_t^f \Theta_t$. This wedge between the foreign interest rate and households' return on bonds is modeled as the real costs of holding foreign bonds, a function of total foreign bond holdings in the economy and changes in the nominal exchange rate:

$$\Theta_t = exp\left(-\theta_a \frac{S_t B_{F,t}(h)}{P_{\mathbb{C},t}\gamma^t} - \theta_s\left(\frac{E(S_{t+1})}{S_t}\frac{S_t}{S_{t-1}} - 1\right) + \varepsilon^s\right), \tag{A6}$$

where γ is the deterministic growth rate of the economy, and θ_a and θ_s are parameters capturing the persistence in the exchange rate data when the model is estimated. ε^s is an autoregressive process capturing the exogenous variation in the foreign bond market. Individual households take these costs as given in their optimal decisions.

Households' optimal bond holdings result in the following conditions:

$$\begin{aligned}
[\partial B_{H,t}(h)] \quad \vartheta_t &= exp(\varepsilon_t^b)R_t\beta E_t\left[\vartheta_{t+1}\frac{P_{\mathbb{C},t}}{P_{\mathbb{C},t+1}}\right], && \text{(A7)}\\
[\partial B_{F,t}(h)] \quad \vartheta_t &= exp(\varepsilon_t^b)R_t^{*f}\beta E_t\left[\vartheta_{t+1}\frac{ES_{t+1}}{S_t}\frac{P_{\mathbb{C},t}}{P_{\mathbb{C},t+1}}\right], && \text{(A8)}
\end{aligned}$$

where ϑ is the associated Lagrange multiplier. Combining these two equations for the home currency, we obtain the equation for the nominal exchange rate in the text (1).

A.3 Intermediate Goods Producers

The intermediate goods firm sets the prices of goods produced: domestic intermediate goods, Y_H, exported intermediate goods, Y_H^*, and exported production goods, Y_H^{*p}. When setting the prices, the firm maximizes its profit and faces Calvo price-setting rigidities. From a domestic firm's perspective:

$$\begin{aligned}
&\max_{\tilde{P}_{H,t}(i)\tilde{P}^*_{H,t}(i)\tilde{P}^{*p}_{H,t}(i)} E_t\sum_{j=0}^{\infty}(\beta\zeta_p)^j\frac{\vartheta_{t+j}P_{\mathbb{C},t}}{\vartheta_t P_{\mathbb{C},t+j}}\left[\tilde{P}_{H,t}(i)\chi_{t,j}Y_{H,t+j}(i) - MC_{t+j}Y_{H,t+j}(i)\right]\\
&+E_t\sum_{j=0}^{\infty}(\beta\zeta^*_{pF})^j\frac{\vartheta_{t+j}P_{\mathbb{C},t}}{\vartheta_t P_{\mathbb{C},t+j}}\Big[S_{t+j}\tilde{P}^*_{H,t}(i)\chi^*_{t,j}Y^*_{H,t+j}(i) - MC_{t+j}Y^*_{H,t+j}(i)\\
&+S_{t+j}\tilde{P}^*_{H,t}(i)\chi^{p*}_{t,j}Y^{p*}_{H,t+j}(i) - MC_{t+j}Y^{p*}_{H,t+j}(i)\Big],
\end{aligned} \tag{A9}$$

where χ is the inflation indexation for each type of good: χ_j for domestic goods, χ_j^* for foreign consumption goods, and χ_j^{p*} for foreign production goods. ι_{pF}^* and $\bar{\pi}_H^*$ are local inflation indexation parameters:

$$\chi_{t,j} = \begin{cases} 1 \quad \text{if} \quad j=0, \\ \Pi_{k=1}^{j} \pi_{H,t+k-1}^{\iota_p} \bar{\pi}_H^{1-\iota_p} \quad \text{if} \quad j=1,...,\infty \end{cases}, \tag{A10}$$

$$\chi_{t,j}^* = \begin{cases} 1 \quad \text{if} \quad j=0, \\ \Pi_{k=1}^{j} \pi_{H,t+k-1}^{*\iota_{pF}^*} \bar{\pi^*}_H^{1-\iota_{pF}^*} \quad \text{if} \quad j=1,...,\infty \end{cases}, \tag{A11}$$

$$\chi_{t,j}^{p*} = \begin{cases} 1 \quad \text{if} \quad j=0, \\ \Pi_{k=1}^{j} (\pi_{H,t+k-1}^{p*})^{\iota_{pF}^*} (\bar{\pi}_H^{p*})^{1-\iota_{pF}^*} \quad \text{if} \quad j=1,...,\infty \end{cases}. \tag{A12}$$

Prices with ˜ denote intermediate goods prices, distinguishing them from final goods prices. Variables with * are exported variables. The price of domestic goods, $\tilde{P}_{H,t}$, is set in domestic currency, and the prices of exported consumption and production goods, $\tilde{P}_{H,t}^*$ and $\tilde{P}_{H,t}^{*p}$, are set in foreign currency. Export prices are rigid in the destination currency. Parameters ζ_p and ζ_{pF}^* are the Calvo probabilities of being unable to re-optimize home and foreign prices, respectively. Prices that are not optimized are indexed to past inflation with a weight ι_p and ι_{pF}^* and to trend inflation with a weight $1-\iota_p$ and $1-\iota_{pF}^*$ for domestic and export prices, respectively. There are three types of trend inflation: domestic inflation, $\bar{\pi}_H$, exported intermediate goods inflation, $\bar{\pi}_H^*$, and exported production goods inflation, $\bar{\pi}_H^{p*}$.

