The Macroeconomics of Border Taxes*

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Abstract

We analyze the dynamic macroeconomic effects of border adjustment taxes, both when they are a feature of corporate tax reform (C-BAT) and for the case of value added taxes (VAT). Our analysis arrives at the following main conclusions. First, C-BAT is unlikely to be *neutral* at the macroeconomic level, as the conditions required for neutrality are unrealistic. The basis for neutrality of VAT is even weaker. Second, in response to the introduction of an unanticipated permanent C-BAT of 20% in the U.S. the dollar appreciates strongly, by almost the size of the tax adjustment, U.S. exports and imports decline significantly, while the overall effect on output is small. Third, an equivalent change in VAT by contrast generates only a weak appreciation of the dollar, a small decline in imports and exports, but has a large negative effect on output. Lastly, border taxes increase government revenues in periods of trade deficit, however, given the net foreign asset position of the U.S., they result in a long-run loss of government revenues and an immediate net transfer to the rest of the world.

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1 Introduction

Border adjustment is a feature of certain tax systems, in particular of the value-added tax (VAT) and in certain cases of the corporate profit tax (C-BAT), which makes export sales tax deductible, while levying the tax on imported inputs. The economic consequences of these adjustments are poorly understood and highly politicized in the public debate. Superficially, border adjustment taxation can indeed appear mercantilistic since it taxes imports but not exports.

Economists have long recognized that, ironically, it is precisely the border adjustment feature which guarantees the absence of protectionist effects. For example, without the rebate of value-added taxes on exports, a VAT would act like an export tax, which by *Lerner (1936) symmetry* is equivalent to an import tariff (see Feldstein and Krugman 1990). Similarly, it also follows from Lerner (1936) symmetry that a C-BAT is *neutral*, with no real effects on the economy (see Grossman 1980).

It is fair to say that these arguments have held limited sway outside the ivory tower. In part, it is because they rely on *long-run* general equilibrium effects mediated by multiple price changes, which, on top of being difficult to understand, might take time to materialize if prices and wages do not adjust immediately. In this paper, we focus squarely on the dynamic effects of C-BAT and VAT tax reforms, from the short run to the long run. These effects are complex and poorly understood, even among economists. We address this hole in the literature.[1]

Our analysis arrives at the following main conclusions. First, C-BAT is unlikely to be *neutral* at the macroeconomic level, as the conditions required for neutrality are unrealistic. The basis for neutrality of VAT is even weaker. Second, in response to the introduction of an unanticipated permanent C-BAT of 20% in the U.S. the dollar appreciates strongly, by almost the size of the tax adjustment, U.S. exports and imports decline significantly, while the overall effect on output is small. Third, an equivalent change in VAT by contrast generates only a weak appreciation of the dollar, a small decline in imports and exports, but has a large negative effect on output. Lastly, border taxes increase government revenues in periods of trade deficit, however, given the net foreign asset position of the U.S., they result in a long-run loss of government revenues and an immediate net transfer to the rest of the world.

The vehicle for our investigation is an open-economy New Keynesian DSGE model with trade in intermediate goods, sticky prices and wages, and monetary policy following a Taylor rule. With nominal rigidities, the short-run pass-through of taxes and exchange rates into different prices becomes crucial. Our model can be specialized to capture different international pricing assumptions, namely Producer Currency Pricing, Local Currency Pricing, and

[1]Other recent papers that contribute to our understanding of border adjustment taxes include Erceg, Prestipino, and Raffo (2017) and Lindé and Pescatori (2017).

Dominant Currency Pricing. It can also be studied under various tax pass-through assumptions. Finally, the model also features pricing to market with variable markups and incomplete desired pass-through of costs into prices. With the U.S. in mind, we take our benchmark specification to be Dominant Currency Pricing, so that both imports and exports are denominated in the domestic currency (the dollar). We also assume that the immediate pass-through of VAT taxes into sticky prices is full (akin to the sales taxes in the US), but that the immediate pass-through of the border adjustment associated with the corporate profit tax is zero. We analyze the dynamic effects of a one-time unanticipated introduction of a value-added tax and of a border adjustment for the corporate profit tax.

We start with the C-BAT, a tax proposal that was hotly debated as a part of the corporate tax reform in the U.S. (Auerbach, Devereux, Keen, and Vella 2017). The C-BAT disallows deductions of imported input costs from corporate revenue when computing taxable corporate profits, and excludes export revenue from taxation. Loosely this policy can be thought as the combination of an import tariff and an export subsidy. In this paper we focus on the macroeconomics of border adjustment, that is, the dynamics effects from border taxes which arise due to nominal rigidities in wages and prices. In particular, we study an environment in which border adjustment would have been neutral in the absence of nominal rigidities, as this helps to streamline and focus the paper on the macro-dynamic implications of border taxes, in particular those for exchange rate and the trade balance. We therefore deliberately leave aside some important long-run benefits of border adjustment in terms of transfer pricing, profit shifting, and business location (see e.g. Auerbach and Devereux 2013, Auerbach, Devereux, Keen, and Vella 2017).

