The Macroeconomic Effects of Trade Policy*

C. Erceg
Federal Reserve Board

A. Prestipino
Federal Reserve Board

A. Raffo
Federal Reserve Board

June 16, 2017

Abstract

We study the short-run macroeconomic effects of trade policies that are equivalent in a frictionless economy, namely a uniform increase in import tariff and export subsidy (IX), a value-added tax increase accompanied by a payroll tax reduction (VP), and a border-adjustment of corporate profit taxes (BAT). Using a dynamic New Keynesian open-economy framework, we show that BAT and IX policies are generically equivalent, but VP is not as nominal price rigidities shift the incidence of value-added taxes. This result holds under a wide range of assumptions, including fixed as well as flexible exchange rates, alternative pricing schemes, and different sources of nominal rigidities. The unilateral implementation of BAT or IX increases domestic output, appreciates the exchange rate, and reduces output abroad, whereas the unilateral implementation of VP is contractionary. The three policies are equivalent and have no allocative effects with permanent tax changes and producer currency pricing.

JEL classification: E32, F30, H22
Keywords: Trade Policy, Fiscal Policy, Exchange Rates, Aggregate Supply

*We thank seminar participants at the Federal Reserve Board, Federal Reserve Bank of Philadelphia, and Macroeconomic Meetings of the Federal Reserve System. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

1 Introduction

There is a longstanding debate about how trade policies can stimulate the macroeconomy. In the context of evaluating the merits of remaining on the gold standard during the early phases of the Great Depression, Keynes (1931) argued that the U.K. could derive a similar degree of stimulus from raising import tariffs and reducing export tariffs as through devaluing the pound against gold. Thirty years later, Mundell (1961) noted that the mercantilist element of this Keynesian policy would be inapplicable to countries that do not peg the nominal exchange as "the equilibrium in the balance of payments is automatically maintained by variations in the price of the foreign exchange rate".

In this article, we examine the short-run macroeconomic effects of alternative trade policies in a two-country DSGE model that builds on contributions by Gali and Monacelli (2005) and Farhi, Gopinath, and Itskhoki (2014, FGI henceforth). We first consider the Keynesian prescription of directly manipulating prices of traded goods through a uniform increase in import tariffs and export subsidies (IX henceforth).

The first key finding of our analysis is that an IX policy can have substantial allocative effects even under floating exchange rates. These policies clearly stimulate aggregate demand if the exchange rate is fixed and interest rate unresponsive, as hypothesized by Keynes and formalized in FGI. However, when exchange rates are flexible IX has been shown to have no allocative effects in various different models that – drawing on familiar Mundell-Fleming reasoning – predict that the exchange rate will adjust enough to fully offset the impact of changes in import and export tariffs on the domestic economy.[1]

The key assumption that breaks this neutrality result in our model is that agents expect foreign economies to retaliate to IX with protecionist policies of their own. This damps the appreciation of the real exchange rate and implies that IX policy stimulates domestic net exports even under floating exchange rates.

We show that higher import tariffs and export subsidies boost GDP and inflation under a Taylor-style reaction function, with the size of the effects depending on the response of monetary policy. Moreover, because the stimulus arises through stronger net exports, foreign

[1] Cite lerner, werning costinot and references therein.

output tends to decline through expenditure-switching channels.

We then turn our attention to fiscal policies that are often considered equivalent to IX. In particular, we study the effects of an increase in value-added taxes accompanied by a reduction in employer payroll contributions (VP), a policy that has been proposed as a possible way to mimick the effects of IX through an itnernal fiscal adjustment (see, for example, FGI).

Finally, we analyze the effects of a border-adjustment of corporate profit taxation (BAT). Border-adjustment of taxes is an issue widely studied in the context of value-added taxation and flexible prices.[2] More recently, several authors, including Auerbach and Holtz-Eakin (2016), Auerbach et al. (2017), have argued that a border adjustment of corporate taxation would be equivalent to VP.

We find that while the import and export subsidies stimulate GDP, boost inflation, and induce domestic interest rates to rise, a combination of a higher VAT and a rise in the payroll subsidy to employers (VP policy) tends to have contractionary effect on aggregate demand and inflation, at least under a Taylor-style interest rate rule. The contractionary effects of VP are particularly large when the monetary policy reaction function is fairly unresponsive, as occurs if the central bank puts a substantial weight on exchange rate stability.

The contractionary effects of VP are due to two key assumptions. First, we assume that pre-tax prices are sticky, so that VAT increases are immediately passed through to consumer prices. Second, we assume once again that agents perceive some chance the VP policy will be reversed. The upshot is that consumers would face a higher real interest rate if policy rates were unchanged and pre-tax goods prices were also unchanged (since households would expect the prices of goods to be lower at some point in the future). Thus, policy rates would have to decline to keep aggregate demand (and hence output) at its pre-shock level, and the exchange rate to depreciate; since a standard Taylor rule does not provide enough accommodation to stabilize the economy, output contracts and inflation falls, and the contraction is much more severe under an exchange rate peg.

These results may seem surprising in light of FGI, which show the VP provides equivalent

[2] See, for example, Meade (1977), Grossman (1980), and Feldstein and Krugman (1990), Costinot and Werning (2017).

stimulus to output and inflation as IX, at least under fixed exchange rates. The key reason for the dramatic difference in results is that we assume that consumer prices adjust quickly to the VAT – so prices are sticky in pre-tax terms – whereas FGI assume that consumer prices are sticky inclusive of the VAT. We discuss some evidence in support of our specification that shows that consumer prices tend to increase quickly in response to VAT increases.[3] Nevertheless, rather than viewing this evidence as dispositive in favor of our specification of price-setting, we view our contribution as highlighting the sensitivity of equivalence results to this feature.

Finally, we also show that in our framework a border adjustment of corporate taxation is equivalent to an IX policy and, as a consequence, not to a VP policy. Intuitively, the BAT eliminates the deductibility of imports from profits, thus acting like a tariff, and exempts exports, thus acting like an export subsidy. Consequently, BAT in general provides stimulus exactly like IX and has no allocative effects only with permanent tax changes and producer currency pricing.

The paper is organized as follows. Section 2 describes the model. Section 3 discusses conditions for equivalence of the IX, VP, and BAT policies as well as the macroeconomic effects of such policies. Section 4 concludes.

2 Model

The benchmark economy features a home (H) country and a foreign (F) country. Agents in the economy include households, retailers, producers of intermediate goods, and the government. The next sections describe the optimization problems solved by each agent. Foreign variables are denoted with an asterisk.

2.1 Households

Households in the home country derive utility from a final good consumption (C_t) and disutility from labor (N_t). Households trade noncontingent nominal bond B_{Ht} and B_{Ft} denominated in the home and foreign currency respectively. The households maximizes expected

[3] See, for instance, Besley and Rosen (1999), Carbonnier (2007), and Andrade et al. (2010).

lifetime utility

$$\mathbb{E}_0 \Sigma_{t=0}^{\infty} \beta^t U\left(C_t, N_t\right) \tag{1}$$

subject to the budget constraint

$$P_t C_t + B_{Ht} + \varepsilon_t B_{Ft} = R_{t-1} B_{Ht-1} + \varepsilon_t R_{t-1}^* B_{Ft-1} + W_t N_t + \widetilde{\Pi}_t + T_t \tag{2}$$

where P_t is the consumer price index, R_{t-1} is the domestic nominal interest rate, R_{t-1}^* is the foreign nominal interest rate, ε_t is the nominal exchange rate (defined as the price of one unit of foreign currency in terms of units of home currency), W_t is the wage rate, $\widetilde{\Pi}_t$ is the aggregate profit of the home firms assumed to be owned by the home consumers, T_t is a lump-sum transfer from the government. We assume for simplicity that the period utility function is

$$U(C, N) = \frac{1}{1-\sigma} C_t^{1-\sigma} - \frac{1}{\eta+1} N_t^{1+\eta} \tag{3}$$

Optimality requires the standard conditions:

$$N_t^{\eta} C_t^{\sigma} = \frac{W_t}{P_t} \tag{4}$$

$$1 = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \frac{P_t}{P_{t+1}} R_t \right] \tag{5}$$

$$1 = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \frac{P_t}{P_{t+1}} \frac{\varepsilon_{t+1}}{\varepsilon_t} R_t^* \right] \tag{6}$$

where $\Lambda_{t,t+1} = \left(\frac{C_t}{C_{t+1}} \right)^{\sigma}$ is the real stochastic discount factor of the home household. The corresponding intertemporal optimality conditions for foreign household holdings of bonds are

$$1 + \chi \left(B_{Ht}^* - \bar{B} \right) = \beta \mathbb{E}_t \left[\Lambda_{t,t+1}^* \frac{P_t^*}{P_{t+1}^*} \frac{\varepsilon_t}{\varepsilon_{t+1}} R_t \right] \tag{7}$$

$$1 = \beta \mathbb{E}_t \left[\Lambda_{t,t+1}^* \frac{P_t^*}{P_{t+1}^*} R_t^* \right] \tag{8}$$

where $\chi \in \{0, \infty\}$ determines foreign households costs of holding home currency denominated bonds in excess of a long-run value $\bar{B}$. Thus, when $\chi = 0$ foreign households can costlessly adjust their holdings of B_{Ht}^*, whereas when $\chi = \infty$ holdings of B_{Ht}^* are fixed at their long-run

value at all times (i.e. $B^*_{Ht} = \bar{B}$). These conditions, together with (6), imply the risk-sharing condition

$$\mathbb{E}_t \left\{ \left[\Lambda_{t,t+1} \frac{Q_{t+1}}{Q_t} - \Lambda^*_{t+1} \right] \frac{P^*_t}{P^*_{t+1}} \right\} = 0 \tag{9}$$

where Q_t is the real exchange rate expressed as the price of the foreign consumption bundle in home currency relative to the price of the domestic consumption bundle, that is

$$Q_t = \varepsilon_t \frac{P^*_t}{P_t} \tag{10}$$

2.2 Retailers

Competitive home retailers combine home and foreign intermediate goods to produce the final consumption good according to the constant-elasticity-of-substitution (CES) aggregator

$$C_t = \left[\omega_H^{\frac{1}{\theta}} y_{Ht}^{\frac{\theta-1}{\theta}} + (1-\omega_H)^{\frac{1}{\theta}} y_{Ft}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{11}$$

where $\theta \geq 0$ determines the elasticity of substitution between home and foreign intermediates and $\omega_H \in [0.5, 1]$ governs home bias. The home good (y_{Ht}) and the foreign good (y_{Ft}) consist of CES aggregators over home and foreign varieties

$$y_{Ht} = \left[\int_0^1 y_{Ht}(i)^{\frac{\gamma-1}{\gamma}} di \right]^{\frac{\gamma}{\gamma-1}} \tag{12}$$

$$y_{Ft} = \left[\int_0^1 y_{Ft}(i)^{\frac{\gamma-1}{\gamma}} di \right]^{\frac{\gamma}{\gamma-1}} \tag{13}$$

Profit for the home retailers are

$$\Pi^R_t = (1-\tau^\pi_t)(P_t C_t - P_{Ht} y_{Ht} - P_{Ft} y_{Ft}) \tag{14}$$

where τ^π_t is the tax rate on profits. Prices of imported goods, are also inclusive of home tariffs (τ^m_t).

Given the CES structure of these aggregators, the home and foreign good demand functions are characterized by

$$y_{Ht} = \omega \left[\frac{P_{Ht}}{P_t} \right]^{-\theta} C_t \tag{15}$$

$$y_{Ft} = (1-\omega)\left[\frac{P_{Ft}}{P_t}\right]^{-\theta} C_t \tag{16}$$

$$y_{Ht}(i) = \left[\frac{P_{Ht}(i)}{P_{Ht}}\right]^{-\gamma} y_{Ht} \tag{17}$$

$$y_{Ft}(i) = \left[\frac{P_{Ft}(i)}{P_{Ht}}\right]^{-\gamma} y_{Ht} \tag{18}$$

The home-country price indexes consistent with the CES aggregators are

$$P_t = \left[\omega P_{Ht}^{1-\theta} + (1-\omega) P_{Ft}^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{19}$$

$$P_{Ht} = \left[\int_0^1 P_{Ht}(i)^{1-\gamma} di\right]^{\frac{1}{1-\gamma}} \tag{20}$$

$$P_{Ft} = \left[\int_0^1 P_{Ft}(i)^{1-\gamma} di\right]^{\frac{1}{1-\gamma}} \tag{21}$$

2.3 Producers

Each country features a continuum $i \in [0,1]$ of monopolistically-competitive firms producing different varieties of intermediate goods. Producers use the technology

$$Y_{Ht}(i) = A_t Z_t(i) N_t^{\alpha}(i) \tag{22}$$

with $0 < \alpha \leq 1$. A_t is the aggregate country-wide level of technology and $Z_t(i)$ is the idiosyncratic level of technology. Producers use labor $N(i)$ as the only input of production. Total production is sold both domestically and abroad

$$y_{Ht}(i) + y_{Ht}^*(i) = Y_{Ht}(i) \tag{23}$$

at price $P_{Ht}(i)$ and $P_{Ht}^*(i)$, respectively.[4] After tax profits of firm i are

$$\Pi_t^i = (1-\tau_t^{\pi})\left[P_{Ht}(i) y_{Ht}(i) + \frac{(1+\varsigma_t^x)}{(1+\tau_t^{m*})} P_{Ht}^*(i) y_{Ht}^*(i) - W_t N_t(i)\right] \tag{24}$$

[4] As indicated before, all prices are inclusive of tariffs levied in the two countries.

where ς_t^x is the export subsidy and τ_t^{m*} are import tariffs levied in the foreign economy.

