The Economics of Border Adjustment Tax

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1 Introduction

Border adjustment is a feature of tax systems, in particular of the value-added tax (VAT) and in certain cases of the corporate profit tax, which makes export sales tax deductible, while levies the tax on imports. The economic rationale behind the border adjustment is to make the tax system *destination-based* by linking the tax jurisdiction to the location of consumption, rather than the location of production, and hence to limit the incentives for cross-border transfer pricing (see Auerbach, Devereux, Keen, and Vella 2017). The border adjustment tax is now in the spotlight as a part of the corporate tax reform proposal under the Trump administration. According to this proposal, the export sales of corporations can be deducted from the corporate profit tax, while expenditure on imported goods are not deductible from the corporate tax base, in contrast with other costs such as the wage bill and purchases of domestic intermediates.[1]

The border adjustment tax (BAT) is equivalent to a combination of an import tariff and an export subsidy. Yet, as is well known from Grossman (1980) and Feldstein and Krugman (1990), this policy combination is neutral, when prices and wages are flexible, due to *Lerner (1936) symmetry* between import and export taxes (see also Costinot and Werning 2017). However, when prices and/or wages are sticky, the neutrality of the border adjustment tax no longer holds in general.[2] For example, Farhi, Gopinath, and Itskhoki (2014) study *fiscal devaluations* — the VAT-based border adjustment policies designed to replicate the effects of a nominal exchange rate devaluation in economies with a fixed exchange rate regime. Such policy proposals were

[1] See Paul Ryan's policy proposal "A Better Way" (https://abetterway.speaker.gov/_assets/pdf/ABetterWay-Tax-PolicyPaper.pdf, in particular, pp. 27–28 on border adjustment tax).

[2] Lerner symmetry relies on the adjustment of the relative nominal wages across countries, possibly by means of a nominal appreciation, which must keep relative prices unchanged and hence ensure trade balance.

especially popular as a means to boost economic competitiveness in the euro-currency-zone countries in the aftermath of the 2008-09 financial crisis.

In this paper, we study instead the macroeconomic consequences of a border adjustment tax in the context of a dynamic general equilibrium model with nominal stickiness and a monetary policy conducted according to a conventional Taylor rule under a floating exchange rate regime. We nest the border adjustment tax into a corporate tax reform, to parallel the recent US policy proposal. However, the analysis equally applies to a VAT reform, which by default features a border adjustment.[3] The stark difference from the case of a fixed exchange rate regime is that the exchange rate adjustment on impact of the tax reform can substitute for price and wage flexibility. Hence, the border adjustment tax may remain *neutral*, that is have no impact on a country's competitiveness and on real macroeconomic outcomes, even in economies with nominal stickiness, provided exchange rates are flexible.

We lay out the general model environment in Section 2. We then establish the exact conditions for neutrality of the border tax adjustment in Section 3. By neutrality we mean an outcome in which the equilibrium path of the macro variables remains unchanged independently of whether the border adjustment is implemented or not as a part of a tax policy reform. We describe these conditions and discuss the reasons why they are likely to fail in practice. We then proceed, in Section 4, to study the quantitative implications of various departures from the exact neutrality of the border adjustment tax.

The conventional static analysis of the border adjustment relies on the trade balance logic, and concludes that BAT neutrality is an immediate implication of the country's budget constraint.[4] We show here, however, that BAT neutrality in a dynamic monetary macro model is a much taller order. Firstly, when prices are sticky, BAT neutrality requires that the nominal exchange rate appreciates on impact to offset the effect of border adjustment on import and export prices. The equilibrium extent of this nominal appreciation depends both on the intertemporal budget constraint of the country and on the monetary policy regime. We show that conventional Taylor rules that respond to output gap and effective consumer price inflation are consistent with BAT neutrality. Yet, neutrality fails if monetary authorities react, directly or indirectly, to the nominal appreciation associated with the border adjustment.[5]

Secondly, beyond a specific type of monetary regime, BAT neutrality imposes restrictions on the timing and implementation of the BAT reform. In particular, exact neutrality requires

[3] In particular, when the value-added tax is coupled with a payroll subsidy (or a reduction in a payroll tax), it reproduces the effects of a corporate profit tax coupled with a border adjustment tax.

[4] See Auerbach and Holtz-Eakin "The Role of Border Adjustments in International Taxation" (AAF, November 30, 2016) and Feldstein "The House GOP's Good Tax Trade-Off" (WSJ, January 5, 2017).

[5] Note that neutrality requires that both: (a) the monetary authority of the country implementing BAT does not change its policy stance in response to the currency appreciation; and (b) the monetary authorities of its trade partners let their respective currencies depreciate. Each of these assumptions may be problematic in practice.

that the border adjustment is an unexpected permanent policy shift, which applies uniformly to all import and export flows.[6] If the border adjustment is expected ahead of time, or is expected to be reversed in the future, or creates expectations of retaliation by trade partners, these expectation effects translate into additional exchange rate movements, which, given price stickiness, result in distortions to the relative import and export prices. In addition, these expectation effects may alter the dynamic savings and portfolio choice decisions made by the private sector.

Thirdly, the specific nature of import and export price stickiness also matters for the neutrality result. In particular, BAT neutrality requires symmetry in the short-run pass-through of exchange rate and tax changes into import and export prices. While the theoretical producer currency pricing (PCP) and local currency pricing (LCP) benchmarks satisfy this symmetry requirement, the more empirically-motivated case of the dollar pricing (DCP) may fail this requirement, and hence result in deviations from BAT neutrality, which we study in Section 4. Interestingly, we find that the extend of nominal appreciation is not particularly sensitive to the nature of price stickiness and to the extent of exchange rate pass-through. Instead, it depends more on the trade openness and the relative duration of wage and price stickiness in the economy adopting BAT. In particular, in our quantitative model calibrated to the United States, a complete and immediate appreciation of the dollar by the extent of the border adjustment remains a good approximation even when the exact neutrality fails.[7]

Lastly, BAT neutrality depends on the currency composition of the net foreign asset position of the country. Border adjustment is, in general, associated with important distributional consequences, both within and across countries. In our analysis, we focus on two types of such distributional effects — namely, between the private sector and the government, and across international borders. The international transfer results from the currency appreciation provided there exists a non-zero net foreign asset position denominated in home currency. Indeed, currency appreciation triggered by BAT leads to a capital loss on home-currency net debt. Under these circumstances, BAT is, of course, not neutral. Interestingly, if the net foreign asset position is entirely in foreign currency, BAT is neutral and there is no associated *valuation effect*, as under these circumstances the purchasing power of the rest of the world does not change with the currency appreciation.[8]

Independently of the currency of net foreign assets and BAT neutrality, border adjustment

[6] It is difficult to apply BAT to exports of some services like education, healthcare and recreation. In the particular case of US with BAT proposed to be part of the the corporate tax, an arguably bigger concern are the S-corps, which are not subject to corporate taxes and pay instead individual income taxes with no border adjustment.

[7] This approximation appears to be robust more generally, and fails only if there are strong expectation effects either about the policy reversal or foreign retaliation, which are however difficult to discipline quantitatively.

[8] The valuation loss on foreign-currency assets is exactly compensated by the border adjustment tax, leaving the foreign-currency trade prices unchanged.

results in a transfer from the private sector to the government in the home country. In particular, in each period the BAT applies, the transfer from the private sector to the government is proportional to that period's trade deficit of the country. If border adjustment is permanent, the country's intertemporal budget constraint implies that the net present value of these transfers equals the net foreign asset position of the country at the time of the policy implementation. The nature of this transfer is akin to a capital levy on the existing net foreign asset position, which is transferred in proportion to the future flow trade deficits.[9] In our model, we make the conventional assumption that macro aggregates do not depend on the distribution of wealth within the home economy, and in particular the *Ricardian equivalence* holds. As a result, BAT neutrality is not violated by this transfer between the home private sector and the government. More generally, currency appreciation associated with BAT has distributional consequences between borrowers and lenders, which may trigger departures from BAT neutrality in richer models.

Lastly, we study quantitatively the trade effects emerging from border adjustment in the plausible cases when BAT neutrality is violated. As trade prices and wages adjust, there are no long-run consequences of BAT for trade flows, and therefore all effects are confined to the short run. Under DCP, we find that border adjustment and the associated appreciation, even if incomplete, are likely to depress both imports and exports, with only second order effects on the overall trade balance. This happens despite the increased profit margins of the home exporters, as they pocket the border adjustment without reducing their dollar export prices in the short run.

Our quantitative model is calibrated to the specific case of the United States and the policy proposal under consideration. The US economy is distinct in a number of ways. First, US holds large gross foreign asset positions, with the majority of liabilities denominated in dollars. This results in a net foreign liability of the order of one US annual GDP denominated in dollars, and hence the dollar appreciation triggered by a 20% border adjustment tax results in a transfer from the US to the rest of the world of the order of magnitude of 20% of the US GDP. Second, US dollar enjoys the status of the dominant currency for world trade flows, and thus both imports and exports of the US are priced in dollars, violating another requirement for BAT neutrality.

We find that, despite these departure from neutrality, the US dollar still appreciates on impact of the policy reform by almost the exact amount of the border adjustment tax. This is because, while the capital loss on the net foreign asset position is large, it is still dwarfed by the

[9] The nominal appreciation triggers a capital loss on the home-currency debt held by the private sector, but not by the government, due to the wedge in the border prices faced by the home private sector and by the foreigners. The home government pockets this wedge in proportion to the trade deficits, which over time cumulates to the amount proportional to the size of the initial net foreign asset position.

present value of all future US gross trade flows. Also, because the US economy is fairly closed, with a trade-to-GDP ratio of 30%, the non-neutrality arising from the dollar pricing assumption has only a small effect on the exchange rate. At the same time, dollar price stickiness results in depressed short-run trade flows, both imports and exports, which gradually recover as trade prices become flexible. Therefore, we find that BAT policy cannot be used to stimulate US exports, with at best a very mild effect on the US trade balance. Instead, it is likely to reduce all international gross trade flows.

Another distinct feature of the US economy is its current trade deficit, despite the fact that it is a net debtor country. As discussed above, this implies that the border adjustment tax results in a transfer from the private sector to the government budget in the short run, but away from the government budget in the long run. Therefore, in the case of the US, BAT cannot be considered a robust long-run source of government revenues.

2 Model

The model economy features two countries, home H and foreign F. There are three types of agents in each economy: consumers, producers and the government, and we describe each in turn. Several ingredients follow from Farhi, Gopinath, and Itskhoki (2014) and Casas, Diez, Gopinath, and Gourinchas (2016).

2.1 Consumers

The home country is populated with a continuum of symmetric households. Households are indexed by $h \in [0,1]$, but we often omit the index h to simplify exposition. In each period, each household h chooses consumption C_t, holdings of H and F bonds and trade a complete set of Arrow-Debreu securities domestically. Each household also sets a wage rate $W_t(h)$ and supplies labor $N_t(h)$ in order to satisfy demand at this wage rate.

The household h maximizes expected lifetime utility, $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$, subject to the flow budget constraint:

$$\begin{aligned} P_t C_t + B_{t+1} + B^*_{t+1}\mathcal{E}_t + \int_{s\in\mathcal{S}_{t+1}} Q_t(s)\mathcal{B}_{t+1}(s)\mathrm{d}s \leq & (1+i_t)B_t + (1+i^*_t)B^*_t\mathcal{E}_t + \mathcal{B}_t \\ & + W_t(h)N_t(h) + \Pi_t + T_t + \zeta_t, \end{aligned} \tag{1}$$

where $\mathcal{E}_t$ is the home currency price of the foreign currency, P_t is the price of the domestic final consumption good C_t. Π_t represents domestic post-tax profits that are transfered to households who own the domestic firms. Households also trade risk-free international bonds denominated in H and F currency that pay nominal interest rates i^*_t and i_t respectively. B_{t+1}

and B^*_{t+1} are the holdings of the H and F bonds respectively. $\mathcal{B}_t$ is the payout on the Arrow-Debreu security that is only traded domestically with $Q_t(s)$ the period-t price of the security that pays one unit of H currency in period $t+1$ and state $s \in \mathcal{S}_{t+1}$, and $\mathcal{B}_{t+1}(s)$ are the corresponding holdings. Finally, T_t and ζ_t capture domestic lump-sum transfers from the government and international transfers. We will use ζ_t to capture valuation effects at a later point.