We specify conditions under which the C-BAT would be completely neutral, not just in the long run, as predicted by Lerner symmetry, but also in the short run. 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. The conventional static analysis of the border adjustment relies on the trade balance logic, and concludes that C-BAT neutrality is an immediate implication of the country's budget constraint.[2] We show here, however, that BAT neutrality in a dynamic monetary macro model is a much taller order.

Firstly, when prices are sticky, C-BAT neutrality requires that the nominal exchange rate appreciates on impact by the magnitude of the border adjustment tax to offset its effect 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

[2] 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).

show that conventional Taylor rules that respond to output gap and effective consumer price inflation are consistent with C-BAT neutrality. Yet, neutrality fails if monetary authorities react, directly or indirectly, to the nominal appreciation associated with the border adjustment.[3]

Secondly, beyond a specific type of monetary regime, C-BAT neutrality imposes restrictions on the timing and implementation of the C-BAT reform. In particular, exact neutrality requires that the border adjustment is an unexpected permanent policy shift, which applies uniformly to all import and export flows.[4] 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, C-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 extent 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.[5]

Lastly, C-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. In-

[3]Note that neutrality requires that both: (a) the monetary authority of the country implementing C-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.

[4]It is difficult to apply C-BAT to exports of some services like education, healthcare and recreation. In the particular case of US with C-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.

[5]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.

deed, currency appreciation triggered by C-BAT leads to a capital loss on home-currency net debt. Under these circumstances, C-BAT is, of course, not neutral. Interestingly, if the net foreign asset position is entirely in foreign currency, C-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. This is because the valuation loss on foreign-currency assets is exactly compensated by the border adjustment tax, which subsidizes exports, leaving the foreign-currency trade prices unchanged.

Independently of the currency of net foreign assets and C-BAT neutrality, border adjustment results in a transfer between the private sector and the government in the home country. In particular, in each period the C-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.[6] 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, C-BAT neutrality is not violated by this transfer between the home private sector and the government. More generally, currency appreciation associated with C-BAT has distributional consequences between borrowers and lenders, which may trigger departures from C-BAT neutrality in richer models.

Finally, we study quantitatively the trade effects emerging from border adjustment in the plausible cases when C-BAT neutrality is violated. As trade prices and wages adjust, there are no long-run consequences of C-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

[6]The nominal appreciation triggers a capital loss on the foreign-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.

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 C-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 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 C-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, C-BAT cannot be considered a robust long-run source of government revenues. We also discuss possible caveats to this argument associated with transfer pricing of US imports and the differential rate of return on US gross assets and liabilities.

After having analyzed the C-BAT, we turn to the VAT. While the C-BAT tax reform can be loosely thought of as the combination of two offsetting taxes from the point of view of Lerner symmetry, the VAT tax reform would have to be coupled with a reduction in domestic payroll taxes in order to satisfy this equivalence. We have studied such coupled policies elsewhere (Farhi, Gopinath, and Itskhoki 2014). Here instead, we are interested in a tax reform that introduces a VAT without a corresponding reduction in payroll taxes, and hence creates a long-run distortion to the equilibrium labor supply.

We also establish a neutrality result for the VAT, but it is much more restrictive than for the C-BAT. In particular, it holds when labor supply is perfectly inelastic or when nominal wages are completely rigid — the two cases in which the VAT-induced labor wedge does not affect equilibrium employment. Under the circumstances of VAT neutrality, there is no effect on the exchange rate, a stark contrast with the appreciation of the exchange rate that was necessary to deliver neutrality for C-BAT tax reforms.[7] The reason for this lack of exchange rate adjustment

[7] The appreciation also happens in response to a coupled policy of an increase in the VAT and a reduction in

is the symmetric VAT treatment of both domestically and internationally produced goods, so that their relative prices remain unaffected.

When equilibrium employment is not fully inelastic, the VAT tax reform leads to a reduction in domestic labor and a partial appreciation of the exchange rate, reflecting the negative productivity effects of distortionary taxation. For our baseline calibration, the appreciation remains modest (2%) in comparison to the tax change (20%). In addition, exports and imports decline much more modestly than under the C-BAT tax reform. This prediction that with VAT the real exchange rate appreciation occurs mainly through prices and not the exchange rate is consistent with empirical evidence in Freund and Gagnon (2017).