Firm i sets prices as in Calvo (1983): In any given period, it can adjust its price with probability $(1-\zeta_P)$ and maintains the same price as in the previous period with probability ζ_P. Therefore, firm $i's$ domestic price evolves according to:

$$P_{Ht}(i) = \begin{cases} \overline{P}_{Ht}(i) & \text{w/prob } (1-\zeta_P) \\ P_{Ht-1}(i) & \text{w/prob } \zeta_P \end{cases} \tag{25}$$

In our benchmark specification, we assume that firms set export prices in their domestic currency (PCP).[5] Hence, the price in foreign currency of exported goods $P_{Ht}^*(i)$ adjusts in order to equalize net unit revenues across markets:

$$P_{Ht}^*(i) = \frac{(1+\tau_t^{m*})}{(1+\varsigma_t^x)} \frac{P_{Ht}(i)}{\varepsilon_t} \tag{26}$$

Firm i chooses a reset price, $\overline{P}_{Ht}(i)$, to maximize the expected present discounted value of profits conditional on no price change

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{s-t} \left[\Lambda_{s,t} \Pi_s^i \right] \tag{27}$$

subject to its production technology (22), the evolution of prices in (25) and (26), retailers' demand in the home market (17), and an analogous demand schedule in the foreign market.

The reset price $\overline{P}_{Ht}(i)$ satisfies the following optimality condition

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{s,t} Y_{Ht}(i) P_{Hs} (1-\tau_s^{\pi}) \left[\overline{P}_{Ht}(i) - \frac{\gamma}{\gamma-1} \frac{W_s}{\alpha A_s Z_s(i) N_s(i)^{\alpha-1}} \right] = 0 \tag{28}$$

Expression (28) indicates that the adjusted price $\overline{P}_{Ht}(i)$ is a constant markup over the weigthed-average expected future marginal costs during the period for which the price will be in effect.

[5] We explore the implications of alternative pricing assumptions, such as local currency pricing (LCP) in Section XX..

Similarly, foreign firm j sets price $\overline{P}^*_{Ft}(j)$ in the foreign market according to

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{*s-t} \Lambda^*_{s,t} Y^*_{Ft}(j) P^*_{Fs} (1-\tau^{\pi *}_s) \left[\overline{P}^*_{Ft}(j) - \frac{\gamma}{\gamma-1} \frac{W^*_s}{\alpha A^*_s Z^*_s(i)^* N^*_s(j)^{\alpha-1}} \right] = 0 \tag{29}$$

and lets the price for the home market $P_{Ft}(j)$ adjust in order to equalize net unit revenues across markets

$$P_{Ft}(j) = \frac{(1+\tau^m_t)}{(1+\varsigma^{x*}_t)} P^*_{Ft}(j) \varepsilon_t \tag{30}$$

Using the evolution of firm $i's$ price in (25) in the P_H price index equation (20) and using the law of large numbers we derive a forward-looking Phillips curve

$$\pi_{Ht} = \left[\zeta_P + (1-\zeta_P) \left(\frac{\bar{P}_{H,t}}{P_{H,t-1}} \right)^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \tag{31}$$

where domestic inflation (π_{Ht}) depends on future marginal costs through the optimal reset price $\bar{P}_{H,t}$.

2.4 Government Policy

Fiscal policy in the home and foreign country is characterized by a vector of taxes and subsidies

$$s_t = (\tau^m_t, \varsigma^x_t, \tau^{m*}_t, \varsigma^{x*}_t) \tag{32}$$

We assume that $s_t \in S$ is a finite state Markov chain and Ω is the associated transition probability matrix, with element $\Omega_{i,j}$ indicating the probability to move from state j to state i. Without loss of generality, we do not consider changes in corporate profit taxes as fiscal instrument under the trade policies (i.e. $\tau^{\pi}_t = \tau^{\pi *}_t = \overline{\tau}$ for $t \geq 0$).

This specification for fiscal policy in the two countries is particularly appealing as it allows to consider a wide range of policy configurations and dynamics. For instance, a large literature has devoted much attention to the stability of the Lerner Symmetry Theorem (Lerner, 1936) that establishes the neutrality of permanent tax reforms that increase import tariffs and export subsidies by the same amount.[6] In our framework, these policy changes

[6] See McKinnon (1966) and, more recently, Costinot and Werning (2017) and Linde' and Pescatori (2017). The Lerner Symmetry Theorem is also a natural starting point for analysis of neutrality of border tax adjustments, as in Meade (1974), Grossman (1980), and Auerbach et al. (2017).

can be modelled as a transition to an absorbing state where only the home-country fiscal instruments vary. Moreover, our formulation enables to study dynamics associated with turnover in governments and policy reversals which could introduce an element of cyclicality in policy changes. Finally, and more importantly for the focus of our analysis, our formulation represents a natural laboratory to study the effects of possible retaliatory actions by foreign governments, albeit in a reduced form specification.[7]

To complete the description of fiscal policy we assume that the government balances its budget in every period:

$$\tau_t^m \varepsilon_t P_{F,t}^* - \varsigma_t^x \varepsilon_t P_{H,t}^* + \frac{\tau_t^\pi}{1+\tau_t^\pi} \widetilde{\Pi}_t^\pi = T_t \tag{33}$$

Monetary policy in the home country follows the interest rate rule

$$R_t = \frac{1}{\beta} \left[\pi_{Ht} \frac{(1-\tau_t^v)}{(1-\tau_{t-1}^v)} \right]^{\varphi_\pi} (\tilde{y}_t)^{\varphi_y} (\varepsilon_t - \bar{\varepsilon}_t)^{\varphi_\varepsilon} \tag{34}$$

where φ_π is the weight on domestic price inflation (π_{Ht}) and φ_y is the weight on the output gap ($\tilde{y}_t$). The parameter $\varphi_\varepsilon \in \{0, M\}$ governs the sensitivity of the interest rate rule to changes in the nominal exchange rate.[8] When $\varphi_\varepsilon = 0$, the home interest rate responds exclusively to fluctuations in domestic inflation and output gaps. When $\varphi_\varepsilon = M$, the home interest rate rule proactively responds to deviations of the nominal exchange rate from a target exchange rate.

3 Equilibrium

Define an initial condition for home holdings of bonds and individual producers prices in the domestic market

$$x_0 = \left(B_{H-1} R_{-1}, B_{F-1} R_{-1}^*, P_{H-1}(i), P_{F-1}^*(i) \right)$$

[7] Ossa (2014, 2016) present estimates about the effects of cooperative and noncooperative commercial policies in multi-country and multi-industry general equilibrium models of international trade. Although his approach allows to solve for optimal governments' policies, the analysis is implemented within the context of steady state changes.

[8] See Benigno *et al.* (2007) for a discussion of interest rate rules that maintain a fixed exchange rate.

Definition. *Given an initial state* x_0*, an equilibrium consists of:*

1. *An allocation* $\{C_t, C_t^*, N_t, N_t^*, B_t, B_t^*, Y_{Ht}, Y_{Ft}, Y_{Ft}^*, Y_{Ht}^*\}_{t\geq 0}$
2. *Individual producer prices* $\left\{P_{Ht}(i), P_{Ft}(i), P_{Ft}^*(i), P_{Ht}^*(i), \bar{P}_{Ht}(i), \bar{P}_{Ft}^*(i)\right\}_{t\geq 0}$
3. *Aggregate prices* $\{P_t, P_t^*, W_t, W_t^*, R_t, R_t^*, P_{Ht}, P_{Ft}, P_{Ft}^*, P_{Ht}^*, \varepsilon_t, Q_t\}_{t\geq 0}$

such that

1. *Given prices, the allocation solves the maximization problems of households and retailers: i.e. it satisfies optimality conditions* $(4)-(6)$ *and* $(15)-(16)$ *and the analogous conditions in the foreign country;*
2. *Individual producer prices maximize producers profits: i.e. they satisfy conditions* $(25), (26)$ and (28) *and the analogous conditions in the foreign country;*
3. *Prices clear all markets. That is:*

   Price indexes satisfy $(19)-(21)$ *and the analogous conditions in the foreign country;*

   Nominal rates are determined according to (87) *and an analogous rule in the foreign country;*

   Labor markets clear:

$$N_t = \int N_t(i)\, di \tag{35}$$

   where $N_t(i)$ *is firms employment demand as determined by its prices, its production function and retailers demand schedules;*

   The bond markets clear

$$\varepsilon_t B_{Ft} - B_{Ht}^* = \varepsilon_t B_{Ft-1} R_{t-1}^* - B_{Ht-1}^* R_{t-1} + NX_t \tag{36}$$

   where net exports (NX_t) *are defined as*

$$NX_t = \frac{P_{Ht}^* y_{Ht}^*}{1+\tau_t^{m*}}\varepsilon_t - \frac{P_{Ft} y_{Ft}}{(1+\tau_t^m)} \tag{37}$$

4 Macroeconomic Effects of Trade Policy

In this section we study the effects of a $\delta-$increase in import tariffs and export subsidies (IX) and investigate the extent to which these effects depend on the exchange rate regime. We discuss conditions under which, in a flexible exchange rate regime, this policy has no effects on the real allocation as the appreciation of the exchange rate perfectly offsets the (partial equilibrium) stimulative effects of IX on net exports and output, an argument originally put forward in Mundell (1961).

4.1 Parameter Values

The parameters values used in our baseline experiments are listed in Table 1. Given our focus on the transmission mechanisms of trade policies rather than their quantitative effects, we consider standard values commonly used in the literature.

Table 1

	Parameter	Value
Discount factor	β	0.99
Risk aversion	σ	1.0
Frisch elasticity of labor supply	η^{-1}	1.0
Labor share	α	0.36
Price stickiness	ζ_P	0.95
Trade elasticity	θ	1.2
Inflation weight in the rule	φ_π	1.25
Output gap weight in the rule	φ_y	0.125

4.2 Import Tariff and Export Subsidies

In our benchmark model we assume that the international trade policy regime belongs to one of three different states, $s_t \in S = \left\{s^1, s^2, s^3\right\}$. In the first state $\left(s^1\right)$ no country levies any taxes. In the second state $\left(s^2\right)$, the home country unilaterally raises import tariffs and export subsidies by the same amount δ. In other words, the only non zero elements of the state s^2

are $\tau_t^m = \varsigma_t^x = \delta$. In the third state $\left(s^3\right)$, the foreign block retaliates with a symmetric policy. Hence, $\tau_t^m = \varsigma_t^x = \tau_t^{m*} = \varsigma_t^{x*} = \delta$.

We assume that the transition probability matrix governing the evolution of s_t is as follows

$$\Omega = \begin{bmatrix} 1-\pi & \pi & 0 \\ 0 & \rho & 1-\rho \\ 1-\rho & 0 & \rho \end{bmatrix}$$

where π is the probability that the home country unilaterally enacts an IX policy given that the economy is in the no-tax state $\left(s^1\right)$ and $(1-\rho)$ is the probability that foreign economies retaliate to the IX policy, implying an expected lag in retaliation of $\frac{1}{1-\rho}$ quarters. The special case of $\rho = 1$ represents the typical experiment considered in the literature of a unilateral permanent tax change. Finally, the economy can transition from the retaliation state $\left(s^3\right)$ to the no-tax state $\left(s^1\right)$ with probability $1-\rho$.

4.2.1 IX policy and exchange rate dynamics

As originally argued by Mundell (1961), equilibrium in the international balance of payments provides the key insight for the allocative effects of the IX policy. For a given level of the exchange rate, higher tariffs make domestic imports more expensive whereas higher export subsidies make domestic exports cheaper in the foreign country. The corresponding expansion in the supply of domestic exports and the symmetric contraction in the supply of foreign exports is depicted in Figure $1a-b$, that use the law of on price in the two countries (26) and (26) to describe the partial equilibrium effect of IX on exporters' supply schedules. Cheaper exports and more expensive imports boost home net exports at each level of the exchange rate, as illustrated by the upward shift of the net export schedule in Figure 2. Therefore, the direct "trade effects" of this policy put upward pressure on the real exchange rate.

The response of consumption and savings in the home country is the other key determinant of the real exchange rate. Recall that no-arbitrage in the market for foreign currency

denominated bonds requires[9,10]

$$\mathbb{E}_t \left\{ \left[\Lambda_{t,t+1} \frac{Q_{t+1}}{Q_t} - \Lambda^*_{t+1} \right] \right\} = 0 \tag{38}$$

Intuitively, an appreciation of the real exchange rate at $t+1$ (a decrease in Q_{t+1}) amounts to a decrease in the real interest rate offered by the foreign country, thus discouraging savings in the home country. This "saving effect" corresponds to an upward shift of the saving supply schedule, in Figure 2. The overall allocative effects of IX will then depend on the relative strength of the trade effects and the savings effects.