A.4 Homogeneous Goods Assemblers

The assemblers are perfectly competitive and produce homogeneous domestic goods, $Y_{H,t}$, and imported goods, $Y_{F,t}$ and $Y_{F,t}^p$, using $Y_{H,t}(i)$, $Y_{F,t}(i)$ and $Y_{F,t}^p(i)$, respectively. They have the following Kimball production functions:

$$1 = \int_0^1 G\left(\frac{Y_{H,t}(i)}{Y_{H,t}}\right) di, \tag{A13}$$

$$1 = \int_0^1 G\left(\frac{Y_{F,t}(j)}{Y_{F,t}}\right) dj, \tag{A14}$$

$$1 = \int_0^1 G\left(\frac{Y_{F,t}^p(l)}{Y_{F,t}^p}\right) dl, \tag{A15}$$

where G has the following properties: $G(1)=1$, $G'(x)>0$ and $G''(x)<0$ for $x>0$.

Assemblers select the optimal input and output levels, taking prices as given. The first-order conditions for domestic goods imply:

$$Y_{H,t}(i) = G'^{-1}\left(\frac{P_{H,t}(i)}{P_{H,t}}\mathbb{I}_t\right) Y_{H,t}, \tag{A16}$$

$$\mathbb{I}_t = \int_0^1 G'\left(\frac{Y_{H,t}(i)}{Y_{H,t}}\right)\frac{Y_{H,t}(i)}{Y_{H,t}} di. \tag{A17}$$

Similarly, for imported goods:

$$Y^{j}_{F,t}(i) = G^{'-1}\left(\frac{P^{j}_{F,t}(i)}{P^{j}_{F,t}}\mathbb{I}^{j}_{F,t}\right)Y^{j}_{F,t}, \tag{A18}$$

$$Y^{j,p}_{F,t}(i) = G^{'-1}\left(\frac{P^{pj}_{F,t}(i)}{P^{pj}_{F,t}}\mathbb{I}^{pj}_{F,t}\right)Y^{pj}_{F,t}, \tag{A19}$$

where the prices are determined by demand from final goods firms. The homogeneous goods assemblers sell domestic and foreign goods, $Y_{H,t}$ and $Y_{F,t}$, to final goods producers and production goods, Y^{p}_{F}, to domestic intermediate goods producers.

A.5 Final Goods Firms

There is a continuum of competitive final goods firms, indexed by m, that produce retail goods (with superscript D) using homogeneous domestic and foreign goods, $Y_{H,t}$ and $Y_{F,t}$, and taking all prices as given. They are assumed to have Leontief technology combining homogeneous domestic and foreign goods with the home product as an input. The home product used in the distribution channel is labeled as Y^{d}:

$$Y^{D}_{H,t}(m) = min\left[(1+\delta_f)Y_{H,t}(m); \frac{1+\delta_f}{\delta_f}Y^{d}_{H,t}\right], \tag{A20}$$

$$Y^{D}_{F,t}(m) = min\left[(1+\delta_f)Y_{F,t}(m); \frac{1+\delta_f}{\delta_f}Y^{d}_{H,t}\right], \tag{A21}$$

where δ_f governs the share of home goods used in the distribution process. Consequently, it also limits the exchange rate and foreign inflation pass-through to domestic inflation. As it is optimal to have no unused inputs at equilibrium, the following conditions arise:

$$(1+\delta_f)Y_{H,t}(m) = \frac{1+\delta_f}{\delta_f}Y^{d}_{H,t} = Y^{D}_{H,t}(m), \tag{A22}$$

$$(1+\delta_f)Y_{F,t}(m) = \frac{1+\delta_f}{\delta_f}Y^{d}_{H,t} = Y^{D}_{F,t}(m). \tag{A23}$$

$Y^{d}_{H,t}$ is pinned down by the demand for consumption goods. The demand for inputs is then a linear function of the distributed goods:

$$Y_{H,t}(m) = \frac{1}{1+\delta_f}Y^{D}_{H,t}(m), \tag{A24}$$

$$Y_{F,t}(m) = \frac{1}{1+\delta_f}Y^{D}_{F,t}(m). \tag{A25}$$

The final goods firms also produce an oil product for final consumption using the same technology but with an oil-specific distribution parameter:

$$O^{D}_{t}(m) = min\left[(1+\delta_o)O^{c}_{t}(m); \frac{1+\delta_o}{\delta_o}Y^{d}_{H,t}\right], \tag{A26}$$

$$P^{D}_{oil,t} = \frac{1}{1+\delta_o}P_{oil,t} + \frac{\delta_o}{1+\delta_o}P_{H,t}, \tag{A27}$$

where $P_{oil,t}$ is the oil price in home currency. For the domestic economy, the oil price is given by the oil price in foreign currency $P^{*}_{oil,t}$ multiplied by the nominal exchange rate:

$$P_{oil,t} = P^{*}_{oil,t} S_t. \tag{A28}$$

A.6 International Trade

Exports are driven by non-oil demand from foreign countries. For the home country, exports are:

$$X_{H,t} = M_{F,t}^{\beta_x} exp(\varepsilon_t^{nt}), \tag{A29}$$

where β_x is the share of foreign exports in domestic exports, ε^{nt} is the exogenous demand from the RoW, modeled as an AR(1) process with i.i.d. errors, and M_F are foreign imports from the domestic economy; the expression is symmetric for the foreign country.

$$M_{H,t} = Y^T_{F,t}, \tag{A30}$$

$$Y^T_{F,t} = \left[\phi_F^{\frac{1}{\lambda_F}} (Y_{F,t})^{\frac{\lambda_F - 1}{\lambda_F}} + (1-\phi_F)^{\frac{1}{\lambda_F}} (Y^p_{F,t})^{\frac{\lambda_F - 1}{\lambda_F}} \right]^{\frac{\lambda_F}{\lambda_F - 1}}, \tag{A31}$$

where Y^T_F stands for total demand for foreign goods. This total demand consists of foreign goods for consumption and production, with the elasticity of substitution between them denoted as λ_F. Parameter ϕ_F governs the relative shares of the total foreign good and the total consumption good in the corresponding aggregates.

