Trade Policies and Fiscal Devaluations*

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Abstract

Fiscal devaluations—an increase in import tariffs and export subsidies (IX) or an increase in value-added taxes and payroll subsidies (VP)—have been shown to provide as much stimulus under fixed exchange rates as a currency devaluation. When the tax pass-through is large and agents expect policies to be reversed, we find that IX boosts output even under flexible exchange rates, while VP tends to be contractionary. A canonical DSGE model requires both features to account, quantitatively, for the response of the German economy to VP in 2007. These findings question the viability of fiscal devaluations in a currency union.

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1 Introduction

There is a long-standing debate about how trade and fiscal policies can provide macroeconomic stimulus by boosting international competitiveness. In considering different ways of alleviating a

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deep economic recession within the confines of the gold standard, Keynes argued that the United Kingdom could derive a similar degree of stimulus from raising import tariffs and providing export subsidies as through devaluing the pound against gold.\footnote{See Macmilan et al. (1931). Eichengreen (1981) provides a detailed account of the contentious political debate that preceded the United Kingdom’s shift toward protectionist trade policies in the early 1930s.} However, even if these policies can provide stimulus under fixed exchange rates, it is unclear to what extent they would do so under flexible exchange rates. Mundell (1961) questioned whether the mercantilist prescription of higher import tariffs and export subsidies would stimulate demand in economies with floating exchange rates, as “equilibrium in the balance of payments is automatically maintained by variations in the price of foreign exchange.”

More recently, there has been renewed interest in the question of how countries constrained by membership in a currency union can implement changes in tax instruments with economic effects akin to a currency depreciation. The approach of financing competitiveness-enhancing payroll tax cuts with VAT increases, in particular, has a strong intuitive appeal and has received attention by both academics and policymakers.\footnote{See Calmfors (1998) for an early argument. Correia et al. (2013) also study the role of VAT changes when monetary policy is constrained by the ZLB.} In a seminal contribution, Farhi et al. (2014) (FGI henceforth) provide conditions so that, under fixed exchange rates, fiscal devaluations implemented via either uniform import tariffs and export subsidies (IX policy) or a reduction in employer payroll taxes financed by an increase in VAT rates (VP policy) reproduce the same allocation as an exchange rate devaluation. Although these policies may need to be supplemented by additional tax instruments, these authors show in a quantitative application that a simple VP policy in Spain would have gone a long way in supporting economic activity during the Great Recession. Some euro-area governments have attempted to provide macroeconomic stimulus by implementing “fiscal devaluations,” including the government of Germany in 2007.

In this paper, we make three contributions to the understanding of these important academic and policy issues by studying IX and VP policies in a New Keynesian open-economy framework that builds on contributions by Gali and Monacelli (2005a) and Corsetti et al. (2010). First, we argue that the transmission of IX and VP policies is fundamentally different under our assumption of full pass-through of taxes. Indeed, in a special case often considered in the literature, we show that under fixed exchange rates IX implements a currency devaluation, whereas VP turns out to have no allocative effects. Second, we find that IX policies tend to boost
output even under flexible exchange rates. The macroeconomic effects of VP, instead, depend critically on the relative strength of two offsetting channels. On the one hand, intertemporal substitution effects make VP contractionary; on the other hand, sluggish wage adjustments allow payroll subsidies to boost aggregate supply and output. We find that the contractionary effects of VP are larger when monetary policy is constrained (e.g., under an exchange rate peg or in a currency union). Third, we assess the empirical relevance of our novel theoretical predictions on the effects of VP by studying the effects of the German fiscal reform in 2007. We find that our model can account for the relatively poor performance of the German economy in response to this attempted fiscal devaluation.

To highlight our theoretical contribution, we illustrate the different transmission mechanisms of IX and VP policies in the special case of unexpected and permanent policy changes and flexible wages. Under flexible exchange rates, IX and VP policies are equivalent and have no allocative effects, as they both are offset by a permanent real exchange rate appreciation of an amount equal to the size of the policy. Nonetheless, the two policies are only beguilingly equivalent, as they achieve neutrality through different adjustments. In the case of IX, an immediate jump in the nominal exchange rate offsets the effect of tariffs on import prices and of export subsidies on export prices, ensuring that all relative prices are unaffected. In the case of VP, a jump in nominal wages induces firms to keep labor demand unchanged, by offsetting the reduction in marginal costs caused by the payroll subsidy, and households to keep their labor supply unchanged, by offsetting the reduction in real wages caused by higher consumer prices. Notably, as VAT changes apply to both imported and domestic goods, the relative price of traded goods is unaffected, and consumer prices drive the appreciation of the real exchange rate. In sum, IX policies are transmitted to the economy by boosting domestic firms’ competitiveness in international markets, whereas VP policies operate by affecting the equilibrium in the domestic labor market.

The different general equilibrium adjustments that deliver neutrality of IX and VP provide the intuition for our main theoretical contribution to the fiscal devaluation literature: Under

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3 The exact conditions that characterize this special case also include that foreign-currency denominated bonds represent the only internationally traded asset and that exporters let prices vary one for one with exchange rates (producer currency pricing).

4 This finding can be interpreted as an application of Lerner (1936) to dynamic economies. See also Costinot and Werning (2017).
fixed exchange rates, IX policies implement an exchange rate devaluation, but VP policies remain neutral. Given that under flexible exchange rates the effects of an IX policy are perfectly offset by a nominal appreciation, it follows that, absent an exchange rate response, IX elicits economic effects identical to a currency depreciation. Instead, the neutrality of VP does not require any adjustment in the nominal exchange rate; hence, the fixed exchange rate regime does not pose any constraint to achieving the same neutrality outcome as under flexible exchange rates. This result is in sharp contrast to FGI and is due to a key difference between our framework and theirs. While we assume that pre-tax prices are sticky and VAT changes are fully passed through to consumer prices, FGI assume that prices are sticky inclusive of VATs and firms reduce margins in response to VAT increases.\(^5\)

We next provide a broader characterization of the macroeconomic effects of the two policies once we depart from the restrictive conditions of the special case described earlier.

First, we abandon the assumption that agents believe that policy changes will remain in place forever. We use a Markov-switching framework to capture the possibility that policy actions may be reversed because of political shifts or that they may induce retaliation by other countries. Second, we consider the role of wage rigidity for the transmission of these policies. The appeal of competitiveness-enhancing payroll tax cuts financed with VAT increases appears greater when nominal rigidities prevent a strong offsetting wage response.\(^6\)

We find that, when IX is expected to be reversed or to trigger retaliation, it tends to boost output and inflation even under flexible exchange rates. In this case, the exchange rate must eventually return to its pre-shock level, and, as a consequence, the immediate appreciation of the currency falls short of completely offsetting the expenditure-switching effects of the policy on imports and exports. We find that the resulting boost to net exports and output is robust to a wide range of environments, including departures from flexible wages and different monetary policy regimes.

Differently from IX policies, the macroeconomic effects of VP depend critically on the details

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\(^5\)In an earlier version of this manuscript, we discussed evidence from a large body of empirical literature pointing to full and immediate pass-through of VAT increases to consumer prices. As our discussant E. Farhi noted, however, this evidence does not directly apply to our analysis of VP policies. We return to this discussion in our quantitative analysis of the German experience in 2007.

\(^6\)For an early argument in favor of variations in payroll taxes in the presence of wage rigidities, see Calmfors (1998). For a recent discussion on the effects of wage rigidity in a small open economy belonging to a currency union, see also Gali and Monacelli (2016).
of the environment. We first show that a VP policy that is not perceived as permanent, perhaps because it may be reversed by future governments, has contractionary effects due to an intertemporal substitution channel. As the expected decline in future VAT rates raises the price of current consumption relative to future consumption, households increase savings and aggregate demand declines. Thus, a temporary VP (1) exerts a strong contractionary impetus unless monetary policy cuts interest rates sufficiently and (2) is even more likely to reduce output under fixed exchange rates or in a currency union. That said, we then show that VP policies can provide macroeconomic stimulus if wages are rigid, as the reduction in firms’ marginal costs induced by payroll subsidies is not mitigated by an offsetting increase in wages.

In sum, our novel theoretical predictions on the effects of VP policies highlight the role of assumptions about tax pass-through and expectations about the evolution of policies. When VAT changes are fully passed through to consumer prices, VP policies can be either contractionary or expansionary, depending on the relative strength of the intertemporal substitution channel induced by possible policy reversals vis-à-vis the competitiveness-enhancing channel arising in the case of slow wage adjustments. In contrast, when prices are sticky inclusive of VATs, the intertemporal substitution channel is muted, and VP policies elicit macroeconomic effects akin to those of IX policies, and, hence, tend to be stimulative.

In the last section, we assess the empirical relevance of assumptions about tax pass-through and expectations about the evolution of policies by studying the attempted fiscal devaluation in Germany. In January 2007, the German government implemented a fiscal reform that simultaneously increased VAT rates and reduced payroll taxes. We first document that, in the data, this VP policy was associated with a large pass-through of the VAT increase to consumer prices and a contraction in domestic demand and output, notwithstanding a small boost to net exports. We then consider a canonical medium-scale DSGE model extended to allow for heterogeneity in the price response to VAT changes. We choose the values of the parameters controlling the share of firms that fully pass through VAT changes and the perceived persistence of the policy change so that they minimize the distance between the German data on output and inflation and the corresponding model-simulated series. Our estimates suggest that the model requires both a large fraction of firms passing VAT changes through to consumer prices and a positive probability of policy reversal in order to account for the data. While obtained purely from aggregate data, our estimate of high tax pass-through is in line with the heteroge-
nous pricing response across firms documented in Bundesbank (2007). Similarly, the positive probability of policy reversal is consistent with reasonable assumptions about the likelihood of political turnover and its implications for the evolution of fiscal policy, as discussed in D’Acunto et al. (2016). In addition, we find that the limiting assumption of permanent policy changes and all prices sticky inclusive of value-added taxes, typically adopted in the fiscal devaluation literature, appears strongly rejected by the data.

The paper is organized as follows. Section 2 describes the model. Section 3 develops some intuition about the effects of IX and VP starting from conditions for equivalence and neutrality. Section 4 discusses the transmission mechanisms of IX and VP policies once we depart from the conditions for equivalence and neutrality, with a focus on reversal and on sticky wages. Section 5 presents our quantitative analysis about the attempted 2007 German fiscal devaluation. Section 6 concludes.

2 Model

The economy consists of a home ($H$) country and a foreign ($F$) country that are isomorphic in structure. Foreign variables are denoted with an asterisk. Agents in each economy include households, retailers, producers of intermediate goods, and the government. For ease of exposition, the next sections describe the optimization problems solved by each type of agent under the assumptions of producer currency pricing (PCP), fully flexible wages, and a simple financial market structure in which only a foreign currency bond is traded internationally. Appendix A presents a more general model that allows for alternative assumptions about price and wage setting and financial market structure, as well as for differences in country size; all of the theoretical results are derived within the context of this general framework.

2.1 Households

Households in the home country derive utility from a final good consumption ($C_t$) and disutility from labor ($N_t$). They maximize expected lifetime utility

$$E_0 \Sigma_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

(1)
subject to the budget constraint

\[ P_t C_t + B_{Ht} + \varepsilon_t \left[ B_{Ft} + \frac{\chi}{2} \left( B_{Ft} - \bar{B}_F \right)^2 \right] = R_{t-1} B_{Ht-1} + \varepsilon_t R_{t-1}^* B_{Ft-1} + W_t N_t + \Pi_t + T_t \]  

(2)

where \( P_t \) is the consumer price index, \( B_{Ht} \) are noncontingent nominal bond holdings denominated in domestic currency, \( B_{Ft} \) are noncontingent nominal bond holdings denominated in foreign currency, \( R_{t-1}^* \) is the foreign nominal interest rate, \( \varepsilon_t \) is the nominal exchange rate (defined as the price of one unit of foreign currency in terms of units of the home currency), \( W_t \) is the wage rate, \( \Pi_t \) is the aggregate profit of the home firms assumed to be owned by the home consumers, and \( T_t \) is a lump-sum transfer from the government. The parameter \( \chi \geq 0 \) allows for the possibility that home households face quadratic costs of adjusting their holdings of foreign bonds.\(^7\) In our baseline calibration we focus on the case, often considered in the literature, in which foreign households cannot invest in the domestic bond so that only the foreign bond is traded internationally.\(^8\)

We assume that the period utility function takes the form

\[ U(C, N) = \frac{1}{1 - \sigma} C_t^{1-\sigma} - \frac{1}{\eta + 1} N_t^{1+\eta} \]  

(3)

Optimality requires

\[ N_t^{\eta} C_t^\sigma = \frac{W_t}{P_t} \]  

(4)

\[ 1 = E_t \left[ \Lambda_{t,t+1} \frac{P_{t+1}}{P_t} R_t \right] \]  

(5)

\[ 1 = E_t \left[ \Lambda_{t,t+1} \frac{P_t}{P_{t+1}} \varepsilon_{t+1} R_t^* \right] \]  

(6)

where \( \Lambda_{t,s} = \beta^{s-t} \left( \frac{C_s}{C_t} \right)^\sigma \) is the real stochastic discount factor of the home household. The

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\( ^7 \)All of our theoretical results go through irrespective of the value of \( \chi \) provided that \( \chi \geq 0 \). For simplicity, the first-order conditions we report in the text assume \( \chi = 0 \). In our simulations, we introduce very small costs of adjustment to ensure stability of a first-order approximation. See Schmitt-Grohé and Uribe (2003).

\( ^8 \)That is, the budget constraint for foreign households is given by

\[ P_t^* C_t^* + B_{Ft}^* + \frac{1}{\xi} \left[ B_{Ht}^* + \frac{\chi}{2} \left( B_{Ft}^* - \bar{B}_F \right)^2 \right] = R_{t-1}^* B_{Ht-1}^* + \frac{1}{\xi} R_{t-1}^* B_{Ft-1}^* + W_t^* N_t^* + \Pi_t^* + T_t^* \]

In our baseline analysis, we set \( \chi^* = \infty \) so that only foreign currency bonds are traded internationally. We consider relaxing this assumption in Section 4.4.
corresponding optimality condition for foreign household holdings of the foreign bond is

\[ 1 = \mathbb{E}_t \left[ \Lambda^*_{t,t+1} \frac{P^*_t}{P^*_{t+1}} R^*_t \right] \tag{7} \]

Combining the optimality conditions for bond holdings (6) and (7), one obtains the risk-sharing condition

\[ \mathbb{E}_t \left\{ \left[ \Lambda^*_{t,t+1} \frac{Q_{t+1}}{Q_t} \Lambda^*_{t+1} \right] \frac{P^*_t}{P^*_{t+1}} \right\} = 0 \tag{8} \]

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,

\[ Q_t = \frac{P^*_t}{P_t} \tag{9} \]

### 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

\[ C_t = \left[ \omega H Y^\theta_{Ht} + (1 - \omega H)^\theta Y^\theta_{Ft} \right]^{\frac{1}{\theta}} \tag{10} \]

where \( \theta \geq 0 \) determines the elasticity of substitution between home and foreign intermediate goods 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

\[ Y_{Ht} = \left[ \int_0^1 Y_{Ht}(i) \frac{\gamma - 1}{\gamma} di \right]^{\frac{\gamma}{\gamma - 1}} \tag{11} \]

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

where \( \gamma \geq 0 \) determines the elasticity of substitution across varieties.

Profits for the home retailers are

\[ \Pi^R_t = (1 - \tau_t^w) [P_t C_t - P_{Ht} Y_{Ht} - P_{Ft} Y_{Ft}] \tag{13} \]
where $P_{Ht}$ and $P_{Ft}$ are the price indexes of the home and foreign goods and $\tau_t^v$ is the VAT rate. The border adjustment implies that the cost of imported goods ($Y_{Ft}$) cannot be deducted from profits. Prices are inclusive of VATs and, in the case of imported goods, are also inclusive of home tariffs ($\tau_t^m$).

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

\[ Y_{Ht} = \omega \left[ \frac{P_{Ht}}{P_t} \right]^{-\theta} C_t \]  
\[ Y_{Ft} = (1 - \omega) \left[ \frac{P_{Ft}}{P_t} \right]^{-\theta} C_t \]  
\[ Y_{Ht}(i) = \left[ \frac{P_{Ht}(i)}{P_{Ht}} \right]^{-\gamma} Y_{Ht} \]  
\[ Y_{Ft}(i) = \left[ \frac{P_{Ft}(i)}{P_{Ft}} \right]^{-\gamma} Y_{Ft} \]

The zero profit conditions for home retailers imply that price indexes satisfy

\[ P_t = \left[ \omega P_{Ht}^{1-\theta} + (1 - \omega) P_{Ft}^{1-\theta} \right]^{\frac{1}{1-\theta}} \]  
\[ P_{Ht} = \left[ \int_0^1 P_{Ht}(i)^{1-\gamma} di \right]^{\frac{1}{1-\gamma}} \]  
\[ P_{Ft} = \left[ \int_0^1 P_{Ft}(i)^{1-\gamma} di \right]^{\frac{1}{1-\gamma}} \]

### 2.3 Producers

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

\[ Y_{Ht}(i) + Y^*_{Ht}(i) = A_t N_t^\alpha(i) \] 

where $Y_{Ht}(i)$ and $Y^*_{Ht}(i)$ are firm $i$’s sales in the domestic and foreign market, respectively; $A_t$ is the aggregate level of technology; and $\alpha \in (0, 1)$ controls the curvature of the production
function.

In our benchmark specification, we assume PCP, that is, producers set prices in the domestic currency while letting prices in the foreign market adjust to ensure that unit revenues are equalized across markets. We can then write firm $i$’s profits as

$$\Pi^P_t(i) = P_{Pt}(i) [Y_{Ht}(i) + Y^*_{Ht}(i)] - (1 - \varsigma^p_t) W_t N_t(i)$$  \hspace{1cm} (22)

where $P_{Pt}(i)$ denotes the unit revenue from domestic sales of the home variety and $\varsigma^p_t$ is a payroll subsidy.