The per-period utility function is separable in consumption and labor and given by,

$$U(C_t, N_t) = \frac{1}{1-\sigma_c} C_t^{1-\sigma_c} - \frac{\kappa}{1+\varphi} N_t^{1+\varphi} \tag{2}$$

where $\sigma_c > 0$ is the household's coefficient of relative risk aversion, $\varphi > 0$ is the inverse of the Frisch elasticity of labor supply and κ scales the disutility of labor. Inter-temporal optimality conditions for H bonds and F bonds are given by:

$$C_t^{-\sigma_c} = \beta(1+i_t)\mathbb{E}_t C_{t+1}^{-\sigma_c} \frac{P_t}{P_{t+1}}, \tag{3}$$

$$C_t^{-\sigma_c} = \beta(1+i_t^*)\mathbb{E}_t C_{t+1}^{-\sigma_c} \frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \tag{4}$$

where $1 + i_t = \left(\int_{s \in \mathcal{S}_{t+1}} Q_t(s) \mathrm{d}s \right)^{-1}$ by the no-arbitrage condition.

Households are subject to a Calvo friction when setting wages: in any given period, they may adjust their wage with probability $1-\delta_w$, and maintain the previous-period nominal wage otherwise. They face a downward sloping demand for the specific variety of labor they supply given by, $N_t(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\vartheta} N_t$, where $\vartheta > 1$ is the constant elasticity of labor demand and W_t is the aggregate wage rate. The standard optimality condition for wage setting is given by:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_w^{s-t} \Theta_{t,s} N_s W_s^{\vartheta(1+\varphi)} \left[\frac{\vartheta}{\vartheta - 1} \kappa P_s C_s^{\sigma} N_s^{\varphi} - \frac{\bar{W}_t(h)^{1+\vartheta\varphi}}{W_s^{\vartheta\varphi}} \right] = 0, \tag{5}$$

where $\Theta_{t,s} \equiv \beta^{s-t} \frac{C_s^{-\sigma_c}}{C_t^{-\sigma_c}} \frac{P_t}{P_s}$ is the stochastic discount factor between periods t and $s \geq t$ and $\bar{W}_t(h)$ is the optimal reset wage in period t. This implies that $\bar{W}_t(h)$ is preset as a constant markup over the expected weighted-average between future marginal rates of substitution between labor and consumption and aggregate wage rates, during the duration of the wage. This is a standard result in the New Keynesian literature, as derived, for example, in Galí (2008).

The foreign households are symmetric.

2.2 Producers

In each country there is a continuum $\omega \in [0,1]$ of firms producing different varieties of goods using a technology with labor and intermediate inputs:

$$Y_t(\omega) = e^{a_t} L_t(\omega)^{1-\alpha} X_t(\omega)^{\alpha}, \qquad 0 < \alpha < 1, \tag{6}$$

where a_t is the (log) aggregate country-wide level of productivity, $L_t(\omega)$ is the firm's labor input, $X_t(\omega)$ is its purchase of intermediate inputs. The labor input L_t is a CES aggregator of the individual varieties supplied by each household, $L_t = \left[\int_0^1 L_t(h)^{(\vartheta-1)/\vartheta} \mathrm{d}h\right]^{\frac{\vartheta}{\vartheta-1}}$ with $\vartheta > 1$.

The firm sells to both the home and foreign market. Markets are assumed to be segmented so firms can set different prices by destination market and invoicing currency. The profit of firm ω is given by

$$\begin{aligned}\Pi_t(\omega) =& (1-\tau_t)\left(P_{HH,t}(\omega)Y_{HH,t}(\omega) + P_{HF,t}(\omega)Y_{HF,t}(\omega) - W_t L_t(\omega) - P_{Xt}X_t(\omega)\right) \\ &+ \iota_t \cdot \tau_t P_{HF,t}(\omega)Y_{HF,t}(\omega)\end{aligned} \tag{7}$$

where τ_t is the profit tax and $\iota_t = 1$ with border tax adjustment, i.e. export revenues not taxed. In this formulation we have all of the intermediate inputs purchased domestically from the bundler at price $P_{Xt} = P_t$ described in the next section.

Denote $\mathcal{MC}_t$ the marginal cost of domestic firms. It is given by:

$$\mathcal{MC}_t = \frac{1}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} \cdot \frac{W_t^{1-\alpha} P_t^{\alpha}}{e^{a_t}}. \tag{8}$$

The optimality conditions for intermediates and labor expenditure are given by:

$$P_t X_t = \alpha \mathcal{MC}_t Y_t \qquad \text{and} \qquad W_t L_t = (1-\alpha)\mathcal{MC}_t Y_t, \tag{9}$$

and $L_t(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\vartheta} L_t$ with $W_t = \left[\int W_t(h)^{1-\vartheta} dh\right]^{\frac{1}{1-\vartheta}}$.

2.3 Bundlers

This sector combines all domestic and imported varieties to produce a good that is both consumed as a final good and used as an intermediate input for production. The aggregator $\mathcal{F}$ is implicitly defined by a Kimball (1995) homothetic demand aggregator:

$$\sum_i \frac{1}{|\Omega_i|} \int_{\omega \in \Omega_i} \gamma_i \Upsilon\left(\frac{|\Omega_i| \mathcal{F}_{iH}(\omega)}{\gamma_i \mathcal{F}}\right) d\omega = 1. \tag{10}$$

In equation (10), $\mathcal{F}_{iH}(\omega)$ represents the demand in country H of variety ω produced by country i, where $i \in \{H, F\}$. $\gamma_H > 1/2$ is a parameter that captures home bias in H and $|\Omega_i|$ is the measure of varieties consumed in country i. The function Υ is increasing and concave, with $\Upsilon(1) = 1$, $\Upsilon'(\cdot) > 0$ and $\Upsilon''(\cdot) < 0$. This demand structure gives rise to strategic complementarities in price setting resulting in variable mark-ups, and giving rise to the classic Dornbusch (1987) and Krugman (1987) pricing to market. The Kimball (1995) structure also nests the CES case with Υ as a power function.

This sector is assumed to be perfectly competitive. Accordingly the break even price index P_t for the bundle satisfies the expenditure equation:

$$P_t\mathcal{F}_t = \int_{\Omega_H} P^{\mathcal{F}}_{HH,t}(\omega)\mathcal{F}_{HH,t}(\omega)d\omega + \int_{\Omega_F} \left[\eta_t(\omega)P^{\mathcal{F}S}_{FH,t}(\omega) + \left(1-\eta_t(\omega)\right)P^{\mathcal{F}C}_{FH,t}(\omega)\right]\mathcal{F}_{FH,t}(\omega)d\omega,$$

where

$$P^{\mathcal{F}}_{HH,t}(\omega) = P_{HH,t}(\omega), \qquad P^{\mathcal{F}C}_{FH,t}(\omega) = \frac{P^*_{FH,t}(\omega)\mathcal{E}_t}{1-\iota_t\tau_t} \quad \text{and} \quad P^{\mathcal{F}S}_{FH,t}(\omega) = P^*_{FH,t}(\omega)\mathcal{E}_t,$$

where $P^*_{FH,t}(\omega)$ the prices charged by foreign suppliers (expressed in foreign currency). There are two points to note here. First, because of the border adjustment tax on imports, the effective prices of imported goods are higher than the border prices. Second, to capture the fact that there may be some firms, the so called S-corps, that are not subject to corporate income tax and hence are not subject to the border adjustment tax, in contrast to the conventional C-corps, we use an indicator $\eta_t(\omega)$. The effective import prices paid by the two types of firms are $P^{\mathcal{F}S}_{FH,t}$ and $P^{\mathcal{F}C}_{FH,t}$ respectively. In what follows, we denote with η the fraction of the S-corps. This is one source of difference with VAT.

The demand for any variety given aggregate demand $\mathcal{F}_t$:

$$\mathcal{F}_{HH,t}(\omega) = \gamma_i\psi\left(D_t\frac{P^{\mathcal{F}}_{iH,t}(\omega)}{P_t}\right)\mathcal{F}_t, \tag{11}$$

where $\psi(\cdot) \equiv \Upsilon'^{-1}(\cdot)$ and $\psi'(\cdot) < 0$, and $D_t \equiv \sum_i \int_{\Omega_i} \Upsilon'\left(\frac{|\Omega_i|\mathcal{F}_{iH,t}(\omega)}{\gamma_i\mathcal{F}_t}\right)\frac{\mathcal{F}_{iH,t}(\omega)}{\mathcal{F}_t}d\omega$. Define the elasticity of demand $\sigma_{iH,t}(\omega) \equiv -\frac{\partial \log \mathcal{F}_{iH,t}(\omega)}{\partial \log P_{iH,t}(\omega)}$. The log of the mark-up is $\mu_{iH,t}(\omega) \equiv \log\left(\frac{\sigma_{iH,t}}{\sigma_{iH,t}-1}\right)$. A relevant characteristic is the elasticity of the mark-up $\Gamma_{iH,t}(\omega) = \frac{\partial \mu_{iH,t}}{\partial \log P_{iH,t}(\omega)}$.

2.4 Pricing

The firms described in Section 2.2 choose prices at which to sell in H and in F, with prices reset infrequently. We consider a Calvo pricing environment where firms are randomly chosen to reset prices with probability $1-\delta_p$. Furthermore, we consider the three pricing paradigms — that of producer, local and dominant currency pricing (PCP, LCP and DCP, respectively). We define H's currency to be the dominant currency.

We assume that all domestic prices are sticky in the home currency. Therefore, in all pricing regimes, the optimal reset price for domestic sales of H firms satisfies:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta_{t,s}(1-\tau_s) Y_{HH,s}(\omega)(\sigma_{HH,s}(\omega)-1)\left(\bar{P}_{HH,t}(\omega) - \frac{\sigma_{HH,s}(\omega)}{\sigma_{HH,s}(\omega)-1}\mathcal{MC}_s\right) = 0,$$

where $Y_{HH,s|t}(\omega)$ is the quantity sold in country H at time s by an H firm that resets prices at time t and $\sigma_{HH,s|t}(\omega)$ is the corresponding elasticity of demand. This expression implies that $\bar{P}_{HH,t}(\omega)$ is preset as a markup over expected future marginal costs during the duration of the price. Observe that because of strategic complementarities, the markup term is not generally constant.

We now turn to the alternative pricing regimes for export and import prices. To keep track of different definitions of prices, it is useful to define the following terms (for $i \neq j \in \{H, F\}$):

- $\hat{P}^*_{ij,t}(\omega)$ is the foreign-currency price at the border of the foreign country. That is, it is the price received by a foreign exporter if $i = F$ and $j = H$; and it is the price paid by a foreign importer if $i = H$ and $j = F$.
- $\hat{P}_{ij,t}(\omega) = \frac{\hat{P}^*_{ij,t}(\omega)\mathcal{E}_t}{1-\iota_t\tau_t}$ is the effective home-currency price after the border adjustment. That is, it is the price paid by the home importers if $i = F$ and $j = H$, which takes into account that the cost of imports is not tax-deductible unlike other costs. Alternative, if $i = H$ and $j = F$, it is the price received by the home exporters inclusive of the reimbursement of the corporate tax when the good is exported.
- $\hat{P}^b_{ij,t}(\omega) = \hat{P}^*_{ij,t}(\omega)\mathcal{E}_t = \hat{P}_{ij,t}(\omega)\cdot(1-\iota_t\tau_t)$ is the home-currency price at the home border, before the border adjustment. In particular, these are the prices paid/received by the foreigners, while the home firms still pay/receive the border adjustment over these prices.

During the periods of price inadjustment, one of these three definitions of prices is kept unchanged.

We consider three types of border currency pricing — producer (PCP), local (LCP), and dollar (or dominant, DCP). We view the PCP and LCP as the pure theoretical benchmarks (see discussion in Obstfeld and Rogoff 2000, Engel 2003), in which either the net producer prices (in producer currency) or the gross consumer prices (in consumer local currency) remain fixed during the period of price inadjustment. We consider dollar pricing as the third alternative, in which both import and export prices are sticky in dollars (home currency), so that currency

Table 1: Which prices are constant during the period of price stickiness?