Combining total non-oil imports with oil imports, the price of total imports is defined as:

$$\mathbb{M}_{H,t} = \left[\phi_m^{oil\,\frac{1}{\lambda_m^{oil}}} (M_{H,t})^{\frac{\lambda_m^{oil} - 1}{\lambda_m^{oil}}} + (1-\phi_m^{oil})^{\frac{1}{\lambda_m^{oil}}} (OIL_t)^{\frac{\lambda_m^{oil} - 1}{\lambda_m^{oil}}} \right]^{\frac{\lambda_m^{oil}}{\lambda_m^{oil} - 1}}, \tag{A32}$$

$$P_{\mathbb{M},t} = \left[\phi_m^{oil} (P_{M,t})^{1-\lambda_m^{oil}} + (1-\phi_m^{oil})(P_{oil,t})^{1-\lambda_m^{oil}} \right]^{\frac{1}{1-\lambda_m^{oil}}}, \tag{A33}$$

where λ_m^{oil} is the elasticity of substitution between oil and non-oil imports and ϕ_m^{oil} is the relative share of non-oil imports in total imports. P_{oil} is the price of crude oil in domestic currency. OIL_t is the total oil imported. Total oil imports consist of oil for consumption and oil for manufacturing purposes:

$$OIL_t = O^c_t + O^p_t. \tag{A34}$$

A.7 Aggregation and Monetary Policy

Final users use distributed goods to invest and consume. It is assumed that government spending and utilization costs are paid only in terms of domestic goods. In other words:

$$Y^D_{H,t} = C_{H,t} + I_{H,t} + G_t + \psi(u_t) K_{t-1}, \tag{A35}$$

$$Y^D_{F,t} = C_{F,t} + I_{F,t}. \tag{A36}$$

Government spending, G_t, is not modeled explicitly but is assumed to be an exogenous AR(1) process with i.i.d. shock μ^g_t and persistence ρ_g.

Each economy features several New Keynesian Phillips curves capturing the development of prices of specific products: imported consumption goods, imported production goods, exported consumption goods, exported production goods, home inflation, and consumer price inflation. To derive the Phillips curves, we first substitute the demand of final goods producers for final goods (A24) and (A25) and the demand of foreign producers for production goods into the demand of homogeneous goods assemblers for intermediate goods (A16), (A18), and (A19):

$$Y_{H,t}(i) = G^{'-1}\left(\frac{P_{H,t}(i)}{P_{H,t}}\mathbb{I}_t\right)\frac{1}{1+\delta_f}Y^D_{H,t}, \tag{A37}$$

$$Y^*_{H,t}(i) = G^{'-1}\left(\frac{P^*_{H,t}(i)}{P^*_{H,t}}\mathbb{I}^*_t\right)\frac{1}{1+\delta^*_f}Y^{*D}_{F,t}, \tag{A38}$$

$$Y^{*p}_{H,t}(i) = G^{'-1}\left(\frac{P^{*p}_{H,t}(i)}{P^{*p}_{F,t}}\mathbb{I}^{*p}_t\right)\frac{1}{\rho^*_m}Y_{F,t}. \tag{A39}$$

Then, from the zero-profit condition of assemblers, the price index for the domestic product is:

$$P_{H,t} = \xi_p \pi^{\iota_p}_{H,t-1}\bar{\pi}_H^{1-\iota_p}P_{H,t-1}G'^{-1}\left(\frac{\pi^{\iota_p}_{H,t-1}\bar{\pi}_{H,}^{1-\iota_p}P_{H,t-1}}{P_{H,t}}\mathbb{I}_t\right) + (1-\xi_p)\tilde{P}_{H,t}G'^{-1}\left(\frac{\tilde{P}_{H,t}}{P_{H,t}}\mathbb{I}_t\right). \tag{A40}$$

The export price indices are the following:

$$\begin{aligned} P^*_{H,t} &= \xi^*_p(\pi^*_{H,t-1})^{\iota^*_p}(\bar{\pi}^*_H)^{1-\iota^*_p}P^*_{H,t-1}G'^{-1}\left(\frac{(\pi^*_{H,t-1})^{\iota^*_p}(\bar{\pi}^*_H)^{1-\iota^*_p}P^*_{H,t-1}}{P^*_{H,t}}\mathbb{I}^*_t\right) + \\ &\quad (1-\xi^*_p)\tilde{P}^*_{H,t}G'^{-1}\left(\frac{\tilde{P}^*_{H,t}}{P^*_{H,t}}\mathbb{I}^*_t\right), \end{aligned} \tag{A41}$$

$$\begin{aligned} P^{*p}_{H,t} &= \xi^*_p(\pi^{*p}_{H,t-1})^{\iota^*_p}(\bar{\pi}^{*p}_H)^{1-\iota^*_p}P^{*p}_{H,t-1}G'^{-1}\left(\frac{(\pi^{*p}_{H,t-1})^{\iota^*_p}(\bar{\pi}^{*p}_H)^{1-\iota^*_p}P^{*p}_{H,t-1}}{P^{*p}_{H,t}}\mathbb{I}^{*p}_t\right) + \\ &\quad (1-\xi^*_p)\tilde{P}^{*p}_{H,t}G'^{-1}\left(\frac{\tilde{P}^{*p}_{H,t}}{P^{*p}_{H,t}}\mathbb{I}^{*pj}_t\right). \end{aligned} \tag{A42}$$

If an intermediate firm were last able to optimize its price at time t, its product would be priced in the distribution channel as:

$$P^D_{H,t+i}(m) = \frac{1}{1+\delta_f}\tilde{P}_{H,t}(m)\chi_{t,i} + \frac{\delta_f}{1+\delta_f}P_{H,t+i}. \tag{A43}$$

Analogously, its export consumption goods would be priced via the foreign distribution channel as follows:

$$P^{D*}_{H,t+i}(m) = \frac{1}{1+\delta^*_f}\tilde{P}^*_{H,t}(m)\chi^*_{t,i} + \frac{\delta^*_f}{1+\delta^*_f}P^*_{H,t+i}. \tag{A44}$$

A similar relationship holds for imported goods for direct consumption:

$$P^D_{F,t+i}(m) = \frac{1}{1+\delta_f}\tilde{P}_{F,t}(m)\chi_{t,i} + \frac{\delta_f}{1+\delta_f}P_{H,t+i}, \tag{A45}$$

The zero-profit condition for final goods producers implies that on aggregation, domestic prices influence the final prices of foreign goods:

$$P^D_{H,t} = \frac{1}{1+\delta_f}P_{H,t} + \frac{\delta_f}{1+\delta_f}P_{H,t} = P_{H,t}, \tag{A46}$$

$$P^D_{F,t} = \frac{1}{1+\delta_f}P_{F,t} + \frac{\delta_f}{1+\delta_f}P_{H,t}. \tag{A47}$$

Appendix B describes the log-linearized New Keynesian Phillips curves.