Figure 3 shows the response of the real exchange rate, net exports, and domestic output in the home country to a uniform increase in import tariffs and export subsidies of 10 percentage points under a flexible exchange rate regime. The solid line shows the response under an expected retaliation lag of five years ($\rho = .95$) while the dotted line portrays the response under a permanent unilateral IX policy ($\rho = 1$) . For simplicity, and without loss of generality, the no-tax state is assumed to be absorbing ($\pi = 0$) in both cases so that the initial transition is an unexpected shock.

When the unilateral implementation of IX is permanent, agents expect the real exchange to remain appreciated forever. Hence, the upward shift of the saving supply perfectly offsets the increase in the net export schedule and the nominal exchange rate needs to jump immediately to ita long-run value. The only effect of IX is a permanent appreciation of the real exchange rate.

When we consider the possibility that the foreign country can retaliate, however, the IX policy affects the allocation in the short run. Agents anticipate that the foreign government will eventually implement its own IX policy, pushing both countries to the initial steady state of no taxes. Thus, the saving effect in the home country will not completely offset the trade effect and net exports will increase. The appreciation of the exchange rate will only attenuate

[9] Notice that under our baseline calibration $\chi = \infty$ and $B^*_{Ht} = B_{Ht} = 0$, so that all aggregate savings by the home country are invested in foreign currency denominated bonds B_{Ht}. As we explain below, the analysis is unaffected if we assume that $\chi = 0$.

[10] For ease of notation we are neglecting the covaraince term, i.e. the UIP condition is in fact given by

$$\left[\mathbb{E}_t \Lambda_{t,t+1} \frac{Q_{t+1}}{Q_t} \right] = \left[\mathbb{E}_t \Lambda^*_{t,t+1} \right] + COV \left(\Lambda^*_{t,t+1}, \frac{\pi^*_{t+1}}{\mathbb{E}_t \pi^*_{t+1}} \right) - COV \left(\Lambda_{t,t+1} \frac{Q_{t+1}}{Q_t}, \frac{\pi^*_{t+1}}{\mathbb{E}_t \pi^*_{t+1}} \right)$$

the mercantilist element of the IX policy but will not prevent an increase in net exports and a short-run expansion in domestic output.

4.2.2 The role of monetary policy

Our previous discussion did not rely on any assumption about monetary policy or price stickiness. Here we compare our benchmark economy with sticky prices and flexible exchange rates with two extreme cases, specifically a flexible price economy and an economy with sticky prices under a fixed exchange rate regime, in order to shed some light on the direction of these effects. As shown in the top row of Figure 4, any transitory IX policy will stimulate net exports irrespective of whether prices are sticky or flexible and whether the exchange rate is pegged or free to float. Nonetheless, different specifications of these details will affect the quantitative response of aggregate demand, prices, and interest rates.

Starting with the benchmark economy with sticky prices (blue lines), higher tariffs raise the price of domestic imports and induce consumers to switch away from imported goods and towards home-produced goods. Consumer price inflation jumps because of the pass-through of tariffs into prices, but firms in the home country are unable to raise their prices in response to demand switching of home consumers. The nominal interest rate rises and restrains the relative increase in the demand of domestic goods, leaving consumption of the home good essentially unaffected. The moderate rise in domestic prices together with the increase in the real exchange rate translate into a decrease in export prices and a boom in exports and output. The IX policy has stimulative effect in home country by diverting global demand towards home varieties and, as a consequence, negative spillovers to the foreign country. Foreign output decreases and lower export prices in the home country push foreign inflation down, calling for lower interest rates

In the flexible price economy (red lines), the expenditure switching effect of IX away from foreign goods and towards home-produced goods is met with an immediate increase in prices of home goods. As a result, policy rates increase more than in the benchmark economy depressing domestic demand for the home good, which actually falls in this case. The home output increase is thus smaller than in the benchmark economy as it is only supported by higher exports.

Finally, when the home exchange rate is pegged (yellow lines), nominal interest rates actually decrease since the negative spillovers of IX to the foreign economy typically require lower policy rates. In this case, firms' inability to raise prices is coupled with a monetary policy that imports the expansionary stance of the foreign economy in order to keep nominal rates fixed. As a result, the appreciation of the real exchange rate is much smaller, as both prices and nominal exchange rates are not allowed to vary flexibly, and the home economy experiences a larger boom in both domestic consumption of the home good and domestic exports.

In sum, unilateral IX policies tend to appreciate the exchange rate, boost net exports, and increase domestic production. These effects do not depend on assumptions about pricing or the exchange rate regime. IX policies have negative spillovers to foreign output and inflation.

4.2.3 Neutrality of IX: a very fragile result

In the sections above we discussed how the prospect of retaliatory behavior by foreign economies can result in substantial stimulative effects of IX at home. For pedagogical purposes we conducted our analysis under a set of assumptions that ensured that, absent the prospect of retaliation, IX would have no allocative effects. While we regard the assumption of eventual retaliation as a highly plausible scenario in the case of a unilateral implementation of IX, there are other important departures from our baseline assumptions that will also break the neutrality result.

The purpose of this section is twofold. First, we spell out the assumptions that are needed in order to obtain neutrality in the absence of retaliatory prospects. Second, we show that our description of the short-run macroeconomic effects of IX under retaliation is largely unaffected when these assumptions for neutrality are relaxed.

Proposition 1. *Let* $x_0 = \left(B^*_{H-1}R_{-1}, B_{F-1}R^*_{-1}, P_{H-1}(i), P^*_{F-1}(i), s^0\right)$ *be the initial condition. A unilateral implementation of IX of size* δ *has no allocative effect if and only if*

1. *It is unanticipated, permanent, and there is no probability of retaliation;*
2. *Foreign holdings of home currency are always zero:* $B^*_{H-1} = 0 = \bar{B}$ and $\chi = \infty$;
3. *Export prices are set in producer currency (PCP) or prices are flexible*

Appendix B contains a formal proof of proposition 1. Here we describe the basic intution behind this result in the special case in which at time 0 a unilateral IX policy is implemented and only the home country actively uses trade policy instruments (i.e. $\tau_t^{m*} = \varsigma_t^{x*} = 0$).

Neutrality to a policy change requires that relative prices must remain unchanged. Under PCP, export prices satisfy the law of one price (for convenience, in real terms)

$$\frac{P_{Ht}^*}{P_t^*} = \frac{P_{Ht}}{P_t} \frac{1}{(1+\varsigma_t^x)\, Q_t} \tag{39}$$

$$\frac{P_{Ft}}{P_t} = \frac{P_{Ft}^*}{P_t^*} (1+\tau_t^m)\, Q_t \tag{40}$$

Equations (39) and (40) imply that relative prices remain unchanged only if a δ increase in import tariffs and export subsidies causes an exchange rate appreciation of the same exact size. Let $Q_t(\delta)$ denote the real exchange rate under an IX policy of size δ, neutrality then requires

$$\frac{1}{Q_t(\delta)} = \frac{1}{Q_t(0)} (1+\delta) \tag{41}$$

At this point we have to check that this appreciation of the exchange rate does not imply violations in other equilibrium conditions. Changes in the real exchange rate affect directly the two optimality conditions for holdings of foreign currency denominated bonds, (6) and (7) , and the equilibrium in the balance of payments.

Equations (6) and (7) are unaffected if, and only if, condition 1 is satisfied: since optimal holdings of foreign currency denominated bonds depend on future exchange rate appreciation, a permanent appreciation of the real exchange rate does not affect demand schedules. That is, under condition 1, equation (41) implies $\frac{Q_{t+1}(\delta)}{Q_t(\delta)} = \frac{Q_{t+1}(0)(1+\delta)}{Q_t(0)(1+\delta)}$.

As for the balance of payment, we can rewrite equation (36) in (foreign good) real terms and, using condition 2, obtain

$$\frac{B_{Ft}}{P_t^*} = \frac{B_{Ft-1}}{P_{t-1}^*} \frac{R_{t-1}^*}{\pi_t^*} + \frac{P_{Ht}^*}{P_t^*} y_{Ht}^* - \frac{P_{Ft}}{P_t} \frac{y_{Ft}}{(1+\tau_t^m)\, Q_t(\tau_t^m)} \tag{42}$$

Equation (42) shows that aggregate home savings in foreign bonds are also unaffected under (41) . Therefore, , the original allocation is still an equilibrium after the implementation of IX.

It might seem surprising that the home household is keeping consumption, C_t, unchanged while the value of its savings in the foreign market, $Q_t \frac{B_{Ft}}{P_t^*}$, declines with the real exchange

rate appreciation. The reason for this result is that, under condition 1, IX induces two perfectly offsetting changes in two different components of households wealth. On the one hand, the real exchange rate appreciation decreases the value of home holdings of foreign bonds, thus generating losses of size

$$\left[Q_t\left(\delta\right)-Q_t\left(0\right)\right]\frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t}=-\frac{\delta}{1+\delta}Q_t\left(0\right)\frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t} \tag{43}$$

On the other hand the IX policy generates fiscal revenues whenever the home country has a trade deficit since in this case revenues from tariffs exceed subsidies to exporters. The wealth increase associated to these fiscal revenues is given by

$$E_t\sum_{i\geq 0}\left(\prod_{j=1}^{i}\frac{1}{R^A_{t+j}}\right)\frac{\tau^m_{t+i}}{1+\tau^m_{t+i}}\left(p_{ft+i}y_{ft+i}-Q_{t+i}\left(0\right)p^*_{ht+i}y^*_{ht+i}\right)=\frac{\delta}{1+\delta}NFA_t \tag{44}$$

which in the case of a permanent unilateral IX policy, $\tau^m_{t+i}=\delta$, is proportional to the present discounted value of future trade deficits. As equation (44) indicates, in equilibrium the present discounted value of future trade deficits is exactly equal to the initial net foreign asset position.

Under condition 2, the net foreign asset position is just given by foreign bond holdings $Q_t\frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t}$, which implies that the increase in home wealth through higher fiscal revenues exactly offsets the decline in wealth induced by losses on foreign holdings

$$-\left[Q_t\left(\delta\right)-Q_t\left(0\right)\right]\frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t}=\frac{\delta}{1+\delta}NFA_t$$

leaving consumption unchanged.

The argument above also shows why condition 2 of no foreign holdings of home currency denominated bonds is necessary for neutrality. When $B^*_{Ht-1}>0$ net foreign assets are given by

$$NFA_t=Q_t\frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t}-\frac{B^*_{Ht-1}}{P_{t-1}}\frac{R_{t-1}}{\pi_t}$$

which implies that the sensitivity of home households wealth to a real exchange rate appreciation through its effect on net foreign assets is bigger than the level of net foreign assets, i.e. the home country has a leveraged exposure to foreign exchange rate variations. In this case

$$-\left[Q_t\left(\delta\right)-Q_t\left(0\right)\right]\frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t}>\frac{\delta}{1+\delta}NFA_t$$

Therefore, given an unchanged path for future trade deficits, an exchange rate appreciation of the same size of the policy, i.e. as in (41) , would induce a decrease in home households wealth as the increase in fiscal revenues is not enough to offset capital losses on holdings of foreign bonds. This negative wealth effects on home households induces them to decrease their saving supply so that in equilibrium the exchange rate appreciates by less and the the trade balance increases.

These effects are portrayed in Figure ??? that shows the response of the economy to a permanent unilateral implementation of IX when condition 2 is not satisfied. In particular we assume that in the initial state trade is balanced but countries hold offsetting position in domestic and foreign currency denominated bonds, i.e. $B_{F_{-1}} = B^*_{H-1} > 0$. In the simulation we set B^*_{H-1} to two times the value of annual GDP. For comparison we also plot the response of our baseline economy. As explained above, positive foreign holdings of home currency denominated bonds results in a shifting in of home saving supply schedule. This dampens the long run effects on the exchange rate and results in a permanent increase in the trade balance at home that is enough to pay interests on its negative net foreign asset position.

Finally, to understand the effects of relaxing condition 3 we also study the effects of a permanent IX policy under the assumption of LCP pricing. Notice that, even though the allocation is unchanged under conditions 1-3, foreign producers are immediately reducing the home currency price they charge on home imports, $\frac{P_{ft}}{1+\tau^m_t}$ However, when firms cannot flexibly adjust the foreign currency price of their exports in response to variations in exchange rates and taxes, foreign exporters will only gradually reduce their prices so consumer prices of home imports will initially spike causing a large increase in import prices and an overshooting of the real exchange rate as the home bundle becomes temporarily more expensive. This movement in relative prices implies that in the short run the home economy experiences a boom in output mostly driven by an increase in domestic demand of the home produced good, as home retailers switch away from more expensive foreign inputs. Exports also increase on impact since the exchange rate rises by more than export subsidies, domestic exporters would also like to increase their prices but their inability to immediately do so results in a temporary increase in exports.

5 Equivalence Results

We begin our comparison of the effects of IX, BAT, and VP by focusing on the special case of permanent policy changes under producer currency pricing and flexible exchange rates also discussed in the previous section. Under these assumptions, the three policies are equivalent and neutral as the real exchange rate appreciate just enough to completely offset any stimulative effect of these policies on net exports and output.

The appreciation of the real exchange rate, however, originates from different sources, namely an immediate jump in the nominal exchange rate under IX or BAT, and an adjustment in the domestic price level under VP. A direct implication of this observation is that when we consider the case of fixed nominal exchange rates, the policies are not equivalent anymore. In this case IX and BAT act like a fiscal devaluation and stimulate output, while VP remains neutral.