The rest of the paper is organized as follows. We lay out the general model environment in Section 2. We then establish the exact conditions for neutrality of the border tax adjustment and of the value-added tax in Section 3. We then proceed, in Section 4 to study the quantitative implications of various departures from the exact neutrality of the two tax reforms respectively and conclude in Section 5.

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 below. Several ingredients follow from Farhi, Gopinath, and Itskhoki (2014) and Casas, Diez, Gopinath, and Gourinchas (2016). We focus our analysis on two types of tax reforms — a corporate tax reform with a border adjustment tax (C-BAT), and a value-added tax (VAT) reform.

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 trades 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

the payroll tax, which is equivalent to a C-BAT policy.

flow budget constraint:

$$P_tC_t + B_{t+1} + B^*_{t+1}\mathcal{E}_t + \int_{s\in\mathcal{S}_{t+1}} Q_t(s)\mathcal{B}_{t+1}(s)\mathrm{d}s \qquad (1)$$
$$\leq (1+i_t)B_t + (1+i^*_t)B^*_t\mathcal{E}_t + \mathcal{B}_t + W_t(h)N_t(h) + \Pi_t + T_t,$$

where $\mathcal{E}_t$ is the home currency price of the foreign currency (i.e., an increase in $\mathcal{E}_t$ is a depreciation of the home 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 capture domestic lump-sum transfers from the government.

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

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

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 (Euler equations) for H bonds and F bonds are standard.

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:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_w^{s-t}\Theta_{t,s}N_sW_s^{\vartheta(1+\varphi)}\left[\frac{\vartheta}{\vartheta-1}\kappa P_sC_s^{\sigma}N_s^{\varphi} - \frac{\bar{W}_t(h)^{1+\vartheta\varphi}}{W_s^{\vartheta\varphi}}\right] = 0, \qquad (3)$$

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.[8] This is a standard result in the New Keynesian literature, as derived, for example, in Galí (2008).

[8]Note that in the limiting case with flexible wages ($\delta \to 0$) and perfectly substitutable labor inputs ($\vartheta \to \infty$), the wage setting condition (3) simplifies to the conventional labor supply condition $\kappa C_t^{\sigma}N_t^{\varphi} = W_t/P_t$.