The presence of VATs introduces a wedge between unit revenues $P_{Pt}(i)$ and the price paid by domestic retailers for $P_{Ht}(i)$:

$$P_{Pt}(i) = (1 - \tau^v_t) P_{Ht}(i)$$  \hspace{1cm} (23)

Similarly, import tariffs ($\tau^m_t$) and export subsidies ($\varsigma^x_t$) create a wedge between the foreign currency price paid by foreign retailers, $P^*_{Ht}(i)$, and firm $i$’s foreign currency unit revenue from exports, $P_{Pt}(i)$:

$$P^*_{Ht}(i) = \frac{(1 + \tau^m_t)}{(1 + \varsigma^x_t)(1 - \tau^m_t)} \frac{P_{Pt}(i)}{\varepsilon_t}$$  \hspace{1cm} (24)

Producers set prices in staggered contracts by following a Calvo-style timing assumption and with full pass-through of VATs. That is, a domestic firm that adjusts its price at time $t$ sets the unit revenues $P_{Pt}(i)$, and, absent any price adjustment until time $s > t$, changes in VATs are fully reflected in retailers’ costs of purchasing the home variety

$$P_{Hs}(i) = \frac{P_{Pt}(i)}{(1 - \tau^v_s)}.$$  \hspace{1cm} (25)

Each firm that reoptimizes at time $t$ will then choose $\tilde{P}_{Pt}$, to solve

$$\max E_t \sum_{s \geq t} \varsigma_{Pt}^{s-t} \Lambda_{t,s} \left\{ \frac{P_{Pt}(i) [Y_{Hs}(i) + Y^*_{Hs}(i)] - (1 - \varsigma^p_t) W_s N_s(i)}{P_s} \right\}$$  \hspace{1cm} (26)

where $\varsigma_{Pt}$ is the probability that the firm will not be able to adjust its price in any given period, labor demand satisfies (21), and domestic and foreign sales are determined by retailers’ demand schedules in both the home and foreign market (i.e., equation (16) and its foreign analogue, respectively). The reset price $\overline{P}_{Pt}(i)$ is a fixed markup over a weighted average of
future marginal costs:

\[
\tilde{P}_{Pt}(i) = (1 - \zeta_P^t) E_t \sum_{s \geq t} \tilde{A}_{t,s}(i) \gamma \frac{W_s}{(1 - \zeta_P^t)^\gamma - 1} \alpha A_s N_s^{\alpha - 1}(i)
\]  

(27)

where the weights

\[
\tilde{A}_{t,s}(i) = \frac{\zeta_s^t - t \Lambda_{t,s}^t P_t^s \Lambda_{s,t}^s P_s^t \left[ Y_{Hs}(i) + Y_{Hs}^*(i) \right]}{E_t \sum_{u \geq t} \zeta_s^u - t \Lambda_{t,u}^u P_t^u P_s^u \left[ Y_{Hu}(i) + Y_{Hu}^*(i) \right]}
\]

(28)

take into account the probability that the contract price will remain in effect, \(\zeta_P^t\); households’ relative value of money over time, \(\Lambda_{t,s}^t\); and firms’ future sales volumes \([Y_{Hs}(i) + Y_{Hs}^*(i)]\).

We let the domestic producer price index \(P_{Pt}\) be defined in a way that mimics the consumer price index in (19)

\[
P_{Pt} = \left[ \int P_{Pt}(i)^{1-\gamma} di \right]^{\frac{1}{1-\gamma}},
\]

(29)

and our Calvo-style pricing assumption then implies that domestic producer price inflation is given by

\[
\pi_{Pt} = \left[ \zeta_P + (1 - \zeta_P) \left( \frac{\tilde{P}_{Pt}}{P_{Pt-1}} \right)^{1-\gamma} \right]^{\frac{1}{1-\gamma}}
\]

(30)

Expression (30) indicates that domestic producer price inflation depends on future marginal costs through the optimal reset price \(\tilde{P}_{Pt}\), which is identical across all firms that reset at time \(t\). Combining equations (27) and (30), one obtains the familiar New Keynesian Phillips curve linking domestic producer price inflation to current and future marginal costs.

Similarly, foreign firm \(j\) sells its good in the foreign country at a price of \(P_{Ft}^*(j)\) and in the home country according to the PCP condition

\[
P_{Ft}(j) = \frac{(1 + \tau_t^m)}{(1 + \tau_t^x)(1 - \tau_t^x)} \varepsilon_t P_{Pt}^*(j)
\]

(31)

Foreign firms that are allowed to reset their price choose their contract price \(\bar{P}_{Pt}^*(j)\) so that

\[
\bar{P}_{Pt}^*(i) = (1 - \zeta_P^{pt}) E_t \sum_{s \geq t} \bar{A}_{t,s}^*(i) \gamma \frac{W_s^*}{(1 - \zeta_P^{pt})^\gamma - 1} \alpha A_s^* N_s^{*\alpha - 1}(i)
\]

(32)
2.4 Government Policy

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

\[ s_t = (\tau^m_t, \varsigma^x_t, \tau^v_t, \varsigma^p_t, \tau^m_*, \varsigma^x_*, \tau^v_*, \varsigma^p_*) \] (33)

We assume that policy actions \( s_t \in S \) follow a finite-state Markov chain. We consider IX and VP policies in isolation. Specifically, when considering IX, the policy regime is in one of three different states \( s_t \in S^{IX} = \{ s^{NT}, s^{IX}, s^{IX,IX} \} \). In the first state \( (s^{NT}) \), no country levies any import tariffs or provides any export subsidy ("No Tax" state). In the second state \( (s^{IX}) \), the home country unilaterally adopts an IX policy that raises import tariffs and export subsidies by the same amount \( \delta \) (i.e., \( \tau^m_t = \varsigma^x_t = \delta \)). In the third state \( (s^{IX,IX}) \), the foreign country retaliates in a symmetric way by raising its own tariffs and subsidies by the same amount as the home country, i.e., \( \tau^m_t = \varsigma^x_t = \tau^m_* = \varsigma^x_* = \delta \). Similarly, when considering VP policies, we assume that \( s_t \in S^{VP} = \{ s^{NT}, s^{VP}, s^{VP,VP} \} \).

The transition probability matrix \( \Omega \) can be expressed as:

\[
\Omega^z = \begin{bmatrix}
1 - a & a & 0 \\
(1 - \pi)(1 - \rho) & \rho & \pi(1 - \rho) \\
(1 - \varphi) & 0 & \varphi
\end{bmatrix}
\] (34)

where \( z \in \{ IX, VP \} \) and element \( \Omega_{i,j} \) indicates the probability of moving from state \( i \) to state \( j \). For instance, the first row of matrix \( \Omega^{IX} \) implies that the transition from the no-tax state \( s^{NT} \) to the \( s^{IX} \) state—where the home country implements the IX policy unilaterally—is anticipated with probability \( a \). The second row indicates that, given an implementation of IX, the economy remains in the state \( s^{IX} \) with probability \( \rho \), returns to the no-tax state with probability \( (1 - \pi)(1 - \rho) \), and transitions to the retaliation state \( s^{IX,IX} \) with probability \( \pi(1 - \rho) \). Once the foreign country retaliates, the economy returns to a no-tax state with probability \( 1 - \varphi \), while, with probability \( \varphi \), it remains in the trade war regime. In this specification, the foreign country does not abandon its retaliatory policies unilaterally, so a trade war can end...
only through a coordinated policy reversal by both countries.\footnote{In our calibration the exact value of $\varphi$ does not have material effects on outcomes (see the discussion in Appendix E). Thus, in our experiments, we set $\varphi$ equal to $\rho$.}

This general specification for the policy regime is helpful for considering a wide range of policy configurations and dynamics as special cases, including unilateral changes in policies that are either permanent or expected to eventually be reversed, and foreign retaliation. Moreover, the Markov structure can be used to study how expectations of future changes in policies affect current macroeconomic outcomes.

The home government balances its budget in every period through levying lump-sum taxes $T_t$:

$$T_t = \left[ \frac{\tau^m_t + \tau^n_t}{1 + \tau^m_t} \right] P_{Ft} Y_{Ft} + \tau^n_t P_{Ht} Y_{Ht} - \frac{\zeta^p_t}{(1 + \zeta^p_t)} P_{Pt} Y_{Ht}^* - \varsigma^p_t W_t N_t. \quad (35)$$

Monetary policy follows a Taylor-style interest rate rule:

$$R_t = \frac{1}{\beta} \left( \pi_{Pt} \right)^{\varphi_{\pi}} \left( \tilde{y}_t \right)^{\varphi_y} \left( \tilde{\varepsilon}_t \right)^{\varphi_{\varepsilon}} \quad (36)$$

where $\varphi_{\pi}$ is the weight on producer price inflation ($\pi_{Pt}$), $\varphi_y$ is the weight on the output gap ($\tilde{y}_t$), and $\varphi_{\varepsilon}$ determines how policy rates respond to deviations of the nominal exchange rate from an exchange rate target (i.e., $\tilde{\varepsilon}_t = \frac{\varepsilon_t}{\bar{\varepsilon}}$).\footnote{Since Galí and Monacelli (2005b), the targeting of domestic producer price inflation in open-economy New Keynesian models has become standard practice. See also Galí and Monacelli (2016). The output gap in the Taylor rule is constructed as output relative to the level of output that would prevail in the absence of price rigidity. For a discussion of interest rate rules that maintain a fixed exchange rate, see Benigno et al. (2007).} When $\varphi_{\varepsilon} = 0$, the home interest rate responds exclusively to fluctuations in the output gap and domestic inflation. This specification implies that the central bank looks through changes in inflation due to the direct effects of tariffs and VATs. When $\varphi_{\varepsilon} = M$, with $M$ large, the interest rate is set so that the country pegs its exchange rate to a predetermined target ($\bar{\varepsilon}$).

### 2.5 Market Clearing and Equilibrium

Labor market clearing equates households’ supply of labor with aggregate firms’ demand

$$N_t = \int N_t(i) \, di. \quad (37)$$

Bond market clearing requires

$$B_{Ft} + B_{*Ft} = 0 \quad (38)$$
\[ B_{Ht} + B_{Ht}^* = 0 \]  

Combining home and foreign households’ budget constraints and using the bond market clearing conditions, we get a balance of payments equilibrium equation,

\[ \varepsilon_t B_{Ft} - B_{Ht}^* = \varepsilon_t B_{Ft-1} R_{t-1}^* - B_{Ht-1}^* R_{t-1} + NX_t \]  

which requires that home households increase their holdings of foreign bonds to meet the total amount of new borrowing demand from abroad, given by home net exports:

\[ NX_t = \frac{P_{Pt}}{(1 + \varepsilon_t)} (Y_{Ht}^* - S_t Y_{Ft}) \]  

where \( S_t \) denotes the terms of trade, the equation for which is

\[ S_t = \varepsilon_t \frac{(1 + \varepsilon_t)}{(1 + \varepsilon_t^*)} P_{Pt}^*. \]

Let the initial condition for home holdings of bonds and individual producer prices in the home and foreign market be

\[ x_0 = [B_{Ft-1} R_{t-1}^*, B_{Ht-1}^* R_{t-1}^*, P_{Ht-1} (i), P_{Ft-1}^* (i)] \]

**Definition.** Given an initial state \( x_0 \) and a stochastic process for fiscal policy \( \{s_t\} \), an equilibrium consists of (i) an allocation at home, \( \Xi = \{C_t, B_{Ft}, N_t, Y_{Ht}, Y_{Ft}, Y_{Ht} (i), Y_{Ft} (i)\}_{t \geq 0} \), and abroad \( \Xi^* \); (ii) firm-level prices and production decisions at home, \( \Phi = \{\bar{P}_{Pt} (i), N_t (i), P_{Ht} (i), P_{Ht}^* (i)\}_{t \geq 0} \), and abroad \( \Phi^* \); (iii) aggregate prices at home, \( \Gamma = \{P_t, P_{Ht}, P_{Ft}, P_{Pt}, \pi_t^P, W_t, R_t\}_{t \geq 0} \) and abroad \( \Gamma^* \); and (iv) (domestic) bond holdings, net exports, currency exchange rates and terms of trade \( \{B_{Ht}, B_{Ft}^*, NX_t, \varepsilon_t, S_t\} \) such that

1. The allocation \( \Xi \) satisfies households’ and retail firms’ optimality conditions (4) – (6) and (14) – (17) as well as the analogous conditions in the foreign country;

2. Individual producer prices and production decisions \( \Phi \) maximize firm profits, i.e., they satisfy conditions (21), (23), (24), and (27) as well as the analogous conditions in the foreign country;

3. Prices \( \Gamma \) clear all markets. That is, price indexes, \( \{P_t, P_{Ht}, P_{Ft}, P_{Pt}, \pi_t^P\}_{t \geq 0} \), satisfy
wages clear the labor market, i.e., (37) is satisfied; and nominal interest rates are determined according to (36). Analogous conditions pin down \( \Gamma^* \).

4. The bond market clears, i.e., equations (38) – (42) are satisfied.

3 Trade and Fiscal Policies: A Theoretical Analysis

In this section, we discuss the key differences in transmission of IX and VP policies. To this end, we first summarize conditions under which both IX and VP are equivalent and have no allocative effects under flexible exchange rates, and we highlight the key role of the real exchange rate as an adjustment mechanism. We show that under such extreme conditions, these two policies look only beguilingly similar, as the forces driving the adjustment in the real exchange rate are fundamentally different.

We then present the main result of this section: Under fixed exchange rates, IX policies implement a currency devaluation and provide macroeconomic stimulus, whereas VP policies remain neutral. As these findings appear in contrast with conventional wisdom (such as, for instance, FGI), we conclude this section with a discussion of the key assumption about tax pass-through.

3.1 Neutrality Under Flexible Exchange Rates

Proposition 1. In an economy with flexible exchange rates \( (\varphi_\varepsilon = 0) \), both a unilateral IX policy of size \( \delta \) and a unilateral VP policy of size \( \frac{\delta}{1+\delta} \) cause a \( \delta \)-percent appreciation of the real exchange rate and have no allocative effect if

1. The policy is permanent and unanticipated, and there is no probability of retaliation \( (a = \pi = 0, \text{ and } \rho = 1) \);

2. Foreign holdings of home-currency-denominated bonds are always zero \( (\chi^* = \infty) \);

3. Export prices are set in the producer’s currency (PCP), or prices are flexible.

The result of IX neutrality contained in Proposition 1 extends Lerner’s Symmetry Theorem
Similarly, neutrality of VP has been discussed in the literature within static models of international trade. The greater relevance of this result for our purposes is that it provides a theoretical benchmark to illustrate the different general equilibrium adjustments that deliver equivalence and neutrality in response to the two policies. This discussion will provide most of the intuition of how the relaxation of conditions 1–3 of Proposition 1 affects transmission of IX and VP. We include the formal proof of proposition 1 in Appendix B.

As stated in the proposition, in response to both unilateral IX and VP, the real exchange rate appreciates permanently by an amount equal to the size of the policy. That is, the relative price of the foreign consumption bundle in terms of the domestic consumption bundle

\[ Q_t = \varepsilon_t \frac{P_t^*}{F_t} = \varepsilon_t (1 - \tau_t^v) \frac{P_t^*}{P_t} \]

(43)
declines permanently by \( \delta \), where \( \delta \) is the size of the policy. In the case of IX, this real exchange rate adjustment happens through a jump in the nominal exchange rate (\( \varepsilon_t \)). In the case of VP, however, the adjustment is mechanically induced by the VAT increase which raises home consumer prices. Hence, VP does not require any change in the value of the currency.

To illustrate why this is the case, it is useful to collect the key equilibrium conditions into two blocks. The first block collects the conditions that regulate trade among countries and its intermediation through foreign bonds:

\[ \frac{Y_{Ft}}{Y_{Ht}} = \left[ (1 + \tau_t^m) \varepsilon_t \frac{P_{Ft}}{P_{Ht}} \right]^{-\theta} \]

(44)

\[ \frac{Y_{Ht}^*}{Y_{Ft}^*} = \left[ \frac{1}{(1 + \zeta_t^v) \varepsilon_t} \frac{P_{Ht}}{P_{Ft}} \right]^{-\theta} \]

(45)

12For other work on Lerner’s symmetry result, see, for instance, McKinnon (1966) and, more recently, Costinot and Werning (2017). Eichengreen (1981) provides an intuitive discussion of the conditions needed to achieve neutrality in a framework similar to ours. Lerner’s Symmetry Theorem is also a relevant result for the neutrality of border tax adjustments, as in Meade (1974), Grossman (1980), Auerbach et al. (2017), Erceg et al. (2018), Lindé and Pescatori (2019), and Barbiero et al. (2019).

13See, for instance, Auerbach et al. (2017).

14While we do not prove that these conditions are necessary, we illustrate in Section 4 and in the Appendix that they are tight in the sense that relaxing any one of them breaks the neutrality of IX.

15All equations reported in this section abstract from foreign instruments for ease of exposition, given that under condition 1 in Proposition 1 and 2 (below) foreign governments do not retaliate to the policies considered.
\[
B_{Ft} - \frac{B_{Ht}}{\varepsilon_t} = B_{Ft-1}R_{t-1}^* - \frac{B_{Ht-1}}{\varepsilon_{t-1}}R_{t-1} + \frac{P_{Pt}}{(1 + \varsigma_t^x)} \varepsilon_t \left[ Y_{Ht}^* - (1 + \varsigma_t^x) \varepsilon_t \frac{P_{Pt}^*}{P_{Pt}} Y_{Ft} \right]
\] (46)

\[
\varepsilon_t = R_{t}^* E_t \left\{ \Lambda_{t,t+1} \frac{P_{Pt}}{P_{Pt+1}} \frac{1 - \tau_t^m}{1 - \tau_t^v} \left[ \frac{\omega + (1 - \omega) \left( 1 + \tau_t^m \right) \varepsilon_t \frac{P_{Pt}^*}{P_{Pt+1}}^{1-\theta} \right]^{1-\theta} \right\}
\] (47)

Equations (44) and (45) determine the relative demand for domestic and foreign varieties in the home and foreign country.\textsuperscript{16} Equations (46) and (47) determine equilibrium in the foreign-currency-denominated bond market. Equation (46) equates home demand for new foreign-currency bonds with foreign supply as determined by the level of foreign trade deficits. Demand for foreign-currency bonds in the home country is determined by equation (47).

Equations (44) and (45) show that, for a given level of the exchange rate, import tariffs and export subsidies shift demand away from foreign goods and toward domestically produced goods, both in the home country and in the foreign country. However, the relative prices of imported to domestic goods in the right-hand sides of equations (44) and (45) remain unchanged if a $\delta$-percent increase in both import tariffs and export subsidies causes an exchange rate appreciation of the same exact size. In other words, under PCP, the exchange rate appreciation lowers the cost of imports in the home country just enough to offset the increase in tariffs and lowers the revenues from sales of domestic varieties in the foreign country by as much as the higher export subsidy. Equation (44) also shows why the assumption of PCP is important in delivering the result as it ensures that foreign exporters’ prices, $\varepsilon_t P_{Pt}^*$, immediately reflect exchange rate fluctuations. If foreign exporters were unable to do so—such as under local currency pricing—this neutrality result would immediately break.\textsuperscript{17} Moreover, as shown in equation (46), the currency appreciation offsets the effect of export subsidies on net exports and leaves the balance of payments unaffected, as, under condition 2 of Proposition 1, all trade is intermediated in foreign-currency-denominated bonds (i.e., $B_{Hs}^* = 0$ for all $s$).\textsuperscript{18} Finally, equation (47) shows that as long as the IX policy change is permanent, demand for foreign currency bonds is unaffected. Section 4 discusses in detail how departures from condition 1 of

\textsuperscript{16}Equation (44) can be derived from the demand schedules in (14) and (15), and the PCP conditions (25) and (31). Analogous derivations for the foreign economy yield 45.

\textsuperscript{17}We discuss alternative pricing assumptions in more detail in the Appendix.

\textsuperscript{18}Section 80 in the Appendix discusses the case in which foreign households can hold home currency denominated bonds.
Proposition 1 affect the transmission of IX by implying that the exchange rate offset to the policy change is only partial.

Regarding VP, equations (44) - (46) make clear that this policy has no direct effect on relative demand for home and foreign varieties and, hence, on net exports. This observation is a consequence of the fact that VAT changes affect equally the price of imported and domestically-produced goods. In addition, as long as it is permanent, VP does not affect home savings demand and, thus, also leaves (47) unaffected. Consequently, under VP, no general equilibrium adjustment of the nominal exchange rate is required to insulate international relative prices from the effects of the policy.