Domestic output in each economy is used for household and government consumption, investment, capital utilization, and net exports, and as a distribution channel, inputs create distributed domestic and foreign goods and oil products. The resource constraint then takes the form:

$$\begin{aligned} Y_t \;=\; & \left(s_{H,t}\frac{1}{1+\delta_f} + s^d_{H,t}\frac{\delta_f}{1+\delta_f}\right)(C_{H,t} + I_{H,t} + G_t + \psi(u_t)K_{t-1}) + s^*_{H,t}Y^*_{H,t} + s^{p*}_{H,t}Y^{*p}_{H,t} \\ & s^d_{H,t}Y_{F,t} + s^d_{H,t}\frac{\delta_o}{1+\delta_o}O^D_t, \end{aligned} \tag{A48}$$

where s terms reflect price dispersion and are calculated as $s_x = \int G'^{-1}\left(\frac{P_{x,t}(m)}{P_{x,t}}\mathbb{I}_{x,t}\right)$.

This paper's model allows all countries to buy and sell foreign bonds. Following de Walque et al. (2017), we assume that all countries have zero foreign bond positions in the steady state. Then the net foreign asset position is the difference between acquired foreign bonds in foreign currency and issued bonds sold abroad, also in foreign currency:

$$NFA_t = S_t B_{F,t}. \tag{A49}$$

$B_{F,t}$ stands for total net acquisition of foreign bonds—bonds bought minus bonds issued.

Definition 1. *Equilibrium. A monopolistically competitive equilibrium for an open economy has the following properties:*

- *Households maximize utility over consumption of domestic and foreign goods, oil consumption, investment, labor, bond holdings, and wages. Intermediate goods producers optimize profits over foreign inputs, oil, labor demand, domestic capital, and prices in each market, and make portfolio decisions on the share of FCLs. Homogeneous and final goods producers maximize profit over demand for home and foreign differentiated intermediate goods and home and homogeneous foreign goods and oil, respectively.*
- *All markets clear.*
- *The nominal exchange rate is determined by (1).*
- *The set of domestic, exported, and imported prices for final goods for consumption, production, and wages clears the markets.*

Appendix B: Log-Linearized Equations

This section describes the log-linearized equations, where small letters with a hat stand for log deviations from the steady state: $\hat{x}_t = log(\frac{X_t}{\bar{X}_t})$. The model features deterministic growth, γ; thus, we first detrend the real variables and divide nominal variables by a composite consumer price, $P_{\mathbb{C}}$. Below, small letters, p, stand for relative prices divided by the composite consumer price. Many of the equations are standard in the DSGE literature and resemble those from de Walque et al. (2017). The text and description follow the corresponding appendixes in Audzei and Brůha (2022) and Audzei (2023).

B.1 Households

Under the assumption of external habit formation, households' total real consumption depends on its past and expected values, expected changes in labor supply, and the expected real interest rate:

$$\begin{aligned} \hat{\mathbf{c}}_t &= \frac{\lambda_{hab}/\gamma}{1+\lambda_{hab}/\gamma}\hat{\mathbf{c}}_{t-1} + \frac{1}{1+\lambda_{hab}}E_t\hat{\mathbf{c}}_{t+1} + \left[(\sigma_c - 1)\frac{\bar{w}}{\bar{l}\bar{\mathbf{c}}}(\sigma_c(1+\lambda_{hab}/\gamma))^{-1}\right](\hat{l}_t - E_t\hat{l}_{t+1}) \\ &- (1-\lambda_{hab}/\gamma)(\sigma_c(1+\lambda_{hab}/\gamma))^{-1}(\hat{r}_t - E_t\hat{\pi}^c_{t+1} + \varepsilon^b_t), \qquad \text{(B1)} \end{aligned}$$

where $\hat{\mathbf{c}}$ is the log deviation of total consumption, $\mathbb{C}$, from its steady state and $\hat{\pi}^c_t = \hat{p}_{\mathbf{c},t} - \hat{p}_{\mathbf{c},t-1}$ is the corresponding deviation of consumer price inflation from its steady state. The term $\frac{\bar{w}}{\bar{l}\bar{\mathbf{c}}}$ stands for the steady-state ratio of the detrended real wage to labor and total consumption, $\hat{r}_t$ is the nominal central bank policy rate, and ε^b is a risk premium AR(1) process with an i.i.d. shock μ^b_t. The first-order conditions concerning investment and capital result in the following equations:

$$\hat{i}_t = \frac{1}{1+\bar{\beta}\gamma}\left(\hat{i}_{t-1} + \bar{\beta}\gamma E_t\hat{i}_{t+1} + \frac{1}{\Psi^{I''}\gamma^2}(\hat{q}_t - \hat{p}_{\mathbf{c},t}) + \frac{1}{\Psi^{I''}\gamma^2}\varepsilon^i_t\right), \qquad \text{(B2)}$$

$$\hat{q}_t = \bar{\beta}(1-\tau)E_t\hat{q}_{t+1} + (1-\bar{\beta}(1-\tau))E_t\hat{r}^k_{t+1} - \bar{\beta}(\bar{r}^k + (1-\tau))(\hat{r}_t - E_t\hat{\pi}^c_{t+1} + \varepsilon^b_t), \qquad \text{(B3)}$$