We next turn our attention to the more general case of transitory policy changes. We show that, for IX and BAT, the same qualitative effects of a permanent change with PCP that materialize under a fixed exchange rate regime extend to both fixed and variable exchange rate regimes and arbitrary pricing conventions (e.g. LCP). IX and BAT are always equivalent, stimulate net exports and domestic output, and reduce foreign output. These policies still appreciate the real exchange rate but this effect only partially offsets the boost to output and net exports. VP is not equivalent to IX or BAT, however. With a significant level of nominal price rigidity or under fixed exchange rates, VP is contractionary even in the home country.

5.1 A special case : a permanent change under PCP

We start by considering the case in which policies are expected to be permanent and retaliation by foreign economies is ruled out.

Further, we assume that monetary policy targets domestic price inflation and the output gap, while exchange rates are perfectly flexible:

$$R_t = \frac{1}{\beta}\left[\pi_{Ht}\frac{(1-\tau_t^v)}{\left(1-\tau_{t-1}^v\right)}\right]^{\varphi_\pi}(\tilde{y}_t)^{\varphi_y} \tag{45}$$

In this case we can state the following proposition.

Proposition 1. *If the exchange rate regime is flexible* ($\varphi_\varepsilon = 0$)*, monetary policy is described by* (45) *and prices are set in producer currency (PCP), a permanent unexpected IX policy*

$$IX = \{\tau_s^m, \varsigma_s^x\}_{s \geq t} \quad s.t. \quad \tau_s^m = \varsigma_s^x = \delta \tag{46}$$

a permanent unexpected BAT policy

$$BAT = \{\tau_s^\pi\}_{s \geq t} \quad s.t. \quad \tau_s^\pi = \frac{\delta}{1+\delta} \tag{47}$$

and a permanent unexpected VP policy

$$VP = \{\tau_s^v, \varsigma_s^v\}_{s \geq t} \quad s.t. \quad \tau_s^v = \varsigma_s^v = \frac{\delta}{1+\delta} \tag{48}$$

have no effect on the real allocation and induce a real exchange rate appreciation of size $\frac{\delta}{1+\delta}$.

Appendix 1a contains the complete proof of Proposition 1. Here we explain the intuition behind equivalence of IX and VP[11]. As discussed above, under the assumptions of Proposition 1 IX will be neutral on the equilibrium allocation. To understand why VP will also be neutral notice that the two laws of one price

$$\frac{P_{Ht}^*}{P_t^*} = \frac{(1-\tau^v)}{(1+\varsigma^x)} \frac{P_{Ht}}{P_t} \frac{P_t}{\varepsilon_t P_t^*} = \frac{(1-\tau^v)}{(1+\varsigma^x)} \frac{P_{Ht}}{P_t} \frac{1}{Q_t} \tag{49}$$

$$\frac{P_{Ft}}{P_t} = \frac{(1+\tau^m)}{(1-\tau^v)} \frac{P_{Ft}^*}{P_t^*} Q_t \tag{50}$$

imply that IX and VP induce the same expansion of domestic exports and contraction of foreign exports. This is because the VAT increase acts like an import tax and the VAT deductibility of exports acts as an export subsidy.

The same exact argument developed in Section 4.2.1 to explain how the balance of payment equilibrium determines the exchange rate response to IX can be applied directly also to the case of the VP policy, with an important difference. In the case of VP, in fact, the tax changes affect two additional equilibrium conditions. First, the optimality condition of

[11] As shown in Section 3.2, IX and BAT are always equivalent in our environment. Hence, we decided to simplify notation and focus on the relation between IX and VP here.

the home firm i requires that a VAT increase is accompanied by a payroll subsidy in order to prevent any distortion in the supply of the home varieties

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{s,t} Y_{Ht}(i) P_{Hs} (1-\tau^{\pi}) \left[\overline{P}_{Ht}(i) (1-\tau^{v}) - (1-\varsigma^{v}) \frac{\gamma}{\gamma-1} \frac{W_s}{\alpha A N_s(i)^{\alpha-1}} \right] = 0 \quad (51)$$

Intuitively, the VAT increase reduces the firm's marginal revenue, $\overline{P}_{Ht}(i)(1-\tau^{v})$, for any given price $\overline{P}_{Ht}(i)$ paid by the consumer. Payroll subsidies (ς^{v}) ensure that this reduction in marginal revenues is offset by an equal reduction in marginal costs .

Second, under our assumption that VAT taxes are fully passed through to the consumer, the Phillips curve for domestic price inflation

$$\pi_{Ht} = \left[\zeta_P \left(\frac{(1-\tau_{t-1}^{v})}{(1-\tau_t^{v})} \right)^{1-\gamma} + (1-\zeta_P) \left(\frac{\bar{P}_{H,t}}{P_{H,t-1}} \right)^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \quad (52)$$

indicates that a VAT increase boosts domestic price inflation π_{Ht}. Given our assumption that monetary policy policy sees through any increase in consumer price inflation due to VAT changes, neutrality of VP follows by letting all prices under VP increase by $\frac{1}{1-\tau_t^{v}} = \frac{\delta}{1+\delta}$

$$P_{H,t}^{VP} = \frac{P_{H,t}^{IX}}{1-\tau_t^{v}}; \quad P_{F,t}^{VP} = \frac{P_{F,t}^{IX}}{1-\tau_t^{v}}; \quad P_t^{VP} = \frac{P_t^{IX}}{1-\tau_t^{v}}$$

In other words, under VP the real exchange rate appreciation is achieved through an adjustment in the price level

$$Q_t^{VP} = \frac{1+\delta}{\delta} Q_t = \varepsilon_t \frac{P_t^*}{P_t^{VP}}$$

The different response of inflation and the nominal exchange rate under IX and VP in a flexible exchange rate regime is key to understand the response of the economy when the nominal exchange rate is fixed. In a fixed exchange rate regime, IX (and BAT) will in general stimulate net exports and output as the inability of the nominal exchange rate to appreciate does not allow the real exchange rate to fully offset the net export stimulus of the policy. Indeed, IX (and BAT) in this case will implement the same allocation of a currency devaluation as conjectured by Keynes (1931) and formalized in the fiscal devaluation literature, such as FGI. VP, in contrast, remains neutral irrespective of the monetary policy regime as the nominal exchange rate is constant even under a flexible exchange rate regime. The proposition below formally states this result. The proof is in the Appendix.

Proposition 2. *If the exchange rate regime is fixed ($\varphi_\varepsilon = M$) and prices are set in producer currency (PCP), a permanent unexpected IX policy*

$$IX = \{\tau_s^m, \varsigma_s^x\}_{s\geq t} \quad s.t. \quad \tau_s^m = \varsigma_s^x = \delta \tag{53}$$

and a permanent unexpected BAT policy

$$BAT = \{\tau_s^\pi\}_{s\geq t} \quad s.t. \quad \tau_s^\pi = \frac{\delta}{1+\delta} \tag{54}$$

have the same allocative effects of a once and for all unexpected currency devaluation of size δ. A *permanent unexpected VP policy of the same size*

$$VP = \{\tau_s^v, \varsigma_s^v\}_{s\geq t} \quad s.t. \quad \tau_s^v = \varsigma_s^v = \frac{\delta}{1+\delta} \tag{55}$$

has no effect on the real allocaticon.

5.2 The general case

In this section we study to the case in which the fiscal adjustments are perceived to be transitory, perhaps because of threat of retaliation. We show that the equivalence between IX and BAT generalizes to transitory changes and arbitrary price settting conventions (i.e. PCP, LCP). In contrast, with nominal rigidities, relaxing any of the assumptions in Proposition 1 will result in different allocative effects of VP and the other two policies. The proposition below states this result formally:

Proposition 3. *Under full pass-through of taxes, the policies*

$$IX = \{\tau_s^m, \varsigma_s^x\}_{s\geq t} \quad s.t. \quad \tau_s^m = \varsigma_s^x = \delta_s \tag{56}$$

and

$$BAT = \{\tau_s^\pi\}_{s\geq t} \quad s.t. \quad \tau_s^\pi = \frac{\delta_s}{1+\delta_s} \tag{57}$$

implement the same allocation. Generically, the policy

$$VP = \{\tau_s^v, \varsigma_s^v\}_{s\geq t} \quad s.t. \quad \tau_s^v = \varsigma_s^v = \frac{\delta_s}{1+\delta_s} \tag{58}$$

does not implent the same allocation as IX or BAT. The three policies are equivalent only if prices are flexible or when the change is permanent and firms set prices in producer currency (See Proposition 1).

Appendix A.1 presents a formal proof of Proposition 3. The intuition for the equivalence of IX and BAT can be summarized by the observation that the non-deductibility of imports acts like an impot tariff whereas the exemption of export sales acts like an export subsidy. Nonetheless, this observation is not sufficient as the IX and BAT policies appear to distort, respectively, the supply and demand of foreign good in the home country. The assumption of full pass through of import taxes ensures that the supply shift under IX is exactly symmetric to the demand shift under BAT, regardless of the specific pricing convention.[12] Therefore, the allocation under BAT will be identical to the allocation under IX with the only difference that import prices will be lower under BAT:

$$\frac{P_{Fs}^{BAT}}{(1-\tau_s^{\pi})} = P_{Fs}^{BAT}(1+\tau_t^m) = P_{Fs}^{IX}$$

The intuition for the lack of equivalence between VP and IX (or BAT) inthe general case follows the same argument as in Proposition 2 above. Under VP, and given our assumption of full pass through of VAT, the slow response of domestic producers in adjusting (pre-tax) prices leads to an increase in consumer prices of the domestic good at home $(P_{H,t})$. This increase depresses domestic demand of the home variety and limit the competitiveness boost coming from the VATdeductibility of exports.

Finally, Figure 9 shows the same exercise with a VAT cum payroll increase of $\frac{.1}{1+.1}$. Again, we can focus on the domestic market for the home good to understand the differences between IX and VP. Under VP, when domestic firms are unable to freely adjust prices, the VAT is fully passed through to consumers causing a big jump in CPI inflation. This results in a sizeable drop in the home consumption of the domestic good, Y_H, and a smaller boost to net exports associated with higher export prices and smaller relative increase in import prices. When prices are rigid enough, this can cause output to actually contract in response to VP.

6 Conclusion

TBA

[12] If import tariffs are not fully passed through, as for example in FGI, BAT and IX would not be equivalent under LCP.

7 References

References

[1] Auerbach, A., Devereux, M.P., Keen, M. and Vella, J. (2017), "Destination-Based Cash Flow Taxation", *Oxford University Center for Business Taxation*.

[2] Andrade, P., Carré, M. and Bénassy-Quéré,A. (2010), "Competition and Pass-Through on International Markets: Firm-level Evidence from VAT Shocks" (CEPII).

[3] Benigno, G., Benigno, P. and Ghironi, F. (2007), "Interest Rate Rules for Fixed Exchange Rate Regimes", *Journal of Economic Dynamics and Control*, **31**, 2196-2211.

[4] Besley, T. J. and Rosen, H. S. (1999), "Sales Taxes and Prices: An Empirical Analysis", *National Tax Journal*, **52**, 157-178.

[5] Calvo, G. (1983), "Staggered Prices in a Utility-Maximizing Framework", *Journal of Monetary Economics*, **12**, 383-398.

[6] Carbonnier, C. (2007), "Who Pays Sales Taxes? Evidence from French VAT Reforms, 1987-1999", *Journal of Public Economics*, **91**, 1219-1229.

[7] Costinot, A. and Werning, I. (2017), "The Lerner Symmetry Theorem: Generalizations and Qualifications", NBER Working Paper 23427.

[8] Farhi, E., Gopinath, G. and Itskhoki, O. (2014), "Fiscal Devaluations", *Review of Economic Studies*, **81**, 725-760.

[9] Feldstein, M. S. and Krugman, P. R. (1990), "International Trade Effects of Value-Added Taxation", *Taxation in the Global Economy*, NBER Chapters (National Bureau of Economic Researcxh, Inc.) 263-282.

[10] Galì, J. and Monacelli, T. (2005), "Monetary Policy and Exchange Rate Volatility in a Small Open Economy", *Review of Economic Studies*, **72**, 707-734.

[11] Grossmann, G. M. (1980), "Border Tax Adjustment", *Journal of International Economics*, **10**, 117-128.

[12] Harberger, A. C. (1950), "Currency Depreciation, Income, and the Balance of Trade", *Journal of Political Economy*, **58**, 47-60.

[13] Laursen, S. and Metzler, L. (1950), "Flexible Exchange Rate and the Theory of Employment", *Review of Economic and Statistics*, **32**, 281-99.

[14] Lerner, A. P. (1936), "The Symmetry Between Import and Export Taxes", Economics 3(11), 306-313.

[15] Linde', J. and Pescatori, A. (2017), "The Macroeconomic Effects of Trade Tariffs: Revisiting the Lerner Symmetry Result", IMF working paper.

[16] Lipińska, A. and Von Thadden, L. (2012), "On the (In)effectiveness of Fiscal Devaluations in a Monetary Union", Finance and Economics Discussion Series, **2012-71**.

[17] Maier, P. (2008), "A Wave of Protectionism? An Analysis of Economic and Political Considerations", Bank of Canada Working Paper 2008-2.