The second block of equations collects the conditions determining equilibrium in the domestic labor market and aggregate demand:

\[ W_t(1 - \tau^v_t) = \left\{ \omega + (1 - \omega) \left[ (1 + \tau^m_t) \varepsilon_t \frac{P_{Pt}^*}{P_{Pt}} \right]^{1-\theta} \right\}^{\frac{1}{1-\theta}} P_{Pt} C_t^\sigma N_t^\eta \]  

(48)

\[ \bar{P}_{Pt}(i) = (1 - \zeta^p_t) \mathbb{E}_t \sum_{s \geq t} \tilde{A}_{t,s}(i) \frac{(1 - \zeta^p_t)}{(1 - \zeta^t_i)} \frac{\gamma}{\gamma - 1} \alpha A_{s} N_{s}^{\alpha - 1}(i) \]  

(49)

\[ \beta \tilde{E}_t \left\{ \frac{C_t^\sigma}{C_{t+1}^\sigma} \frac{R_t}{\pi_{pt+1}} \frac{1 - \tau^v_{t+1}}{1 - \tau^v_t} \left[ \frac{\omega + (1 - \omega) \left[ (1 + \tau^m_{t+1}) \varepsilon_{t+1} \frac{P_{Pt+1}^*}{P_{Pt+1}} \right]^{1-\theta}}{\omega + (1 - \omega) \left[ (1 + \tau^m_{t+1}) \varepsilon_{t+1} \frac{P_{Pt+1}^*}{P_{Pt+1}} \right]^{1-\theta}} \right] \right\}^{\frac{1}{1-\theta}} = 1 \]  

(50)

IX enters (48) and (50) only through its effect on import prices, which, as explained earlier, is perfectly offset by the currency appreciation.

The transmission of VP, instead, works through its direct effects on the equilibrium in the labor market. Equations (48) and (49) show that the increase in the payroll subsidy and the VAT hike have offsetting effects on labor demand and labor supply. Under our assumption of full pass-through of taxes, at fixed producer prices, a VAT hike induces consumer prices \( (P_t) \) to jump by \( \delta \) percent (see equation (23)). In order for the households’ labor supply to remain unchanged, equation (48) requires an adjustment in the nominal wage of the same exact percentage of the VAT hike. In addition, as evident from the optimal pricing decision of producers (49), the commensurate increase in payroll subsidies \( (\zeta^p_t) \) ensures that firms are willing to pay this higher wage. Equation (49) also implies that a VP policy that is expected

\[ \text{See Feldstein and Krugman (1990) for a similar argument.} \]
to be eventually reversed would have direct effects on aggregate supply, breaking the neutrality result. The importance of assumption 1 in Proposition 1 for the neutrality of VP can also be seen by inspection of the intertemporal optimality conditions for households consumption. In particular, the intertemporal substitution effects induced by expectations about the future declines in the VAT, as implied by equation 50, turn out to have large quantitative effects on the economic response to VP. We will discuss this channel in detail in section 4.1 and assess its quantitative relevance in our empirical experiment of Section 5.4.

3.2 Fiscal Devaluations Revisited

We now turn to study the effects of IX and VP policies under the assumption that exchange rates are fixed by the monetary policy of the home economy.

Proposition 2. In a fixed exchange rate regime ($\varphi = \infty$), under assumptions 1.- 3. of Proposition 1, an IX policy of size $\delta$ has the same allocative effects as a once-and-for-all unexpected currency devaluation of size $\delta$. A VP policy of the same size $\frac{\delta}{1+\delta}$ has no effect on the allocation but causes the real exchange rate to appreciate by $\delta$.

After our earlier discussion about how neutrality is achieved by IX and VP, this result should come as no surprise. Given that when the currency exchange rate is free to move the effects of an IX policy are perfectly offset by a nominal appreciation, it follows that, absent an exchange rate response, IX elicits economic effects identical to a currency depreciation. In contrast, as VP neutrality does not require any adjustment in the currency exchange rate, the fixed exchange rate regime does not pose any constraint to achieving the same outcome as under flexible exchange rates. VP remains neutral under fixed exchange rates.

The neutrality of VP under fixed exchange rates is in stark contrast with recent results in the fiscal devaluation literature, such as FGI. The key difference between the two frameworks is the assumption about how VAT changes are passed through to consumer prices in the presence of nominal rigidities. Our analysis assumes that pre-tax prices are sticky and taxes are fully passed through. Specifically, we assume that absent a price adjustment by the firm, producer prices $P_{Pt}$ remain unchanged and consumer prices $P_{Ht} = \frac{P_{Pt}}{(1-\tau)}$ jump in response to a VAT increase. In the fiscal devaluation literature, instead, prices are typically assumed to be sticky inclusive of taxes (and hence pre-tax prices are free to adjust). That is, firms control directly consumer
prices $P_{H,t}$ and, absent price adjustment by the firm, VAT increases are absorbed through a reduction in firms’ margins, i.e., producer prices decline $P_{pt} = P_{Ht}(1 - \tau_v)$. To understand how this assumption would affect transmission of VP through the margin determining relative demand for domestic and foreign varieties, we rewrite (44) and (45) using consumer prices rather than producer prices:

$$
\frac{Y_{Ft}}{Y_{Ht}} = \left[ \frac{(1 + \tau_{m}^n) \varepsilon_t P_{pt}}{(1 - \tau_v) P_{Ht}} \right]^{-\theta} 
$$  \hspace{1cm} (51)

$$
\frac{Y_{Ht}^*}{Y_{Ft}^*} = \left[ \frac{(1 - \tau_v) P_{Ht}}{(1 + \gamma) \varepsilon_t P_{pt}} \right]^{-\theta} 
$$  \hspace{1cm} (52)

Notice that, by virtue of (23), equations (51) and (52) are equivalent to (44) and (45). Equations (51) and (52), however, make clear that if the adjustment in consumer prices, $P_{Ht}$, is sluggish in response to a VAT increase, then the VAT policy itself gives domestic firms a competitive boost and acts exactly as the IX policy. Under our assumption that firms’ prices $P_{pt}$ are slow to adjust, in contrast, this competitiveness-enhancing effect of VATs disappears, as evident from (44) and (45).

4 Macroeconomic Effects of IX and VP Policies

In this section, we provide a broader characterization of the macroeconomic effects of IX and VP policies and their different transmission mechanisms. To this end, we focus on two departures from the limiting case considered in Section 3 that appear to be the most relevant both qualitatively and quantitatively.\footnote{The Appendix contains a full treatment of deviations from the remaining conditions.} Specifically, we first study the role of agents’ beliefs about the persistence of tax changes and the risk of retaliation by the foreign economy. We show that, when IX policies are expected to be reversed (or trigger symmetric retaliatory policies abroad), they exert sizable expansionary effects \textit{even under flexible exchange rates}. In contrast, when VP policies are expected to be eventually reversed, intertemporal substitution effects tend to make them contractionary, \textit{especially in a currency union}. We then turn to the role of wage rigidity in affecting transmission of the two policies. While transmission of IX is affected only quantitatively by the presence of wage rigidities, VP policies can provide macroeconomic stimulus when sluggish wage adjustments allow payroll subsidies to boost aggregate supply.
In our discussion, we calibrate the model with fairly standard values used in the literature, which are reported in the top panel of Table 1.\textsuperscript{21}

4.1 IX and VP Policies: The Role of Reversal

The neutrality of IX policies in our dynamic framework requires that the real exchange rate jumps to a new long-run value, reflecting the public’s belief that trade actions will remain in place forever. However, historical experience suggests that trade policy actions are often reversed or spur retaliation. These reversals may occur because the trade policies are implemented as cyclical measures to boost the economy or as a negotiating tool in foreign policy.\textsuperscript{22} Alternatively, they may result from an electoral shift toward a political party more supportive of free trade.\textsuperscript{23} Moreover, although some trade policy legislation has been enacted with the expectation that it would remain in effect for a long time, the tariff wars that ensued during the 1930s or, more recently, between the United States and China serve to underscore the high likelihood of foreign retaliation under such circumstances.

Given these considerations, we next apply our benchmark model to study the effects of IX policies that have no long-run effect on the real exchange rate. Through the lens of our Markov structure, the effects on the exchange rate may prove temporary because the policy action is reversed or, alternatively, because the home country’s implementation of IX policies prompts the foreign government to retaliate by adopting similar policies. As the implications of either type of policy turn out to be nearly identical, for expositional simplicity, we focus here on the case in which a unilateral IX policy is expected to be reversed ($1 - \rho > 0, \pi = 0$).

In our benchmark framework, a unilateral IX policy of size $\delta$ that is expected to be reversed with probability $1 - \rho > 0$ exerts allocative effects by boosting real net exports, as the associated exchange rate appreciation only partially insulates international relative prices. In order to explain the intuition behind this result, it is helpful to proceed by way of contradiction. Assume

\textsuperscript{21} See, for instance, Gali and Monacelli (2005a)
\textsuperscript{22} In this vein, Irwin (2017) discusses how President Nixon favored the imposition of a 10 percent across-the-board tariff in 1971 partly to enhance his prospects in the 1972 election, as well as to put pressure on foreign trading partners to revalue their exchange rates. As it turned out, the tariffs were lifted fairly quickly when the foreign policy objectives were viewed as largely achieved, as well as from pressure coming even from some members of the Administration.
\textsuperscript{23} For example, in the U.S. experience, President Wilson, a free-trade Democrat, strongly supported the passage of the Underwood Tariff Act of 1913 which scaled back the high tariffs that had prevailed under previous Republican Administrations (see Irwin (2017)).
that the allocation is unaffected. Then (44) and (45) imply that the exchange rate must appreciate by \( \delta \) for as long as the policy remains in effect. This exchange rate movement suffices to completely offset the effects of IX on relative prices, leaving relative demand for imported and domestic varieties unaffected. However, the expectation that the IX policy will eventually be reversed implies that the home exchange rate depreciates in the future which causes an increase in the demand for foreign bonds. This result can be seen by inspection of equation (47), which we report here for convenience as:

\[
\varepsilon_t = \beta E_t \left\{ \frac{C^\sigma_t}{C^\sigma_{t+1}} \frac{P_t}{P_{t+1}} \varepsilon_{t+1} \right\} R^*_t. \tag{53}
\]

The increase in the demand for foreign bonds associated with the expected depreciation of the currency turns out to lead to a smaller simultaneous appreciation of the exchange rate and an expansion of net exports.\(^{24,25}\)

The solid lines in Figure 1 show the expected paths of key variables after the home country adopts a unilateral IX policy in our benchmark model with sticky prices. The IX policy consists of a 10 percentage point increase in import tariffs and export subsidies that is expected to be reversed with probability \((1 - \rho) = 0.05\) by the following quarter. The policy causes a small appreciation of the exchange rate that does not fully insulate relative prices, and, as a consequence, imports fall and exports rise. Monetary policy reacts to the stronger external demand by raising interest rates, which reduces home consumption and contributes to the appreciation of the real exchange rate, thus dampening some of the stimulus to net exports. Because the stimulus to domestic output occurs through expenditure-switching channels, it has negative spillovers to the foreign economy so that both foreign output and inflation decline (not shown).

IX policies operate not only through trade channels, but also through intertemporal channels. As seen in equation (50), an increase in import tariffs that is expected to be reversed raises the relative price of current consumption, as imported goods are expected to be cheaper in the future. These dynamic effects of tariffs not only differ markedly from the effects of export

\(^{24}\)The use of appropriately targeted capital controls, i.e. designed so that equation (53) holds without requiring an adjustment in the interest rate, would restore neutrality. We thank our discussant E. Farhi for this insight.

\(^{25}\)Notably, this argument does not rely on nominal rigidities. In fact, transitory IX policies are non-neutral both under flexible prices and under sticky prices, although specific assumptions about the form of nominal rigidities and the monetary policy rule affect the transmission of the boost to net exports to the rest of the economy.
subsidies—which affect the real interest rate only through the strength of the monetary policy response—but also are quantitatively important in pushing down consumption. Returning to Figure 1, note that the dashed lines show the effects of import tariffs only: An increase in import tariffs has essentially no effect on output under our baseline calibration ($\sigma = 1; \theta = 1.25$), so that all of the output stimulus from IX policies comes from the increase in export subsidies (i.e., the distance between the solid and dashed lines). The quasi-invariance of output to the tariff increase reflects that the expenditure-switching effect, which pushes up the desired share of consumption spent on home goods, is offset by the intertemporal-substitution effect, which pushes down overall consumption. Stepping beyond our specific calibration, we find that the output effects of higher import tariffs depend on the relative strength of these two effects. If the intertemporal elasticity of substitution is low relative to the trade price elasticity, higher tariffs would tend to boost output (as the expenditure-switching effect dominates), whereas higher tariffs would reduce output if the intertemporal elasticity is high relative to the trade elasticity. Even so, under standard calibrations for these parameters, a combination of import tariffs and export subsidies that is expected to be reversed increases output in the near term.

The magnitude of the stimulus from temporary IX policies depends on the response of monetary policy as well. For instance, a larger interest rate response to producer price inflation (higher $\varphi_{\pi}$ in the policy rule) and, consequently, to the external demand stimulus would imply smaller output effects. By contrast, when monetary policy gives high weight to stabilization of the exchange rate (high $\varphi_{\varepsilon}$ in the policy rule), the output stimulus is larger, with a fixed exchange rate regime an interesting limiting case. In this spirit, Figure 2 shows how the IX policies play out in our baseline model, in which the home exchange rate is fixed to that of the foreign economy (solid lines). Home output rises significantly more in this case than under flexible exchange rates. This larger output expansion largely reflects that consumption expands robustly—rather than contracts—as the home policy rate declines in lockstep with the foreign policy rate. The rise in output is also reinforced by the larger increase in exports.

We next turn to the effects of VP policies that are expected to be reversed. As evident from equation (50), temporary VP policies have strong intertemporal substitution effects on consumption, much more so than temporary IX policies. While IX policies generate deflationary pressure only through higher prices of imported goods, VP policies induce direct deflationary pressure on the entire consumption bundle.
The contractionary effect of this intertemporal substitution channel turns out to be the most relevant quantitative force driving the macroeconomic effects of temporary VP policies. Figure 3 shows the effects of VP policies of size $\delta = 10$ percent that are reversed with probability $(1 - \rho) = 0.05$ by the following quarter. The red solid line shows the case in which exchange rates are flexible, while the red dashed line shows the case in which exchange rates are fixed. The higher real interest rate under VP depresses aggregate demand markedly, causing a contraction in output. When exchange rates are flexible, the central bank lowers policy rates in response to depressed economic activity, which limits the decline in consumption, depreciates the exchange rate, and boosts net exports. Under fixed exchange rates, the output decline is even larger, as the exchange rate peg prevents monetary policy in the home country from providing sufficient stimulus in response to the decline in economic activity.

While the contractionary effects of a temporary VP contrast sharply with the expansion of output under a temporary IX, the two policies have similar effects on trade quantities. This outcome, however, reflects very different channels. The IX policy has direct “competitiveness-enhancing” effects on relative trade prices that raise exports and cause imports to contract. This stimulus is only partially counterbalanced by a tightening of policy rates and an appreciation of the home currency. In contrast, the stimulus to net exports from the VP policy is mainly due to the depreciation of the exchange rate induced by the fall in policy rates in the face of lower aggregate demand.

Taken together, our results underscore how the different transmissions of VP and IX imply that, once the restrictive conditions in Proposition 1 are relaxed, these policies will, in general, have very different macroeconomic effects. In particular, given the importance of intertemporal substitution channels in shaping the macroeconomic effects of a temporary VP, such a policy runs the risk of providing a contractionary impetus to output, especially if the policy interest rate and exchange rates cannot adjust much. One important caveat to this claim is that, so far, we have assumed that wages are perfectly flexible. Indeed, when wages are sticky, the expansionary effect of payroll subsidies on aggregate supply can allow VP to provide stimulus. Hence, we turn to study the case of sticky wages next.
4.2 IX and VP Policies: The Role of Wage Rigidity

A large macroeconomic literature assumes that households set nominal wages in Calvo-style staggered contracts that are similar in form to the price contracts outlined in Section 2.\textsuperscript{26} In addition, the appeal of competitiveness-enhancing payroll tax cuts financed with VAT increases appears greater when rigid wages prevent strong offsetting general equilibrium responses.\textsuperscript{27}

Figure 4 shows the response of the economy to unexpected and permanent VP (solid red lines) and IX (dashed blue lines) policies under flexible exchange rates and sticky wages.\textsuperscript{28} Recall from our discussion of Proposition 1 that IX policies do not rely on adjustment in wages to achieve neutrality. Hence, IX policies continue to have no allocative effects when wages are sticky, as shown by the blue lines in Figure 4. On the contrary, VP policies required a jump in the nominal wage to have no allocative effects. It follows that, when wages are sticky, VP policies are no longer neutral. The nominal wage rises only gradually with sticky wages, implying that the higher payroll subsidy persistently reduces producers’ marginal costs, thus pushing producer price inflation down and increasing labor demand. As monetary policy cuts the policy rate in response to below-target producer price inflation, consumption expands. The increase in consumption and the rise in (net) exports—due to the induced decline in the terms of trade—contribute to an expansion in home country output.

5 Why Did the 2007 German “Fiscal Devaluation” Fail?

Our previous discussion was inconclusive on the overall macroeconomic effects of VP policies. On the one hand, a VP policy implemented on a temporary basis in an economy with full pass-through of tax changes tends to be contractionary. On the other hand, a permanent VP policy implemented in an economy with high wage rigidity tends to be expansionary. In this section, we analyze the historical episode of the 2007 VP reform in Germany through the lens of a canonical DSGE model in order to assess quantitatively the role of these assumptions.

\textsuperscript{26}See, for instance, Erceg et al. (2000).

\textsuperscript{27}For instance, the quantitative analysis in FGI suggests that an appropriately calibrated VP policy would have allowed the Spanish economy to suffer almost no employment and output losses in 2008-09, largely by correcting the macroeconomic instability introduced by rigid wages.

\textsuperscript{28}We choose the parameter controlling the degree of wage stickiness to imply that wages are adjusted with the same frequency as prices.
5.1 Data

In November 2005, the newly-elected German government followed through on its campaign promises and announced its intentions to increase fiscal revenues through a VAT hike and to boost competitiveness of German firms by cutting payroll taxes. The details of these tax shifts were finalized over the course of 2006 with the goal of going into effect starting January 2007.

Figure 5 presents the evolution of key macroeconomic variables in Germany and other euro-area economies in the years 2006 and 2007. In January 2007, the standard VAT rate in Germany increased from 16 percent to 19 percent, while the reduced VAT rate remained unchanged at 7 percent. The overall increase in the standard VAT rate affected about half of the bundle of goods included in the consumer price index, resulting in an average VAT increase of about 1.4 percent. At the same time, payroll taxes declined more than 1 percent (black lines in the first and second panels). Notably, VAT and payroll taxes remained stable in the rest of the euro area (dashed red lines). Hence, the 2007 VP reform in Germany constitutes a very stark example of a fiscal devaluation attempted by a country in a currency union.