where $\hat{i}$ is the log deviation of investment and $\hat{q}$ is the log deviation of the real price of capital. Parameter $\Psi^{I''}$ is the steady-state second derivative of the investment adjustment cost function, $\bar{\beta} \equiv \beta\gamma^{-1}$ and $\bar{\beta}(\bar{r}^k + (1-\tau)) = 1$, where τ is the depreciation rate. $\hat{p}_{\mathbf{c},t}$ is the deviation of the price of total consumption. As we divide nominal variables by the total consumption price, $\hat{p}_{\mathbf{c},t} = 0$. Capital is accumulated according to the rule:

$$\hat{k}_t = \frac{1-\tau}{\gamma}\hat{k}_{t-1} + \left(1 - \frac{1-\tau}{\gamma}\right)(\hat{i}_t + \varepsilon^i_t). \qquad \text{(B4)}$$

With $\bar{r}^k = \psi'(1)$, capital utilization is determined as:

$$\hat{u} = \frac{\psi'(1)}{\psi''(1)}\hat{r}^k_t. \qquad \text{(B5)}$$

Wages are subject to Calvo stickiness with probability ξ_w and partial indexation with probability ι_w. Real wages then depend on past and future wages, consumer price inflation, and the wage markup:

$$\begin{aligned} \hat{w}_t &= \frac{1}{1+\bar{\beta}\gamma}\left(\hat{w}_{t-1} + \bar{\beta}\gamma E_t\hat{w}_{t+1} + \iota_w\hat{\pi}_{t-1} + \bar{\beta}\gamma E_t\hat{\pi}_{t+1} - (1+\bar{\beta}\gamma\iota_w)\hat{\pi}_t\right. \\ &+ \left.(1-\iota_w)\hat{\bar{\pi}}_t - \bar{\beta}\gamma(1-\iota_w)\hat{\bar{\pi}}_{t+1}\right) \\ &+ \frac{(1-\bar{\beta}\gamma\xi_w)(1-\xi_w)}{\xi_w\left(1+\frac{1+\lambda_w}{\lambda_w}\sigma_l\right)}\left(\frac{1}{1-\lambda_{hab}/\gamma}(\hat{\mathbf{c}}_t - \lambda_{hab}/\gamma\hat{\mathbf{c}}_{t-1}) + \sigma_l\hat{l}_t - \hat{w}_t\right) \\ &+ \varepsilon^w_t. \qquad \text{(B6)} \end{aligned}$$

In the expression above, $\hat{\bar{\pi}}$ stands for the deviation of the inflation trend from the steady state.

B.2 Producers and Prices

Intermediate goods producers' optimal conditions for output, demand for capital, and the resulting marginal costs are:

$$\hat{y}_t = \Phi_y \left(\alpha \hat{\bar{k}}_t + (1-\alpha)\hat{l}_t + \varepsilon_t^a \right), \tag{B7}$$

$$\hat{k}_t = \hat{w}_t - \hat{\bar{r}}_t^k + \hat{l}_t, \tag{B8}$$

$$\widehat{mc}_t = \Phi_y \left(\frac{1}{\Phi_y} - \rho_m - \rho_o \right) \left(\alpha \hat{\bar{r}}_t^k + (1-\alpha)\hat{w}_t - \varepsilon_t^a \right)$$
$$\Phi_y \left(\rho_m \hat{p}_{F,t}^p + \rho_o \hat{p}_{oil,t} + \widehat{fcf}_t \right). \tag{B9}$$

In the lines above, $\hat{\bar{k}} = \hat{u}_t \hat{k}_{t-1}$ stands for log-linearized effective capital and $\Phi_y = \frac{\bar{y}+\Phi}{\bar{y}}$ is the inverse of the share of the variables' costs in intermediate goods production.

Before linearizing the share of FCLs in (13), we convert the variables to real terms:

$$\kappa_t(i) = \frac{E_t \Pi_{\mathbb{C},t+1} \left[\frac{R_t}{\Pi_{\mathbb{C},t+1}} - \frac{\tilde{R}_t^f}{\Pi_{\mathbb{C},t+1}^*} \Delta RS_{t+1,t} \right]}{\rho Var(\tilde{R}_t^f \Delta S_{t+1,t})}. \tag{B10}$$

In the steady state with $\Delta RS = 1$, $\bar{\kappa} = \frac{\bar{R} - \bar{R}^f \bar{\Xi}}{\rho Var(\tilde{R}_t^f \Delta S_{t+1,t})}$. With linearization:

$$\hat{\kappa}_t \bar{\kappa} = \frac{\hat{r}_t \bar{R} - \bar{R}^f \bar{\Xi}(\hat{r}_t^f + \hat{\xi}_t + \Delta \widehat{rs}_{t+1} + \hat{\pi}_{\mathbb{C},t+1} - \hat{\pi}_{\mathbb{C},t+1}^f)}{\rho Var(\tilde{R}_t^f \Delta S_{t+1,t})}, \tag{B11}$$

$$\hat{\kappa}_t = \frac{\hat{r}_t \bar{R} - \bar{R}^f \bar{\Xi}(\hat{r}_t^f + \hat{\xi}_t + \Delta \widehat{rs}_{t+1} + \hat{\pi}_{\mathbb{C},t+1} - \hat{\pi}_{\mathbb{C},t+1}^f)}{\bar{R} - \bar{R}^f \bar{\Xi}}. \tag{B12}$$

The steady state value is thus affected by the *adjusted* interest rate differential, which is close to but not equal to the actual differential.