[18] Mundell, R. (1961), "Flexible Exchange Rate and Employment Policy", *The Canadian Journal of Economics and Political Science*, **27**, 509-517.

[19] Ossa, R. (2014), "Trade Wars and Trade Talks with Data", *American Economic Review*, **104**(12), 4104-4146.

[20] Ossa, R. (2016), "Quantitative Models of Commercial Policy", *Handbook of Commercial Policy*, Ch. 4, 207-259.

8 Appendix A. LCP Pricing

9 Appendix B. Proof of Proposition 1

We start by giving a broad definition of a unilateral IX policy.

Definition 1. *Let the evolution of trade policy at home and abroad* $s_t = (\tau_t^m, \varsigma_t^x, \tau_t^{m*}, \varsigma_t^{x*})$ *be determined by the stochastic process* $\{S, \Omega\}$. *A unilateral implementation of IX of size* δ *which happens with state dependent probability* p^{IX} *starting from* $\{S, \Omega\}$, *is described by a new stochastic process* $\left\{\tilde{S}, \tilde{\Omega}\right\}$ *such that* $\tilde{S} = S \cup S^{IX} \cup S^W$

$$S^{IX} = \sigma_\delta^{IX}([S]) \tag{59}$$

$$\sigma_\delta^{IX}(\tau_t^m, \varsigma_t^x, \tau_t^{m*}, \tau_t^{x*}) = ((1+\tau_t^m)\delta - 1, (1+\varsigma_t^x)\delta - 1, \tau_t^{m*}, \varsigma_t^{x*})$$

$$S^W = \sigma_\delta^W([S]) \tag{60}$$

$$\sigma_\delta^{IX}(\tau_t^m, \varsigma_t^x, \tau_t^{m*}, \tau_t^{x*}) = ((1+\tau_t^m)\delta - 1, (1+\varsigma_t^x)\delta - 1, (1+\tau_t^{m*})\delta - 1, (1+\varsigma_t^{x*})\delta - 1)$$

and

$$\tilde{\Omega} = \begin{bmatrix} diag\left(1-\pi^{IX}\right)\Omega & diag\left(\pi^{IX}\right)\Omega \\ \Omega^R & \Omega^{IX} \end{bmatrix} \tag{61}$$

$$\tilde{\Omega} = \begin{bmatrix} diag\left(1-\pi^{IX}\right)\Omega & diag\left(\pi^{IX}\right)\Omega & 0 \\ diag\left(\pi^R\right)\Omega & diag\left(1-\pi^R-\pi^W\right)\Omega & diag\left(\pi^W\right)\Omega \end{bmatrix} \tag{62}$$

where the ordering of states in the matrix $\tilde{\Omega}$ *is the obvious one.*

When IX is implemented, import tariffs and export subsidies proportionally increase at home by δ, that is the economy transits from a given state $s_t = (\tau_t^m, \varsigma_t^x, \tau_t^{m*}, \tau_t^{x*})$ in the no policy set S to the corresponding element $\sigma^{IX}(s_t) = (\tilde{\tau}_t^m, \tilde{\varsigma}_t^x, \tau_t^{m*}, \tau_t^{x*})$ in S^{IX} that satisfies $\frac{1+\tilde{\tau}_t^m}{1+\tau_t^m} = \frac{1+\tilde{\varsigma}_t^x}{1+\varsigma_t^x} = \delta$ as given by (59). The definition above encompasses the possibility that the policy change is anticipated, with the vector π^{IX} indicating the probability of implementing IX in each pre implementation state $s \in S$. Moreover the transition matrices Ω^{IX} and Ω^R govern the behavior of trade and fiscal policy conditional on IX being implemented. These matrices can therefore be specified to capture different assumptions about retaliation or eventual reversal. If, for instance, $\Omega^{IX} = \Omega$ the policy does not trigger retaliatory behavior

and it is permanent, since the probability of changes in trade policy in the foreign country are unaffected by implementation of IX at home and the probability of a transition back to no policy states S is zero. On the other hand if Ω^R has non zero elements there is a positive probability that the policy will eventually be reversed.

Consider a unliateral IX implementation $\left\{\tilde{S},\tilde{\Omega}\right\}$ starting from $\{S,\Omega\}$. Take any $\tilde{s}^t = (\tilde{s}_1,\tilde{s}_2,...,\tilde{s}_t) \in \tilde{S}^t$ and let $\mu_t^{IX}\left(\tilde{s}^t\right) = s^t$ be a function mapping any finite history $\tilde{s}^t \in \tilde{S}^t$ into the corresponding no IX policy history $s^t = (s_1,s_2,....,s_t) \in S^t$, that is for $s = 1,...,t$

$$s_s = \begin{cases} \sigma_\delta^{IX-1}(\tilde{s}_s) & if\ \tilde{s}_s \in S^{IX} \\ \tilde{s}_s & if\ \tilde{s}_s \in S \end{cases}$$

Definition 2. *Let* $\left\{A_t\left(s^t\right)\right\}_{s^t\in S^t,t\geq 0} = \left\{C_t\left(s^t\right),C_t^*\left(s^t\right),N_t\left(s^t\right),N_t^*\left(s^t\right),Y_{Ht}\left(s^t\right),Y_{Ft}\left(s^t\right),Y_{Ft}^*\left(s^t\right),Y_{Ht}^*\left(s\right.\right.$ *be part of an equilibrium allocation for a given state* $x_0 = \left(B_{H-1}^*R_{-1},B_{F-1}R_{-1}^*,P_{H-1}(i),P_{F-1}^*(i),s_0\right)$, *and stochastic process for the fiscal state described by* $\{S,\Omega\}$. *A unilateral implementation of IX of size* δ, $\left\{\tilde{S},\tilde{\Omega}\right\}$, *has no allocative effect if* $\tilde{A}_t\left(\tilde{s}^t\right) = A_t\left(\mu_t^{IX}\left(\tilde{s}^t\right)\right)$ *is still part of an equilibrium under* $\left\{\tilde{S},\tilde{\Omega}\right\}$.

We now report below proposition 1

Proposition 1. *Let* $x_0 = \left(B_{H-1}^*R_{-1},B_{F-1}R_{-1}^*,P_{H-1}(i),P_{F-1}^*(i)\right)$ *be the initial condition and* $\{S,\Omega\}$ *describe trade policy. A unilateral implementation of IX* $\left\{\tilde{S},\tilde{\Omega}\right\}$ *of size* δ *has no allocative effect if and only if*

1. *It is unanticipated, i.e.*

$$p^{IX} = 0$$

, *permanent, i.e.for any* ξ

$$\Pr\left\{1+\tau_{t+1}^m = \xi | s_t = \tilde{s}_- \in S^{IX}\right\} = \Pr\left\{1+\tau_{t+1}^m = \frac{\xi}{1+\delta} | s_t = \sigma_\delta^{IX-1}(\tilde{s}_-) \in S\right\}$$

$$\Pr\left\{1+\sigma_{t+1}^x = \xi | s_t = \tilde{s}_- \in S^{IX}\right\} = \Pr\left\{1+\sigma_{t+1}^m = \frac{\xi}{1+\delta} | s_t = \sigma_\delta^{IX-1}(\tilde{s}_-) \in S\right\}$$

and there is no probability of retaliation, i.e. for any ξ

$$\Pr\left\{\frac{\tau_{t+1}^{m*}}{\tau_{t+1}^m} = \frac{\xi}{1+\delta} | s_t = \tilde{s}_- \in S^{IX}\right\} = \Pr\left\{\frac{\tau_{t+1}^{m*}}{\tau_{t+1}^m} = \xi | s_t = \sigma_\delta^{IX-1}(\tilde{s}_-) \in S\right\}$$

$$\Pr\left\{\frac{\varsigma_{t+1}^{x*}}{\varsigma_{t+1}^x} = \frac{\xi}{1+\delta} | s_t = \tilde{s}_- \in S^{IX}\right\} = \Pr\left\{\frac{\varsigma_{t+1}^{x*}}{\varsigma_{t+1}^x} = \xi | s_t = \sigma_\delta^{IX-1}(\tilde{s}_-) \in S\right\}$$

2. *There is no trade in home currency denominated bonds:* $B^*_{H-1} = 0 = \bar{B}$ *and* $\chi = \infty$. (*Or if* $\chi = 0$ *the equilibrium under* $\{S, \Omega\}$ *features* $B^*_{Ht} = 0$)

3. *Export prices are set in producer currency or prices are flexible*

We start by collecting all of the equilibrium equations affected by trade policy and the real exchange rate:

$$\frac{P^*_{Ht}}{P^*_t} = \frac{P_{Ht}}{P_t} \frac{(1+\tau^{m*}_t)}{(1+\varsigma^x_t)\, Q_t} \tag{63}$$

$$\frac{P_{Ft}}{P_t} = \frac{P^*_{Ft}}{P^*_t} \frac{(1+\tau^m_t)}{(1+\varsigma^{x*}_t)} Q_t \tag{64}$$

$$\mathbb{E}_t \left\{ \left[\frac{C_t}{C_{t+1}} \frac{Q_{t+1}}{Q_t} - \frac{C^*_t}{C^*_{t+1}} \right] \frac{P^*_t}{P^*_{t+1}} \right\} = 0 \tag{65}$$

$$\mathbb{E}_t \left\{ \left[\frac{C^*_t}{C^*_{t+1}} \frac{Q_t}{Q_{t+1}} - \frac{C_t}{C_{t+1}} \right] \frac{P_t}{P_{t+1}} \right\} = \chi \left(\frac{B^*_{Ht} - \bar{B}}{R_t} \right) \tag{66}$$

$$\frac{B_{Ft}}{P^*_t} - \frac{B^*_{Ht}}{P_t} \frac{1}{Q_t} = \frac{B_{Ft-1}}{P^*_{t-1}} \frac{R^*_{t-1}}{\pi^*_t} - \frac{B^*_{Ht-1}}{P_{t-1}} \frac{R_{t-1}}{\pi_t} \frac{1}{Q_t} + \frac{P^*_{Ht}}{P^*_t} \frac{y^*_{Ht}}{1+\tau^{m*}_t} - \frac{P_{Ft}}{P_t} \frac{y_{Ft}}{(1+\tau^m_t)\, Q_t\, (\tau^m_t)} \tag{67}$$

First notice that, retaliers demand schedules imply that if the IX policy is neutral on the allocation than it must be neutral also on all relative prices:

$$\frac{\tilde{P}_{Ht}\left(\tilde{s}^t\right)}{\tilde{P}_t\left(\tilde{s}^t\right)} = \frac{P_{Ht}\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}{P_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}$$

$$\frac{\tilde{P}^*_{Ht}\left(\tilde{s}^t\right)}{\tilde{P}^*_t\left(\tilde{s}^t\right)} = \frac{P^*_{Ht}\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}{P^*_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}$$

$$\frac{\tilde{P}_{Ft}\left(\tilde{s}^t\right)}{\tilde{P}_t\left(\tilde{s}^t\right)} = \frac{P_{Ft}\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}{P_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}$$

$$\frac{\tilde{P}^*_{Ft}\left(\tilde{s}^t\right)}{\tilde{P}^*_t\left(\tilde{s}^t\right)} = \frac{P^*_{Ft}\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}{P^*_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}$$

And similarly households demand imply that intertemporal prices are also the same

$$\frac{\tilde{P}_{t+1}\left(\tilde{s}^t, s_{t+1}\right)}{\tilde{P}_t\left(\tilde{s}^t\right)} = \frac{P_{t+1}\left(\mu^{IX}_t\left(\tilde{s}^t, s_{t+1}\right)\right)}{P_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}$$

$$\frac{\tilde{P}^*_{t+1}\left(\tilde{s}^t, s_{t+1}\right)}{\tilde{P}^*_t\left(\tilde{s}^t\right)} = \frac{P^*_{t+1}\left(\mu^{IX}_t\left(\tilde{s}^t, s_{t+1}\right)\right)}{P^*_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)}$$

Let the real exchange rate in the origianl equilibrium under $\{S, \Omega\}$ and in the new equailibrium under $\left\{\tilde{S}, \tilde{\Omega}\right\}$ be denoted by

$$Q_t\left(s^t; 0\right) \text{ for } s^t \in S^t$$

$$Q_t\left(s^t; \delta\right) \text{ for } s^t \in \tilde{S}^t$$

It is straigthforward that at any $\tilde{s}^t = (\tilde{s}_1, \tilde{s}_2, ..., \tilde{s}_t) \in \tilde{S}^t$ equations (63) and (64) are satisfied by the same relative prices that hold at $\mu^{IX}_t\left(\tilde{s}^t\right)$ in the original equilibrium if and only if

$$\frac{1}{Q_t\left(\tilde{s}^t; \delta\right)} = \begin{cases} \frac{1}{Q_t\left(\mu^{IX}_t(\tilde{s}^t); 0\right)} & if\ \tilde{s}_t \in S \\ \frac{1}{Q_t\left(\mu^{IX}_t(\tilde{s}^t); 0\right)}(1+\delta) & if\ \tilde{s}_t \in S^{IX} \end{cases} \tag{68}$$

.Given this, IX is neutral if and only if equations (65) - (67) are satisfied by $A_t\left(\mu^{IX}_t\left(\tilde{s}^t\right)\right)$ given $Q_t\left(\tilde{s}^t; \delta\right)$ and neutrality on all relative prices.