PCP	LCP	DCP
$\hat{P}_{HF,t}$ and $\hat{P}^*_{FH,t}$	$\hat{P}^*_{HF,t}$ and $\hat{P}_{FH,t}$	$\hat{P}^b_{HF,t}$ and $\hat{P}^b_{FH,t}$

fluctuations are absorbed in the short run into the margins of the foreign firms. At the same time, we assume that the border adjustment taxes are absorbed into the margins of the US (home) firms during the period of price inadjustment. While there are many other possible departures from the limiting theoretical benchmarks of PCP and LCP, we view our formulation of DCP as the empirically-relevant case, at least given our focus on the US economy, but arguably even more generally (see Gopinath, Itskhoki, and Rigobon 2010, Casas, Diez, Gopinath, and Gourinchas 2016). We summarize the three types of price setting in Table 1 and discuss them in detail next.

Producer Currency Pricing In this case prices are sticky in H currency for H firms and in F currency for F firms. Furthermore, we assume that the firm presets the pre-tax price, and the border adjustment tax operates on top of the preset price. This way, the firm targets an optimal level of markup over its domestic currency marginal cost, and both exchange rate and taxes are added on top of this factory-gate price. This means that under PCP, $\hat{P}^*_{FH,t}(\omega)$ and $\hat{P}_{HF,t}(\omega)$ are kept unchanged during the periods of price inadjustment, while the other four definitions of prices adjust one-to-one with changes in $\mathcal{E}_t$ and τ_t. In particular, $\hat{P}^b_{FH,t}(\omega)$ moves one-to-one with $\mathcal{E}_t$, while $\hat{P}_{FH,t}(\omega)$ in addition decreases one-to-one with $(1-\tau_t)$ provide the border adjustment is in effect ($\iota_t = 1$).

Therefore, the optimal reset price of the home firms for foreign sales satisfies:[10]

[10]The home-currency after-tax profits from foreign sales in period $s \geq t$ with a price preset at t under PCP, LCP and DCP can be written respectively as:

$$\bar{\Pi}^P_{HF,s} = (1-\tau_s)\left[\hat{P}_{HF,t} - MC_s\right] Y_{HF,s}\left(\frac{\hat{P}_{HF,t}(1-\iota_s\tau_s)}{\mathcal{E}_s}\right),$$

$$\bar{\Pi}^L_{HF,s} = (1-\tau_s)\left[\frac{\hat{P}^*_{HF,t}\mathcal{E}_s}{1-\iota_s\tau_s} - MC_s\right] Y_{HF,s}\left(\hat{P}^*_{HF,t}\right),$$

$$\bar{\Pi}^D_{HF,s} = (1-\tau_s)\left[\frac{\hat{P}^b_{HF,t}}{1-\iota_s\tau_s} - MC_s\right] Y_{HF,s}\left(\hat{P}^b_{HF,t}/\mathcal{E}_s\right)$$

The price setting equations in the text derive from the optimality conditions with respect to $\hat{P}_{HF,t}$, $\hat{P}^*_{HF,t}$ and $\hat{P}^b_{HF,t}$ respectively, averaged and discounted over the period of price duration. We provide the parallel expressions for the foreign firms serving the home market in Appendix A.1.

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta_{t,s} (1-\tau_s) Y_{HF,s}(\omega)(\sigma_{HF,s}(\omega)-1) \left(\bar{P}_{HF,t}(\omega) - \frac{\sigma_{HF,s}(\omega)}{\sigma_{HF,s}(\omega)-1} \mathcal{MC}_s \right) = 0,$$

which exactly parallels the price-setting equation for the home market, allowing however for a different desired markup due to pricing-to-market. Note that exchange rate and border adjustment tax do not enter this expression directly, as the firm only wants to maintain a certain desired level of markup over its home currency marginal cost. The exchange rate and border adjustment tax affect the price setting indirectly, as the foreign-currency consumer price $\hat{P}_{HF,s} = \bar{P}_{HF,t}(\omega) \cdot \frac{1-\iota_s \tau_s}{\mathcal{E}_s}$ determines both the location and the slope (elasticity) of demand, $Y_{HF,s}(\omega)$ and $\sigma_{HF,s}(\omega)$. Also note that when the border adjustment is implemented at $s > t$, the price received by the firm inclusive of the tax $\hat{P}_{HF,s} = \bar{P}_{HF,t}$ is unchanged, yet the border price charged to the foreigners $\hat{P}^b_{HF,s} = \bar{P}_{HF,t}(1-\iota_s\tau_s)$ falls one-to-one with the border adjustment tax $(1-\tau_s)$.

A symmetric equation characterizes the optimal price setting by the foreign PCP firms for the home market:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta^*_{t,s} Y_{FH,s}(\omega)(\sigma_{FH,s}(\omega)-1) \left(\bar{P}^*_{FH,t}(\omega) - \frac{\sigma_{FH,s}(\omega)}{\sigma_{FH,s}(\omega)-1} \mathcal{MC}^*_s \right) = 0,$$

so that the price received by the foreign firm at $s \geq t$ is $\hat{P}^*_{FH,s} = \bar{P}^*_{FH,t}$ and the effective after-border-adjustment price paid by the home importer is $\hat{P}_{FH,s} = \bar{P}^*_{FH,t} \frac{\mathcal{E}_s}{1-\iota_s\tau_s}$, and this latter price determines the location and the slope (elasticity) of demand, $Y_{FH,s}$ and $\sigma_{FH,s}$.

Local Currency Pricing In this case, prices are sticky in the destination currency and inclusive of the border adjustment, so that the consumers face a constant effective price during the period of price inadjustment. This means that for prices set at t, the effective consumer prices at $s \geq t$ are $\hat{P}^*_{HF,s} = \bar{P}^*_{HF,t}$ and $\hat{P}_{FH,s} = \bar{P}_{FH,t}$. At the same time, the prices received by the exporting firms change with both the exchange rate and the border adjustment tax according to: $\hat{P}_{HF,s} = \frac{\bar{P}^*_{HF,t}\mathcal{E}_s}{1-\iota_s\tau_s}$ and $\hat{P}^*_{FH,s} = \bar{P}_{FH,t}(1-\iota_s\tau_s)/\mathcal{E}_s$. Therefore, the optimal price setting equations are given by:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta_{t,s} Y_{HF,s}(\omega)(\sigma_{HF,s}(\omega)-1) \left(\frac{\mathcal{E}_s \bar{P}^*_{HF,t}(\omega)}{1-\iota_s\tau_s} - \frac{\sigma_{HF,s}(\omega)}{\sigma_{HF,s}(\omega)-1} \mathcal{MC}_s \right) = 0,$$
$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta^*_{t,s} Y_{FH,s}(\omega)(\sigma_{FH,s}(\omega)-1) \left(\frac{\bar{P}_{FH,t}(\omega)(1-\iota_s\tau_s)}{\mathcal{E}_s} - \frac{\sigma_{FH,s}(\omega)}{\sigma_{FH,s}(\omega)-1} \mathcal{MC}^*_s \right) = 0.$$

Dominant Currency Pricing In this case, we assume that both the import and export prices are sticky in dollars (the home currency), however, the domestic firms face the border adjustment tax on top of the preset prices. In particular, the home exporters fix prices in dollars, $\hat{P}^b_{HF,s} = \bar{P}_{HF,t}$ for $s \geq t$, so that the foreign importers pay $\hat{P}^*_{HF,s} = \bar{P}_{HF,t}/\mathcal{E}_s$. However, when the border adjustment tax is introduced after the prices are preset, the home exporters effectively receive a higher price of $\hat{P}_{HF,s} = \bar{P}_{HF,t}/(1-\iota_s\tau_s)$, while the price faced by the foreign importers does not respond immediately to τ_s. Similarly, the foreign firms set their export price in home currency, $\hat{P}^b_{FH,s} = \bar{P}_{FH,t}$, and therefore the price that they receive changes with the exchange rate, $\hat{P}^*_{FH,s} = \bar{P}_{FH,t}/\mathcal{E}_s$, while the effective price paid by the home importers responds immediately only to the border adjustment tax, $\hat{P}_{FH,s} = \bar{P}_{FH,t}/(1-\iota_s\tau_s)$.

Note the two types of asymmetries relative to the PCP and LCP pricing regimes. The first obvious one is the asymmetry in the currency use, as the home exports are prices in home currency, while the foreign exports are also priced in the home currency. Second, there is also an asymmetry in the treatment of the exchange rate movements and the border adjustment tax — while the foreigners absorb all of the exchange rate movements, the domestic firms absorb the border tax adjustment into their profit margins, in the short run. We view this as a realistic description of the dominant price setting strategies for the US import and export flows.

Given this price setting assumption, the optimal preset prices under the DCP regime satisfy the following conditions:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta_{t,s} Y_{HF,s}(\omega)(\sigma_{HF,s}(\omega)-1)\left(\frac{\bar{P}_{HF,t}(\omega)}{1-\iota_s\tau_s} - \frac{\sigma_{HF,s}(\omega)}{\sigma_{HF,s}(\omega)-1}\mathcal{MC}_s\right) = 0,$$
$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta^*_{t,s} Y_{FH,s}(\omega)(\sigma_{FH,s}(\omega)-1)\left(\frac{\bar{P}_{FH,t}(\omega)}{\mathcal{E}_s} - \frac{\sigma_{FH,s}(\omega)}{\sigma_{FH,s}(\omega)-1}\mathcal{MC}^*_s\right) = 0.$$

2.5 Government and country budget constraints

We assume that the government must balance its budget each period, returning all tax revenues in the form of lump-sum transfers to the households (T_t). This is without loss of generality since Ricardian equivalence holds in this model.

The government budget constraint in period t is:

$$T_t = \frac{\tau_t}{1-\tau_t}\Pi_t - \frac{\iota_t\tau_t}{1-\tau_t}NX_t, \qquad NX_t \equiv \left[P_{HF,t}Y_{HF,t} - P^*_{FH,t}\mathcal{E}_t Y_{FH,t}\right], \tag{12}$$

where $\Pi_t = \int_{\Omega_H}\Pi_t(\omega)\mathrm{d}\omega$, and $P_{HF,t}$ and $P_{FH,t}$ are the price indexes corresponding respectively to the home-currency export price charged to foreigners and the foreign-currency import price paid to foreigners. Combining this together with the household budget constraint and aggregate profits, we arrive at the aggregate country budget constraint:

$$\frac{1}{\mathcal{E}_t}B_{t+1}+B^*_{t+1}-\frac{1}{\mathcal{E}_t}B_t-B^*_t(1+i^*_t)=\frac{1}{\mathcal{E}_t}(NX_t+\zeta_t). \tag{13}$$

2.6 Monetary Policy

The domestic risk-free interest rate is set by H's monetary authority and follows a Taylor rule:

$$i_t-i^*=\rho_m(i_{t-1}-i^*)+(1-\rho_m)\left(\phi_M\pi_t+\phi_Y\tilde{y}_t\right)+\varepsilon_{i,t} \tag{14}$$

In equation (14), ϕ_M captures the sensitivity of policy rates to domestic price inflation $\pi_t = \Delta\ln P_t$, ϕ_Y captures the sensitivity to the domestic output gap $\tilde{y}_t$, measured as the distance between equilibrium output and flexible price output, ρ_m is the interest rate smoothing parameter, and $\varepsilon_{i,t}$ is the monetary policy shock.

3 Border Adjustment Neutrality

In this section we consider the case under which the border adjustment is neutral in the following sense:

Definition 1 (Neutrality) *Border adjustment is neutral if the equilibrium path of all real macroeconomic variables does not depend on whether the border adjustment is implemented or not.*

The neutrality concerns only real macro variables, and does not concern prices, exchange rates and distributional variables (across agents or between private and public sector). As above, $\iota_t\in\{0,1\}$ denotes the indicator for whether the border adjustment takes effect, and the neutrality property formally implies that the choice of $\iota_t\in\{0,1\}$ is immaterial for the equilibrium path of the economy.