These tax changes failed to elicit the boost in economic activity typically associated with a currency devaluation. As shown in Figure 5, the implementation of this VP policy produced two main effects on the German economy: First, consumer prices increased markedly in the first quarter of 2007, when VAT rates increased. Second, barring some pulling forward of consumption in anticipation of the VAT hike, economic activity in Germany underperformed relative to its euro-area counterparts. In 2007, consumption growth in Germany was negative, investment was weak, and, despite a boost to net exports, GDP remained significantly below

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29 A number of services, including those for non-profit organizations and services provided directly by the government, are exempt from the VAT.

30 We are implicitly assuming that most of the difference between the performance of the German economy and other euro-area economies over the 2006Q1-2007Q4 period can be attributed to the implemented fiscal measures. Two considerations support this view. First, the historical narrative indicates that these fiscal measures were the most important economic development in Germany during this period. See, for instance, Bundesbank (2007) and D’Acunto et al. (2016). Second, the stable performance of the remaining euro-area economies over this period seems to be inconsistent with the hypothesis that a common macroeconomic shock had disproportionately larger effects in Germany than in other countries.
5.2 The Extended Model

We next extend our baseline model along several dimensions to study the observed economic effects of the 2007 German VP policy within the euro area. First, we model the monetary policy framework of the European Central Bank via an inertial Taylor rule that responds to an average measure of inflation and the output gap within the currency union, with the home country representing Germany (H) and the foreign country representing an aggregate of all other euro-area economies (F). Monetary policy is described by the rule

\[
\left( \frac{R_{t}^{EA}}{R} \right) = \left( \frac{R_{t-1}^{EA}}{R} \right)^{\rho_R} \left( \left( y_{P,t} \bar{y}^{1-s} \right)^{\phi_{\pi}} \left( \bar{y}_{t} \bar{y}_{1-s} \right)^{\phi_{y}} \right)
\]

where \( (R_{t}^{EA}) \) is the euro-area policy rate, \( \rho_R \) is the interest-smoothing parameter, and \( s \) denotes the normalized size of the home country (Germany).

Second, we introduce capital as an additional input in the production function and assume that capital accumulation is subject to adjustment costs. The production function is Cobb-Douglas

\[
Y_t = K_t^\alpha L_t^{1-\alpha}
\]

where \( K_t \) is the capital stock and \( L_t \) is the aggregate labor input consisting of differentiated labor services supplied by households. The law of motion of capital is:

\[
I_t = K_{t+1}^{\delta_K} - (1 - \delta_K) K_t + \frac{\kappa}{2} \left[ \frac{K_{t+1}^{1-\delta_K} K_t}{\delta_K K_t} - 1 \right]^2 K_t
\]

where \( I_t \) is investment in final goods, \( \delta_K \) is the depreciation rate, and \( \kappa \) is the parameter governing the curvature of the cost of adjusting capital.

Third, given the large body of evidence in support of wage rigidity and its importance for the macroeconomic effects of VP policies, we depart from the baseline assumption of flexible wages and consider sticky wages. As in Erceg et al. (2000), we assume that monopolistically

\[31\]The Eurostat measure of consumption for European economies includes non-durable goods, durable goods, and services. Much of the initial increase and subsequent decline in German consumption is due to changes in durable goods, such as motor vehicle purchases, for which there is evidence of nearly full pass-through of the VAT increase. See Erceg et al. (2018) and D’Acunto et al. (2016) for further discussion.

\[32\]In order to be consistent with our modeling approach of a currency union, our definition of GDP excludes net trade with countries outside the euro area.
competitive households supply labor services that are considered imperfect substitutes by the production sector. Taking labor demand as given, households set nominal wages in staggered contracts that are analogous to the price contracts described for producers. These assumptions yield the conditions

\[ \bar{W}_t = E_t \sum_{s \geq t} \bar{A}_{t,s} (i) \frac{\gamma W}{\gamma W - 1} n_s (i) \gamma W - 1 \]  

\[ W_t = \left[ \zeta W + (1 - \zeta W) \left( \frac{\bar{W}_t}{W_{t-1}} \right)^{1-\gamma W} \right]^{\frac{1}{1-\gamma W}} \]  

determining the optimal reset wage \( \bar{W}_t \) and the evolution of wages, which jointly imply a standard wage Phillips curve. The parameter \( \zeta W \) is the probability that the household will not be able to adjust its wage in a given period and \( \gamma W \) governs the elasticity of substitution across labor services.\(^{33}\)

Fourth, we introduce heterogeneity in the price response to VAT changes. We assume that firms in the set \( F \) of measure \( \mu \) fully pass through VAT changes as in our baseline model (described above). For the remaining proportion \( 1 - \mu \) of firms in the set \( I \), we assume that prices are sticky inclusive of taxes and thus the pass-through is incomplete, as in FGI. Hence, the price indexes for the two sets of firms are

\[ P_{F,t} = \left[ \zeta P_P (P_{F,t-1}^{F})^{1-\gamma} + (1 - \zeta P_P) (\bar{P}_{F,t}^{F})^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \]  

\[ P_{I,t} = (1 - \tau_t) \left[ \zeta P_P \left( \frac{P_{I,t-1}^I}{1 - \tau_{t-1}^I} \right)^{1-\gamma} + (1 - \zeta P_P) (\bar{P}_{H,t}^{I})^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \]  

Equation (60) shows that, for firms in the set \( I \) that do not adjust their price, an increase in the VAT causes producer prices, and hence margins, to drop mechanically. The overall response of average prices for firms in \( I \) will then depend on the endogenous response of optimizing firms that reset consumer prices \( \bar{P}_{H,t}^{I} \).

Domestic producer price inflation in the home country is approximately given by the weighted average of the inflation rates of the two sets of firms

\[ \pi_{P,t} \approx \mu \pi_{P,t}^F + (1 - \mu) \pi_{P,t}^I \]  

\( ^{33} \)See the Appendix for details.
5.3 Parameter Values

Table 2 presents the parameter values used in our quantitative analysis. We partition the model parameters in two sets. The first includes conventional parameters that are either fixed to standard values commonly used in the literature or calibrated using German data. We set the discount factor \( \beta \) to 0.99; the coefficient of relative risk aversion \( \sigma \) to unity; the elasticities of substitution among good varieties \( \gamma \) and among labor varieties \( \gamma_W \) to 11 and 6, respectively; the labor share \( \alpha \) to 0.64, and the capital depreciation rate \( \delta_K \) to 0.025. In addition, we set the coefficient controlling inertia in the monetary policy response \( \rho_R \) to 0.85, and the coefficients controlling the response to inflation and the output gap, \( \varphi \) and \( \varphi_y \), to 1.5 and 0.25, respectively. These values are all fairly conventional. We then calibrate the size of the home country and the import share to match the share of German GDP in the euro area and the average value of goods and services imported from other euro-area countries relative to German GDP between 2000 and 2006. The resulting parameter values are \( s = 0.25 \) and \( 1 - \omega_H = 0.15 \).

For the Frisch elasticity of labor supply, \( \eta^{-1} \), we choose a value of 1, which is in the middle of the range of estimates. For the value of the elasticity of substitution between domestic and foreign goods, \( \theta \), we choose a value of 1.25 based on the evidence discussed in FGI and Imbs et al. (2010). The Calvo parameters controlling price and wage stickiness, \( \zeta_P \) and \( \zeta_W \), are both set to 0.85, consistent with the evidence for euro-area countries discussed in Galí and Monacelli (2016). Finally, we calibrate the curvature of the capital adjustment cost function to 10, in the middle of the range of estimates that go from more than 20 (Hayashi (1982)) to as low as 2 (Cao et al. (2019)).

The finite-state Markov chain that controls the evolution of tax instruments is calibrated to the German fiscal devaluation. In particular, VATs and payroll subsidies are a function of the Markov state \( s_t, \tau_t^\nu = \psi_\tau(s) \) and \( \zeta_t^p = \psi_\sigma(s) \), where \( s_t \in S = \{\bar{s}_1, \bar{s}_1, \bar{s}_3\} \). The transition probability matrix is given by

\[
T = \begin{bmatrix}
1 & 0 & 0 \\
0 & 0 & 1 \\
(1 - \rho) & 0 & \rho
\end{bmatrix}
\]

(62)

where the element in the \( i \)th row of the \( j \)th column of \( T \) measures the probability of moving from state \( i \) to state \( j \). The first state is the steady state with no taxes \( \psi_\tau(\bar{s}_1) = \psi_\sigma(\bar{s}_1) = 0 \). In
the second state, taxes are still not implemented, \(\psi_\tau(\bar{s}_1) = \psi_\sigma(\bar{s}_1) = 0\), but they are announced for the following quarter, \(Pr\{s_{t+1} = \bar{s}_3|s_t = \bar{s}_1\} = 1\). In the third state, the VP policy is implemented, \(\psi_\tau(\bar{s}_1) = \tau^V\) and \(\psi_\varsigma(\bar{s}_1) = \varsigma^P\). The third row of matrix \(T\) indicates that \(1 - \rho\) measures the probability that the policy is reversed and fiscal policy returns to the steady state. We set \(\tau^V = 1.45\) percent and \(\varsigma^P = 1.25\) percent, consistent with the fiscal measures implemented by the German government in 2007.

The second set of parameters, which includes the fraction of firms that fully pass VAT changes through to consumer prices (\(\mu\)) and the parameters that control the evolution of VATs and payroll subsidies (\(\rho\)), is estimated. Given the importance of these parameters for the macroeconomic effects of VP policies, we set \(\Theta = [\mu; \rho]\) so that it minimizes the distance between the German data on output and inflation presented in Figure 5 and the corresponding model-implied series. In particular, we denote by \(M_D = \{\bar{\pi}_D^T\}_{t=t_0}, \{\bar{y}_D^T\}_{t=t_0}\), with \(t_0 = 2006 : Q4\) and \(T = 2007 : Q4\), the vector containing data on German output and consumer price inflation in deviation from the euro-area data on output and inflation between 2006:Q4 and 2007:Q4. Similarly, we let \(M_M(\Theta) = \{\bar{\pi}_t^M\}_{t=t_0}^T, \{\bar{y}_t^M\}_{t=t_0}^T\) denote the corresponding vector of model-simulated series obtained under a specific vector of parameter \(\Theta\), conditional on the calibrated values of all other parameters discussed earlier, including the size of the policy innovations.\(^{34}\) We assume that in 2006:Q3, the model economy is in the steady state, \(s_t = \bar{s}_1\) for \(t = 2006 : Q3\). The policy is then announced in 2006:Q4, and agents expect it to be implemented in the following quarter, \(s_t = \bar{s}_2\) for \(t = 2006 : Q4\). The policy is implemented in 2007:Q1 and remains in effect throughout 2007, although agents give positive probability, \(1 - \rho\), to a reversal. That is, for \(t \in \{2007 : Q1, 2007 : Q2, 2007 : Q3, 2007 : Q4\}\), \(s_t = \bar{s}_2\) so that in 2007:Q1 \(\tau_t^V\) increases 1.45 percent and \(\varsigma_t^P\) increases 1.25 percent, and they remain at the higher level throughout 2007 as in the data. We then choose \(\Theta\) to solve

\[
\Theta^* = \arg \max \mathcal{O}(\Theta) = \arg \max [M_D - M_M(\Theta)]' [M_D - M_M(\Theta)]
\]

Figure 6 presents how the objective function \(\mathcal{O}\) behaves as we vary \(\Theta\). Two key results

\(^{34}\) Given the small GDP share of the home country, spillovers to the foreign country are quantitatively negligible in the model, as in the data. Hence, we include in \(M_M(\Theta)\) the model response of the German economy in deviation from the steady state, which will facilitate the economic interpretation of our simulations. The effects on the other euro-area economies are shown in the Appendix.
emerge. First, the objective function is maximized at the point $\Theta^* = [0.6; 0.97]$. These values suggest that, in order to account for the price increase and output decline observed in the data, the model requires a significant fraction of firms passing VAT changes through to consumer prices ($\mu = 0.6$) and a positive probability of policy reversal ($1 - \rho = 0.03$). While the large estimated share of firms passing through VAT changes to prices is obtained purely from aggregate data, it is also in line with the heterogeneous pricing response across sectors documented in Bundesbank (2007). For instance, the pass-through during the first quarter of 2007 was full in the automotive sector but muted in the retail sector. Similarly, an expected duration of the policy of about eight years, as implied by our estimated value of $\rho$, is consistent with reasonable assumptions about the likelihood of political turnover and its implications for the evolution of fiscal policy.\(^{35}\)

Second, the limiting assumption of permanent policy changes ($1 - \rho = 0$) and all prices sticky inclusive of VATs ($\mu = 0$), typically adopted in the fiscal devaluation literature, appears strongly rejected by the data. As shown in Figure 6, the fit of the model not only declines sharply as $\Theta$ takes these limiting values, with the objective function $O$ reaching its lowest value of negative 12, compared with a value of negative 2 at the optimum. In addition, the objective function features very strong nonlinear behavior, particularly along the dimensions of the policy reversal parameter, suggesting that even small departures from the assumption of permanent policy changes greatly reduce the ability of the model to account for the observed evolution of German output and inflation.

5.4 Model vs. Data

Figure 7 compares the response of the German economy with an announced VP policy in our model and in the data. For each variable except net exports, the data line shows the behavior of German variables relative to their euro-area counterparts. The model lines show the response in the home country in deviation from the steady state. In particular, the solid blue line shows our “Baseline” experiment constructed using our estimated values ($\mu^*, \rho^*) = (0.6, 0.97)$.

The dashed red line shows the response of the economy in the case of a “quasi” fiscal

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\(^{35}\)As noted in D’Acunto et al. (2016), at the time there was severe disagreement between the two main parties on the benefit of the VP policy and, thus, uncertainty about the duration of the policy in case of a change in government.
devaluation as in FGI, which we capture by assuming that there is no pass-through of VAT changes \((\mu = 0)\) and that the policy is known to be permanent \((1 - \rho = 0)\). As the first two panels show, in our baseline experiment, the policy remains in effect throughout 2007, but agents give positive probability to a reversal.

Our baseline experiment reproduces, both qualitatively and quantitatively, the evolution of the macroeconomic data of Germany. First, the model reproduces well the behavior of output and inflation. While these data were targeted in estimating the value of \((\mu^*, \rho^*)\), this estimation was conditional on the calibrated values of all other parameters, including the size of the policy changes, and the assumption that VP was the only shock hitting the German economy. Second, it is quite remarkable how well the model captures the behavior of the GDP components, which were not targeted in the estimation. Consumption increases upon announcement of the tax changes, as agents substitute away from future consumption in anticipation of higher prices. When the policy is implemented, consumption drops as the transitory increase in intertemporal prices due to the dynamics of the VAT changes more than offsets the stimulative effects of the payroll subsidy. Similarly, the model reproduces quite well the decline in investment, the increase in net exports, and, despite some timing differences between model and data, the evolution of wages.

In contrast, the VP policy under the FGI assumptions generates a boom in consumption and output that appears at odds with the data. Given that the policy is expected to be permanent, VAT changes introduce no distortions to intertemporal prices in this case. In addition, as all prices are assumed to be sticky inclusive of VATs, there is no pass-through of VAT changes to consumer prices in the short run or anticipation of higher prices in the future. Both forces produce a counterfactually large and persistent boom in consumption and output. Notably, the increase in prices in 2007:Q1 is largely driven by the mechanical increase in import prices induced by the VAT increase. The payroll subsidy, as in the baseline model, contributes to a reduction in marginal costs as well as domestic producer prices and boosts exports.

As explained in FGI, this VP policy would only approximate a currency devaluation for three reasons: First, a devaluation would require a capital subsidy. Second, monetary policy for the currency union responds to developments in the home country. Third, in our calibrated experiment, the change in the VAT is slightly different from the change in the payroll subsidy. That said, their quantitative analysis suggests that this policy would still provide significant macroeconomic stimulus, as confirmed by our experiment.

As argued by Gali and Monacelli (2016) temporary payroll tax reductions are much less effective in stimulating economic activity under a fixed exchange rate regime.

Irrespective of the value of \(\mu\), the pass-through of VAT changes into import prices is full and complete.
Figures 8 and 9 describe how the parameters controlling VAT pass-through and expected policy reversal each help the baseline experiment account for the German data. The red dashed lines in figure 8 show that even under our estimated value of VAT pass-through ($\mu^*$), a permanent VP policy provides a large boost to consumption, as the intertemporal substitution effect is absent when the policy is expected to remain in place forever. As noted earlier, the relationship between the economic effects of VP and variations in $\rho$ appears highly nonlinear: When the persistence of the policy is decreased to 0.9, the dotted light-blue lines, the macroeconomic effects of the policy are essentially identical to those under the baseline estimated value of $\rho^* = 0.97$. Similarly, the dashed red lines in 9 show that, when prices are sticky inclusive of taxes for all firms ($\mu = 0$), the intertemporal substitution effects are muted even under policy reversal, as VATs are slow to show through in consumer prices. As a result, consumption increases and investment drops less. Moreover, the boost to international competitiveness induced by higher VATs under incomplete pass-through leads to a larger increase in net exports, leaving output little changed. In contrast, when all firms fully pass through VAT increases, the dotted light-blue lines show that the macroeconomic effects of VP are broadly similar to our baseline effects, apart from the larger immediate increase in consumer prices that is offset by subsequent declines.

5.5 Robustness

We conclude this section with a discussion of the robustness of our main quantitative findings to variation in parameters that we calibrated to conventional values. Recall that, in our baseline experiment with the extended model, we estimated the share of firms that passes VAT changes through to consumer prices ($\mu$) and the probability of policy reversal ($\rho$) by minimizing the distance between model and data series for output and inflation. This optimization was conditional on our calibration for other parameters. The estimated values of $\mu$ and $\rho$, together with the shape of the objective function ($O$) shown in figure 6, underscored the importance of departing from the limiting assumption of incomplete passthrough and permanent policies, i.e. $\mu = 0$ and $\rho = 1$, in order for the model to account for the data.

Here we show that this conclusion does not depend on the specific values of the other calibrated parameters. We do so by reestimating $\mu$ and $\rho$ for different values of the Frisch
elasticity of labor supply ($\eta$), the trade elasticity ($\theta$), the capital adjustment cost elasticity ($\kappa$), and the price and wage Calvo adjustments ($\zeta_p$ and $\zeta_w$). Figure 10 then shows how the optimized value of the objective function changes as we vary each of these parameters, $O(\mu^*(x), \rho^*(x))$ for $x \in \{\eta, \theta, \kappa, \zeta_p, \zeta_w\}$, and the corresponding value of the objective function under the assumption of incomplete pass-through and permanent policy changes, $O(0, 1)$. We can interpret the distance between the optimized value (the blue solid line), and the value under the limiting assumption of $\mu = 0$ and $\rho = 1$ (the red dashed line), as a measure of the importance of full pass-through of VAT taxes and expected reversal of VP in accounting for the data.

The distance between the fit of the model under the (re-)optimized degrees of pass-through and persistence, $O(\mu^*(x), \rho^*(x))$, and under the assumption of incomplete pass-through and permanent policy changes, $O(0, 1)$, remains very large with almost all parameter changes. It only declines when wages and prices become more flexible. When wages are flexible the output stimulus associated with a permanent VP with incomplete pass-through decreases, causing the fit of the model under this limiting assumption to improve, as shown by the red dotted line in the forth panel. When prices become flexible, the fit of the model under the optimized values of $\mu$ and $\rho$ deteriorates sharply. This is due to the fact that the key channel that helps the model match the data becomes muted in this case. In fact, the intertemporal substitution channel induced by a temporary VP under full pass-through of taxes relies on the presence of sticky prices.