The if part is straightforward and can be easily checked following the same arguments in the main text.

For the only if part, let's start from condition 1. For any $\tilde{s}^t = (\tilde{s}_1, \tilde{s}_2, ..., \tilde{s}_t) \in \tilde{S}^\infty$ let $t^{ix}\left(\tilde{s}^t\right)$ be the first time that $\tilde{s}_t \in S^{IX}$. If p^{IX} has a non zero element p^{IX}_i there exists $\tilde{s}^t$ such that $\tilde{s}_{t^{ix}(\tilde{s}^t)} \in S^{IX}$, $\tilde{s}_{t^{ix}(\tilde{s}^t)-1} \in S$ and $\Pr\left\{s_{t+1} = \tilde{s}_{t^{ix}(\tilde{s}^t)} | s_t = \tilde{s}_{t^{ix}(\tilde{s}^t)-1}\right\} = p^{IX}_i > 0$. Then consider the left hand side of equation (65) at $t^* = t^{ix}\left(\tilde{s}^t\right) - 1$. This is given by

$$\left(1 - p^{IX}_i\right)\mathbb{E}_{t^*}\left\{\left[\frac{C_{t^*}\left(\tilde{s}^{t^*}\right)}{C_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)}\frac{Q_t\left(\tilde{s}^{t^*}, s_{t^*+1}; 0\right)}{Q_t\left(\tilde{s}^{t^*}\right)} - \frac{C^*_{t^*}\left(\tilde{s}^{t^*}\right)}{C_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)}\right]\frac{P^*_{t^*}\left(\tilde{s}^{t^*}\right)}{P^*_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)} | s_{t^*+1} \in S\right\}$$

$$+$$

$$p^{IX}_i\mathbb{E}_{t^*}\left\{\left[\frac{C_{t^*}\left(\tilde{s}^{t^*}\right)}{C_{t^*+1}\left(\mu_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)\right)}\frac{Q_t\left(\tilde{s}^{t^*}, s_{t^*+1}; \delta\right)}{Q_t\left(\tilde{s}^{t^*}\right)} - \frac{C^*_{t^*}\left(\tilde{s}^{t^*}\right)}{C_{t^*+1}\left(\mu_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)\right)}\right]\frac{P^*_{t^*}\left(\tilde{s}^{t^*}\right)}{P^*_{t^*+1}\left(\mu_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)\right)} | s_{t^*+1} \in S^{IX}\right\}$$

Since $\left\{A_t\left(s^t\right)\right\}_{s^t \in S^t, t \geq 0}$ is an equilibrium under $\{S, \Omega\}$ the first term is equal to zero. Using (68), and the definition of μ_{t^*+1} the second term is given by

$$p^{IX}_i\mathbb{E}_{t^*}\left\{\left[\frac{C_{t^*}\left(\tilde{s}^{t^*}\right)}{C_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)}\frac{Q_t\left(\tilde{s}^{t^*}, s_{t^*+1}; 0\right)}{Q_t\left(\tilde{s}^{t^*}\right)}\frac{1}{1+\delta} - \frac{C^*_{t^*}\left(\tilde{s}^{t^*}\right)}{C_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)}\right]\frac{P^*_{t^*}\left(\tilde{s}^{t^*}\right)}{P^*_{t^*+1}\left(\tilde{s}^{t^*}, s_{t^*+1}\right)} | s_{t^*+1} \in S\right\} = -p^{IX}_i\mathbb{E}_{t^*} \tag{69}$$

where we have used the the structure of $\tilde{\Omega}$ to change the conditioning set. Equation (69) shows that equation (65) is not satisfied.

Similarly we have that if the policy induces retaliatory behavior or it is eventually reversed a similar argument can be applied by showing that equation (65) won't be satified at $t^* = t^{ix}\left(\tilde{s}^t\right)$.

In order to show that the policy is neutral, we have to check that this appreciation of the exchange rate does not imply that other equilibrium conditions are violated with an unchanged allocation. The only other equilibrium conditions that are affected by changes in the real exchange rate are the two optimality conditions for holdings of foreign currency denominated bonds, (6) and (7), and the equilibrium equation in the balance of payments.

It is immediate that equations (6) and (7) are unaffected if and only if condition 1 is satsfied: since optimal holdings of foreign currency denominated bonds depend on future exchange rate appreciation, a permanent appreiciation of the real exchange rate does not affect demand schedules. That is, under condition 1, equation (41) implies $\frac{Q_{t+1}(\delta)}{Q_t(\delta)} = \frac{Q_{t+1}(0)(1+\delta)}{Q_t(0)(1+\delta)}$.

Turning to the equilbrium in the balance of payment, we can rewrite equation (36) in (foreign good) real terms and using condition 2, i.e. $B^*_{Ht-1} = B^*_{Ht} = 0$, we obtain

$$\frac{B_{Ft}}{P^*_t} = \frac{B_{Ft-1}}{P^*_{t-1}}\frac{R^*_{t-1}}{\pi^*_t} + \frac{P^*_{Ht}}{P^*_t}y^*_{Ht} - \frac{P_{Ft}}{P_t}\frac{y_{Ft}}{\left(1+\tau^m_t\right)Q_t\left(\tau^m_t\right)} \tag{70}$$

$$1 = \beta\mathbb{E}_t\left[\Lambda_{t,t+1}\frac{P_t}{P_{t+1}}R_t\right] \tag{71}$$

$$1 = \beta\mathbb{E}_t\left[\Lambda_{t,t+1}\frac{P_t}{P_{t+1}}\frac{\varepsilon_{t+1}}{\varepsilon_t}R^*_t\right] \tag{72}$$

where $\Lambda_{t,t+1} = \left(\frac{C_t}{C_{t+1}}\right)^\sigma$ is the real stochastic discount factor of the home household. The corresponding intertemporal optimality conditions for foreign household holdings of bonds are

$$1 = \beta\mathbb{E}_t\left[\Lambda^*_{t,t+1}\frac{P^*_t}{P^*_{t+1}}R^*_t\right] \tag{73}$$

where $\chi \in \{0, \infty\}$ determines foreign households costs of holding home currency denominated bonds in excess of a long-run value $\bar{B}$. Thus, when $\chi = 0$ foreign households can costlessly adjust their holdings of B^*_{Ht}, whereas when $\chi = \infty$ holdings of B^*_{Ht} are fixed at their long-run

value at all times (i.e. $B^*_{Ht} = \bar{B}$). These conditions, together with (6), imply the risk-sharing condition

10 Appendix C. Equilibrium Equations under VP and BAT

In Section XX, we analyze the short-run macroeconomic effects of trade policies by focusing on IX policies. Here we present the full description of the model inclusive of VP and BAT policies with an emphasis on how these policies compare and contrast with IX in key equations.

10.1 Retailers

Profit for the home retailers are

$$\Pi^R_t = (1-\tau^v_t)(1-\tau^\pi_t)\left\{P_tC_t - P_{Ht}y_{Ht} - \frac{P_{Ft}}{(1-\tau^\pi_t BAT_t)}y_{Ft}\right\} \tag{74}$$

where τ^v_t is the value-added tax rate, τ^π_t is the tax rate on profits, and $BAT_t \in \{0,1\}$ indicates wheter profit taxes are adjusted at the border or not. The border adjustment implies that the cost of imported goods (y_{Ft}) cannot be deducted from profits. Prices are inclusive of value-added taxes and, in the case of imported goods, are also inclusive of home tariffs (τ^m_t).

Given the CES structure of the aggregators (11), (12), and (13) , the foreign good demand is

$$y_{Ft} = (1-\omega)\left[\frac{P_{Ft}}{(1-\tau^\pi_t BAT_t)\,P_t}\right]^{-\theta} C_t \tag{75}$$

and the home-country consumer price index consistent with the CES aggregators is

$$P_t = \left[\omega P^{1-\theta}_{Ht} + (1-\omega)\left(\frac{P_{Ft}}{1-\tau^\pi_t BAT_t}\right)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{76}$$

10.2 Producers

After tax profits of firm i are

$$\Pi_t^i = (1-\tau_t^\pi)\left[(1-\tau_t^v)\,P_{Ht}(i)y_{Ht}(i) + \frac{(1+\varsigma_t^x)}{(1+\tau_t^{m*})\,(1-\tau_t^\pi BAT_t)}P_{Ht}^*(i)y_{Ht}^*(i) - (1-\varsigma_t^v)\,W_tN_t(i)\right] \tag{77}$$

where ς_t^v is a payroll subsidiy, ς_t^x is the export subsidy, and τ_t^{m*} are import tariffs levied in the foreign economy. Expression (77) indicates that export sales are excluded from the definition of profits when the corporate profit tax is adjusted at the border. Similarly, export sales are not subject to VATs.

Firm i sets prices as in Calvo (1983) so that, in any given period, it can adjust its price with probability $(1-\zeta_P)$ and maintains the same price as in the previous period with probability ζ_P. We assume that, absent any price adjustment by the firm, changes in VAT rates are fully passed through to the retailers and, as a consequence, consumers. Therefore, firm $i's$ domestic price inclusive of VAT evolves according to:

$$P_{Ht}(i) = \begin{cases} \overline{P}_{Ht}(i) & \text{w/prob } (1-\zeta_P) \\ P_{Ht-1}(i)\,\frac{(1-\tau_{t-1}^v)}{(1-\tau_t^v)} & \text{w/prob } \zeta_P \end{cases} \tag{78}$$

where ς_t^v is a payroll subsidiy, ς_t^x is the export subsidy, and τ_t^{m*} are import tariffs levied in the foreign economy. In our benchmark specification, we assume that firms set export prices in their domestic currency (PCP).[13] Hence, the price in foreign currency of exported goods $P_{Ht}^*(i)$ adjusts in order to equalize net unit revenues across markets:

$$P_{Ht}^*(i) = \frac{(1+\tau_t^{m*})\,(1-\tau_t^\pi BAT_t)\,(1-\tau_t^v)}{(1+\varsigma_t^x)}\frac{P_{Ht}(i)}{\varepsilon_t} \tag{79}$$

where ς_t^v is a payroll subsidiy, ς_t^x is the export subsidy, and τ_t^{m*} are import tariffs levied in the foreign economy.[14] Expression

[13] Our results are robust to alternative pricing assumptions, such as local currency pricing (LCP). We explore the implications of LCP in Section XX..

[14] We do not study the case in which foreign economies raise VAT taxes.

Firm i chooses a reset price, $\overline{P}_{Ht}(i)$, to maximize the expected present discounted value of profits conditional on no price change

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{s-t} \left[\Lambda_{s,t} \Pi_s^i \right] \tag{80}$$

subject to its production technology (22) , the evolution of prices in (78) and (79), retailers' demand in the home market (17) , and an analogous demand schedule in the foreign market.

The reset price $\overline{P}_{Ht}(i)$ satisfies the following optimality condition

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{s,t} \Omega_{s,t} \left[\overline{P}_{Ht}(i) \left(1 - \tau_t^v\right) - \left(1 - \varsigma_s^v\right) \frac{\gamma}{\gamma - 1} \frac{W_s}{\alpha A_s Z_s(i) N_s(i)^{\alpha - 1}} \right] = 0 \tag{81}$$

where $\Omega_{s,t} = Y_{Ht}(i) P_{Hs} \left(1 - \tau_s^{\pi}\right)$. Expression (81) indicates that the adjusted price $\overline{P}_{Ht}(i)$ is a constant markup over the weigthed-average expected future marginal costs during the period for which the price will be in effect.

Similarly, foreign firm j sets price $\overline{P}_{Ft}^*(j)$ in the foreign market according to

$$\mathbb{E}_t \Sigma_{s=t}^{\infty} \zeta_P^{*s-t} \Lambda_{s,t}^* Y_{Ft}^*(j) P_{Fs}^* \left[\overline{P}_{Ft}^*(j) - \frac{\gamma}{\gamma - 1} \frac{W_s^*}{\alpha A_s^* Z_s^*(i)^* N_s^*(j)^{\alpha - 1}} \right] = 0 \tag{82}$$

and lets the price for the home market $P_{Ft}(j)$ in order to equalize net unit revenues across markets:

$$P_{Ft}(j) = \frac{\left(1 + \tau_t^m\right)}{\left(1 + \varsigma_t^{x*}\right)\left(1 - \tau_t^v\right)} P_{Ft}^*(j) \varepsilon_t \tag{83}$$

Using the evolution of firm $i's$ price in (78) in the P_H price index equation (20) and using the law of large numbers we derive a forward-looking Phillips curve

$$\pi_{Ht} = \left[\zeta_P \left(\frac{1 - \tau_{t-1}^v}{1 - \tau_t^v} \right)^{1-\gamma} + (1 - \zeta_P) \left(\frac{\bar{P}_{H,t}}{P_{H,t-1}} \right)^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \tag{84}$$

where domestic inflation, π_{Ht}, depends on future marginal costs through the optimal reset price $\bar{P}_{H,t}$. This expression also reveals that, in the presence of nominal price rigidities ($\zeta_P > 0$), a VAT rate increase translates directly into higher domestic price inflation because of our assumption of full pass through of taxes.