We introduce two additional definitions that prove useful below. First:

Definition 2 (Complete appreciation) *The dollar appreciation caused by the border adjustment is said to be complete if* $\frac{\mathcal{E}^1_t}{1-\tau_t}=\mathcal{E}^0_t$ *for all* t*, where* $\mathcal{E}^1_t$ *and* $\mathcal{E}^0_t$ *denote the equilibrium values of the exchange rate in otherwise identical economies with* ($\iota_t=1$) *and without* ($\iota_t=0$) *border adjustment respectively.*

Second, consider the short-run response of border prices. We denote with $\hat{P}^*_{HF,t}(\omega)$ the foreign currency prices paid by the foreigners for a variety of the home good. We also denote with $\hat{P}^*_{FH,t}(\omega)$ the foreign currency price received by the foreigners for a variety of their good exported to the home market. The hats indicate that these prices are *not adjusted* in period t in whatever currency they were set prior to t, as we focus here on the short run behavior of prices. Note that the corresponding home-currency 'after-tax' prices paid and received by the home exporters and importers are thus:

$$\hat{P}_{FH,t}(\omega) = \frac{\hat{P}^*_{FH,t}(\omega)\mathcal{E}_t}{1-\iota_t\tau_t} \qquad \text{and} \qquad \hat{P}_{HF,t}(\omega) = \frac{\hat{P}^*_{HF,t}(\omega)\mathcal{E}_t}{1-\iota_t\tau_t}.$$

Indeed, the border adjustment $1/(1-\iota_t\tau_t)$ raises both import costs paid by home importers and after-tax export prices received by home exporters.

Definition 3 (Symmetric short-run pass-through) *The preset prices respond symmetrically to both the border adjustment tax and the exchange rate:*

$$\frac{\partial \log \hat{P}^*_{ij,t}(\omega)}{\partial \log \mathcal{E}_t} = -\frac{\partial \log \hat{P}^*_{ij,t}(\omega)}{\partial \log(1-\iota_t\tau_t)}, \qquad i,j \in \{H,F\}, \quad i \neq j.$$

Note that this is not an assumption about the strategic price setting behavior of the firms. Instead, it is an assumption on the mechanical behavior of prices during the period of price stickiness. There are two cases in which short-run pass-through is symmetric. The first case is that of the PCP pricing, in which the firm fixes the after-tax home-currency price. In this case, any changes in taxes and exchange rates have an immediate complete pass-through into the foreign-market consumer price, and the symmetric short-run pass-through assumption holds. The alternative case is that of LCP, in which the firm fixes the export market consumer price in foreign currency, and changes in taxes or exchange rate both have a zero short run pass-through into the consumer price. The alternative scenarios, in which the firm absorbs in the short run the tax changes, but adjusts in response to the exchange rate movements, or vice versa, would violate the symmetric short-run pass-through assumption. This, in particular, is the case under our definition of the DCP pricing regime. Lastly, we note that symmetric pass-through implies that the short-run home-currency border prices, $\hat{P}^b_{ij,t} = \hat{P}^*_{ij,t}\mathcal{E}_t$, have to decline with the currency appreciation (decline in $\mathcal{E}_t$), to keep the after-tax local prices stable. We return to this discussion in Section 3.2

We now introduce the following set of assumptions:

Assumptions:

A1. Short-run pass-through is symmetric (Definition 3).

A2. The monetary policy rule depends only on the output gap and the effective CPI inflation (or its expectations), as in (14), and does not depend on the exchange rate or trade price inflation.

A3. The foreign assets and liabilities of the countries are exclusively in terms of foreign-currency bonds.

A4. The border adjustment tax is a one-time permanent and unanticipated policy shift.

A5. The border adjustment tax is uniform and applies to all imports and exports of the home country.

Under these assumptions, we can prove the main neutrality result:

Proposition 1 *When Assumptions A1-A5 are satisfied, the border adjustment is neutral and the associated currency appreciation is complete, as defined above.*

This proposition can be viewed as a complementary result to Proposition 3 in Farhi, Gopinath, and Itskhoki (2014; henceforth, FGI) for the polar opposite case of a flexible exchange rate regime (i.e., Taylor monetary policy rule), as opposed to a fixed exchange rate regime. In FGI, under fixed exchange rate regime, we showed that an equivalent fiscal policy to the border adjustment tax has the same effect as a nominal devaluation. In contrast, when exchange rate is flexible and monetary policy follows a conventional Taylor rule, the border adjustment tax results in an instantaneous and complete nominal appreciation, and the policy has no real consequences for the macroeconomy, i.e. is neutral.

The logic of the proof: Consider an equilibrium allocation in an economy without border adjustment ($\iota_t \equiv 0$ for all t). We check that the same path of macroeconomic variables remains an equilibrium allocation in an economy with the border adjustment ($\iota_t \equiv 1$) and a complete exchange rate appreciation, $\mathcal{E}_t^1 = (1-\tau_t)\mathcal{E}_t^0$ for all t. The combinations of Assumptions A1 and A5, together with the complete exchange rate appreciation result, ensures that all relative prices in the economy remain unchanged, both in the short and in the long runs. Assumption A2 then ensures that the monetary policy stance is also unchanged, despite the appreciation, and hence so is the aggregate demand in the economy. Assumption A4 ensures that there are no expectation effects that would alter the savings and portfolio choice decisions of the agents. Finally, Assumption A3 is needed to guarantee that there are no international wealth transfers triggered by the border adjustment. Indeed, this can be observed from the country budget constraint (13), which in this case reads as:

$$B_{t+1}^* - B_t^*(1+i_t^*) = NX_t^* = P_{HF,t}^* Y_{HF,t} - P_{FH,t}^* Y_{FH,t},$$

with the foreign-currency trade prices $P_{HF,t}^*$ and $P_{FH,t}^*$ following the same equilibrium path. Therefore, we conclude that the same macroeconomic allocation (consumption, output, trade flows, price levels and interest rates) still characterizes the equilibrium path of the economy in the border adjustment regime, coupled with a nominal appreciation of the home currency.

The neutrality results relies on strong Assumptions A1-A5. In Section 3.2, we discuss these assumptions in detail and what goes wrong for the neutrality result when some of them fail. Then, in Section 4, we explore quantitatively the various departures from the neutrality result. Before turning to the violations of the border adjustment neutrality, we look into the budget revenue consequences of this policy when neutrality holds.

3.1 Government revenues

We consider here the case when Assumptions A1–A5 and hence Proposition 1 hold, and therefore the border adjustment tax is neutral for the macroeconomic outcomes. Nonetheless, this does not exclude the possibility of the distributional effects, for example between borrowers and lenders. We focus here on another distributional effect, namely the transfer between the government and the private sector. Indeed, while the overall country budget constraint does not change (i.e., there is no transfer from foreign to home), the border adjustment tax is associated with a lump-sum transfer between the private sector (households) and the government budget constraints. In particular, this transfer is given by $-\frac{\tau}{1-\tau}NX_t$, where $NX_t = P_{HF,t}Y_{HF,t} - P^*_{FH,t}\mathcal{E}_tY_{FH,t}$. That is, if a country runs a trade deficit, the border adjustment is associated with a lump-sum transfer from the private sector to the government proportional to the size of the trade deficit and the magnitude of the border adjustment. In contrast, when the trade balance is in surplus, the border adjustment policy is associated with an equivalent transfer, but now from the government towards the households. Overall, the net present value of these transfers depends on the initial net foreign asset position of the country, which determines the present value of the future trade surpluses and deficits:

$$B^*_t = -\sum_{s\geq t}\frac{NX^*_s}{\prod_{j=0}^{s-t}(1+i^*_{t+j})},$$

and hence the present value of the government budget surplus is $\tau B^*_t\mathcal{E}^1_t = \frac{\tau}{1-\tau}B^*_t\mathcal{E}^0_t$. Since for the US, $B^*_t < 0$ and $NX_t < 0$, there should be a short-run budget surplus from the border adjustment, offset by a greater long-run deficit.

Proposition 2 *Under the assumptions of Proposition 1 of the border adjustment neutrality, the border adjustment is associated with a lump-sum transfer from the private sector to the government in periods of trade deficit, and vice versa. The net present value of these transfers towards the government is proportional to the initial net foreign asset position of the coutnry.*

What is the nature of this transfer? Note that we call it lump-sum because it is associated with no change in relative prices and macroeconomic allocations. Consider a representative household holding $B_t^* > 0$ of foreign-currency assets. An appreciation ($\mathcal{E}_t \downarrow$) reduces its home-currency purchasing power, $B_t^* \mathcal{E}_t / P_t$, since the home consumer-price index P_t is not affected, while the value of the assets $B_t^* \mathcal{E}_t$ declines. Similarly, it reduces the purchasing power of B_t^* in terms of foreing goods in the home market, $B_t^*(1-\tau)/P_{FH,t}^*$, but not in terms of pre-tax border prices, $B_t^*/P_{FH,t}^*$ (recall that the foreign-currency price paid to foreigners, $P_{FH,t}^*$, stays unchanged). As a result, this generates a gap between the price paid by the US private sector and the border price received by the foreigners. The net present value of this gap is exactly τB_t^*, in terms of foreign-currency purchasing power. This capital loss on the asset position is realized gradually as the households are purchasing the foreign goods and run trade deficits, which result in the transfer of funds to the government. The opposite happens in the case of a negative foreign asset position, $B_t^* < 0$. Due to the Ricardian equivalence, this distributional consequence is not distortionary.

Note that the discussion above assumes that net foreign assets are held privately. In the alternative case, where all net foreign assets are held by the government, there is no distributional gain for the government.

3.2 Departures from BAT neutrality

We now consider in turn what happens when certain assumptions fail and the neutrality result of Proposition 1 does not hold. Consider first that the pass-through assumption A1 does not hold. In particular, assume that instead of PCP or LCP, the DCP regime applies. The export prices are fixed in the home currency (complete short-run exchange rate pass-through), but are set inclusive of the border adjustment tax (zero short-run BAT pass-through). The import prices are set in home currency (zero pass-through), but the border adjustment tax is paid by the home importers (complete pass-through). We view this as a likely scenario for the US. In this case, even if exchange rate appreciates fully, the relative prices of traded and non-traded goods will be distorted in the short run, before prices adjust, and therefore the neutrality fails. We explore this case quantitatively in the next section.

When neutrality does not hold, the appreciation of the exchange rate does not necessarily have to be complete. However, there are two limiting case, which result in a complete appreciation even when assumption A1 fails. The first is the limit of a closed economy ($\gamma_H^* = \gamma_F \to 0$), as imported goods become a trivial part of the consumption basket, the behavior of their prices is irrelevant for equilibrium outcomes, and the exchange rate appreciates fully. By continuity, the economies that trade little are likely to experience full appreciations in response to a border adjustment, independently of the nature of price stickiness. The second is the limit in which wages are increasingly more sticky relative to prices ($\frac{1-\delta_w}{1-\delta_p} \to 0$), as, once prices adjust, this case is akin to PCP. In our quantitative analysis below, we establish that indeed for an economy calibrated to realistic degree of trade openness and relative price and wage stickiness, a complete exchange rate appreciation on impact of BAT provides a reasonable approximation even when BAT neutrality does not hold.

Next consider the case when assumption A2 fails, and foreign country targets a particular value of the exchange rate $\bar{\mathcal{E}}_t$, and does not want to let the dollar appreciate. This would require raising an interest rate in foreign, resulting in a reduction in foreign demand for both foreign- and home-produced goods.

Next consider the violation of assumption A3, with home holding net foreign assets in home currency, $B_t > 0$. In this case, if appreciation were complete, home would generate a capital gain of $B_t \left(1 - \frac{\mathcal{E}'_t}{\mathcal{E}_t}\right) = \tau B_t$, which would be a net transfer from the foreign and would improve the home's budget constraint as a country. Therefore, this cannot be an equilibrium, and the appreciation needs to be more than complete for $B_t > 0$ and less than complete for $B_t < 0$. In the case of the US, $B_t < 0$ (large home-currency foreign liabilities), and hence the border adjustment tax with the resulting appreciation results in a net transfer from the US to the rest of the world, as we discuss quantitatively below.