Dividing both sides of (A40) by $P_{\mathbb{C},t}$ we obtain that in the steady state, the relative price of individual manufacturers equals the home price, $\bar{\bar{p}}_H(i) = \bar{p}_H$. Using this expression, we derive the relative distribution prices of intermediate products in (A43):

$$\bar{p}_H^D(i) = \frac{1}{1+\delta_f}\bar{p}_H + \frac{\delta_f}{1+\delta_f}\bar{p}_H = \bar{p}_H = \bar{p}_H^D. \tag{B13}$$

All home goods have the same relative price in the steady state, and this price equals the distribution price. We further normalize $\bar{p}_H = \bar{p}_H^D = 1$ and $\bar{p}_F^D = 1$ in each country. From the exporters' point of view, the relative distribution prices of their goods in foreign countries are also unity in the steady state:

$$\bar{p}_F^D = \frac{1}{1+\delta_f}\bar{p}_F + \frac{\delta_f}{1+\delta_f}\bar{p}_H = 1, \tag{B14}$$

which results in $\bar{p}_F = 1$. With home and relative foreign prices equal to unity, the steady-state relative price of non-oil consumption composite goods is also unity, $\bar{p}_c = 1$. It must then follow that the oil price relative to the total consumption price is also unity, $\bar{p}_{oil} = 1$, together with relative import and export prices. Therefore, the normalization implies that all relative prices are unity in the steady state.

Linearizing the equation for the price of the total consumption aggregate, $P_{\mathbb{C},t}$, with $\hat{p}_{\mathbb{C},t} = 0$, we obtain the dependencies between home, foreign, and oil prices as:

$$0 = (1-\phi_{oil})\left[\frac{\phi_c+\delta_f}{1+\delta_f}\hat{p}_{H,t} + \frac{1-\phi_c}{1+\delta_f}\hat{p}_{F,t}\right] + \phi_{oil}\hat{p}^D_{oil} + \varepsilon^p_t, \tag{B15}$$

$$0 = (1-\phi_{oil})\hat{p}_{c,t} + \phi_{oil}\hat{p}^D_{oil} + \varepsilon^p_t. \tag{B16}$$

When linearizing (A40) in relative prices, in the steady state $G^{'-1} = 1$ and $\bar{\mathbb{I}} = G'(1)$, which we use to obtain the New Keynesian Phillips curve for home inflation:

$$\begin{aligned}\hat{\pi}_{H,t} &= \frac{1}{1+\beta\iota_p}\left(\beta\hat{\pi}_{H,t+1} + \iota_p\hat{\pi}_{H,t-1}\right) \\ &+ \frac{(1-\xi_p)(1-\beta\xi_p)}{\xi_p(1+\beta\iota_p)}\frac{\eta_H-1-\delta_f}{\eta_H+\varepsilon-1}(\widehat{mc}_t - \hat{p}_{H,t}) + \varepsilon^{pH}_t - \nu\varepsilon^p_t.\end{aligned} \tag{B17}$$

Parameter η_H is the steady-state price elasticity of demand in the home country, with $\eta_{j,t} = -\frac{G'(z_{j,t})}{z_{j,t}G"(z_{j,t})}$ and $z_{j,t} = G^{'-1}\left(\frac{P^D_{j,t}(i)}{P^D_{j,t}}\mathbb{I}_t\right)$, where $j = H,F$. ε is the curvature of Kimball's aggregator G. Following de Walque et al. (2017) among others, we define the curvature as the steady-state elasticity of the price elasticity of demand concerning the relative price. For home prices, it is defined as:

$$\varepsilon = \frac{\bar{\bar{p}}_j/\bar{P}_j}{\eta_j(z_{j,SS})}\frac{\partial\eta_j(z_{j,SS})}{\partial\bar{\bar{p}}_j}|_{z_{j,SS}=1} = 1+\eta_j\left(1+\frac{G'''(1)}{G''(1)}\right), \tag{B18}$$

$$\frac{\left(1+(1+\delta_f)\frac{G''(1)}{G'(1)}\right)}{\left(2+\frac{G'''(1)}{G''(1)}\right)} = \frac{\eta_j-1+\delta_f}{\eta_j-1+\varepsilon}. \tag{B19}$$

The domestic inflation New Keynesian Phillips curve features two stochastic AR(1) processes, each with i.i.d. errors: the domestic price markup, ε^{pH}_t, and the feedback from the consumer price markup, ε^p_t, with a negative sign. The consumer price inflation index data contain some elements that introduce additional volatility into the index; however, they are not modeled here, so we use the feedback from ε^p_t to subtract them from home inflation.

The Phillips curves for the imported inflation indices, where superscript * denotes foreign variables, are derived similarly:

$$
\begin{aligned}
\hat{\pi}_{F,t} &= \frac{1}{1+\beta^{*}\iota^{*}_{pF}}\left(\beta^{*}\hat{\pi}_{F,t+1}+\iota^{*}_{pF}\hat{\pi}_{F,t-1}\right)\\
&+\frac{(1-\xi^{*}_{pF})(1-\beta\xi^{*}_{pF})}{\xi^{*}_{pF}(1+\beta^{*}\iota^{*}_{pF})}\frac{1}{\eta_F+\varepsilon-1}((\widehat{mc}^{*}_{t}+\widehat{rs}_t)+\delta_f\hat{p}_H-(\eta-1)\hat{p}_{F,t})\\
&+\varepsilon^{pF}_{t}, \qquad \text{(B20)}\\
\hat{\pi}^{p}_{F,t} &= \frac{1}{1+\beta^{*}\iota^{*}_{pF}}\left(\beta^{*}\hat{\pi}^{p}_{F,t+1}+\iota^{*}_{pF}\hat{\pi}^{p}_{F,t-1}\right)\\
&+\frac{(1-\xi^{*}_{pF})(1-\beta\xi^{*}_{pF})}{\xi^{*}_{pF}(1+\beta^{*}\iota^{*}_{pF})}\frac{\eta_F-1}{\eta_F+\varepsilon-1}(\widehat{mc}^{*}_{t}+\widehat{rs}_t-\hat{p}^{p}_{F,t})\\
&+\varepsilon^{pF}_{t}, \qquad \text{(B21)}
\end{aligned}
$$

where $\hat{\pi}_F$ and $\hat{\pi}^p_F$ are imported inflation and imported production goods inflation, respectively. Foreign intermediate goods producers set their export prices directly in the currency of the importing (destination) country and take into account the destination distribution costs, δ_f, and price elasticity, η. Calvo pricing parameters ξ^{*}_{pF} and ι^{*}_{pF} stand for the probability and degree of price indexation of imported goods in the destination market. Note that these parameters can be different from those for goods produced locally in the destination country, ξ_p and ι_p, even though they are applied on the same destination market. The real marginal costs in foreign currency, $\widehat{mc}^{*}$, are converted into local currency using the real exchange rate, $\widehat{rs}$. Production goods are not processed through the distribution channel; therefore, the distribution costs, δ_f, do not enter the corresponding expression for inflation. Both imported inflation indices are affected by markup shocks, which are AR(1) processes with i.i.d. disturbances. These markup processes originate in the local market but only affect foreign goods prices.