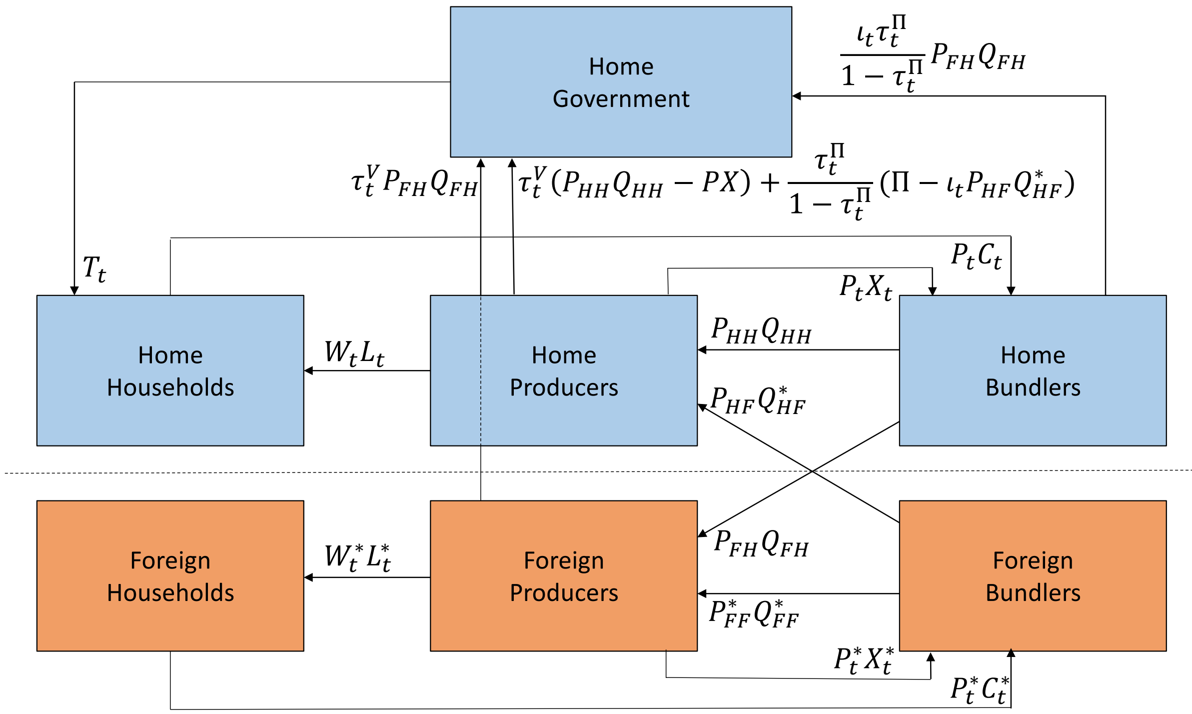


Figure 1: Value flows

Note: Transaction value flows between agents in the economy. All flows with Home are in home currency. Flows within Foreign are in foreign currency. For brevity we suppress government consumption flow $P_t G_t$, as well as time subscript t on certain flows. The direction of arrows indicates the direction of payments; the goods/factors flow in the reverse direction. τ_t^V is the VAT and τ_t^Π is the profit tax with $\iota_t = 1$ if it includes the BAT.

The foreign households are symmetric.

2.2 Producers

Production In each country there are a continuum $\omega \in [0, 1]$ of firms producing different varieties of goods using a technology with labor and intermediate inputs. Specifically, a representative home firm produces according to:

$$Y_t(\omega) = e^{a_t} L_t(\omega)^{1-\alpha} X_t(\omega)^\alpha, \qquad 0 < \alpha < 1, \tag{4}$$

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 $\vartheta > 1$, at a variety-specific wage $W_t(h)$. This implies that the cost of the basket of labor inputs is $W_t = \left[\int W_t(h)^{1-\vartheta} dh\right]^{\frac{1}{1-\vartheta}}$ and the demand for individual type of labor is $L_t(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\vartheta} L_t$.

Furthermore, we adopt the Basu (1995) roundabout production structure, where the intermediate input X_t is the same as the local final good. The price of the final good is P_t, the domestic price index, but the effective price for firms is $(1-\tau_t^V)P_t$, since they are reimbursed the value-added tax τ_t^V on intermediate good purchases. With this, the marginal cost of a domestic firm is given by:

$$\mathcal{MC}_t = \kappa e^{-a_t} W_t^{1-\alpha}\big[(1-\tau_t^V)P_t\big]^{\alpha}, \tag{5}$$

where $\kappa \equiv 1/\big(\alpha^{\alpha}(1-\alpha)^{1-\alpha}\big)$, and the optimal intermediate good and labor expenditures are:

$$(1-\tau_t^V)P_t X_t = \alpha \mathcal{MC}_t Y_t \qquad \text{and} \qquad W_t L_t = (1-\alpha)\mathcal{MC}_t Y_t. \tag{6}$$

The firm sells its product to both the home and foreign market, and we denote the respective quantities demanded by $Q_{HH,t}(\omega)$ and $Q^*_{HF,t}(\omega)$. Therefore, goods market clearing requires $Y_t(\omega) = Q_{HH,t}(\omega) + Q^*_{HF,t}(\omega)$. The profits of a home firm ω are given by:

$$\Pi_t(\omega) = (1-\tau_t^{\Pi})\left[(1-\tau_t^V)\big(P_{HH,t}(\omega)Q_{HH,t}(\omega) - P_t X_t(\omega)\big) + \frac{P_{HF,t}(\omega)Q^*_{HF,t}(\omega)}{1-\iota_t\tau_t^{\Pi}} - W_t L_t(\omega)\right], \tag{7}$$

where τ_t^{Π} is the profit tax and $\iota_t \in \{0,1\}$ is an indicator for whether the profit tax features border adjustment, i.e. that exports are deductible from the base of the profit tax. We assume that the value added tax τ_t^V is not assessed on the export sales of the firm, as is the case in practice.

Competitive bundlers We assume that the final good is not tradable internationally and is used for final consumption, government consumption and as an intermediate input in production of the domestic firms:

$$Q_t = C_t + G_t + X_t. \tag{8}$$

The final good in each country is assembled in a sector of competitive bundlers, who combine all domestic and imported varieties using a Kimball (1995) aggregator, which defines implicitly the resulting output of the final good Q_t:

$$\int_0^1 \left[\gamma_H \Upsilon\left(\frac{Q_{HH,t}(\omega)}{\gamma_H Q_t}\right) + \gamma_F \Upsilon\left(\frac{Q_{FH,t}(\omega)}{\gamma_F Q_t}\right)\right] \mathrm{d}\omega = 1, \tag{9}$$

where $Q_{iH,t}(\omega)$ is the input of variety ω produced in country $i \in \{H,F\}$ and γ_i is the preference parameter, which in particular captures home bias when $\gamma_H > \gamma_F$. The function Υ is increasing and concave, with $\Upsilon(1) = 1$, $\Upsilon'(\cdot) > 0$ and $\Upsilon''(\cdot) < 0$. This demand aggregation structure gives rise to strategic complementarities in price setting resulting in variable markups and pricing to market (Dornbusch 1987, Krugman 1987). The Kimball (1995) structure also nests the CES case with Υ as a power function.