If border adjustment is anticipated (assumption A4 fails), then the movement of the dollar will happen prior to the policy, at least in part, resulting in extra short run dynamics, absent under no border adjustment policy. If the policy is expected to be reversed, then appreciation is likely to be incomplete.

Lastly, if the border adjustment policy is not uniform across all goods (assumption A5 fails), then it acts effectively as a trade policy of a differential tariff. For example, assumption A5 is violated if some business can avoid border adjustment tax on imports (like S-corps in the US). It is also violated for services sold domestically to foreigners, such as tourism, education, and health services.

This discussion suggests that the border adjustment neutrality is a tall order, as the assumptions A1–A5 are strong and clearly violated in the case of the US. Once the exact neutrality fails, analytical results in a dynamic environment become infeasible. This is why we turn next to a quantitative exploration of a calibrated model to assess the likely consequences of a border adjustment tax in practice.

4 Quantitative Analysis of Border Adjustment

In this section we numerically evaluate the impact of a border adjustment tax. As discussed in Section 3, the introduction of a border adjustment policy is neutral only under specific conditions on currency price stickiness, currency of foreign assets, import and export tax symmetry, and shock timing. We explore the short-term and long-term implications of relaxing these assumptions by presenting impulse response functions within the model environment described in Section 2 and calibrated to the United States economy. For this reason, we refer to the home country as the US and the home currency as the US dollar.

Benchmark Specification Our benchmark specification considers a home-biased CES demand structure for consumption and intermediate goods. We assume both sticky wages and sticky prices. Home firms set export prices in the home currency and foreign firms set prices in the currency of the destination market. As discussed above, we call this pricing regime Dominant Currency Pricing (DCP). We choose DCP as the benchmark given the extensive evidence of the dominant role of the US dollar in trade invoicing, specifically for US imports and exports (see Goldberg and Tille 2008, Gopinath and Rigobon 2008, Gopinath, Itskhoki, and Rigobon 2010).

We focus on incomplete markets in which bonds are denominated exclusively in the foreign currency (an assumption we will later relax) and the world interest rate faced by domestic households depends on the amount borrowed by the country as a whole. Specifically:

$$i^*_{t+1} = i^* + \psi \left(e^{\bar{B}_F - B_{F,t+1}} - 1 \right),$$

where $\bar{B}_F$ is the steady state foreign debt and $i^* = 1/\beta - 1$. This assumption ensures that the model is stationary.

Calibration The parameter values used in the simulation are listed in Table 2. The time period is a quarter. Several parameters take standard values as in Galí (2008). We follow Christiano, Eichenbaum, and Rebelo (2011) and set the wage stickiness parameter $\delta^w = 0.85$, which corresponds to roughly a year and a half wage duration on average. The elasticity of substitution between home and foreign varieties and between varieties within the home region are assumed to be the same. Accordingly, we set this parameter as $\sigma = 2$. This is an average of the median elasticity estimate of 2.9 for substitution across imported varieties found by Broda and Weinstein (2006) and an estimate of 1 for the elasticity of substitution across domestic and foreign varieties found by Feenstra, Obstfeld, and Russ (2010). We later relax the CES demand assumption. The foreign bond holdings are set to $\bar{B}_F = 2.6$, to obtain a net foreign asset position of -60% of GDP in steady state. The home bias share is set to $\gamma_H = 0.9$ to obtain a 15% steady state value of imports over GDP.

Border Adjustment Shock At time 0, the economy is in its non-stochastic steady state with a corporate tax of 20%. In the first quarter, export sales become fully deductible for home good producers. Simultaneously, home bundlers face a 20% tax increase on imported goods, which

Table 2: Parameter Values

	Parameter	Value
Household Preferences		
Discount Factor	β	0.99
Risk aversion	σ_c	2.00
Labor Frisch elasticity	φ^{-1}	0.50
Disutility of labor	κ	1.00
Production		
Labor share	$1-\alpha$	0.33
SS log-productivity	$\bar{a}$	1.9
Rigidities		
Wage	δ_w	0.85
Price	δ_p	0.75
Monetary Rule		
Inertia	ρ_m	0.50
Inflation sensitivity	ϕ_m	1.50

Note: Other parameter values are reported in the text.

they pass on as a cost to consumers and home good producers. Unless otherwise specified, the shock is unanticipated and permanent.

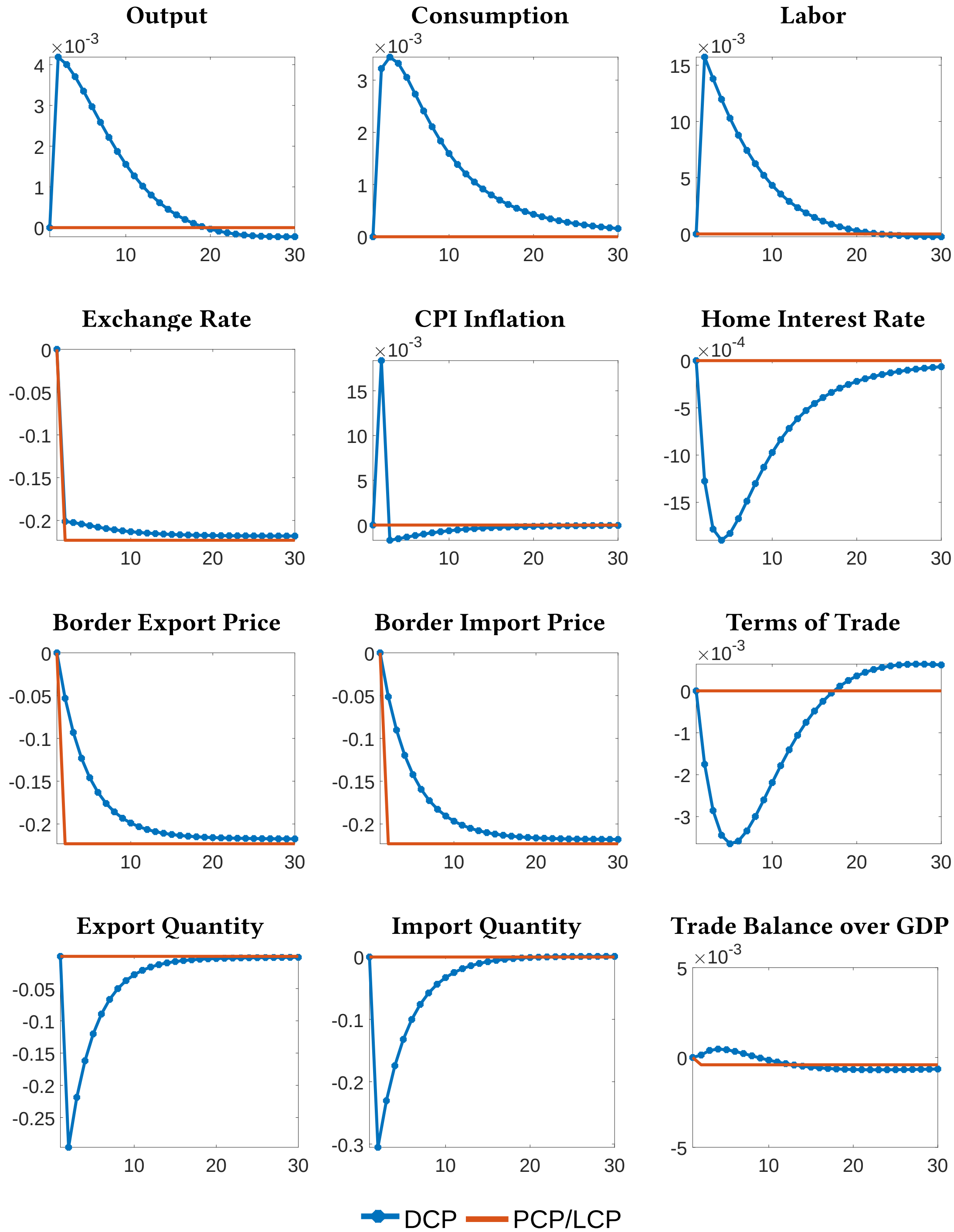
4.1 Pricing Regimes

Figure 1 shows the impulse response to the permanent introduction of a border adjustment tax. In each subfigure we compare the response under producer currency pricing (PCP), local currency pricing (LCP) and dominant currency pricing (DCP). Regardless of the pricing regime assumed, differences in price rigidity can generate only short-run departures from neutrality. In the long-run, prices are flexible, and adjust to fully offset the effect of the border adjustment. Therefore, we focus on the short-run effects.

First, consider the response under the PCP regime. Consistent with Proposition 1, the dollar instantaneously reaches complete appreciation and all the other variables are fully neutral to the tax reform.[11] When border prices are not subject to nominal frictions, the tax changes are fully passed-through to the trade and currency exchange market. This pass-through occurs because the import tax and the equivalent export deduction are levied at the border, only after home and foreign firms establish domestic prices. US imports and exports face a tax change

[11] The exchange rate impulse response function shows a 22% rather than a 20% appreciation as $\log(\mathcal{E}^1) - \log(\mathcal{E}^0) = \log(1-\tau) = \log(0.8) = -0.22$.

Figure 1: Response to a Border Adjustment Tax across Pricing Regimes



that is instantaneously offset by the appreciation of the dollar.[12]

Similarly, the economy is neutral to a border adjustment tax under the LCP regime. In this case, prices *inclusive of taxes* are sticky in the destination currency. When the border adjustment tax is introduced, prices in local currency do not change. Prices are not reset because the tax adjustment is compensated right away by the dollar appreciation in the pricing decisions of exporters. The dollar achieves complete appreciation because the import tax on dollar prices and the export deduction on foreign currency prices makes the dollar instantaneously more valuable by the amount of the tax adjustment. We would not obtain neutrality under LCP if the import tax was levied on top of the preset import prices, as we discuss in Appendix A.2.

In the more realistic DCP case, prices are sticky in dollars for both US exporters and foreign exporters to the US. Moreover, the border adjustment is applied on top of the preset export and import prices. When the import tax is introduced, foreign exporters to the US cannot update their dollar prices right away and as a consequence import demand drops by 30%. Similarly, when the sales tax on exports is repealed, US exporters cannot immediately update their dollar border price.[13] Since US exporters cannot pass-through the tax cut and the dollar appreciates by 18%, US exports are more expensive and export demand drops by almost 30%. The DCP case effectively implies a significant decrease in trade compared to PCP and LCP. The terms of trade and the trade balance stay stable due to the counterbalancing effects on imports and exports.

How does the rest of the US economy react? CPI inflation spikes in the first quarter due to the more expensive imports and, over time, turns slightly negative due to the slow negative adjustment of import prices. Therefore, US consumers face high but declining prices back towards the initial equilibrium level. Given the Taylor policy rule, which reacts to the consumer price inflation rate rather than the consumer price level, the central bank cuts interest rates to mitigate the expected deflation triggered by import price adjustment.[14] Output increases by 0.4% due to both the effect of import substitution on the production of home goods and the effect of the negative real rate in stimulating consumption.

The instantaneous exchange rate appreciation is lower for DCP (18%) than for LCP and PCP because, for an instantaneous appreciation, the higher demand for dollar generated by the border adjustment must fully pass-through in the first quarter. However, under DCP, the demand for dollars in trade markets is less responsive in the short-run due to the temporary drop in trade. Nevertheless, even under DCP, the exchange rate response is fairly close to be

[12]The reason why import and export prices change in Figure 1 is that we show *tax-exclusive* dollar import prices and *tax-inclusive* dollar export prices at the border.

[13]In contrast to the PCP case, a US producer can now set two different dollar prices for home and foreign consumers. This implies that the dollar border export price is sticky at the moment of the tax reform.

[14]The response of the interest rate would be opposite under price level targeting.

complete due the low openness of the economy and the fact that wages are calibrated to be stickier than prices, as we discussed in Section 3.2. In Appendix A.2, we explore the sensitivity of this result to alternative calibrations of trade openness and wage stickiness.

4.2 Strategic Complementarities in Pricing

We now compare the economic response to a border adjustment tax with different degrees of strategic complementarity in pricing. Mounting evidence suggests that firms give importance to the prices of their competitors when setting up their own prices.[15] Strategic complementarities generate incomplete pass-through of exchange rate shocks on prices and for this reason they may potentially amplify the departures from the neutrality of border adjustment policies. Note however that the exact neutrality result of Proposition 1 does not impose any assumptions on the demand and competition structure, and thus allows for strategic complementarities in price setting and incomplete pass-through. The reason is that under the circumstances of neutrality no relative price changes with border adjustment, and therefore it is not essential whether the pass-through is complete or incomplete.