B.3 Exchange Rates and International Trade

To derive the equation for the real exchange rate as domestic currency per unit of foreign currency, we utilize the UIRP condition (1). We follow de Walque et al. (2017) in assuming that the net foreign asset position is zero in the steady state. In the equation below, the net foreign asset position, nfa, is linearized; however, the rest of the terms are log-linearized around the steady state:

$$
\begin{aligned}
\widehat{rs}_t &= (1-\theta_s)E_t\widehat{rs}_{t+1}+\\
&\theta_s\widehat{rs}_{t-1}+r^{f}_{t}-r_t-E_t\hat{\pi}^{f}_{t+1}+E_t\hat{\pi}_{t+1}-\rho_{nfa}nfa_t+\varepsilon^{s}_{t}, \qquad \text{(B22)}
\end{aligned}
$$

where $\widehat{rs}$ is the real exchange rate in indirect quotation (domestic currency per unit of foreign currency), θ_s is the parameter on exchange rate persistence obtained from the definition of the risk premium over foreign bonds (Θ_t), and $\rho_{nfa}=\Theta'(0)\bar{y}\gamma^{t}$ ensures stationarity and is set to a very small number. Foreign consumption and investment goods from the home country's perspective are derived using the expression for the non-oil consumption aggregate and the adjustment costs for foreign goods consumption.

$$
\begin{aligned}
\hat{c}_{F,t} &= \hat{c}_t - \lambda(\hat{p}^D_{F,t} - \hat{p}_{c,t}) - \Omega_c\lambda(\hat{c}_{F,t} - \hat{c}_t - \hat{c}_{F,t-1} + \hat{c}_{t-1}) \\
&+ \beta\Omega_c\lambda(\hat{c}_{F,t+1} - \hat{c}_{t+1} - \hat{c}_{F,t} + \hat{c}_t), && \text{(B23)} \\
\hat{i}_{F,t} &= \hat{i}_t - \lambda(\hat{p}^D_{F,t} - \hat{p}_{c,t}) - \Omega_i\lambda(\hat{i}_{F,t} - \hat{i}_t - \hat{i}_{F,t-1} + \hat{i}_{t-1}) \\
&+ \beta\Omega_c\lambda(\hat{i}_{F,t+1} - \hat{i}_{t+1} - \hat{i}_{F,t} + \hat{i}_t), && \text{(B24)} \\
\hat{c}_t &= \hat{\mathbf{c}}_t - \lambda_{oil}\hat{p}_{c,t}, && \text{(B25)}
\end{aligned}
$$

where $\hat{c}_{F,t}$ and $\hat{i}_{F,t}$ are, respectively, consumption and investment of foreign goods, and $\hat{c}_t$ is total non-oil consumption.

Log-linearization of non-oil imports (A30), together with (A31) and the use of $Y^D_{F,t} = C_{F,t} + I_{F,t}$, results in:

$$
\begin{aligned}
\hat{m}_{H,t} &= \left(\frac{\bar{y}_F}{\bar{y}^T_F}\hat{y}_{F,t} + \frac{\bar{y}^p_F}{\bar{y}^T_F}\hat{y}^p_{F,t}\right) \\
&= \left(\frac{\bar{y}_F}{\bar{y}^T_F}\left[\frac{\bar{c}_F}{\bar{y}^D_F}\hat{c}_{F,t} + \frac{\bar{i}_F}{\bar{y}^D_F}\hat{c}_{F,t}\right] + \frac{\bar{y}^p_F}{\bar{y}^T_F}\frac{1}{\rho_m}\frac{\bar{y}}{\bar{y}^p_F}\hat{y}_t\right). && \text{(B26)}
\end{aligned}
$$

Employing the trick by de Walque et al. (2017), we express the coefficients in the above expression as:

$$
\begin{aligned}
\frac{\bar{c}_F}{\bar{y}^D_F} &= \frac{\bar{y}}{\bar{\mathbf{m}}}\frac{\bar{\mathbf{m}}}{\bar{m}_H}\frac{\bar{y}^T_F}{\bar{y}_F}\frac{\bar{y}_F}{\bar{y}^D_F}\frac{\bar{c}_F}{\bar{c}}\frac{\bar{c}}{\hat{\mathbf{c}}}\frac{\hat{\mathbf{c}}}{\bar{y}}\frac{\bar{y}_F}{\bar{y}^T_F} \\
&= \alpha_m^{-1}(1-\phi_m^{oil})^{-1}(1+\delta_f)^{-1}(1-\phi_c^H)(1-\phi_c^{oil})\alpha_c, && \text{(B27)} \\
\frac{\bar{i}_F}{\bar{y}^D_F} &= \alpha_m^{-1}(1-\phi_m^{oil})^{-1}(1+\delta_f)^{-1}(1-\phi_c^H)\alpha_i, && \text{(B28)}
\end{aligned}
$$

where α_c and α_i are the steady-state ratios of total consumption to GDP and total investment to GDP, respectively. The expression for imports then becomes:

$$
\begin{aligned}
\hat{m}_{H,t} &= \alpha_m^{-1}(1-\phi_m^{oil})^{-1}(1+\delta_f)^{-1}(1-\phi_c^H)\left[(1-\phi_{oil})\alpha_c\hat{c}_{F,t} + \alpha_i\hat{i}_{F,t}\right] + (1-\phi_F)\hat{y}_t \\
\phi_F &= \left(\frac{1-\phi_H}{1+\delta_f}((1-\phi_{oil})\alpha_c + \alpha_i)\right) / \left(\frac{1-\phi_H}{1+\delta_f}((1-\phi_{oil})\alpha_c + \alpha_i) + \rho_m\right). && \text{(B29)}
\end{aligned}
$$