6 Concluding Remarks

Existing literature suggests that a uniform increase in import tariffs and export subsidies (IX) and an increase in value-added taxes accompanied by a payroll tax deduction (VP) are equivalent, are neutral under flexible exchange rates, and can provide as much stimulus as a currency devaluation under fixed exchange rates. These results are particularly relevant for countries constrained by membership in a currency union. In 2007, the German government implemented a fiscal reform along these lines, as “shifting the tax burden from direct taxation and fiscal

\footnote{We thank a referee for suggesting robustness to these calibrated parameters. Results for the remaining parameters are available upon request.}
charges to indirect taxation...are elements of a revenue structure that is both more conducive to growth and more competitive.”

In this paper, we question this conventional wisdom. First, we argue that the transmission of IX and VP policies is fundamentally different under the assumption of full pass-through of taxes. Indeed, in a special case often considered in the literature, we show that under fixed exchange rates IX implements a currency devaluation, whereas VP turns out to have no allocative effects. Second, we find that IX policies that are expected to be reversed or trigger retaliation tend to boost output even under flexible exchange rates. The macroeconomic effects of VP, instead, are ambiguous and depend critically on the relative strength of two offsetting channels. On the one hand, intertemporal substitution effects make VP contractionary, especially in a currency union. On the other hand, sluggish wage adjustments allow payroll subsidies to boost aggregate supply and output. Third, we assess the empirical relevance of our novel theoretical predictions on the effects of VP by studying the effects of the 2007 German fiscal reform. We find that a canonical DSGE model of a currency union can account for the relatively poor performance of the German economy in the aftermath of this attempted fiscal devaluation. In order for the model to fit the data, it is essential that a large share of firms fully passes VAT increases through to consumer prices and that the policy is expected to be eventually reversed with positive probability. In contrast, the limiting assumption of limited tax pass-through and permanent policy changes, typically adopted in the fiscal devaluation literature, appears strongly rejected by the data.

All told, our analysis provides some caveats on the practical viability of fiscal devaluations as a tool to supply macroeconomic stimulus in a currency union. The approach of financing competitiveness-enhancing payroll tax cuts with VAT increases, while intuitively appealing, can easily elicit contractionary macroeconomic effects.

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40See Germany SPG (2007).
References


### Table 1: Baseline Model Calibration

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<th>Value</th>
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<td>Price stickiness</td>
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<td>Trade elasticity</td>
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<tr>
<td>Import share</td>
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<tr>
<td>Inflation weight in the Taylor rule</td>
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Table 2: Parameter Values for the Extended Model

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<td>Output gap weight in the Taylor rule</td>
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<td>Inflation weight in the Taylor rule</td>
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<td>Complete pass-through</td>
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<tr>
<td>Persistence</td>
<td>ρ</td>
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</table>
Figure 1: Macroeconomic Effects of IX with Expected Reversal

Note: In both experiments we assume that prices are sticky, wages are flexible, and the exchange rate is flexible. The figure shows the expected path of each variable after the policy is implemented and given that it is expected to be permanently abandoned with probability 0.05 as long as it is in place.
Figure 2: Macroeconomic Effects of IX with Expected Reversal: Fixed vs. Flex Exchange Rate Regime

Note: In both experiments we assume that prices are sticky and wages are flexible. The dashed line shows the case in which the home country pegs to the foreign country which follows a standard Taylor rule. The solid line is the case in which the exchange rate is flexible. The figure shows the expected path of each variable after the policy is implemented and given that it is expected to be permanently abandoned with probability 0.05 as long as it is in place.
Figure 3: Macroeconomic Effects of VP with Expected Reversal: Fixed vs. Flex Exchange Rate Regime

Note: In both experiments we assume that prices are sticky and wages are flexible. The solid line shows the case in which the home country pegs to the foreign country which follows a standard Taylor rule. The dashed line is the case in which the exchange rate is flexible. The figure shows the expected path of each variable after the policy is implemented and given that it is expected to be permanently abandoned with probability 0.05 as long as it is in place.
Figure 4: Permanent IX and VP with Sticky Wages and Flexible Exchange Rates

Note: In both experiments we assume that prices and wages are sticky, and the exchange rate is flexible. The solid line shows the response to VP and the dashed line the response to IX. In both cases the policies are (expected to be) permanent.
Figure 5: 2007 German VP: Data

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**Note:** Macroeconomic data for Germany and the euro area (EA) are from Haver (EU Database). See Appendix for details. Consumption, investment and GDP are normalized to equal one in 2006 Q3. To be consistent with our model we show net exports from Germany to the other EA countries. Accordingly, GDP excludes trade with the rest of the world both for Germany and for EA ex-Germany.
Figure 6: Policy Reversal, Pass-Through, and Distance between German Data and Model

**Note:** The figure plots the objective function in 64, that is the negative of the squared distance between the model implied time series on inflation and output and the observed realizations. The blue diamonds show the optimal point on the surface and its projection in the $(x, y)$ plane which reports an optimal value of $\mu^* = .6$ and $1 - \rho^* = .03$. 
Figure 7: 2007 German VP, Model vs Data

![Figure 7: 2007 German VP, Model vs Data](image)

**Note:** For all variables except net exports the data line shows difference between the variable in Germany and in the EA ex-Germany, i.e. the difference between the black and red dotted line in Figure 5. The model lines show the response in the home country in deviation from steady state to a perfectly anticipated VP policy announced in 2006Q4 and implemented in 2007Q1. CPI and wage inflation are annualized percentages. Net exports are in percent of GDP. The other variables are percent deviations from steady state. The dashed line assumes that pass-through of VAT taxes is complete and that, while VP remains in place throughout 2007, it is expected to be abandoned with a 0.05 probability in every quarter. The solid line assumes that the tax pass-through of VAT changes is incomplete and the policy is (expected to be) permanent.
Figure 8: The role of expectations about policy reversal

Note: The data line (solid) and the baseline (dashed) are as in figure 7. The dashed-dotted line assumes that pass-through of VAT taxes is complete and that VP is permanent. The dotted line assumes that the pass-through of VAT changes is incomplete and that, while VP remains in place throughout 2007, it is expected to be abandoned with a 0.05 probability in every quarter.
Figure 9: The role of the tax pass-through

NOTE: The data line (solid) and the baseline (dashed) are as in figure 7. The dashed-dotted line assumes that pass-through of VAT taxes is complete and that VP is permanent. The dotted line assumes that the pass-through of VAT changes is incomplete and that, while VP remains in place throughout 2007, it is expected to be abandoned with a 0.05 probability in every quarter.
Figure 10: Sensitivity of model fit to different values of calibrated parameters

\[ \mathcal{O}(\mu^*(x), \rho^*(x)) \text{ for } x \in \{\eta, \theta, \kappa, \zeta_w, \zeta_p\} \quad \text{red dashed lines} \quad \mathcal{O}(\mu = 0, \rho = 1) \quad \text{yellow diamonds} \quad \mathcal{O}(\mu^*(\bar{x}), \rho^*(\bar{x})) \text{ with calibrated } \bar{x} \]

**Note:** Each panel reports in the blue solid line

\[
\mathcal{O}(\mu^*, \rho^*; C(x)) = \max_{\mu, \rho} \mathcal{O}(\mu, \rho; C(x)) = \arg \max_{\mu, \rho} -[M_D - M_M(\Theta)]'[M_D - M_M(\Theta)] \tag{64}
\]

where \( C(x) \) is the vector of calibrated parameters each at its calibrated value, apart from variable \( x \in \{\eta, \theta, \kappa, \zeta_w, \zeta_p\} \) which varies over the values in the \( x \)-axis. The red dashed lines show the values of \( \mathcal{O}(0, 1; C(x)) \). The yellow diamonds show the value of the objective in our baseline, i.e. when all parameters in \( C \) are at their calibrated values.
Appendix

A  Model Equations

A.1  Households

Household \( i \in H = [0, 1] \) chooses \( \{\bar{w}_t(i), w_t(i), n_t(i), c_t(i), a_{t,t+1}(i), B_{Ht}(i), B_{Ft}(i)\} \) to maximize

\[
\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{[c_t(i)]^{1-\sigma}}{1-\sigma} - \frac{[n_t(i)]^{1+\eta}}{1+\eta} \right] \quad (A.1)
\]

subject to

\[
P_t c_t(i) + \sum_{t+1} a_{t,t+1}(i) + B_{Ht}(i) + \varepsilon_t \left[ B_{Ft}(i) + \frac{\chi}{2} (B_{Ft}(i) - \bar{B}_F)^2 \right] = R_{t-1} B_{Ht-1}(i) + \varepsilon_t R_{t-1}^* B_{Ft-1}(i) + P_t a_{t-1,t}(i) + w_t(i) n_t(i) + \bar{\Pi}_t + T_t \quad (A.2)
\]

\[
w_t(i) = \begin{cases} \frac{w_{t-1}(i)}{\bar{w}_t(i)} & \text{w.p. } \zeta_W \\ \frac{w_t(i)}{W_t} & \text{w.p. } 1 - \zeta_W \end{cases} \quad (A.3)
\]

\[
n_t(i) = \left[ \frac{w_t(i)}{W_t} \right]^{-\gamma_n} N_t \quad (A.4)
\]

where \( W_t \) is a wage index (described below) and \( q_{t,t+1} \) is the price of a state contingent Arrow security paying one unit of consumption in a specific state at time \( t+1 \). We assume that a complete set of Arrow securities is traded domestically so that perfect risk sharing within each country allows for simple aggregation. Equation (A.3) states that households can only adjust their wage with probability \( \zeta_W \). Equation (A.4) is the firms’ demand schedule for labor variety \( i \), derived below.

Optimality conditions are

\[
1 = \beta \mathbb{E}_t \left[ \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} R_t \right] \quad (A.5)
\]

\[
1 + \chi (B_{Ft}(i) - \bar{B}_F) = \beta \mathbb{E}_t \left[ \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} \varepsilon_{t+1} R_t^* \right] \quad (A.6)
\]

\[
\mathbb{E}_t \zeta_W \sum C_s^{-\sigma} \left\{ \frac{[n_s(i)]^\eta}{C_s^{-\sigma} (\gamma_n - 1)} - \frac{\bar{W}_t}{P_s} \right\} n_s(i) = 0 \quad (A.7)
\]

A.2  Retailers

The problem of retailers is as described in the main text.
A.3 Producers

A.3.1 PCP pricing

Producer \( i \in F = [0, 1] \) chooses an optimal reset price \( P_{Pt}(i) \), export prices \( \{P_{Hs}^{*}(i)\}_{s \geq t} \) quantities \( \{Y_{Hs}(i), Y_{Hs}^{*}(i)\}_{s \geq t} \) and employment \( \{N_{s}(i), \{n_{s}(j; i)\}_{j}\}_{s \geq t} \) to maximize

\[
\max E_t \sum_{s \geq t} \zeta_{s-t}^{s-l} \Lambda_{t,s} (1 - \tau_{s}^{*}) \left\{ \frac{\bar{P}_{Pt}(i) Y_{Hs}(i) + \frac{s^{*}}{s} Y_{Hs}^{*}(i)}{P_{s}} - (1 - \zeta_{s}^{*}) \int w_{s}(j) n_{s}(j; i) d j \right\} (A.8)
\]

s.t.

\[
Y_{Hs}(i) + \frac{s^{*}}{s} Y_{Hs}^{*}(i) = A_{s} N_{s}^{\alpha}(i) \tag{A.9}
\]

\[
N_{s}(i) = \left\{ \int [n_{s}(j; i)]^{\gamma^{n-1}} \gamma^{n-1} \right\} (A.10)
\]

\[
Y_{Hs}(i) = \left[ \frac{\bar{P}_{Pt}(i)}{P_{Ps}} \right]^{-\gamma} Y_{Hs} \tag{A.11}
\]

\[
Y_{Hs}^{*}(i) = \left[ \frac{P_{Hs}^{*}(i)}{P_{Ps}} \right]^{-\gamma} Y_{Hs}^{*} \tag{A.12}
\]

\[
P_{Hs}^{*}(i) = \frac{(1 + \tau_{s}^{m*}) \bar{P}_{Pt}(i)}{(1 + \zeta_{s}^{*})} \varepsilon_{s} \tag{A.13}
\]

where \( s^{*} \) and \( s \) are the size of the foreign and home country respectively.

The optimality conditions for this problem are constraints (A.9) – (A.13) as well as an optimal pricing condition as in the text:

\[
E_t \sum_{s=t}^{\infty} \zeta_{s-t}^{s-l} \Lambda_{t,s} \left[ Y_{Hs}(i) + \frac{s^{*}}{s} Y_{Hs}^{*}(i) \right] (1 - \tau_{s}^{*}) \frac{1}{P_{s}} \left[ \bar{P}_{Pt}(i) - \frac{\gamma}{\gamma - 1} \alpha A_{s} N_{s}(i)^{\alpha-1} \right] W_{s} = 0 \tag{A.14}
\]

where \( W_{s} \) is the wage index

\[
W_{s} = \left[ \int [w_{s}(j)]^{1-\gamma_{n}} \right]^{1-\gamma_{n}} \tag{A.15}
\]

A.3.2 LCP pricing

Producer \( i \) chooses optimal reset prices \( P_{Pt}(i) \) and \( P_{Xt}^{*}(i) \), where \( P_{Xt}^{*}(i) \) is the foreign currency price of domestic export net of tariffs, export prices \( \{P_{Hs}^{*}(i)\}_{s \geq t} \), quantities \( \{Y_{Hs}(i), Y_{Hs}^{*}(i)\}_{s \geq t} \) and employment \( \{N_{s}(i), \{n_{s}(j; i)\}_{j}\}_{s \geq t} \) to maximize

\[
\max E_t \sum_{s \geq t} \zeta_{s-t}^{s-l} \Lambda_{t,s} \left\{ \frac{\bar{P}_{Pt}(i) Y_{Hs}(i) + \varepsilon_{s} P_{Xt}^{*}(i) (1 + \zeta_{s}^{*}) \frac{s^{*}}{s} Y_{Hs}^{*}(i) - (1 - \zeta_{s}^{*}) \int w_{s}(j) n_{s}(j; i) d j}{P_{s}} \right\} (A.16)
\]
s.t.

\[ Y_{Hs}(i) + \frac{S^*}{s} Y_{Hs}^*(i) = A_s N_s^\gamma(i) \]  
(A.17)

\[ N_s(i) = \left\{ \int [n_s(j;i)] \frac{\gamma n_{s-1}}{\gamma n_{s-1}} \, dj \right\}^{\frac{\gamma n_{s-1}}{\gamma n_{s-1}}} \]  
(A.18)

\[ Y_{Hs}(i) = \left[ \frac{\bar{P}_{Pt}(i)}{P_{Ps}} \right]^{-\gamma} Y_{Hs} \]  
(A.19)

\[ Y_{Ht}^*(i) = \left[ \frac{P_{Hs}^*(i)}{P_{Ht}^*} \right]^{-\gamma} Y_{Ht}^* \]  
(A.20)

\[ P_{Hs}^*(i) = (1 + \tau_s^m) P_{Xt}^*(i) \]  
(A.21)

The optimality conditions for this problem are constraints (A.17) – (A.21) and optimal pricing conditions for domestic and foreign markets:

\[ E_t \sum_{s=t}^{\infty} \zeta_s^{s-t} \Lambda_{t,s} \left( 1 - \tau_s^\pi \right) \frac{Y_{Hs}(i)}{P_s} \left[ \bar{P}_{Pt}(i) - \frac{\gamma}{\gamma - 1} \frac{(1 - \xi_s^p) W_s}{\alpha A_s N_s(i)^{\alpha-1}} \right] = 0 \]  
(A.22)

\[ E_t \sum_{s=t}^{\infty} \zeta_s^{s-t} \Lambda_{t,s} \left( 1 - \tau_s^\pi \right) \frac{Y_{Hs}^*(i)}{P_s} \left[ \varepsilon_s (1 + \varepsilon_s^x) P_{Xt}^*(i) - \frac{\gamma}{\gamma - 1} \frac{(1 - \xi_s^x) W_s}{\alpha A_s N_s(i)^{\alpha-1}} \right] = 0 \]  
(A.23)

where \( W_s \) is the wage index

\[ W_s = \left\{ \int [w_s(j)]^{1-\gamma_n} \, dj \right\}^{\frac{1}{1-\gamma_n}} \]  
(A.24)

An analogous problem for the foreign producers yield

\[ E_t \sum_{s=t}^{\infty} \zeta_s^{s-t} \Lambda_{t,s} \frac{Y_{Fs}(i)}{P_s} \left[ \bar{P}_{Pt}(i) - \frac{\gamma}{\gamma - 1} \frac{W_s^*}{\alpha A_s^* N_s^*(i)^{\alpha-1}} \right] = 0 \]  
(A.25)

\[ E_t \sum_{s=t}^{\infty} \zeta_s^{s-t} \Lambda_{t,s} \frac{Y_{Fs}(i)}{P_s} \left[ \frac{1}{\varepsilon_s} (1 + \varepsilon_s^x) P_{Xt}^*(i) - \frac{\gamma}{\gamma - 1} \frac{W_s^*}{\alpha A_s^* N_s^*(i)^{\alpha-1}} \right] = 0 \]  
(A.26)

where

\[ P_{Fs}(i) = \frac{(1 + \tau_s^m) P_{Xt}^*(i)}{(1 - \tau_s^m)} \]

\section{Equilibrium equations}

Equations (A.27) – (A.58) below determine the equilibrium process \( \{ \Psi(s^t) \} s^t \in (S^t, t \geq 0) \) for any initial value \( (M_{-1}, s_0) \) where \( s_0 \) is the policy regime at time 0 and \( M_{-1} \) collects bond holdings and the distribution of prices and wages:

\[ M_{-1} = \{ A_{-1}, P_{-1} \} \]
\[ A_{-1} = \{ B_{H,-1} R_{-1}, B_{F,-1} R_{-1}^*, B_{F,-1}^* R_{-1}, B_{H,-1}^* R_{-1} \} . \]

\[ \mathcal{P}_{-1} = \left\{ \{ P_{P,-1} (j), P_{X,-1}^* (j) \} \}_{j \in J}, \{ W (i) \} \}_{i \in I}, \{ W_{P,-1} (j), P_{X,-1}^* (j) \} \}_{j \in J^*}, \{ W^* (i) \} \}_{i \in I^*} \right\} \]

For ease of exposition we group elements of \( \Psi \) into variables that we associate with households optimality conditions, \( \Psi_{HH} \) and \( \Psi_{HH}^* \) abroad, retailers optimality conditions, \( \Psi_{RE} \) and \( \Psi_{RE}^* \), firms optimality conditions, \( \Psi_{FI} \) and \( \Psi_{FI}^* \), price indexes, \( \Psi_{PI} \) and \( \Psi_{PI}^* \), and market clearing conditions, \( \Psi_{MC} \). We have that \( \Psi = \{ \Psi_{HH}, \Psi_{HH}^*, \Psi_{RE}, \Psi_{RE}^*, \Psi_{FI}, \Psi_{FI}^*, \Psi_{P}, \Psi_{P}^*, \Psi_{MC} \} \)