To generate strategic complementarities, we specify a functional form for the demand function $\psi(\cdot)$ introduced in Section 2.3. We adopt the Klenow and Willis (2006) formulation that gives rise to the following demand for individual varieties:

$$Y_{FH,t}(\omega) = \gamma_F \left(1 + \epsilon \ln \frac{\sigma - 1}{\sigma} - \epsilon \ln Z_{FH,t}\right)^{\sigma/\epsilon} \cdot (C_t + X_t)$$

where $Z \equiv \frac{P_{FH}(\omega)}{P} D$ as previously defined and σ and ϵ are two parameters that determine the elasticity of demand and its variability. The elasticity of demand and the elasticity of the mark-up are given by,

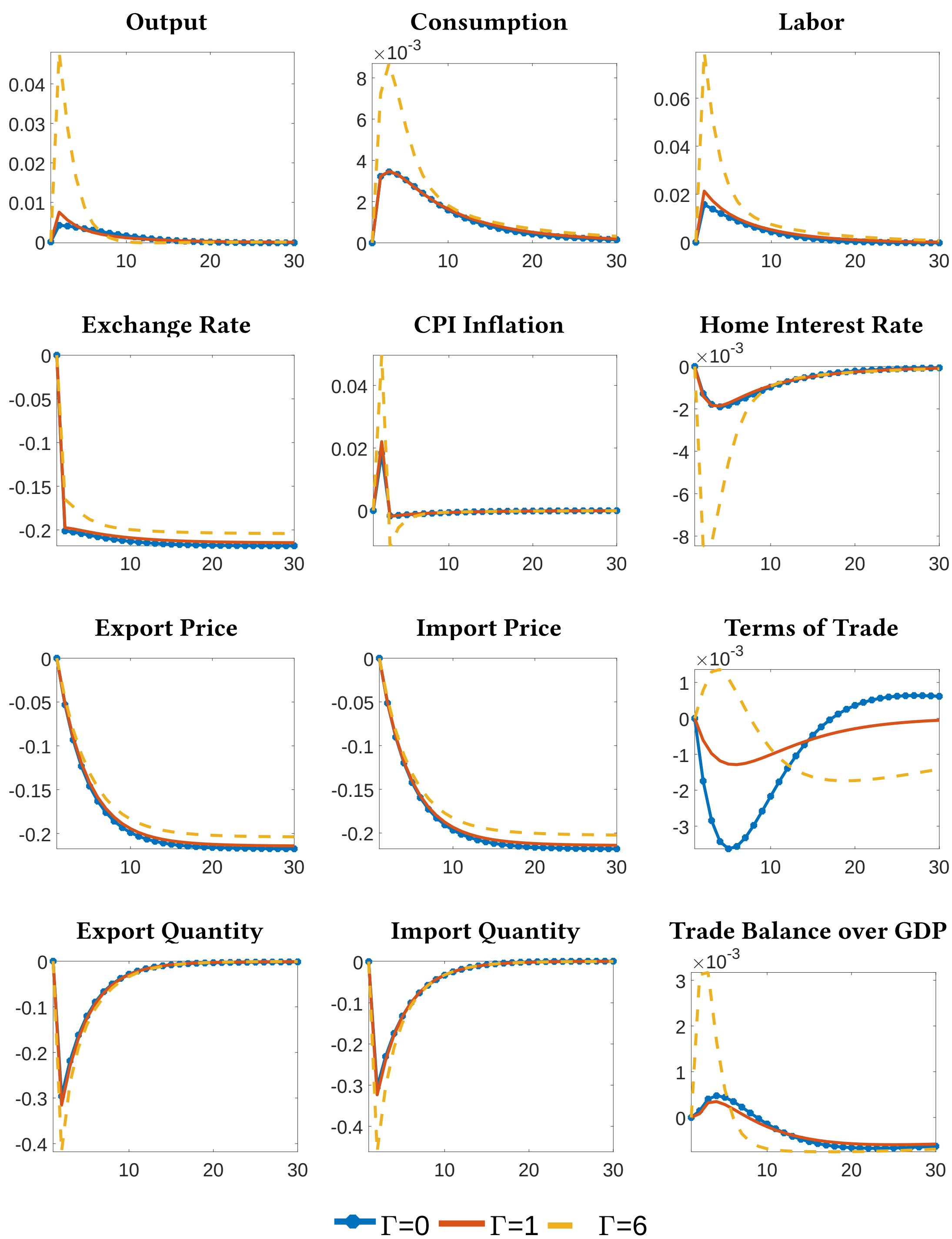
$$\sigma_{FH,t} = \frac{\sigma}{\left(1 + \epsilon \ln \frac{\sigma-1}{\sigma} - \epsilon \ln Z_{FH,t}\right)} \qquad \Gamma_{FH,t} = \frac{\epsilon}{\left(\sigma - 1 - \epsilon \ln \frac{\sigma-1}{\sigma} + \epsilon \ln Z_{FH,t}\right)}$$

In a symmetric steady state $Z_{FH,t} = (\sigma - 1)/\sigma$, the elasticity of demand is σ and the elasticity of mark-up is $\Gamma \equiv \frac{\epsilon}{\sigma-1}$. When ε is zero, the demand collapses to the CES benchmark case.

Figure 2 shows impulse responses assuming $\Gamma \in \{0, 1, 6\}$ and DCP pricing. The constant markup case coincides with CES; $\Gamma = 1$ corresponds to the estimates by Amiti, Itskhoki, and Konings (2016); we show results for $\Gamma = 6$ for the sake of exposition. In general, we can see that higher markup elasticity does not affect long-run neutrality but generates less than complete long-run appreciation. Accordingly, prices of imports and exports respond slightly

[15] See Gopinath and Itskhoki (2011) and Amiti, Itskhoki, and Konings (2016).

Figure 2: Dominant Currency Pricng with Strategic Complementarities



less aggressively to the border adjustment than in the CES case. Nevertheless, the results for plausible values of markup elasticity barely differ from the benchmark.

Consider US import prices first. When $\Gamma > 0$, the desired prices set by foreign exporters to the US falls for two reasons. The first is the fall in the *idiosyncratic marginal cost* generated by the dollar appreciation. The second is the loss in *price competitiveness* relative to the US producers, generated by the introduction of the import tax. For the CES case, all the weight determining the new desired price is on the marginal cost motive. As we increase markup elasticity, more weight is given to the price competitiveness motive. However, with low Γ these two forces almost coincide because the dollar appreciation is almost complete. This is why the case with $\Gamma = 1$ and CES have similar effects. However, when Γ is high, the less than complete long-term appreciation becomes large enough to clearly dominate the price competitiveness motive.[16]

The lower appreciation of the dollar arises because of the higher penalty for the loss in price competitiveness entailed by the Kimball demand. This makes trade fall even more than in the benchmark case (around 40% for $\Gamma = 6$) in the short run, together with the demand for dollars. Note that, as strategic complementarity motives increase, the equilibrium terms of trade starts deteriorating. Import prices are slightly more unresponsive than export prices because we assume that the marginal costs of the rest of the world in foreign currency are constant. For the same reason, the trade balance improves for high values of strategic complementarities.

The mechanisms behind the response of the domestic US economy are in line with the ones presented in Figure 1. CPI inflation reacts proportionally to the dollar appreciation. The central bank cuts interest rates to mitigate the expected deflation triggered by import price adjustment. Output increases due to both the effect of import substitution on the production of home goods and the effect of the negative real rate in stimulating consumption.

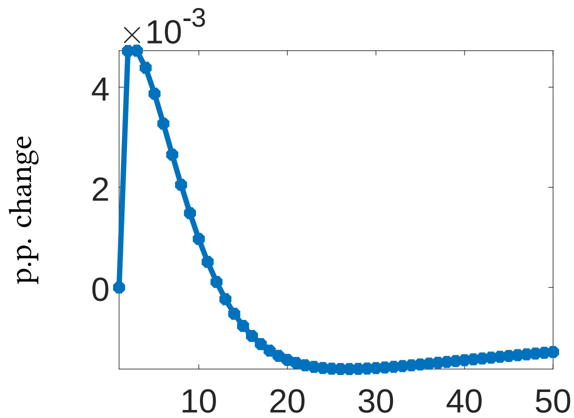
4.3 Government Revenues

We now consider the effect of the border adjustment tax on government revenues under DCP regime and mark-up elasticity $\Gamma = 1$. To reflect economic conditions in line with the United States, we calibrate an impatience shock to domestic households to obtain a baseline economy with a trade deficit of 2% of GDP in the first quarter, turning into surplus after 3 years.

Figure 3 shows the percentage point change in government revenues over GDP for the first 50 quarters of the simulation. As discussed in Section 3.1, the border adjustment generates a transfer from the private sector to the government when a country runs a trade deficit. On

[16]For US exporters, the drop in marginal cost is generated by the new deduction on sales. The loss in competitiveness is generated by the dollar appreciation. As the markup elasticity increases, more weight is put on the loss of competitiveness, but this loss is counterbalanced by the long run lower appreciation.

Figure 3: Government Revenues over GDP



impact, government revenues increase by about half a percent of GDP, proportionately to the initial deficit times the size of the border adjustment tax.[17] The budget surplus lasts for 3 years and then turns into a longer period of budget deficits. This happens because in the long run the economy runs a trade surplus to sustain the initial negative net foreign asset position.

4.4 Valuation Effects

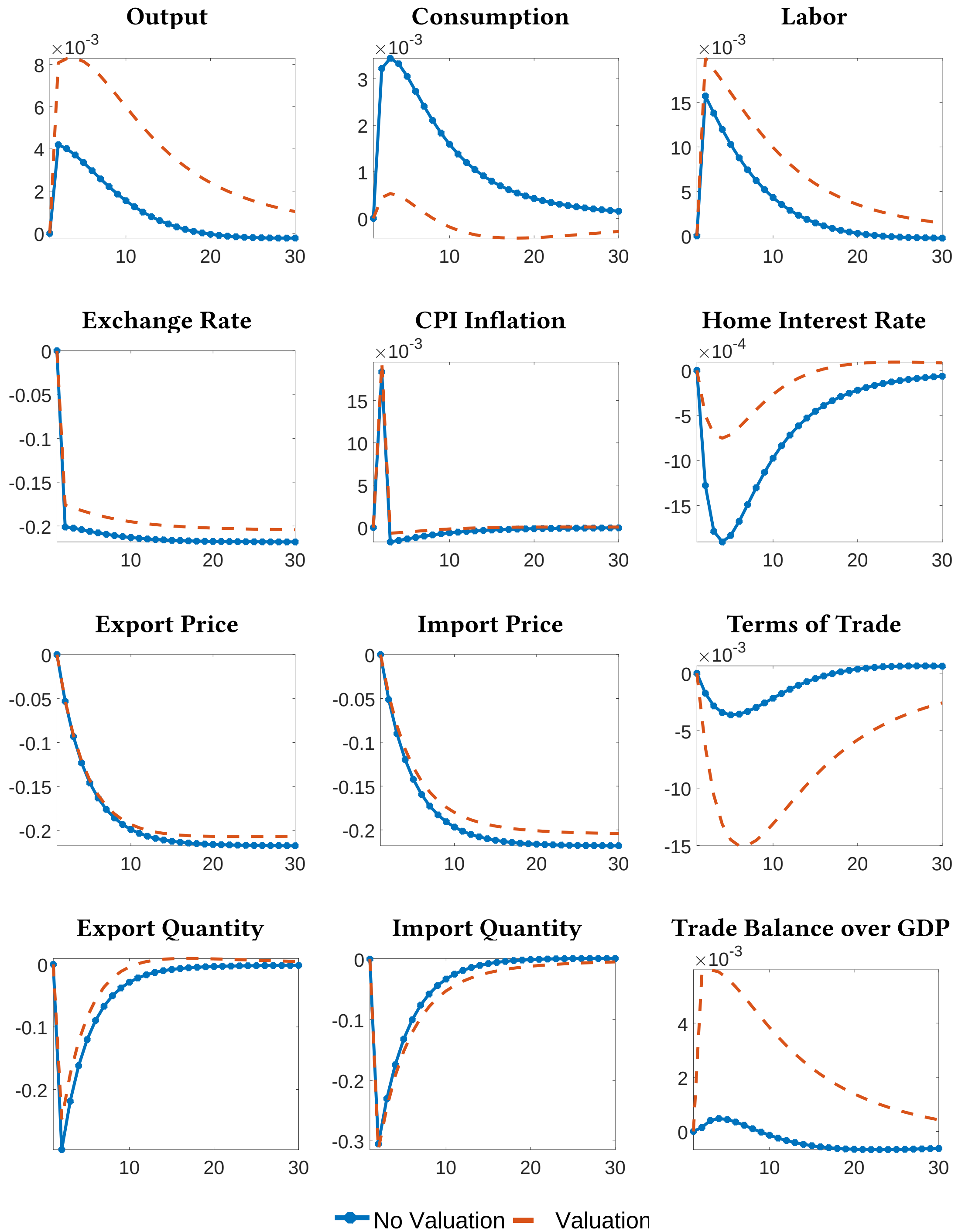
We now discuss the case where the home country holds debt in both foreign currency and home currency. In the benchmark case, when debt is fully denominated in foreign currency, the countries on net do not experience capital gains or losses, despite the possible redistribution effects within countries (see Proposition 2). In contrast, when debt is partially owned in home currency, the home currency appreciate triggers a capital loss and net transfer from the debtor to the lender country. Effectively, if the home country is debtor, it experiences a negative valuation effect.