10.3 Government Policy

Fiscal policy in the home and foreign country is characterized by a vector of fiscal instruments

$$s_t = (\tau_t^m, \varsigma_t^x, \tau_t^v, \varsigma_t^v, \tau_t^\pi, BAT_t, \tau_t^{m*}, \varsigma_t^{x*}) \tag{85}$$

We assume that $s_t \in S$ is a finite state Markov chain and Ω is the associated transition probability matrix, with element $\Omega_{i,j}$ indicating the probability to move from state i to state j. In our experiments below, we consider different configurations of S and Ω to capture alternative scenarios for the evolution of fiscal policy at home and possible retaliatory behavior abroad.

To complete the description of fiscal policy we assume that the government balances its budget in every period:

$$\tau_t^m \varepsilon_t P_{F,t}^* - \varsigma_t^x \varepsilon_t P_{H,t}^* + \frac{\tau_t^p}{1+\tau_t^p}\widetilde{\Pi}_t^\pi + \frac{\tau_t^v}{1+\tau_t^v} P_{F,t}^* - \frac{\varsigma_t^v}{1+\varsigma_t^v} W_t N_t = T_t \tag{86}$$

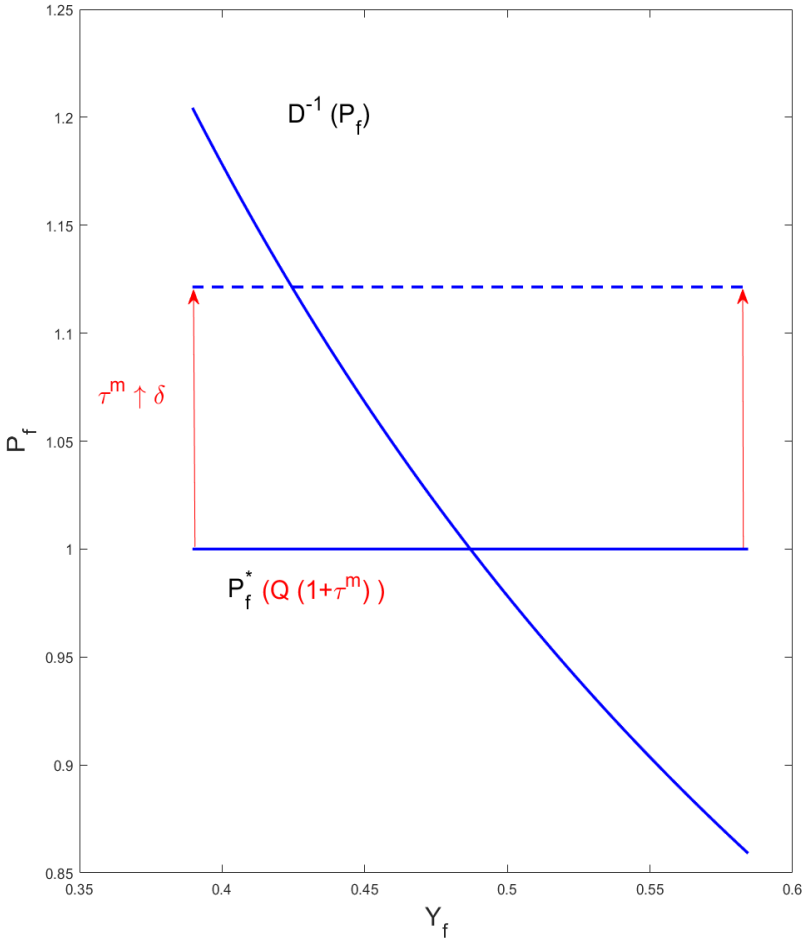
Monetary policy in the home country follows the interest rate rule

$$R_t = \frac{1}{\beta}\left[\pi_{Ht}\frac{(1-\tau_t^v)}{(1-\tau_{t-1}^v)}\right]^{\varphi_\pi} (\tilde{y}_t)^{\varphi_y} (\varepsilon_t - \bar{\varepsilon}_t)^{\varphi_\varepsilon} \tag{87}$$

where φ_π is the weight on domestic price inflation (π_{Ht}) and φ_y is the weight on the output gap $(\tilde{y}_t)$. The parameter $\varphi_\varepsilon \in \{0, M\}$ governs the sensitivity of the interest rate rule to changes in the nominal exchange rate.[15] When $\varphi_\varepsilon = 0$, the home interest rate responds exclusively to fluctuations in domestic inflation and output gaps. When $\varphi_\varepsilon = M$, the home interest rate rule proactively responds to deviations of the nominal exchange rate from a target exchange rate.

[15] See Benigno *et al.* (2007) for a discussion of interest rate rules that maintain a fixed exchange rate.

Figure 1: Supply Effects of IX (Partial Equilibrium: Fixed RER)