**Households optimality**

\( \Psi_{HH} = \{ w_t (i), \bar{W}_t, n_t (i), C_t, B_{Ht} \} \) (leaving out budget constraint and \( B_{Ft} \))

\[ w_t (i) = \begin{cases} w_{t-1} (i) & \text{w.p. } \zeta_W \\ \bar{W}_t & \text{w.p. } 1 - \zeta_W \end{cases} \] (A.27)

\[ E_t \zeta_{W_{s-t}} \cdot \sum C_s^{-\sigma} \left[ \frac{[n_s (i)]^\eta}{C_s^{-\sigma}} \cdot \frac{\gamma_n}{(\gamma_n - 1)} - \frac{\bar{W}_t}{P_s} \right] n_s (i) = 0 \] (A.28)

\[ n_t (i) = \left( \frac{w_t (i)}{\bar{W}_t} \right)^{-\gamma_n} N_t \] (A.29)

\[ 1 = \beta \mathbb{E}_t \left[ \frac{C_{t+1}^{-\sigma} P_{t+1}}{C_t^{-\sigma} P_{t+1} R_t} \right] \] (A.30)

\[ 1 + \chi (B_{Ft} (i) - \bar{B}_F) = \beta \mathbb{E}_t \left[ \frac{C_{t+1}^{-\sigma} P_{t+1} \varepsilon_{t+1}}{C_t^{-\sigma} P_{t+1} \varepsilon_t R_t} \right] \] (A.31)

and symmetric conditions for \( \Psi_{HH}^* = \{ w_{Ht}^* (i), \bar{W}_{Ht}^*, n_{Ht}^* (i), C_t^*, B_{Ht}^* \} \) abroad

**Retailers optimality**

\( \Psi_{RE} = \{ Y_{Ht}, Y_{Ft}, Y_{Ht}^* (i), Y_{Ft}^* (i) \} \)

\[ Y_{Ht} = \omega \left[ \frac{P_{Ht}}{P_t} \right]^{-\theta} C_t \] (A.32)

\[ Y_{Ft} = (1 - \omega) \left[ \frac{P_{Ft}}{P_t} \right]^{-\theta} C_t \] (A.33)

\[ Y_{Ht}^* (i) = \left( \frac{P_{Ht} (i)}{P_{Ft} (i)} \right)^{-\gamma} Y_{Hs} \] (A.34)

\[ Y_{Ft}^* (i) = \left( \frac{P_{Ft} (i)}{P_{Ft}^*} \right)^{-\gamma} Y_{Ft} \] (A.35)

and symmetric conditions for \( \Psi_{RE} = \{ Y_{Ft}^*, Y_{Ht}^*, Y_{Ft}^* (i), Y_{Ht}^* (i) \} \)

**Firms optimality**

\( \Psi_{FI} = \{ P_{Hs}^* (i), P_{Ft}^* (i), P_{Pl}^* (i), \bar{P}_{Pl} (i), \bar{P}_{Pl}^* (i), \bar{P}_{Xt}^* (i), \bar{P}_{Xt}^* (i), P_{s'ti}^* (i), P_{Xs}^* (i) \} \)

\[ P_{Ht}^* (i) = (1 + \gamma_t^{m*}) P_{Xt}^* (i) \] (A.36)
\[ P_{Ft}(i) = \frac{1 + \tau^m}{1 - \tau^w} P_{X^t}(i) \]  
(A.37)

\[
P_{Pt}(i) = \begin{cases} 
P_{Pt-1}(i) & \text{w.p. } \zeta_p \\
P_{Pt}(i) & \text{w.p. } 1 - \zeta_p \end{cases}
\]  
(A.38)

\[
P_{Pt}^*(i) = \begin{cases} 
P_{Pt-1}^*(i) & \text{w.p. } \zeta_p \\
P_{Pt}^*(i) & \text{w.p. } 1 - \zeta_p \end{cases}
\]  
(A.39)

\[
\mathbb{E}_t \sum_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{t,s} \left[ Y_{Ht}(i) + \frac{s^x}{s} Y^*_{Ht}(i) \right] \frac{1}{P_s} \left[ \bar{P}_{Pt}(i) - \frac{\gamma}{\gamma - 1} \frac{1 - \zeta_s^x}{\alpha A_s N_s(i)^{\alpha - 1}} \right] = 0 \quad PCP 
\]  
(A.40a)

\[
\mathbb{E}_t \sum_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{t,s} \frac{Y_{Fs}(i)}{P_s} \left[ \bar{P}_{Pt}(i) - \frac{\gamma}{\gamma - 1} \frac{1 - \zeta_s^x}{\alpha A_s N_s(i)^{\alpha - 1}} \right] = 0 \quad LCP 
\]  
(A.40b)

\[
\mathbb{E}_t \sum_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{t,s} \left[ Y_{Fs}(i) + Y^*_{Fs}(i) \right] \frac{1}{P_s} \left[ \bar{P}_{Pt}(i) - \frac{\gamma}{\gamma - 1} \frac{1 - \zeta_s^x}{\alpha A_s N_s(i)^{\alpha - 1}} \right] = 0 \quad PCP 
\]  
(A.41a)

\[
\mathbb{E}_t \sum_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{t,s} \frac{Y^*_{Fs}(i)}{P_s} \left[ \bar{P}_{Pt}^*(i) - \frac{\gamma}{\gamma - 1} \frac{1 - \zeta_s^x}{\alpha A_s N_s(i)^{\alpha - 1}} \right] = 0 \quad LCP 
\]  
(A.41b)

\[
P^*_{Ht}(i) = \frac{(1 + \tau^m) P_{Pt}(i)}{(1 + \tau^w_i)} \quad PCP 
\]  
(A.42a)

\[
\mathbb{E}_t \sum_{s=t}^{\infty} \zeta_P^{s-t} \Lambda_{t,s} \frac{Y^*_{Fs}(i)}{P_s} \left[ \varepsilon_s (1 + \zeta_s^x) \bar{P}_{Xt}^*(i) - \frac{\gamma}{\gamma - 1} \frac{1 - \zeta_s^x}{\alpha A_s N_s(i)^{\alpha - 1}} \right] = 0 \quad LCP 
\]  
(A.42b)
\[ P_{Ft}(i) = \frac{1+\gamma^n}{1-\gamma^n} \frac{\varepsilon_t}{(1+\gamma^n)} \]  

(A.43a)

\[ \mathbb{E}_t \sum_{s=t}^{\infty} \varepsilon_t A^*(i) \frac{Y_{Ht}(i)}{P_s} \left[ \frac{(1+\gamma^n)}{\varepsilon_t} \bar{P}_{X^*t}(i) - \frac{\gamma}{\gamma-1} \frac{W^*_t}{\alpha A_r N^*_t(i)} \right] = 0 \]  

LCP  

(A.43b)

\[ P_{X^*t}(i) = P_{X^*t}(i) \]  

PCP  

(A.44a)

\[ P_{X^{*t+1}}(i) = \begin{cases} P_{X^*t}(i) & \text{w.p. } \zeta_w \\ \bar{P}_{X^*t+1}(i) & \text{w.p. } 1 - \zeta_w \end{cases} \]  

LCP  

(A.44b)

and symmetric conditions for \( \Psi_{FI} = \{ N_t^*(i), P_{Ft}(i), P_{Pt}(i), T_{Pt}(i), \bar{P}_{X^*t}(i), P_{X^*t}(i) \} \)

**Price indexes**

\( \Psi_{PI} = \{ P_t, P_{Ht}, P_{Pt}, P_{Ft}, W_t \} \)

\[ P_t = [\omega P_{Ht}^{1-\theta} + (1 - \omega) P_{Ft}^{1-\theta}]^{1-\theta} \]  

(A.45)

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

(A.46)

\[ P_{Pt} = P_{Ht} (1 - \tau^n) \]  

(A.47)

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

(A.48)

\[ W_s = \left[ \int [w_s(j)]^{1-\gamma_n} dj \right]^{1-\gamma_n} \]  

(A.49)

and symmetric conditions for \( \Psi_{PI} = \{ P^*_t, P^*_F, P^*_P, P^*_H, W^*_t \} \)

**Market Clearing**

\( \Psi_{MC} = \{ N_t(i), N^*_t(i), N_t^*, N_t, B_{Ft}, B^*_H, \varepsilon_t, R_t, R^*_t \} \)

\[ Y_{Ht}(i) + \frac{s^*}{s} Y_{Ht}^*(i) = A_t N^*_t(i) \]  

(A.50)
\[ Y_{Ft}(i) + \frac{s}{s^*}Y_{Ft}(i) = A_tN_t^{s*}(i) \]  

(A.51)

\[ N_t = \int_{j \in F} N_t(j) \, dj \]  

(A.52)

\[ N_t^* = \int_{j \in F} N_t^*(j) \, dj \]  

(A.53)

\[ B_{Ft} + B_{Ft}^* = 0 \]  

(A.54)

\[ B_{Ht} + B_{Ht}^* = 0 \]  

(A.55)

\[ B_{Ft} - \frac{B_{Ht}^*}{\varepsilon_t} = B_{Ft-1}R_{t-1}^* - \frac{B_{Ht}^*}{\varepsilon_t}R_{t-1} + \frac{P_{Pt}}{(1 + \varepsilon_t^x)} \left[ Y_{Ht}^* - \frac{(1 + \varepsilon_t^x)}{(1 + \varepsilon_t^x)} \right] \]  

(A.56)

\[ R_t^* = \frac{1}{\beta} \left( \frac{P_{Pt}}{P_{Pt-1}} \right)^x \left( \frac{Y_{Ft} + Y_{Ft}^*}{Y_{Ft}^{flex} + Y_{Ft}^{flex}} \right) \left( \frac{\varepsilon_t}{\varepsilon_t} \right)^x \]  

(A.57)

\[ R_t = \frac{1}{\beta} \left( \frac{P_{Pt}}{P_{Pt-1}} \right)^x \left( \frac{Y_{Ht} + Y_{Ht}^*}{Y_{Ht}^{flex} + Y_{Ht}^{flex}} \right) \left( \frac{\varepsilon_t}{\varepsilon_t} \right)^x \]  

(A.58)

\section{C Proof of Proposition 1}

We let the policy regime \( s_t \) be a vector collecting all policy variables at time \( t \)

\[ s_t = (\tau_t^m, \varsigma_t^x, \tau_t^v, \varsigma_t^p, \varepsilon_t, \tau_t^{m*}, \varsigma_t^{x*}) \]

We start by giving defining what it means to implement a new policy in our Markov Switching regime framework.

\textbf{Definition 1.} Assume that \( s_t \) is governed by \( \{S, \Omega\} \) from \( t = 0, ..., t^* \). A new policy from \( t^* \) is defined by a new stochastic process \( \{\tilde{S}, \tilde{\Omega}\} \) and a function \( \tilde{\sigma} : S \to \tilde{S} \) that determines how the policy configuration at \( t^* \) changes, \( \tilde{s}_{t^*} = \tilde{\sigma}(s_t^*) \), upon introduction of the new policy.

We next define neutrality of a policy and equivalence between policies.

\textbf{Definition 2.} Assume that a new policy \( \{\tilde{S}, \tilde{\Omega}; \tilde{\sigma}\} \) is implemented at time \( t^* \) replacing \( \{S, \Omega\} \). The implementation of the policy has no allocative effects, i.e., it is neutral, if for any endogenous state \( \mathcal{M}_{t-1} \) and any (continuation) equilibrium process \( \{\tilde{\Psi}(s^t)\}_{s^t \in (S)^{t+1-t^*}, t \geq t^*} \) under \( \{S, \Omega\} \), there is an equilibrium process, \( \{\bar{\Psi}(\tilde{s}^t)\}_{\tilde{s}^t \in (\tilde{S})^{t+1-t^*}, t \geq t^*} \) under \( \{\tilde{S}, \tilde{\Omega}\} \) that induces the same probability distribution for the real allocation.

That is, letting

\[ \Xi = \{C(s^t), C^*(s^t), \{n(i, s^t), n^*(i, s^t), Y_H(i, s^t), Y_F(i, s^t), Y_H^*(i, s^t), Y_F^*(i, s^t)\}\}_{s^t \in (S)^{t+1-t^*}, t \geq t^*} \]

\[ \Xi = \{\tilde{C}(\tilde{s}^t), \tilde{C}^*(\tilde{s}^t), \{\tilde{n}(i, \tilde{s}^t), \tilde{n}^*(i, \tilde{s}^t), \tilde{Y}_H(i, \tilde{s}^t), \tilde{Y}_F(i, \tilde{s}^t), \tilde{Y}_H^*(i, \tilde{s}^t), \tilde{Y}_F^*(i, \tilde{s}^t)\}\}_{\tilde{s}^t \in (\tilde{S})^{t+1-t^*}, t \geq t^*} \]
denote the real allocation under \( \{ \Psi (s^t) \}_{s^t \in (S)^{t+1-t^*}, t \geq t^*} \) and \( \{ \tilde{\Psi} (\tilde{s}^t) \}_{\tilde{s}^t \in (\tilde{S})^{t+1-t^*}, t \geq t^*} \) respectively.

For any \( \tilde{s}_i \in S \)

\[
\Pr_{(\tilde{s}, \tilde{\Omega})} \{ \tilde{\Xi}(\tilde{s}^{n+1}) = \xi | \tilde{s}_{t^*} = \tilde{s}_i \} = \Pr_{(S, \Omega)} \{ \Xi(s^{n+1}) = \xi | s_{t^*} = s_i \}
\]

We also say that two policies described by \( \{ \tilde{S}, \tilde{\Omega}, \tilde{\sigma} \} \) and \( \{ \tilde{S}, \Omega, \tilde{\sigma} \} \) are equivalent if they induce the same probability distribution for the real allocation.

Finally we give a definition of IX and VP policies.

**Definition 3.** Assume that \( s_t \) is governed by \( \{ S, \Omega \} \) from \( t = 0, \ldots, t^* \). A unilateral implementation of IX of size \( \delta \) is described by \( \{ GP^{IX}, \Omega^{IX}, \sigma^{IX}_\delta \} \) with \( GP^{IX} = S \cup S^{IX} \) where the new set of states is

\[
S^{IX} = \left\{ \tilde{s} = (\tilde{m}, \tilde{x}, \tilde{v}, \tilde{p}, \tilde{\epsilon}, \tilde{m}^*, \tilde{x}^*) \mid \frac{1+\tilde{m}}{1+\tilde{m}^*} = \frac{1+\tilde{v}}{1+\tilde{p}} = 1 + \delta \right\},
\]

the transition matrix

\[
\Omega^{IX} = \begin{bmatrix} (1 - \pi^{IX}) \Omega & \pi^{IX} \Omega \\ (1 - \rho) \Omega & \rho \Omega \end{bmatrix}
\]

allows for the possibility that the tax change is anticipated with probability \( \pi^{IX} \) and then reversed with probability \( \rho \).

The implementation of IX is **anticipated** if \( \pi^{IX} > 0 \) and \( \sigma^{IX}_\delta \) is the identity function, i.e. \( \sigma^{IX}_\delta(s) = s \) for any \( s \in S \).

The implementation of IX is **unanticipated** if \( \pi^{IX} = 0 \) and \( \sigma^{IX}_\delta \) maps each element of \( S \) to its associated element in \( S^{IX} \). That is for any \( s = (m, x, v, p, \epsilon, m^*, x^*) \in S \)

\[
\sigma^{IX}_\delta(s) = (\tilde{m}, \tilde{x}, \tilde{v}, \tilde{p}, \tilde{\epsilon}, \tilde{m}^*, \tilde{x}^*)
\]

s.t.

\[
\frac{1+\tilde{m}}{1+\tilde{m}^*} = \frac{1+\tilde{v}}{1+\tilde{p}} = 1 + \delta
\]

We define an anticipated and unanticipated VP policy analogously. The policy is described by \( \{ GP^{VP}, \Omega^{VP}, \sigma^{VP}_\delta \} \) with \( GP^{VP} = S \cup S^{VP} \) where the new set of states is

\[
S^{VP} = \left\{ \tilde{s} = (m, x, \tilde{v}, p, \epsilon, m^*, x^*) \mid \frac{1-\tilde{v}}{1-v} = \frac{1-\tilde{p}}{1-p} = 1 + \delta \right\},
\]

the transition matrix is

\[
\Omega^{VP} = \begin{bmatrix} (1 - \pi^{VP}) \Omega & \pi^{VP} \Omega \\ (1 - \rho) \Omega & \rho \Omega \end{bmatrix}
\]

A.8
and the function describing the unanticipated transition to VP is given by

$$
\sigma_{\delta}^{VP} (s) = (\tau^m, \varsigma^x, \bar{\tau}^v, \bar{\varsigma}^p, \bar{\epsilon}, \tau^{m*}, \varsigma^{x*})
$$

s.t.

$$
\frac{1 - \bar{\tau}^v}{1 - \tau^v} = \frac{1 - \bar{\varsigma}^p}{1 - \varsigma^p} = \frac{1}{1 + \delta}.
$$

(A.62)

Notice that the process $\{GP^{IX}, \Omega^{IX}\}$ does not encompass the possibility of retaliation which we will introduce below.

**Proposition 1.** In an economy with flexible exchange rates ($\varphi_\epsilon = 0$) a unilateral IX policy of size $\delta$ and a unilateral VP policy of size $\delta + \frac{\delta}{1 + \delta}$ are both neutral and cause a $\delta$– percent appreciation of the real exchange rate if

1. The policy is permanent and unanticipated;
2. Foreign holdings of home-currency-denominated bonds are always zero ($\chi^* = \infty$);
3. Export prices are set in the producer’s currency (PCP), or prices are flexible.

**Proof.** Condition 1 implies that $\pi^{IX} = \pi^{VP} = 0$ and $\rho = 1$. In this case the transition matrices in A.59 and A.61 are simply

$$
\Omega^{IX} = \Omega^{VP} = \begin{bmatrix} \Omega & 0 \\ 0 & \Omega \end{bmatrix}
$$

(A.63)

Let $\{\Psi(s_i^t)\}_{s_i \in (S)^t, t \geq 0}$ denote an equilibrium process before the implementation of the new policy, i.e. when $s_i$ is governed $\{S, \Omega\}$. Assume without loss of generality that the new policy is implemented at $t^* = 0$.

**Neutrality of IX**

Let $\{\mu^{IX}_t\}_{t \geq 0}$ be a sequence of function that map histories in which IX is implemented into a histories in which IX is not implemented: i.e. $\forall \vec{s}^t = (\vec{s}_0, ..., \vec{s}_t) \in (GP^{IX})^{t+1}$, $\mu_t(\vec{s}^t) = s^t = (s_0, ..., s_t) \in (S)^{t+1}$ where $\forall i \geq 1$

$$
s_i = \begin{cases} 
\tilde{s}_i & \text{if } \tilde{s}_i \in S \\
(\sigma^{IX}_\delta)^{-1}(\tilde{s}_i) & \text{if } \tilde{s}_i \in S^{IX}
\end{cases}
$$

where $\sigma^{IX}_\delta$ is as defined in A.60.