We calibrate the valuation effect to the features of the US net foreign asset position. US external liabilities are 180% of GDP, of which 82% are in dollars. US external assets are 120% of GDP, of which 32% is in dollars. Therefore, we simulate a negative valuation effect of $1.09 \cdot GDP_0 \cdot \left(1 - \frac{\mathcal{E}_1}{\mathcal{E}_0}\right) = B_0 \left(1 - \frac{\mathcal{E}_1}{\mathcal{E}_0}\right)$, where $1.09 = 0.82 \cdot 1.8 - 0.32 \cdot 1.2$.

Figure 4 shows simulation results when the debt is partially held in dollars, under DCP pricing and CES demand. In this case both long-run neutrality is violated and the appreciation is less than complete (as the US is a net debtor in dollars). As discussed in Section 3.2, holding negative net foreign assets in dollars generates a less-than-complete appreciation because otherwise the border adjustment would result in a violation of the intertemporal budget

[17] On impact we would expect government transfer equal to $-\frac{\tau}{1-\tau}\frac{NX_t}{GDP_t} = \frac{0.2}{1-0.2} \cdot 0.02 = 0.5\%$. The reason why we see a slightly lower transfer in Figure 3 is that the border adjustment also has a general equilibrium effect on the initial trade deficit, as showed in Figure 2.

Figure 4: Valuation Effects



constraint due to the valuation effect resulting in a transfer from the US to the rest of the world. This wealth transfer should be offset by smaller imports and greater exports, which are sustained as a result of a smaller dollar appreciation, resulting in an improved trade balance, higher output and lower consumption in the US. The quantitative difference from the no-valuation-effect case is not very large, however, as the wealth transfer to the rest of the world, while large as a fraction of annual GDP, is still small relative to the present value of all future gross trade flows.

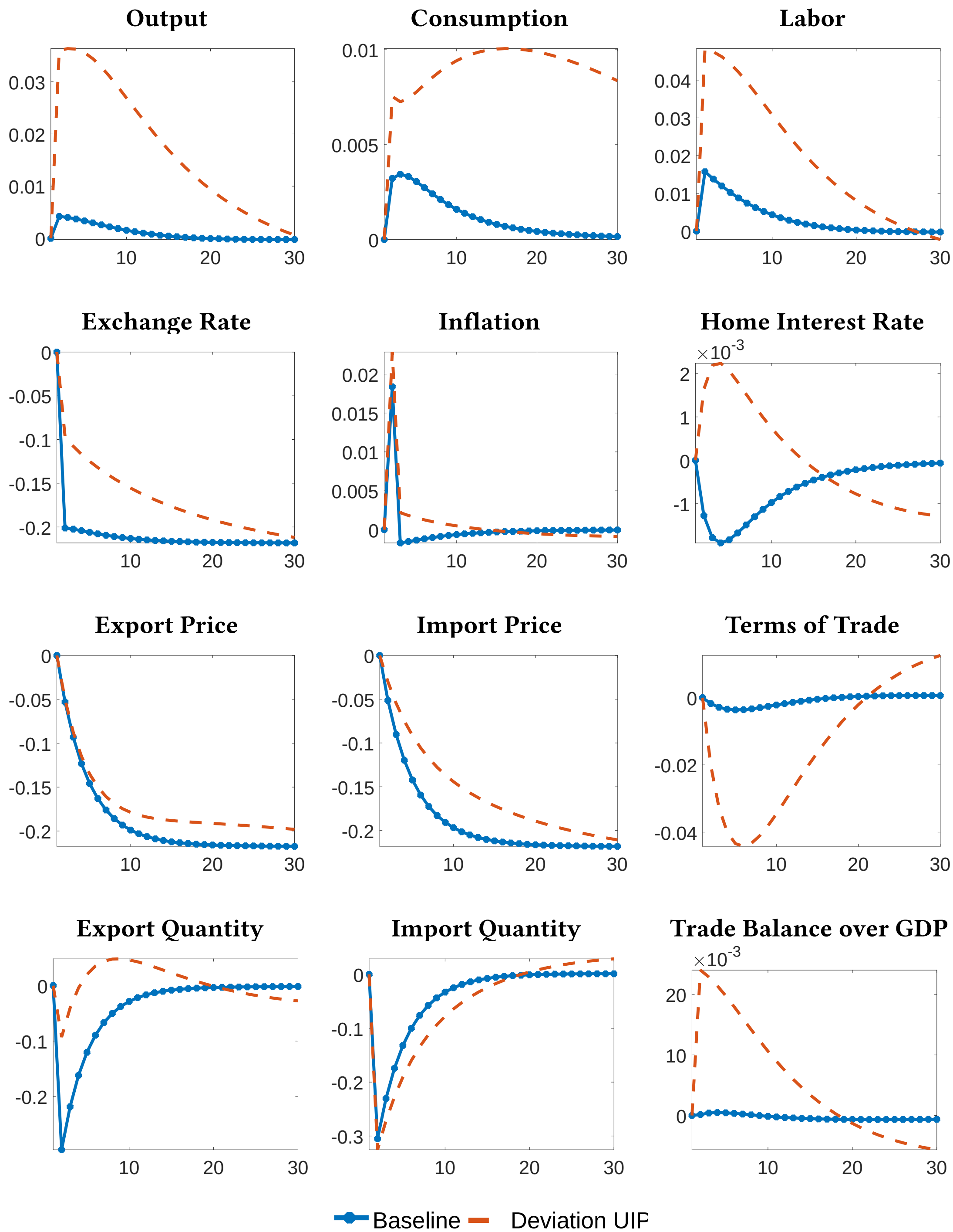
4.5 Expectation effects

We now study the effect of a deviation from the Uncovered Interest Parity (UIP) condition, contemporaneous to the introduction of the border adjustment. This can be interpreted as a risk premium shock, but similar effects can be replicated under models of imperfect financial markets or deviations from rational expectations (see Itskhoki and Mukhin 2017). We calibrate this UIP shock to have a half-life of two years and to generate a short-term appreciation of 10%, about a half of the complete appreciation associated with the border adjustment tax. In other words, this shock forces a smaller than complete appreciation relative to the benchmark case. We, therefore, view this shock as a reduced-form way to capture various expectation effects, such as a probability of policy reversal or a probability of foreign retaliation, which are likely to result in an incomplete appreciation on impact. Figure 5 shows the results in this case.

Neutrality and appreciation completeness continue to hold in the long-run, but short-run dynamics looks considerably different. Import prices now respond differently than export prices. The dollar marginal costs of import producers are closely tied to the exchange rate movements, hence reset prices respond much more slowly. Marginal costs of export producers instead are instantaneously responsive to the deduction on export sales and only partially affected by higher import costs. For this reason, export prices at the border have dynamics closer to the benchmark. Overall, this results in a larger deterioration of the terms of trade and improvement in the trade balance. Exports still fall on impact, but by less, and then increase in the medium run, while import dynamics is close to the benchmark. The improvement in the trade balance stimulates domestic output and employment.

Another difference is that now consumer prices are not only elevated, but there is also a period of increased consumer price inflation, as dollar keeps appreciating over time. This leads to a different monetary policy response — instead of cutting the rates, the monetary authority increases them. This difference would be absent if the monetary authority targeted the price level rather than the inflation rate.

Figure 5: Deviation from UIP



4.6 S-Corps

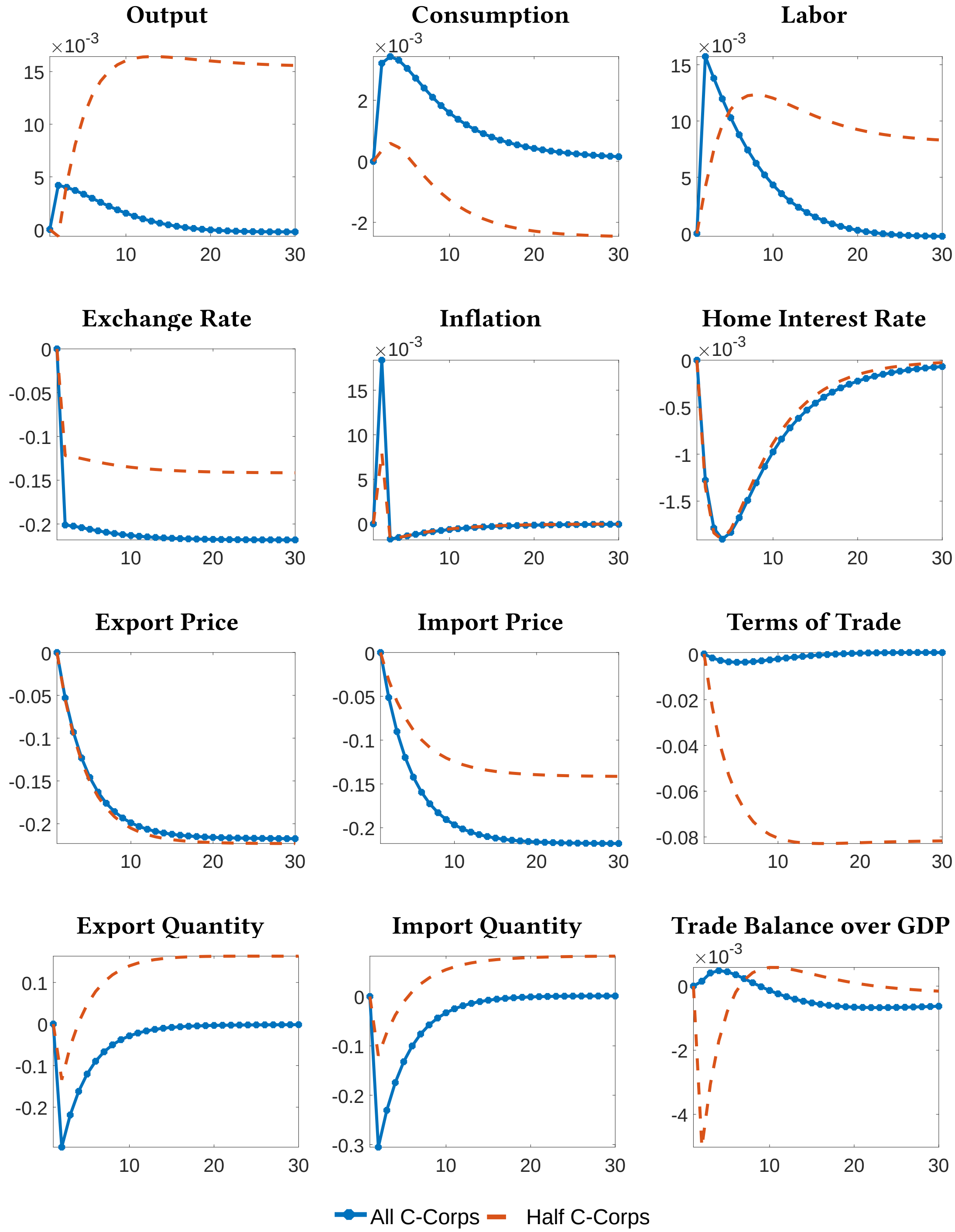
We now model the possibility that a fraction of importers are not subject to the border adjustment. The import tax may not be universal whenever ad-hoc exemptions apply to certain industries, whenever some transactions, such as tourism or internet services, are hard to monitor or whenever companies can engage in tax avoidance. We call such companies *S-Corps*.