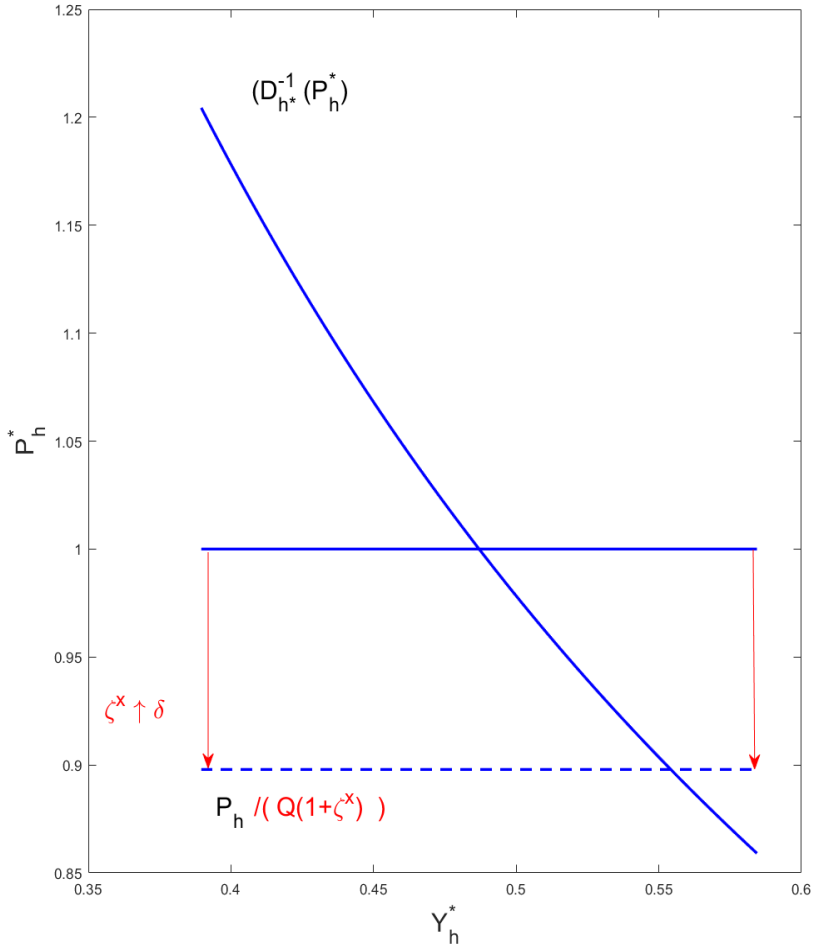


Figure 2: Exchange Rate and Trade Balance

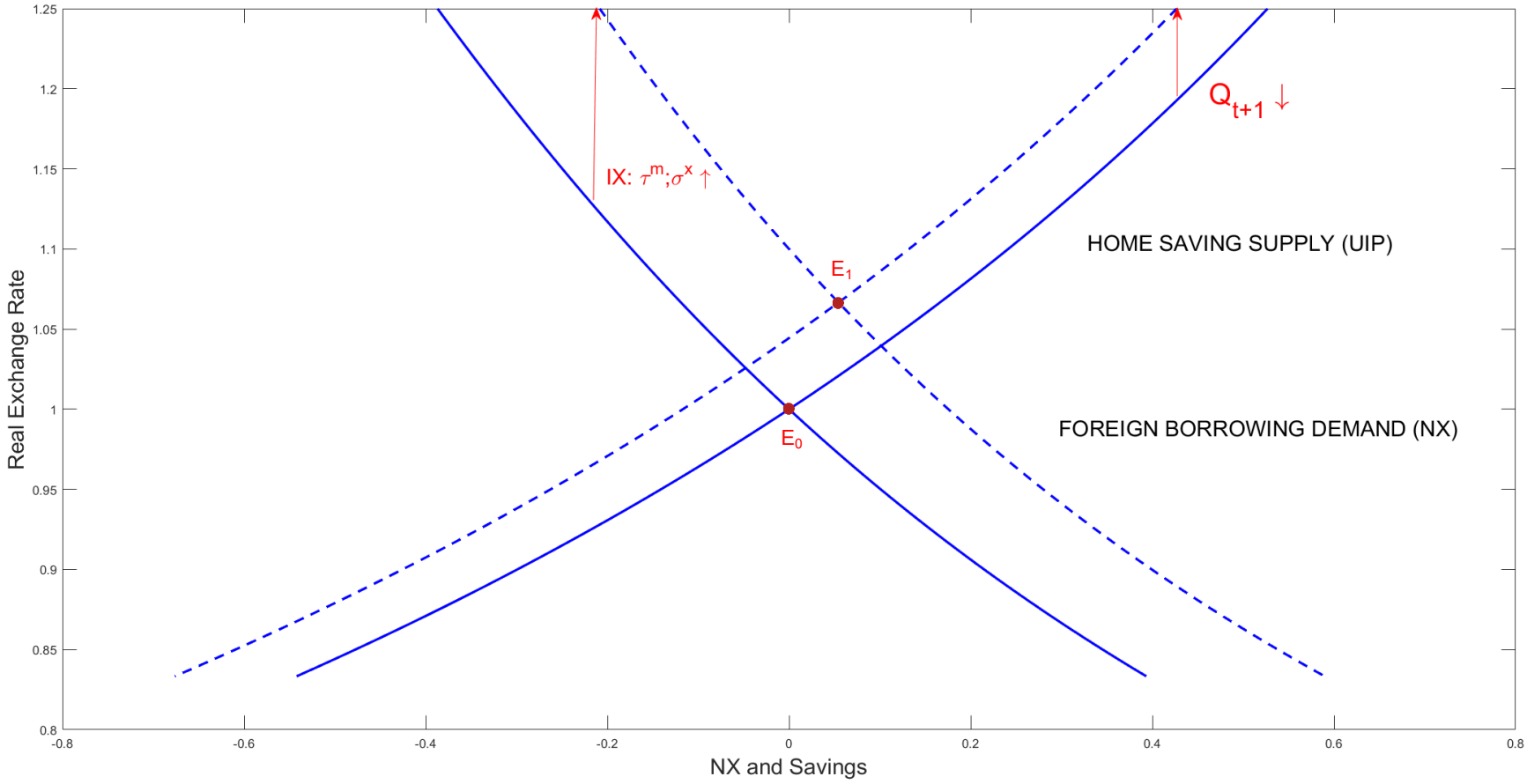


Figure 3: Permanent IX vs. IX with Retaliation

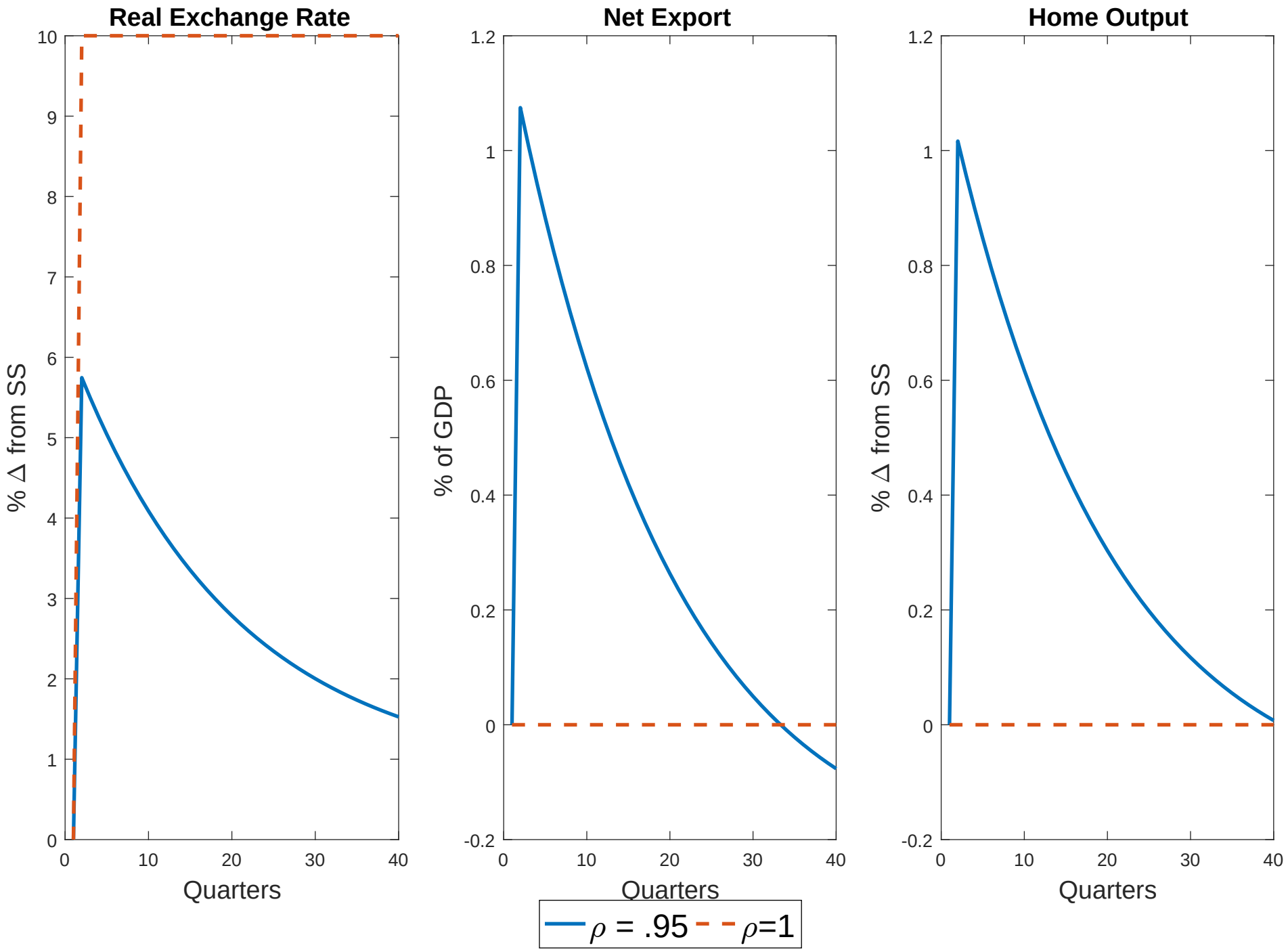


Figure 4: Macroeconomic Effects of IX

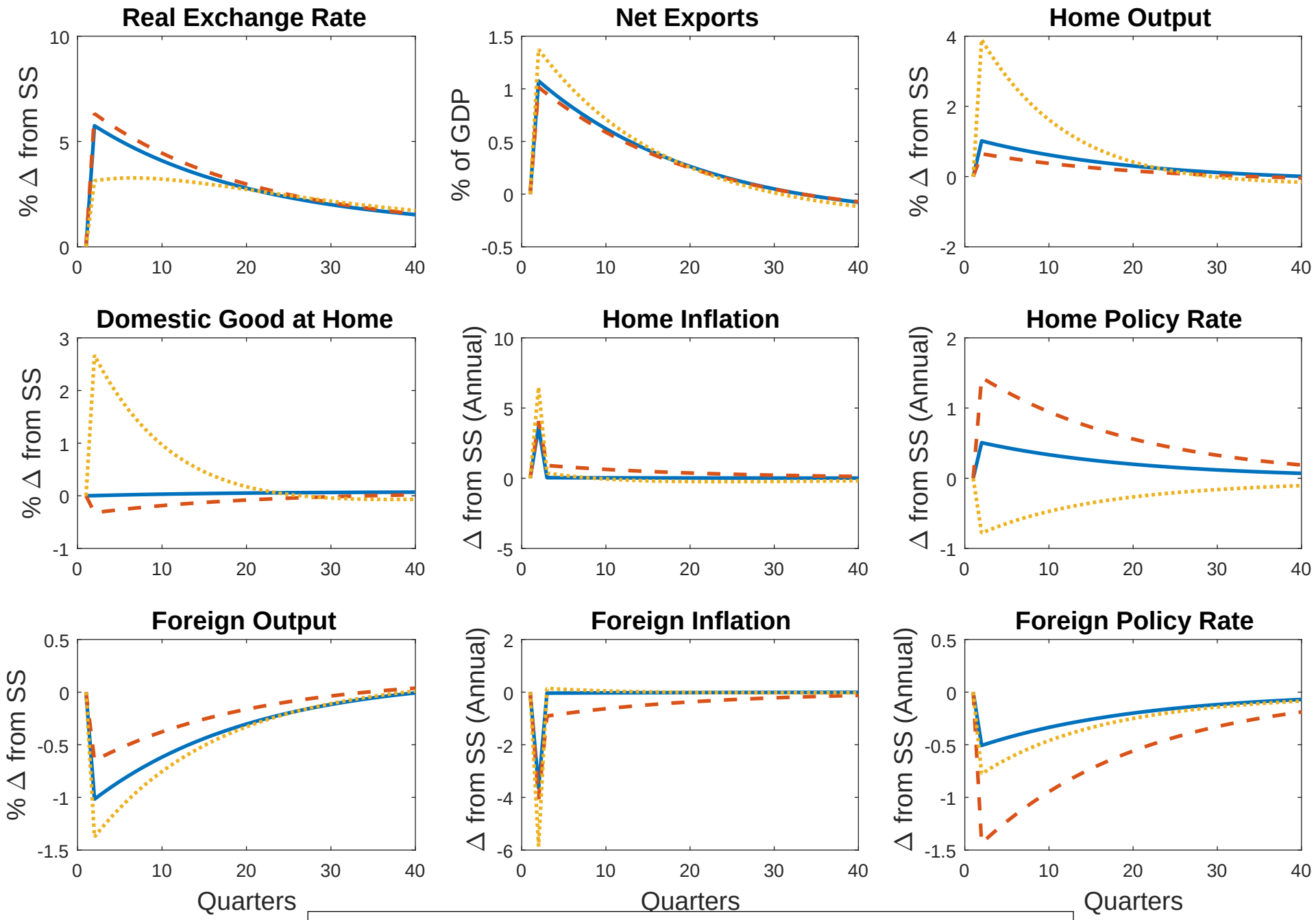


Figure 5: Permanent Unilateral IX With and Without Foreign Holdings of Home Bonds

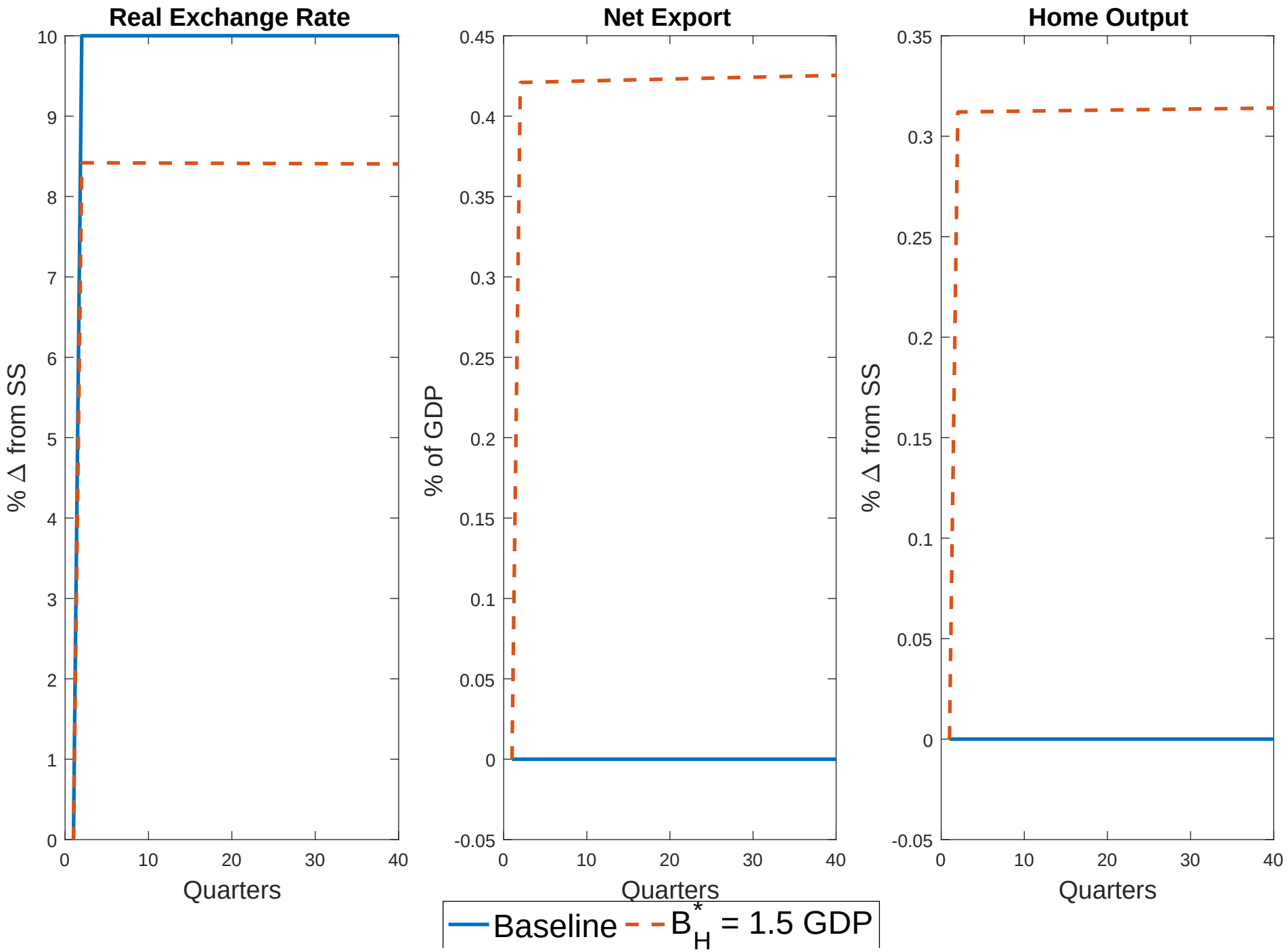
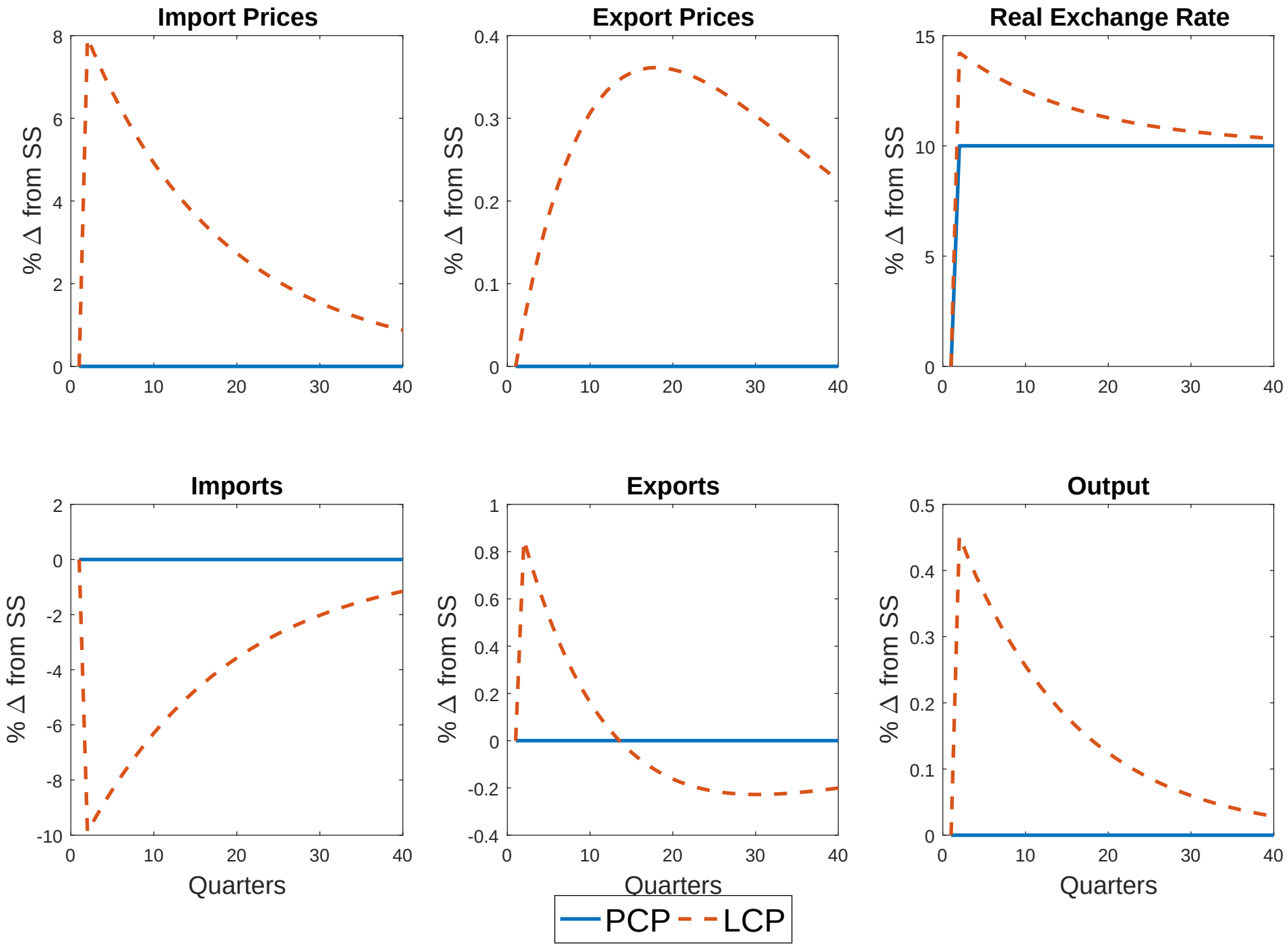


Figure 6: Permanent Unilateral IX With PCP and LCP



VP vs IX Calvo Rigidities (PCP)