Exports are driven by foreign demand normalized by the export share to account for the presence of the RoW:

$$
\hat{x}_{H,t} = \beta^j_x\hat{m}_{F,t} + \varepsilon^{nt}_t. \quad \text{(B30)}
$$

Total imports, including imports of oil products, are log-linearized as follows:

$$
\hat{\mathbf{m}}_t = (1-\phi_m^{oil})\hat{m}_{h,t} + \phi_m^{oil}\hat{oil}_t. \quad \text{(B31)}
$$

B.4 Resource Constraint and Monetary Policy

Log-linearized around the steady state, the resource constraint (A48) is as follows:

$$\hat{y}_t = \frac{\bar{\mathbf{c}}}{\bar{y}}\hat{\mathbf{c}}_t + \frac{\bar{i}}{\bar{y}}\hat{i}_t + \frac{\bar{g}}{\bar{y}}\hat{g}_t + \frac{\bar{r}^k\bar{k}}{\gamma\bar{y}}\hat{u}_t + \frac{\bar{\mathbf{m}}}{\bar{y}}(\hat{x}_{H,t} - \mathbf{m}_t) + (\rho_o + \rho_m)\hat{y}_t. \tag{B32}$$

Note that as $\bar{SB_F} = 0$ in the steady state, the trade balance is also zero in the steady state and $\frac{\bar{x}}{\bar{y}} = \frac{\bar{\mathbf{m}}}{\bar{y}}$. When log-linearizing (A49), we linearize the terms in nfa and log-linearize the rest:

$$\beta^* nfa_t = \gamma^{-1} nfa_{t-1} + \frac{\bar{\mathbf{m}}}{\bar{y}}(\hat{p}_{x,t} + \hat{x}_F - \hat{p}_{\mathbf{m},t} - \mathbf{m}). \tag{B33}$$

The trade balance is then defined as:

$$\widehat{tb}_t = \hat{p}_{x,t} + \hat{x}_F - \hat{p}_{\mathbf{m},t} - \mathbf{m}. \tag{B34}$$

Monetary policy is set as the following rule:

$$\hat{r}_t = \rho^r \hat{r}_{t-1} + (1-\rho^r)(\rho^\pi \hat{\pi}_t + \rho^y(\hat{y}_t - \hat{y}_t^f)) + \rho^\Delta(\hat{y}_t - \hat{y}_{t-1} - \hat{y}_t^f + \hat{y}_{t-1}^f) + \varepsilon_t^r. \tag{B35}$$

Appendix C: Calibration

Below we report parameters for the euro area taken mostly from the de Walque et al. (2017) estimated posterior mode, except for the Taylor rule parameters; the parameters for the small open economy are the authors' calculations or are taken from the Czech National Bank's core forecasting model where applicable. As for the Taylor rule parameters, for clarity of the results, we chose to make them the same in both economies. Furthermore, we decided to limit the policy response to inflation only. While neither the Czech National Bank nor the ECB is a strictly inflation-targeting central bank, we believe it is more convenient for the reader to interpret the model outcome for a purely inflation-targeting central bank. It is straightforward to adjust the findings in the case of one or more central banks choosing to engage in output support. We choose the reaction to inflation and the lag in the central bank policy rule as estimated by Coenen et al. (2018) for both economies. Trade statistics are taken from Eurostat and the Czech Statistical Office.

All the standard deviations of the shocks are set to 0.01, all the AR(1) parameters are set to 0.85, and the MA(1) parameters are set to 0.3 for domestic and foreign PPI shocks.

Table C1: Calibrated Parameters: Matched Data and Steady-State Ratios

Name	Symbol	EA	CZ
Consumption to GDP	α_c	0.564	0.66
Investment to GDP	α_i	0.22	0.29
Imports to GDP	α_m	0.2	0.7
Oil demand elasticity	λ^{oil}	0.3	0.3
Oil share in consumption	ϕ^{oil}	0.04	0.06
Oil share in exports	ϕ_x^{oil}	0.04	0.08

Table C2: Calibrated Parameters

	EA	CZ
cap. util. adj. costs	0.651	.651
capital depreciation	0.025	0.025
capital share	0.29	0.35
con. elast. of substitution	2.757	2.757
oil demand elasticity	0.3	0.3
distrib. in cons.	0.46	0.46
distrib. in oil	5.762	5.762
fixed costs	1.536	1.536
habit	0.762	0.8
home bias in cons	0.87	0.85
imp. goods in prod.	0.09	0.1
inv. adj. costs	7.697	5
inv. Frisch elast.	1.029	1
Kimball curvature	10	10
oil in production	0.006	0.01
oil in consumption	0.04	0.04
oil in export	0.04	0.04
rel. risk aversion	0.909	1
trade adj. cost	3.027	3.027
wage elasticity	0.25	0.25
Trade parameters		
bilateral exp. share	0.04	0.62
bilateral imp. share	0.05	0.52
import content of export	0.08	0.38
Nominal rigidities		
Calvo im. price	0.30	0.4
im. price index.	0.19	1
Calvo price	0.846	0.65
price index.	0.193	1
Calvo wage	0.786	0.85
wage index.	0.214	1
Exch. rate and Oil price		
UIRP CZK/EUR smooth. param	0.35	-
Taylor rule parameters		
inflation	2.7	2.7
lagged int. rate	0.93	0.93

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