Figure 6 compares the simulation results when the import tax applies to all imports and when S-Corps make up 50% of imports. When S-Corps are present, long run-neutrality does not hold anymore. The border adjustment effectively works as a net export subsidy because the tax discount on export sales is not matched by an equivalent import tax. As a result, the equilibrium dollar appreciation is smaller by about a half.

As in the benchmark, the instantaneous appreciation of the dollar, paired with the short-term dollar price stickiness makes imports and exports fall in the short run. However, as prices adjust, the long run equilibrium dynamics start to dominate and trade increases after two years from the border adjustment due to the effective import subsidy. In the short run, the trade balance deteriorates by 0.4% because at the initial price levels import demand is slightly less affected due to the presence of S-Corps.

In the domestic economy, initial inflation spikes less but has similar dynamics as in the benchmark case. Output and labor boost by 1.5% and 1%, respectively, thanks to the trade improvement. Consumption initially goes up but quickly drops after 1 year.

Figure 6: S-Corps



A Appendix

A.1 Price Setting

The foreign-currency profits of foreign firms serving the domestic market under the PCP, LCP and DCP regimes are given respectively by:

$$
\begin{aligned}
\bar{\Pi}^{P*}_{FH,s} &= \left[\hat{P}^*_{FH,t} - MC^*_s\right] Y_{FH,s}\left(\frac{\hat{P}^*_{FH,t}\mathcal{E}_s}{1-\iota_s\tau_s}\right),\\
\bar{\Pi}^{L*}_{FH,s} &= \left[\frac{\hat{P}_{FH,t}(1-\iota_s\tau_s)}{\mathcal{E}_s} - MC^*_s\right] Y_{FH,s}\left(\hat{P}_{FH,t}\right),\\
\bar{\Pi}^{D*}_{FH,s} &= (1-\tau_s)\left[\frac{\hat{P}^b_{FH,t}}{\mathcal{E}_s} - MC^*_s\right] Y_{HF,s}\left(\frac{\hat{P}^b_{FH,t}}{1-\iota_s\tau_s}\right)
\end{aligned}
$$

The optimal price setting equations derive from the optimality conditions with respect to $\hat{P}^*_{FH,t}$, $\hat{P}_{FH,t}$ and $\hat{P}^b_{FH,t}$ respectively, averaged and discounted over the period of price duration.

A.2 Extensions

Alternative LCP formulation Figure 7 shows the impulse response to the introduction of a border adjustment tax in the case of LCP when import taxes are levied on top of the initially preset import prices (LCP, BA post-border). The figure additionally reproduces the PCP and DCP impulse responses from Figure 1 for comparison. Import prices are sticky in US dollars while export prices are sticky in foreign currency. The dollar instantaneously appreciates by 19% and later reaches 20% appreciation in around 5 years. Foreign exporters to the US cannot update their dollar prices right away and once the tax is levied on their products, US import demand drops by 30%. US exporters, in contrast, barely change their foreign-currency export prices because the border adjustment they receive is almost fully offset by the dollar appreciation. In large part, export quantities do not react. Border price movements imply a 15% deterioration in the terms of trade and a 1.5 percentage point increase in the trade balance over GDP.

Robustness to parameters Figure 8 quantifies the importance of trade openness and wage stickiness for the extent of dollar appreciation under DCP, when BAT neutrality fails. Specifically, Figure 8 compares the benchmark DCP case with (i) a case with greater trade openness ($\gamma_H = 0.6 \ll 0.9$) and (ii) a case where wages are more flexible than prices ($\theta_p = 0.85$ and $\theta_w = 0.75$). Indeed, as we explained in Section 3.2, in both of these cases the dollar appreciates by less than in the benchmark. Quantitatively, home bias plays a more important role: in a more open economy, the dollar appreciation on impact is far from complete.

Figure 7: Response to a Border Adjustment Tax across Pricing Regimes

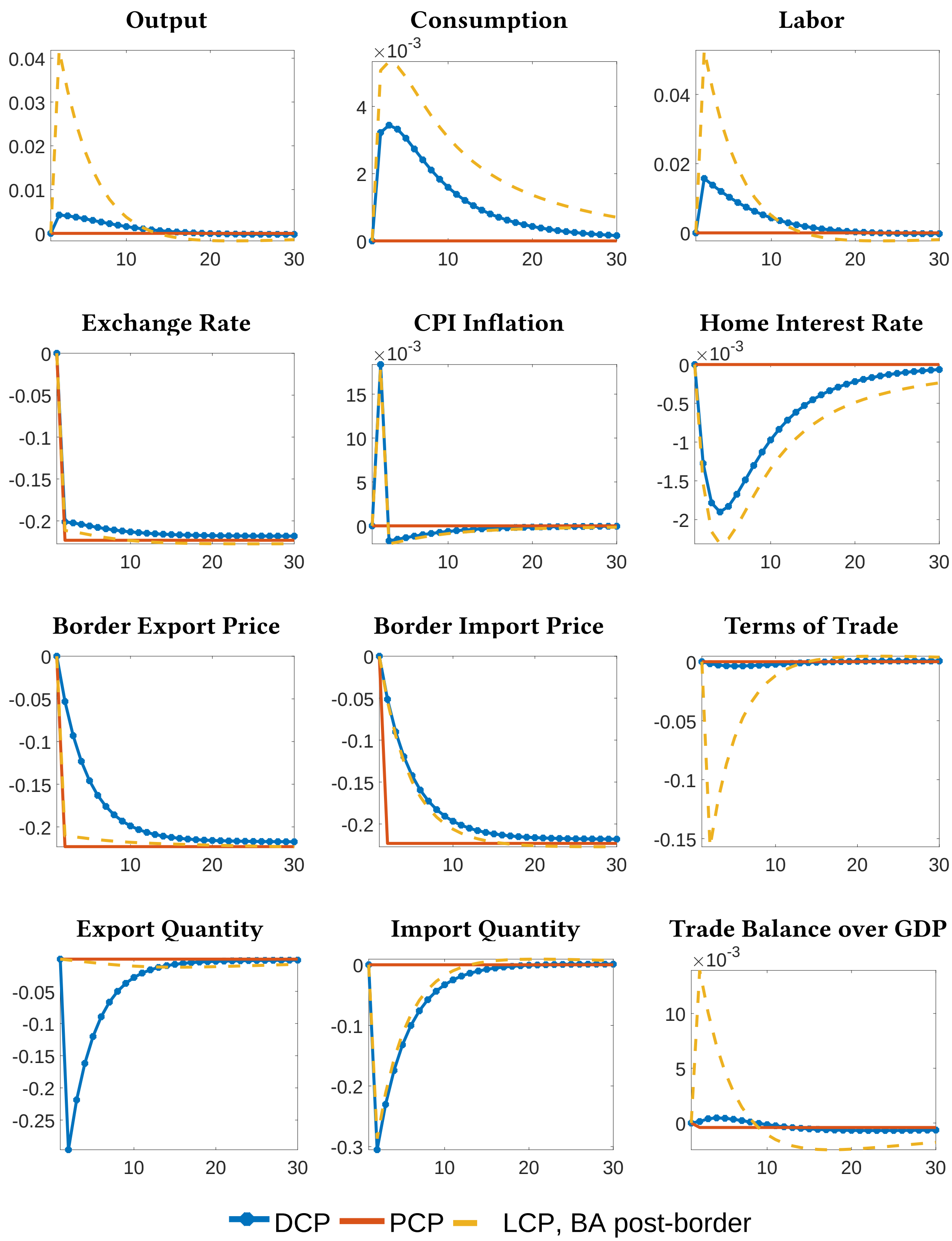
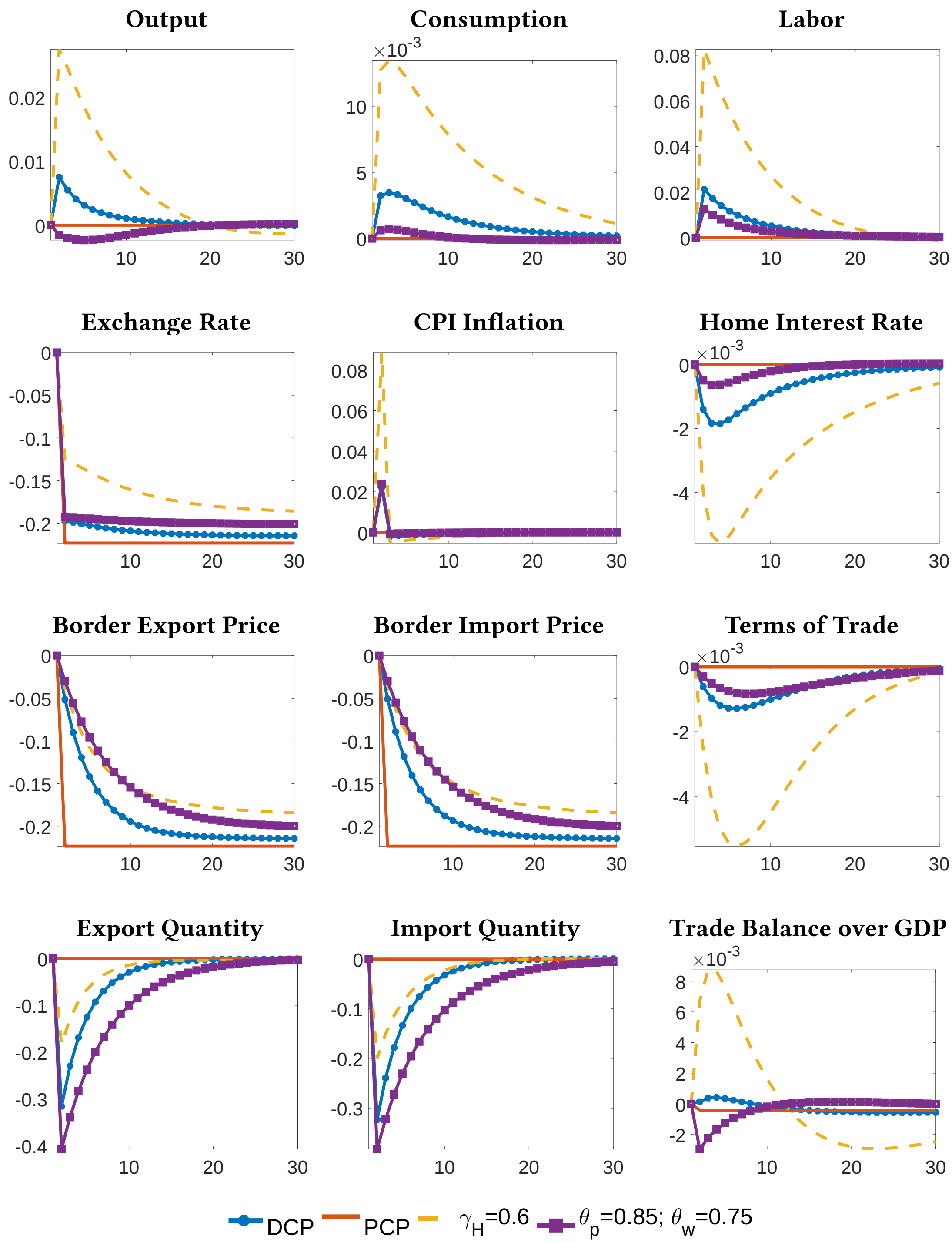


Figure 8: Dynamics under different openness and stickiness assumptions



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