Consider now a process $\{\tilde{\Psi}^{IX}(s^t)\}_{s^t \in (\tilde{S})^t, t \geq 0}$ with an unanticipated permanent IX such that, for each element $\tilde{x}^{IX}$ of $\tilde{\Psi}^{IX}$, other than the nominal exchange rate, $\tilde{\epsilon}^{IX}$, and home currency producer prices of foreign exporters, $\tilde{P}^{IX}_{X^*}(i)$, we have

$$
\tilde{x}^{IX} (\vec{s}^t) = \kappa (\mu^{IX}_t (\vec{s}^t)) \quad \forall \vec{s}^t \in (GP^{IX})^t, \forall t \geq 0
$$

(A.64)

where $\kappa$ is the corresponding element of the equilibrium process $\Psi$ without IX. For ease of notation in what follows, for any $\vec{s}^t = (\vec{s}_0, ..., \vec{s}_t) \in (GP^{IX})^{t+1}$, we let $\tilde{x}^{IX} = \tilde{x}^{IX} (\vec{s}^t)$ and $\kappa_t = \kappa (\mu^{IX}_t (\vec{s}^t))$.

A.9
The nominal exchange rate and the home currency producer prices of foreign exporters are 
\( \forall s^t = (s_0, \ldots, s_t) \in (GP^IX)^{t+1} \)

\[
\varepsilon_{IX} = \begin{cases} 
\varepsilon_t & \text{if } s_t \in S \\
\frac{\varepsilon_t}{1+\delta} & \text{if } s_t \in S^{IX} 
\end{cases}
\]  
\[\text{(A.65)}\]

\[\tilde{P}_{X^t}^t(i) = \begin{cases} 
P_{X^t}^t(i) & \text{if } s_t \in S \\
\frac{1}{1+\delta}P_{X^t}^t(i) & \text{if } s_t \in S^{IX} 
\end{cases}
\]  
\[\text{(A.66)}\]

We want to show that \( \Psi^{IX} (s^t) \) has positive probability, \( \text{Pr} \{s^t \in (GP^IX)^{t+1}, t \geq 0 \} \) is an equilibrium.

We first show that \( \Psi^{IX} (s^t) \) satisfies all of the equations directly affected by the tariffs and export subsidy change when \( s_t \in S^{IX} \). These equations are the laws of one price (A.42a) – (A.43a), the tax pass-through equations (A.37) – (A.36), and the balance of payment equilibrium (A.56). Considering the law of one price for domestic goods at an history \( \tilde{s}^t \) such that \( \tilde{s}_t \in S^{IX} \) and letting \( (\sigma_{\delta}^{IX})^{-1} (\tilde{s}_t) \in S \) we see that

\[
\tilde{P}_{H^t}^t(i) = P_{H^t}^t(i) = P_{H^t}^t(i) \frac{1 + \tau_t^m}{1 + \sigma_t^x} \varepsilon_t 
\]  
\[\text{(A.67)}\]

\[
\tilde{P}_{H^t}^t(i) = \tilde{P}_{H^t}^t(i) \frac{1 + \tau_t^m}{1 + \sigma_t^x} \varepsilon_t 
\]  
\[\text{(A.68)}\]

where the first and third equalities follow from (A.64), (A.65) and (A.60) and the second from the fact that \( \Psi \) is an equilibrium. An analogous argument holds for (A.43a) and (A.37).

Consider now the balance of payment equilibrium which, under condition 2 is

\[
\tilde{B}_{F^t} = \tilde{B}_{F^t-1} R_{t-1} + \frac{\tilde{P}_{IX}^t}{(1 + \omega_t^x)} \varepsilon_t \left[ \tilde{Y}_{H^t}^t - (1 + \xi_t^x) \varepsilon_t \tilde{P}_{IX}^t \tilde{Y}_{F^t}^t \right] 
\]

to see that this is satisfied, let again \( (\sigma_{\delta}^{IX})^{-1} (s_t) = s_t \in S \) to get

\[
\tilde{B}_{F^t} = B_{F^t} = B_{F^t-1} R_{t-1} + \frac{P_{Pl}^t}{(1 + \omega_t^x)} \varepsilon_t \left[ Y_{H^t}^t - (1 + \xi_t^x) \varepsilon_t \tilde{P}_{Pl}^t Y_{F^t}^t \right] 
\]

\[= \tilde{B}_{F^t-1} R_{t-1} + \frac{\tilde{P}_{IX}^t}{(1 + \omega_t^x)} \varepsilon_t \left[ \tilde{Y}_{H^t}^t - (1 + \xi_t^x) \varepsilon_t \tilde{P}_{IX}^t \tilde{Y}_{F^t}^t \right] 
\]

where the first and third equality follow from (A.64) – (A.65) and (A.60) and the second from the fact that \( \Psi \) is an equilibrium.

We then need to check that the adjustment of the nominal exchange rate and local currency producer prices of exports in (A.65) – (A.66) does not induce violations in other equilibrium equations. Under PCP \( \tilde{P}_{X^t}^t(i) \) and \( \tilde{P}_{X^t}^t(i) \) only affect (A.37) and (A.36), i.e. they are definitions. The exchange rate \( \varepsilon_t \) affects optimal holdings of foreign bonds (A.31) and an analogous condition abroad. As long as \( \pi^{IX} = 0 \) and \( \rho = 1 \) we have that \( \forall s^t \in (GP^IX)^t \), if \( s^{t+1} \in (GP^IX)^t \) has positive probability, \( \text{Pr} \{s^{t+1} \mid s^t \} > 0 \), the appreciation is identical across
equilibria:
\[
\frac{\bar{\varepsilon}_{t+1}}{\varepsilon_t} = \frac{\varepsilon_{t+1}}{\varepsilon_t}
\]
and since these conditions only depend on exchange rate appreciation they are satisfied.

**Neutrality of VP**

Let \(\{\mu_t^{VP}\}_{t \geq 0}\) be a sequence of function that map histories in which VP is implemented into a histories in which VP is not implemented: i.e. \(\forall \bar{s}^t = (\bar{s}_0, ..., \bar{s}_t) \in (GP^{VP})^{t+1}, \mu_t(\bar{s}^t) = s^t = (s_0, ..., s_t) \in (S)^{t+1}\) where \(\forall i \geq 1\)

\[
s_i = \begin{cases} 
\tilde{s}_i & \text{if } \tilde{s}_i \in S \\
(\sigma^{VP}_s)^{-1}(\tilde{s}_i) & \text{if } \tilde{s}_i \in S^{VP}
\end{cases}
\]

where \(\sigma^{VP}_s\) is as defined in A.60.

Consider the process \(\{\tilde{\Psi}^{VP}(s^t)\}_{s^t \in (GP^{VP})^{t}, t \geq 0}\) with an unanticipated permanent VP implementation such that, for each element \(\tilde{\Psi}^{VP}\) of \(\Psi^{VP}\), other than domestic prices \((\tilde{P}^{VP}_{H,t}(i), \tilde{P}^{VP}_{F,t}(i), \tilde{P}^{VP}_t(i))\) and wages \((\tilde{w}^{VP}_{t}(i), \tilde{w}^{VP}_t(i), \tilde{W}^{VP}_t)\) and the associated price indexes \((\tilde{P}^{VP}_{H,t}, \tilde{P}^{VP}_{F,t}, \tilde{P}^{VP}_t)\),

\[
\tilde{\Psi}^{VP}(s^t) = \Psi(\mu^{VP}_s (\bar{s}^t)) \quad \forall s^t \in (\bar{S}^{VP})^t, \forall t \geq 0 \quad (A.69)
\]

where \(\Psi\) is the corresponding element of the equilibrium process \(\Psi\) without VP.

Prices and wages satisfy \(\forall s^t = (\bar{s}_1, ..., \bar{s}_t) \in (GP^{VP})^t\)

\[
\frac{\tilde{P}^{VP}_{H,t}(i)}{P_{H,t}(i)} = \frac{\tilde{P}^{VP}_{F,t}(i)}{P_{F,t}(i)} = \frac{\tilde{P}^{VP}_t(i)}{P_t(i)} = \begin{cases} 
1 & \text{if } \tilde{s}_t \in S \\
(1 + \delta) & \text{if } \tilde{s}_t \in S^{VP}
\end{cases} \quad (A.70)
\]

\[
\frac{\tilde{w}^{VP}_{t}(i)}{w_t(i)} = \frac{\tilde{w}^{VP}_t(i)}{w_t(i)} = \frac{\tilde{W}^{VP}_t}{W_t} = \begin{cases} 
1 & \text{if } \tilde{s}_t \in S \\
(1 + \delta) & \text{if } \tilde{s}_t \in S^{VP}
\end{cases} \quad (A.71)
\]

We want to show that \(\{\tilde{\Psi}^{VP}(s^t)\}_{s^t \in (GP^{VP})^{t}, t \geq 0}\) is an equilibrium, which given (A.70) and the fact that \(\varepsilon_t\) is unaffected also implies that the real exchange rate appreciates by \(\delta\).

As discussed in section 3, VP instruments directly effect the two equations determining the labor market equilibrium and the dynamic Euler equations for consumption. Consider the optimality condition for the price of the domestic good at home at an history \(\bar{s}^t \in (GP^{VP})^t\) such that \(\tilde{s}_t \in S^{VP}:

\[
P^{VP}_{Pt}(i) = P_{Pt}(i) = (1 - \zeta^P_i)\mathbb{E}_t \sum_{s \geq t} \bar{A}_{t,s}(i) \frac{(1 - \zeta^P_s)}{(1 - \zeta^P_t)} \frac{\gamma}{\gamma - 1} \frac{W_s}{\alpha A_s N_{s^t-1}}(i) \]

\[
= (1 - \zeta^P_i)\mathbb{E}_t \sum_{s \geq t} \bar{A}_{VP,s}(i) \frac{(1 - \zeta^P_s)}{(1 - \zeta^P_t)} \frac{\gamma}{\gamma - 1} \frac{W^{VP}_s}{\alpha A_s (N^{VP})^{s-1}}(i) \quad (A.72)
\]

where the first equality follows from A.69, the second from the fact that \(\Psi\) is an equilibrium.
and the third from A.62 and A.71 together with the fact that with \( \rho = 1 \), we have \( \frac{\tilde{w}_{VP}^{t,s}}{w_{s}} = \frac{(1-\varsigma^t)}{(1-\varsigma^s)} = 1 + \delta \) w.p. 1. Notice that the permanent effect on consumer price inflation is need to ensure that \( \tilde{\Lambda}_{t,s}^{VP} = \tilde{\Lambda}_{t,s}^{VP} \) state by state, as can be seen by 28.

With flexible wages, optimal labor supply is also satisfied since real wages are unaffected:

\[
\frac{[\tilde{n}_{VP}^{t,i}(i)]^\eta}{\gamma_n} \gamma_n - \frac{\tilde{w}_{VP}^{t,i}(i)}{\tilde{P}_{VP}^{t}} = 0
\]

Moreover, since the transition from \( s_{t-1} \in S \) to \( s_t \in S^{VP} \) is unanticipated, the different inflation dynamic ex post does not affect optimal bond holdings ex ante. On the other hand, since the policy is permanent, future inflation is unaffected by its implementation as is clear from \( (A.70) \).

\[\text{D Proof of Proposition 2}\]

We start by giving a definition of a permanent unexpected appreciation of the nominal exchange rate.

**Definition 4.** Assume that \( s_t \) is governed by \( \{S, \Omega\} \) from \( t = 0, ..., t^* \). A currency devaluation of size \( \delta \) is described by \( \{GP^e, \Omega^e, \sigma^e\} \) with \( GP^e = S \cup S^e \) where the new set of states is

\[
S^e = \left \{ \tilde{s} = (\tau^m, \xi^x, \tau^v, \xi^p, \tilde{\epsilon}, \tau^{m*}, \xi^{x*}) \left| \frac{\tilde{\epsilon}}{\tilde{\epsilon}} = 1 + \delta \right. \right \},
\]

the transition matrix is

\[
\Omega^e = \begin{bmatrix}
(1 - \pi^t) \Omega & \pi^t \Omega \\
(1 - \rho) \Omega & \rho \Omega
\end{bmatrix}
\]

and the function describing the unanticipated transition to VP is given by

\[
\sigma^e_\delta(s) = (\tau^m, \xi^x, \tau^v, \xi^p, \tilde{\epsilon}, \tau^{m*}, \xi^{x*})
\]

s.t.

\[
\frac{\tilde{\epsilon}}{\tilde{\epsilon}} = 1 + \delta.
\]

(A.73)
Proposition 2. In a fixed exchange rate regime \((\varphi_e = \infty)\), under assumptions 1.- 3. of Proposition 1, an IX policy of size \(\delta\) has the same allocative effects as a once-and-for-all unexpected currency devaluation of size \(\delta\). A VP policy of the same size \(\frac{\delta}{1+\delta}\) has no effect on the allocation but causes the real exchange rate to appreciate by \(\delta\).

Proof. The fact that VP is still neutral even under fixed exchange rates is a straightforward consequence of the proof of Proposition 2. Since under flexible exchange rates VP is neutral and the nominal exchange rate is unaffected by its implementation, it follows that even if monetary policy targets a given fixed exchange rate the policy still remains neutral.

Turning to the equivalence between a currency devaluation and IX, let \(\{\mu_t^\epsilon\}_{t \geq 0}\) be a sequence of functions that map histories in which IX is implemented into histories in which a currency devaluation is implemented instead: i.e. \(\forall \tilde{s}^t = (\tilde{s}_0, ..., \tilde{s}_t) \in (GP^{IX})^{t+1}, \mu_t^\epsilon(\tilde{s}^t) = s^t = (s_0, ..., s_t) \in (GP^\epsilon)^{t+1}\) where \(\forall i \geq 1\)

\[
s_i = \begin{cases} 
\tilde{s}_i & \text{if } \tilde{s}_i \in S \\
\sigma_\delta^X \left( (\sigma_\delta^{IX})^{-1} (\tilde{s}_i) \right) & \text{if } \tilde{s}_i \in S^{IX} 
\end{cases}
\]

where \(\sigma_\delta^{IX}\) is as defined in A.60 and \(\sigma_\delta^X\) is as defined in A.73.

Let \(\{\Psi^\epsilon(s^t)\}_{s^t \in (ST)^t, t \geq 0}\) denote an equilibrium process under \(\{GP^\epsilon, \Omega^\epsilon, \sigma_\delta^X\}\) and consider now the process \(\{\tilde{\Psi}^{IX}(s^t)\}_{s^t \in (GP^{IX})^t, t \geq 0}\) with an unanticipated permanent IX such that, for each element \(\tilde{\kappa}^{IX}\) of \(\tilde{\Psi}^{IX}\), apart from the nominal exchange rate, we have

\[
\tilde{\kappa}^{IX}(\tilde{s}^t) = \kappa^\epsilon \left( \mu_t^\epsilon(\tilde{s}^t) \right) \quad \forall \tilde{s}^t \in (GP^{IX})^t, \forall t \geq 0 \tag{A.74}
\]

where \(\kappa^\epsilon\) is the corresponding element of the equilibrium process \(\Psi^\epsilon\).

The exchange rate satisfies \(\forall \tilde{s}^t = (\tilde{s}_1, ..., \tilde{s}_t) \in (GP^{IX})^t\)

\[
\tilde{\varepsilon}_t^{IX} = \begin{cases} 
\varepsilon_t^\epsilon & \text{if } \tilde{s}_t \in S \\
\frac{\varepsilon_t^\epsilon}{1+\delta} & \text{if } \tilde{s}_t \in S^{IX} 
\end{cases} \tag{A.75}
\]

To show that \(\{\tilde{\Psi}^{IX}(s^t)\}_{s^t \in (GP^{IX})^t, t \geq 0}\) is an equilibrium we can follow the same steps as in the proof Proposition 1.

At \(\tilde{s}^t = (\tilde{s}_1, ..., \tilde{s}_t) \in (GP^{IX})^t\) such that \(\tilde{s}_t \in S^{IX}\), the laws of one price and the balance of
payment equilibrium equations are satisfied since

$$\frac{\bar{\varepsilon}_t}{\varepsilon_{t}^{IX}} = \frac{(1 + \bar{\sigma}_t^x)}{(1 + \sigma_t^x)} = \frac{(1 + \tau_t^m)}{(1 + \tau_t^m)}$$

and the only other equations in which the exchange rate appears only depend on its expected appreciation which is the same in the two processes.

### E Reversal of IX policies and retaliation

We have asserted that the IX policy with reversal considered in the text has very similar effects to an IX policy subject to possible retaliation, meaning in the latter case that agents expect that the foreign government may retaliate in kind sometime in the future. Here we make this argument formally.

First we introduce a new variable, $T_t^I$, that measures international transfers from the foreign to the home country. The introduction of these transfers allows us to measure the distance between the allocations under reversal and under retaliation in a very simple way. The only equilibrium equation that is modified by the introduction of this transfer is the balance of payment equation A.56 which becomes

$$B_{Ft} - B_{Ht}^* = B_{Ft-1}^* \frac{R_{t-1}^*}{\varepsilon_t} - R_{t-1}^* + \frac{P_{Pt}}{(1 + \varepsilon_t^* \bar{\sigma}_t^x)} \left[ Y_{*}^{Ht} - (1 + \varepsilon_t^*) \frac{P_{Pt}}{(1 + \varepsilon_t^* \bar{\sigma}_t^x)} \right] + T_t^I. \quad (76)$$

Consider an IX policy subject to policy reversal and characterized by $\{S^T, \Omega^T\}$ where $S^T = \{s^{NT}, s^{IX}\}$. In state $(s^{NT})$ no country levies any taxes and in the second state $(s^{IX})$ the home country unilaterally raises import tariffs and export subsidies by the same amount $\delta$. The transition matrix is

$$\Omega^T = \begin{bmatrix} 1 & 0 \\ 1 - \rho & \rho \end{bmatrix} \quad (77)$$

Consider also an IX policy that triggers retaliation and characterized by $\{S^R, \Omega^R\}$, where $S^R = \{s^T, s^{TW}\}$. $S^T$ includes the same two states as described above but in $s^{TW}$ the foreign country retaliates with a symmetric policy (i.e. $\tau_t^m = \zeta_t^x = \tau_t^{m*} = \zeta_t^{x*} = \delta$). In this case the
transition probability matrix is:

\[
\Omega^R = \begin{bmatrix}
1 & 0 & 0 \\
(1 - \pi)(1 - \rho) & \rho & \pi (1 - \rho) \\
1 - \varphi & 0 & \varphi
\end{bmatrix}
\]  \hspace{1cm} (78)

**Lemma 1** If export prices are set in producer currency, a unilateral implementation of IX with policy reversal, i.e. \(s_t\) governed by \(\{S^T, \Omega^T\}\), implements the same equilibrium allocation as a unilateral implementation of IX that triggers retaliation, i.e. \(s_t\) governed by \(\{S^R, \Omega^R\}\), coupled with international transfers that satisfy:

\[
T^I_{t_1} = -\frac{\delta}{1 + \delta} \left[ B_{F,t_1-1} R^*_{t_1-1} \varepsilon_{t_1} + B_{H,t_1-1} R_{t_1-1} \right]
\]

\[
T^I_{t_2} = \delta \left[ B_{F,t_2-1} R^*_{t_2-1} \varepsilon_{t_2} + B_{H,t_2-1} \frac{R_{t_2-1}}{\pi_{t_2}} \right]
\]

where \(t_1\) is the first time the economy transits to the retaliation state \(s^{TW}\) and \(t_2 > t_1\) is the first time it leaves the retaliation state \(s^{TW}\).