The profits of the bundlers are given by:

$$\Pi_{Ht}^{B} = (1-\tau_t^V)(1-\tau_t^{\Pi}) \left[P_t Q_t - \int_0^1 P_{HH,t}(\omega) Q_{HH,t}(\omega) \mathrm{d}\omega - \frac{1}{1-\iota_t \tau_t^{\Pi}} \int_0^1 P_{FH,t}(\omega) Q_{FH,t}(\omega) \mathrm{d}\omega \right]. \tag{10}$$

Since bundlers only use intermediate goods, the VAT applies to their profits, akin to a profit tax. At the same time, profit tax with a border adjustment ($\iota_t = 1$) prevents the deduction of imported products from the base of the profit tax. The competitive bundlers are flexible-price zero-profit firms and price the final output according to the marginal cost of assembly, that is they immediately pass-through their input price changes into the final good price P_t, which is the consumer price index at home. The final good price satisfies:

$$P_t = \int_0^1 \left[P_{HH,t}(\omega) \frac{Q_{HH,t}(\omega)}{Q_t} + \frac{P_{FH,t}(\omega)}{1-\iota_t \tau_t^{\Pi}} \frac{Q_{FH,t}(\omega)}{Q_t} \right] \mathrm{d}\omega, \tag{11}$$

where the quantity demanded satisfy:

$$\frac{Q_{HH,t}(\omega)}{Q_t} = \gamma_H \psi \left(\frac{P_{HH,t}(\omega)}{P_t/D_t} \right) \quad \text{and} \quad \frac{Q_{FH,t}(\omega)}{Q_t} = \gamma_F \psi \left(\frac{P_{FH,t}(\omega)}{1-\iota_t \tau_t^{\Pi}} \frac{D_t}{P_t} \right), \tag{12}$$

where $\psi(\cdot) \equiv \Upsilon'^{-1}(\cdot)$ is the demand curve with $\psi'(\cdot) < 0$ and D_t is an auxiliary variable.[9] Note that the definition of the price index in (11) ensures zero profits for bundlers.

We adopt this formulation with bundlers to reflect that in reality virtually all of imports are done by firms, subject to the profit tax, rather than directly by consumers. We return to this assumption and evaluate the robustness of our results in Section 4.

Foreign firms are symmetric, producing output according to a counterpart to (4) and facing marginal costs $\mathcal{MC}_t^*$ in parallel with (5). The produced output is split between home- and foreign-markets: $Y_t^*(\omega) = Q_{FF,t}^*(\omega) + Q_{FH,t}(\omega)$. The profits of the foreign firms (in foreign currency) are given by:

$$\Pi_t^*(\omega) = P_{FF,t}^*(\omega) Q_{FF,t}^*(\omega) + \frac{1-\tau_t^V}{\mathcal{E}_t} P_{FH,t}(\omega) Q_{FH,t}(\omega) - W_t^* L_t^*(\omega) - P_t^* X_t^*(\omega), \tag{13}$$

[9] The auxiliary variable satisfies $D_t = \int_0^1 \left[\Upsilon'\left(\frac{Q_{HH,t}(\omega)}{\gamma_H Q_t}\right) \frac{Q_{HH,t}(\omega)}{Q_t} + \Upsilon'\left(\frac{Q_{FH,t}(\omega)}{\gamma_F Q_t}\right) \frac{Q_{FH,t}(\omega)}{Q_t} \right] \mathrm{d}\omega$. In the special case of CES, $\Upsilon(z) = z^{\frac{\sigma-1}{\sigma}}$, so that $\psi(x) = \left(\frac{\sigma}{\sigma-1} x\right)^{-\sigma}$, $D_t = \frac{\sigma-1}{\sigma} = const$ and $P_t = \int_0^1 \left[\gamma_H \left(\frac{P_{HH,t}(\omega)}{P_t}\right)^{1-\sigma} + \gamma_F \left(\frac{P_{FH,t}(\omega)/P_t}{1-\iota_t \pi_t^{\Pi}}\right)^{1-\sigma} \right] \mathrm{d}\omega$.

where we quote $P^*_{FF,t}(\omega)$ in foreign currency and $P_{FH,t}(\omega)$ in home currency, hence the nominal exchange rate $\mathcal{E}_t$ in the expression. The value added tax τ^V_t is levied at the border on all imports, creating a wedge between the consumer price $P_{FH,t}(\omega)$ paid by the home bundlers and the producer price $(1-\tau^V_t)P_{FH,t}(\omega)$ received by the foreign firms. For simplicity, we assume that the foreign country does not levy profit or value added taxes, which should be viewed as a normalization without loss of generality for our dynamic analysis.

The foreign bundlers assemble the foreign final good Q^*_t according to an aggregator as in (9), with preference parameters $\gamma^*_F > \gamma^*_H$, reflecting home bias. The foreign bundlers are also competitive flexible-price firms with profits

$$\Pi^{B*}_{Ft} = P^*_t Q^*_t - \int_0^1 P^*_{FF,t}(\omega) Q^*_{FF,t}(\omega)\mathrm{d}\omega - \int_0^1 \frac{P_{HF,t}(\omega)}{\mathcal{E}_t} Q^*_{HF,t}(\omega)\mathrm{d}\omega = 0.$$

The price index P^*_t and demand schedules for $Q^*_{FF,t}(\omega)$ and $Q^*_{HF,t}(\omega)$ are given by equations similar to (11) and (12).

2.3 Price setting

Markets are assumed to be segmented so firms can set different prices by destination market and invoicing currency, with prices reset infrequently. We consider a Calvo pricing environment where firms are randomly chosen to reset prices with probability $1-\delta_p$ in any given period. In setting prices, the firms maximize the discounted present value of expected profits conditional on the price staying in effect. Furthermore, we consider three pricing paradigms — that of producer, local and dominant currency pricing (PCP, LCP and DCP, respectively), with home currency (dollar) being the dominant currency. In an extension in Section 4 we additionally discuss alternative assumptions about short-run pass-through of taxes, as well as on the incidence of the C-BAT, to study the robustness of our results.

To fix ideas, it is useful to define three types of prices: (i) producer prices (net prices received by producers in producer currency); (ii) consumer prices (net prices paid by consumers in local currency); and (iii) border prices (net prices paid/received by foreigners at the border in dollars). Depending on the pricing paradigm (PCP, LCP or DCP), either type of price can be sticky, while others move in the short run together with exchange rate and taxes. We summarize the three types of prices in Table 1 below (we omit indicators ω for brevity):

Desired prices Before we characterize equilibrium price setting, we first define desired prices of the firms, that is prices that they would set if they could flexibly adjust them. The

Table 1: Types of prices

Transaction price	Producer price (in producer currency)	Consumer Price (in local currency)	Border Price (in dollars)
$P_{HH,t}$	$P^p_{HH,t} = (1-\tau^V_t)P_{HH,t}$	$P^c_{HH,t} = P_{HH,t}$	–
$P_{HF,t}$	$P^p_{HF,t} = \dfrac{1}{1-\iota_t\tau^\Pi_t}P_{HF,t}$	$P^{c*}_{HF,t} = \dfrac{1}{\mathcal{E}_t}P_{HF,t}$	$P^b_{HF,t} = P_{HF,t}$
$P_{FH,t}$	$P^{p*}_{FH,t} = \dfrac{1-\tau^V_t}{\mathcal{E}_t}P_{FH,t}$	$P^c_{FH,t} = \dfrac{1}{1-\iota_t\tau^\Pi_t}P_{FH,t}$	$P^b_{FH,t} = (1-\tau^V_t)P_{FH,t}$

Note: Transaction prices are conventionally used in the formulas above and in Figure 1. The border prices refer to the net prices paid/received by foreigners, but evaluated in dollars. We omit $P^*_{FF,t}$ for brevity, since it involves no taxes.

desired producer prices for home and foreign firms respectively are given by:

$$\tilde{P}^p_{Hj,t} = \frac{\sigma_{Hj,t}(\omega)}{\sigma_{Hj,t}(\omega)-1}\mathcal{MC}_t \qquad \text{and} \qquad \tilde{P}^{p*}_{Fj,t} = \frac{\sigma_{Fj,t}(\omega)}{\sigma_{Fj,t}(\omega)-1}\mathcal{MC}^*_t, \qquad j \in \{H,F\},$$

and where $\sigma_{ij,t}(\omega)$ is effective elasticity of demand:

$$\sigma_{iH,t}(\omega) \equiv -\frac{\partial \log Q_{iH,t}(\omega)}{\partial \log \tilde{P}^c_{iH,t}(\omega)} \qquad \text{and} \qquad \sigma_{iF,t}(\omega) \equiv -\frac{\partial \log Q^*_{iF,t}(\omega)}{\partial \log \tilde{P}^{c*}_{iF,t}(\omega)}, \qquad i \in \{H,F\},$$

where $\{\tilde{P}^c_{iH,t}, \tilde{P}^{c*}_{iF,t}\}_i$ are the local-currency consumer prices associated with the desired producer prices $\{\tilde{P}^p_{Hj,t}, \tilde{P}^{p*}_{Fj,t}\}_j$ in producer currency, according to the transformation summarized in Table 1. Because of strategic complementarities, the desired markup is not constant, in general, and depends on the relative price of the firm.