The intuition of this lemma can be easily understood by considering the special case of a permanent transition to a trade war regime starting from balanced trade. In this case, \(T^I_{t_1} = 0\) and \(T^I_{t_2}\) never occurs so that Lemma 1 implies that the effects of starting a trade war are identical to the effects of abolishing all tariffs and subsidies in both countries. The reason can be easily understood by inspecting equation \((A.43a)\), where export subsidies in the foreign country exactly offset import tariffs in the home country, and, symmetrically, equation \((A.42a)\).

When the home country has a positive net foreign asset position, however, a transition to a trade war regime will not be equivalent to a transition to a state with no taxes. Given that a positive net foreign asset position implies that the home country is expected to run trade deficits in the future, import tariff revenues will exceed export subsidy expenditures, implying a positive wealth effect and an associated appreciation of the home currency. Symmetrically, the foreign economy will suffer wealth losses from its implementation of IX. Consequently, a transfer of resources that corrects this international wealth redistribution is needed to implement the same allocation under policy reversal and retaliation. Under our assumption of balanced trade in the long run, however, the economic effects of these transfers are of second order.
Proof. Let $\{\Psi (s^t)\}_{s^t \in (ST)^t, t \geq 0}$ be an equilibrium with no international transfers and no retaliation, i.e. $T^t (s^t) = 0 \ \forall s^t \in (ST)^t$.

Consider now the process $\{\tilde{\Psi} (s^t)\}_{s^t \in (SR)^t, t \geq 0}$ such that, for each element $\tilde{\kappa}$ of $\tilde{\Psi}$, other than bond holdings and local currency producer prices of exports, we have

$$\tilde{\kappa} (s^t) = \kappa (\mu_t (s^t)) \ \forall s^t \in (SR)^t, \ \forall t \geq 0$$

(79)

where $\kappa$ is the corresponding element of the equilibrium process $\Psi$ without trade wars and function $\mu_t$ maps all histories in which a trade war occurs into a history in which no taxes are levied: that is $\forall s^t = (s_1, ..., s_t) \in (SR)^t$, $\mu_t (s^t) = \tilde{s}^t = (\tilde{s}_1, ..., \tilde{s}_t) \in (ST)^t$ where $\forall i \geq 1$

$$\tilde{s}_i = \begin{cases} s_i & \text{if } s_i \neq s^{TW} \\ s^{NT} & \text{if } s_i = s^{TW} \end{cases}$$

For ease of notation in what follows, for any $s^t = (s_1, ..., s_t) \in (SR)^t$, we let $\tilde{\kappa}_t = \tilde{\kappa} (s^t)$ and $\kappa_t = \kappa (\mu (s^t))$.

Bond holdings and local currency producer prices of exports satisfy $\forall s^t = (s_1, ..., s_t) \in (SR)^t$

$$\frac{\tilde{B}_{F,t}}{B_{F,t}} = \frac{\tilde{B}_{H,t}}{B_{H,t}} = \begin{cases} 1 & \text{if } s_t \neq s^{TW} \\ \frac{1}{1+\delta} & \text{if } s_t = s^{TW} \end{cases}$$

(80)

$$\frac{\tilde{P}_{X^{*t}}}{P_{X^{*t}}} = \frac{\tilde{P}_{X_{t}}}{P_{X_{t}}} = \begin{cases} 1 & \text{if } s_t \neq s^{TW} \\ \frac{1}{1+\delta} & \text{if } s_t = s^{TW} \end{cases}$$

(81)

We want to show that $\{\tilde{\Psi} (s^t)\}_{s^t \in (SR)^t, t \geq 0}$ is an equilibrium when international transfers satisfy

$$\tilde{T}^t (s^t) = \begin{cases} 0 & \text{if } s_{t-1} \neq s^{TW} \text{ and } s_t \neq s^{TW} \\ -\frac{\delta}{1+\delta} \left[ \tilde{B}_{F,t-1} \tilde{R}_{t-1}^{*} \tilde{\varepsilon}_t + \tilde{B}_{H,t-1} \tilde{R}_{t-1} \right] & \text{if } s_{t-1} \neq s^{TW} \text{ and } s_t = s^{TW} \\ \frac{\delta}{1+\delta} \left[ \tilde{B}_{F,t-1} \tilde{R}_{t-1}^{*} \tilde{\varepsilon}_t + \tilde{B}_{H,t-1} \tilde{R}_{t-1} \right] & \text{if } s_{t-1} = s^{TW} \text{ and } s_t \neq s^{TW} \end{cases}$$

(82)
It is straightforward to check that if \( \Psi_t \) is an equilibrium then \( \tilde{\Psi}_t \) satisfies all equilibrium equations other than (A.56). When \( s_t = s^{TW} \) the only conditions that need to be checked are the laws of one price (A.42a) – (A.43a) and the tax pass-through equations (A.37) – (A.36) which are satisfied under (81). All the other equations are clearly satisfied by construction of \( \tilde{\Psi} \), and by the fact that the probability of leaving the unilateral IX state is the same in (77) and (78).

Consider now the balance of payment equilibrium (A.56) which we rewrite as follows

\[
\tilde{A}_t = \tilde{A}_{t-1}r_t^a + N\tilde{X}_t + \tilde{T}_t^d
\]

where

\[
\tilde{A}_{t-1} = \tilde{B}_{F,t-1}\tilde{\xi}_{t-1} + \tilde{B}_{ht-1}
\]

\[
r_t^a = \frac{[\tilde{B}_{F,t-1}\tilde{R}_{t-1}\tilde{\xi}_t + \tilde{B}_{ht-1}\tilde{R}_{t-1}]}{\tilde{A}_{t-1}}
\]

\[
N\tilde{X}_t = \epsilon_t \frac{P_{ht}^*}{1 + \tau_t^m} \frac{s^*}{s} Y_{ht}^* - \frac{(1 - \tau_t^v)}{(1 + \tau_t^m)} P_{Ft} Y_{Ft}
\]

Take any history \( \tilde{s}^\infty = (\tilde{s}_1, ..., \tilde{s}_t, ...) \in (SR)^\infty \) such that \( s_i = s^{TW} \) \( \forall i \). Let \( t_1 \) and \( t_2 \) satisfy \( s_{t_1} = s^{TW} \), \( s_{t_1-1} \neq s^{TW} \), \( s_{t_2} \neq s^{TW} \), \( s_{t_2-1} = s^{TW} \). At \( t_1 \) we have

\[
\tilde{A}_{t_1} = \frac{A_{t_1}}{1 + \delta} = \frac{A_{t_1-1}r_{t_1}^a + N\tilde{X}_{t_1}}{1 + \delta} = \frac{A_{t_1-1}r_{t_1}^a + N\tilde{X}_{t_1}}{1 + \delta} - \frac{\delta}{1 + \delta} A_{t_1-1}r_{t_1}^a = \tilde{A}_{t_1-1}r_{t_1}^a + N\tilde{X}_{t_1} + \tilde{T}_{t_1}^d
\]

where, the first follows from (80) given \( s_{t_1} = s^{TW} \); the second from the fact that \( \Psi \) is an equilibrium; and the last follows from the fact that (80) imply \( A_{t_1-1}r_{t_1}^a = \tilde{A}_{t_1-1}r_{t_1}^a \) given \( s_{t_1-1} \neq s^{TW} \) together with the fact that \( s_{t_1} = s^{TW} \) implies \( N\tilde{X}_{t_1} = \frac{N\tilde{X}_{t_1}}{1 + \delta} \) and that \( \tilde{T}_{t_1}^d \) is given by (82).
As long as the trade war is in place (80) readily imply that ∀s and \( t_1 < s < t_2 \)

\[
\tilde{A}_s = \frac{A_s}{1 + \delta} = \tilde{A}_{s-1} r^a_s + N \tilde{X}_s
\]  

(84)

And when it ends, at \( t_2 \), we have

\[
\tilde{A}_{t_2} = A_{t_2} = \tilde{A}_{t_2-1} r^a_{t_2} + N X_{t_2} = \frac{A_{t_2-1}}{1 + \delta} r^a_{t_2} + N X_{t_2} + \frac{\delta}{1 + \delta} A_{t_2-1} r^a_{t_2} = \tilde{A}_{t_2-1} r^a_{t_2} + N X_{t_2} + \tilde{T}^I_{t_2}
\]  

(85)

where we are using again (80) as in (83).

### F Anticipation Effects of IX

While we have shown that IX policies may boost output if their implementation is a surprise, the anticipation that such policies may be implemented sometime in the future can have immediate contractionary effects. The importance of anticipation effects was recognized by Krugman (1982) in a setting in which agents were certain about the future implementation date, but is useful to revisit in our Markov-switching framework given that it provides a convenient way of capturing uncertainty about the implementation date. In this vein, Figure 1 shows the response of the economy when agents learn that IX policies will be introduced in the future, but are unsure about the timing. Specifically, as long as IX policies are not implemented, agents believe that there is a 10 percent chance that IX policies will be implemented in the subsequent period (i.e., \( a = 0.10 \)), and that – once implemented – the policies will not be reversed (\( \rho = 1.0 \)).

The anticipation effects of IX policies work through an exchange rate channel: The expectation that the exchange rate must appreciate in the long-run causes the exchange rate to appreciate in the near-term, when agents first come to believe that IX policies will eventually be implemented (first panel). The stronger currency leads to a decline in competitiveness for domestic firms, a drop in exports, and an output contraction.
The neutrality result presented in Proposition 1 requires the strong condition that asset market incompleteness takes the form of no international trade in home currency denominated bonds. To understand the role of this restriction, note that the implementation of IX induces changes in two different components of households wealth. First, 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 with a permanent IX policy of size \( \delta \), \( G^F_t(\delta) \), is then given by the present discounted value of the fiscal revenues it generates

\[
G^F_t(\delta) = \mathbb{E}_t \sum_{i \geq 0} \left( \prod_{j=1}^{i} \frac{\pi_{t+j}^*}{R_{t+j}^*} \right) \frac{\delta}{1+\delta} \left( \frac{P_{Fl+i}^*}{P_{t+j}^*} Y_{Fl+i} - Q_{t+i}(0) \frac{P_{Hi+i}^*}{P_{t+j}^*} Y_{Hi+i}^* \right)
\]

where the second equality uses the fact that in equilibrium the present discounted value of future trade deficits is equal to the net foreign asset position of the home country, that is, the difference between home country holdings of foreign bonds \( [Q_t(0) B_{Fl-1}^* R_{t-1}^* / \pi_t^* - B_{Hi-1}^* R_{t-1} / \pi_t] \) and foreign country holdings of home bonds \( [B_{Hi-1}^* R_{t-1} / \pi_t] \).

Second, the exchange rate appreciation decreases the value of home holdings of foreign bonds. Denote with \( L^B_t(\delta) \) the losses on foreign bond holdings under an appreciation of size \( \delta \), then

\[
L^B_t(\delta) = [Q_t(\delta) - Q_t(0)] \frac{B_{Fl-1}^* R_{t-1}^* / \pi_t^*}{P_{t-1}^*} = -\frac{\delta}{1+\delta} Q_t(0) \frac{B_{Fl-1}^* R_{t-1}^* / \pi_t^*}{P_{t-1}^*} \quad (87)
\]

Equations (86) and (87) imply:

\[
L^B_t(\delta) = G^F_t(\delta) + \frac{\delta}{1+\delta} \frac{B_{Hi-1}^* R_{t-1}}{P_{t-1}^* \pi_t} \quad (88)
\]

Expression (88) summarizes the wealth effects associated with IX policies. When there is no international trading of bonds denominated in home currency \( B_{Hi}^* = 0 \), as required in Proposition 1, wealth gains through higher fiscal revenues \( G^F_t(\delta) \) are exactly offset by the wealth losses induced by lower valuations of foreign holdings \( L^B_t(\delta) \), thus preserving neutrality of IX policies. In contrast, when the home country borrows in home currency bonds \( B_{Hi-1}^* > 0 \) and invests in foreign currency bonds \( B_{Fl-1}^* > 0 \), it acquires a leveraged exposure to foreign
exchange variations and the sensitivity of wealth in the home country to an exchange rate appreciation is bigger than its net foreign asset position. Consequently, given an unchanged path for future trade deficits, an exchange rate appreciation of the same size of the policy reduces wealth in the home country as the increase in fiscal revenues is not large enough to offset the capital losses on foreign bonds holdings implied by equation (88). These wealth losses induce households to reduce their savings and, in equilibrium, the exchange rate appreciates less while the trade balance increases.

Figure 2 shows the response of the economy to a permanent unilateral IX policy when the home country has a leveraged exposure to exchange rate fluctuations. In particular, this experiment assumes that in the initial state international trade is balanced but countries hold offsetting positions in domestic and foreign currency denominated bonds \((i.e. \ B_{F^{-1}} = B_{H^{-1}}^* > 0)\) scaled to be twice as large as the value of annual GDP. As anticipated in our previous discussion, when foreign holdings of home currency denominated bonds are positive the implementation of a permanent IX lowers households wealth, consumption, and savings, thus dampening the appreciation of the exchange rate (solid lines). As a result, the home country runs a permanently positive trade balance to pay interest on its negative net foreign asset position. For comparison, we also plot the response of the baseline economy when there is no international trade in domestic currency bonds, as required in Proposition 1, and a permanent IX policy is neutral (dashed lines).

H Departing from Producer’s Currency Pricing

We conclude this section with a brief discussion on the requirement of producer’s currency pricing (PCP) in Proposition 1 to deliver neutrality of IX policies. We follow the literature and compare the transmission of policies under PCP, local currency pricing (LCP), and dominant currency pricing (DCP).

Figure 3 compares the effects of an IX policy under PCP (dotted lines), LCP (solid lines), and DCP (dashed lines), assuming that all other conditions in Proposition 1 are satisfied. As discussed before, under PCP international relative prices are insulated by the immediate

\footnote{For a discussion of transmission under PCP and LCP see, for instance, Devereux and Engel (2002). In our two-country model, under DCP the home country adopts PCP and the foreign country adopts LCP. See section ?? for further discussion of transmission under alternative pricing assumptions.}
appreciation of the exchange rate and the allocation is unaffected. In contrast, when foreign exporters prices are sticky in the currency of the home country the IX policy has allocative effects: Imports contract, inflation jumps, and output experiences a very small boost.

The source of non-neutrality, both for LCP and DCP, is the asymmetric pass-through of tariff changes and exchange rate movements to import prices. As shown by the expression for the price of imported goods in the home country

$$P_{Ft} = (1 + \tau^m_t) P_{X^*_t}$$

changes in import tariffs are fully passed through to import prices ($P_{Ft}$) whereas movements in the exchange rate only pass-through gradually as foreign exporters adjust their prices in the home market ($P_{X^*_t}$) infrequently under our Calvo pricing assumption. Hence, the rise in import prices reduces the demand for imported varieties and boosts output through import-substitution channels. The effects under DCP are nearly identical to the effects under LCP. The only difference is that with full exchange rate pass-through, home exports become more expensive causing exports to contract slightly and, accordingly, output to expand less.

I Data Sources and Calculation for the Quantitative Section ”2007 Fiscal Devaluation In Germany”

Macroeconomic data for Germany and the euro area (EA) are from Haver (EU Database). Mnemonics and details about the construction of the series are provided below.

**Germany.** Consumption is real private final consumption (J134PCT) and investment is real gross fixed capital formation (J134IFT). Net exports are the difference between nominal exports to the euro area (DESIXEZ) and nominal imports form the euro area (DESIMEZ) relative to nominal GDP (J134GDPN). We construct real GDP as the sum of nominal final domestic demand (J134DDN) and nominal net exports to the euro area, divided by the GDP deflator (J134GDPI). Consumer price inflation is the annualized quarterly change in the price level of the core HICP series, which excludes energy, food, alcohol, and tobacco (H134HOEF). Wage inflation is the annualized quarterly change in the series “Wage and Salaries for the Business Sector” (S134LWBN).
**EA ex-Germany.** Variables are constructed by subtracting the nominal German counterparts from the EA nominal data and then deflating the resulting series using the NIPA deflators. Specifically, consumption is EA nominal private final consumption (J025TCN) less Germany’s nominal private final consumption (J134PCN) divided by the EA consumption deflator (J025PCP). Investment is EA nominal gross fixed capital formation (J025IFN) less Germany’s nominal gross fixed capital formation (J134IFT) divided by the EA investment deflator (J025IFP). Nominal GDP is EA nominal final domestic demand (J025DDN) less the sum of Germany’s nominal final domestic demand (J134DDN) and Germany’s net exports to the euro area. Real GDP is nominal GDP divided by the EA GDP deflator (J025GDPI). The inflation series is constructed as a GDP-weighted average the annualized quarterly change in the price level of the core HICP series, which excludes energy, food, alcohol, and tobacco, of Belgium (H124HOEF), France (H132HOEF), Italy (H136HOEF), the Netherlands (H138HOEF), and Spain (H184HOEF). Wage inflation constructed as a GDP-weighted average the annualized quarterly change in the series “Wage and Salaries for the Business Sector” of Belgium (S124LWBN), France (S132LWBN), Italy (S136 LWBN), the Netherlands (S138 LWBN), and Spain (S184 LWBN). These countries altogether account for about 85 percent of the euro area ex-Germany region.

**Fiscal data.** Data on social security contributions are from the OECD Tax - Tax Wedge Database obtained through Haver (OECD Government Statistics Database). Data for Germany refer to the average social security tax rate as a percent of total labor costs for workers with income equal to the average wage and include both employer (A132ME2) and employee (A132MS2) taxes. The aggregate for the EA ex-Germany is constructed as a GDP-weighted average the average social security tax rates of Belgium (A124ME2, A124MS2), France (A132ME2, A132MS2), Italy (A134ME2, A134MS2), the Netherlands (A138ME2, A138MS2), and Spain (A184ME2, A184MS2). Data on VAT tax rates refer to the standard VAT rate for Germany and for the EA ex-Germany as in European Commission (2019), “VAT rates applied in the member States of the European Union”. On a GDP basis, the countries of Belgium, France, Italy, the Netherlands, and Spain altogether account for about 85 percent of the EA ex-Germany region.
Figure 1: Macroeconomic Effects of an Anticipated Permanent IX

**Note**: In both experiments we assume that prices are sticky, wages are flexible, and the exchange rate is flexible. The solid line shows the expected path of each variable after the policy is announced and agents expect it to be permanently implemented with probability 10 percent in the subsequent quarter as long as it is not implemented. The dashed line is the case in which the policy is permanently implemented at time 2.
Figure 2: Permanent IX with Foreign Holdings of Home Currency Bonds

Note: In both experiments we assume that prices are sticky, wages are flexible, and the exchange rate is flexible. The solid line shows the case in which, in the initial state, the home country has offsetting bond holdings in domestic and foreign currency equal to two times annual GDP. The dashed line is the case in which countries hold no bonds in the initial state. The figure shows the (expected) path of each variable after the policy is implemented and given that it is (expected to be) permanent.
Figure 3: Permanent IX: LCP, DCP and PCP

**Note:** In all the experiments we assume that prices are sticky, wages are flexible, and the exchange rate is flexible. The solid line shows the case in which both domestic and foreign exporters adopt LCP. The dashed line shows the case in which domestic exporters adopt PCP and foreign exporters adopt LCP. The dotted line shows the case in which both foreign and domestic exporters adopt PCP. The figure shows the (expected) path of each variable after the policy is implemented and given that it is (expected to be) permanent.