Local market We assume that all domestic prices are sticky in the local currency and exhibit a full pass-through of the value-added tax in the short run. Therefore, in all pricing regimes, the optimal reset price for domestic sales of home firms satisfies (see Appendix A.1 for details):

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t}\Theta_{t,s}(1-\tau^\Pi_s)Q_{HH,s}(\sigma_{HH,s}-1)\left(\bar{P}^p_{HH,t} - \frac{\sigma_{HH,s}}{\sigma_{HH,s}-1}\mathcal{MC}_s\right) = 0, \qquad (14)$$

where $\Theta_{t,s}$ is the stochastic discount factor of home households, as defined in (3), and we omitted firm indicator ω for brevity. This expression implies that $\bar{P}^p_{HH,t}$ is preset as a markup over expected future marginal costs during the duration of the price. All firms adjusting prices at t set their producer price at $\bar{P}^p_{HH,t}$, since we assume no idiosyncratic productivity shocks. In periods of price duration $s \geq t$, the associated consumer price is $P^c_{HH,s} = \bar{P}^p_{HH,t}/(1-\tau^V_s)$, and it fluctuates in proportion with the VAT. The price setting by foreign firms for the foreign market is characterized by a symmetric equation.

Border prices We consider three types of border pricing — producer (PCP), local (LCP), and dollar (or dominant, DCP). We view PCP and LCP as the pure theoretical benchmarks (see discussion in Obstfeld and Rogoff 2000, Engel 2003), in which either net producer prices (in producer currency) or net consumer prices (in consumer local currency) remain fixed during the period of price non-adjustment. Therefore, under PCP there is full pass-through of both exchange rates and border taxes into the consumer prices, while under LCP both pass-through elasticities are zero. We consider dollar pricing as the third alternative, in which both import and export prices are sticky in dollars (home currency), so that currency fluctuations are absorbed in the short run into the profit margins of foreign firms. At the same time, we assume that border adjustment taxes are absorbed into the margins of the US (home) firms during the period of price non-adjustment. 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, Boz, Gopinath, and Plagborg-Møller 2017). These three types of price setting correspond to the three notions of prices in Table 1.

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 border adjustment taxes operate on top of the preset price. This way, the firm targets an optimal level of markup over its producer-currency marginal cost, and both exchange rate and taxes are added on top of this factory-gate price. This means that under PCP, $P^p_{HF,t}(\omega)$ and $P^{p*}_{FH,t}(\omega)$ are kept unchanged during the period of price non-adjustment, while consumer and border prices move with the exchange rate and border taxes.

Therefore, the optimal reset price of home firms for foreign sales satisfies (again omitting indicator ω for brevity):

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

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 the 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 affects price setting indirectly, as the foreign-currency consumer price $P^{c*}_{HF,s} = (1 - \iota_s \tau^{\Pi}_s)\bar{P}_{HF,t}/\mathcal{E}_s$ affects both the quantity sold abroad $Q^*_{HF,s}$ and the elasticity of demand $\sigma_{HF,s}$. Finally, note the asymmetry between the effects of the VAT and BAT (associated with the profit tax): τ^V_s affects directly the consumer price to home consumers, but not to foreign consumers, while in contrast $\iota_s \tau^{\Pi}_s$ affects the foreign consumer price, but not the home.

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

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

and the associated consumer price at home is $P^c_{FH,s} = \frac{\mathcal{E}_t \bar{P}^{p*}_{FH,t}}{(1-\iota_s\tau^{\Pi}_s)(1-\tau^V_s)}$, that is the VAT and the BAT affect it symmetrically.

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

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta_{t,s}(1 - \tau^{\Pi}_s) Q^*_{HF,s}(\sigma_{HF,s} - 1)\left(\frac{\mathcal{E}_s \bar{P}^{c*}_{HF,t}}{1 - \iota_s \tau^{\Pi}_s} - \frac{\sigma_{HF,s}}{\sigma_{HF,s} - 1}\mathcal{MC}_s\right) = 0,$$

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta^*_{t,s} Q_{FH,s}(\sigma_{FH,s} - 1)\left(\frac{(1 - \tau^V_s)(1 - \iota_s\tau^{\Pi}_s)\bar{P}^c_{FH,t}}{\mathcal{E}_s} - \frac{\sigma_{FH,s}}{\sigma_{FH,s} - 1}\mathcal{MC}^*_s\right) = 0.$$

Dominant Currency Pricing In this case, we assume that both import and export prices are sticky in dollars (the home currency), however, domestic firms face the border adjustment tax on top of the preset prices. In particular, the home exporters preset the border price $\bar{P}^b_{HF,t}$ for $s \geq t$, so that the foreign consumers pay $P^{c*}_{HF,s} = \bar{P}^b_{HF,t}/\mathcal{E}_s$, while the home producers receive on net $P^p_{HF,s} = \bar{P}^b_{HF,t}/(1 - \iota_s\tau^{\Pi}_s)$. In this case, the producer price responds immediately to C-BAT, while the consumer price responds immediately to the exchange rate, resulting in an asymmetry in pass-through of exchange rate and border taxes. Similarly, foreign firms also preset the border price $\bar{P}^b_{FH,t}$, and therefore the price that they receive changes with the exchange rate, $P^{p*}_{FH,s} = \bar{P}^b_{FH,t}/\mathcal{E}_s$, while the net price paid by home importers responds immediately to C-BAT and VAT: $P^c_{FH,s} = \bar{P}^b_{FH,t}/[(1 - \tau^V_s)(1 - \iota_s\tau^{\Pi}_s)]$.

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

Given this price setting assumption, optimal preset prices under DCP satisfy:

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

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

2.4 Government and country budget constraints

We assume that the government must balance its budget each period, returning all tax revenues from the VAT and the profit tax in the form of lump-sum transfers T_t to households after financing exogenous government expenditure G_t. This is without loss of generality since Ricardian equivalence holds in this model. Hence, the period t government budget constraint is:

$$T_t + P_t G_t = TR_t^{\Pi} + TR_t^{V}, \tag{15}$$

where (see derivation in Appendix A.2):

$$TR_t^{\Pi} = \frac{\tau_t^{\Pi}}{1-\tau_t^{\Pi}} \Pi_t + \frac{\iota_t \tau_t^{\Pi}}{1-\tau_t^{\Pi}} \left(P_{FH,t} Q_{FH,t} - P_{HF,t} Q_{HF,t}^{*} \right), \tag{16}$$

$$TR_t^{V} = \tau_t^{V} \left[P_{HH,t} Q_{HH,t} + P_{FH,t} Q_{FH,t} - P_t X_t \right], \tag{17}$$

where we used the convention that $P_{HH,t} Q_{HH,t} = \int_0^1 P_{HH,t}(\omega) Q_{HH,t}(\omega) \mathrm{d}\omega$, and similarly for other variables (including aggregate profits Π_t).

The value added tax simply applies to the total value added at home. Similarly, in the absence of border adjustment ($\iota_t = 0$), tax revenues from the profit tax are proportional to aggregate profits Π_t . However with BAT ($\iota_t = 1$), profit tax revenues are instead proportional to aggregate profits minus the trade balance (the difference between the value of aggregate exports and imports).

Combining the above expressions with the household budget constraint (1) and aggregate profits (7), we arrive at the aggregate country budget constraint (see Appendix A.2):

$$B_{t+1} + \mathcal{E}_t B^*_{t+1} - (1+i_t)B_t - (1+i^*_t)\mathcal{E}_t B^*_t = NX_t, \tag{18}$$

where net exports NX_t are defined as the value of exports minus the value of imports, evaluated at the effective border prices paid/received by foreigners (see Table 1):[10]

$$NX_t \equiv P_{HF,t}Q^*_{HF,t} - (1-\tau^V_t)P_{FH,t}Q_{FH,t}. \tag{19}$$

2.5 Monetary Policy

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

$$i_t - i^* = \rho_m(i_{t-1} - i^*) + (1-\rho_m)\left(\phi_M \pi_t + \phi_Y \tilde{y}_t\right) + \varepsilon_{i,t} \tag{20}$$

In equation (20), 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

We start this section by considering the case of the corporate profit tax with and without the border adjustment (C-BAT), assuming there is no VAT. We lay out the conditions for C-BAT neutrality, as well as discuss what happens when they are not satisfied. We also explore the implications for the government budget. We finish the section with an analysis of the VAT.

3.1 C-BAT neutrality

In this section we study the dynamic effects of a corporate profit tax τ^Π_t reform at some date t_0, in the absence of any changes in the VAT, so for simplicity we normalize $\tau^V_t = 0$ for all t. More specifically, we are interested in analyzing the circumstances under which the border adjustment associated with the corporate profit tax is consequential for macroeconomic allocations. Therefore, we compare the dynamic paths of the economy under the two scenario — a corporate tax reform with ($\iota_t = 1$) and without ($\iota_t = 0$) the border adjustment, and we refer

[10] Note the difference between this definition of NX_t and the C-BAT term in (16), which we can rewrite as $TR^\Pi_t = \frac{\pi^\Pi_t}{1-\pi^\Pi_t}\Pi_t - \iota_t \frac{\pi^\Pi_t}{1-\pi^\Pi_t} NX_t + \iota_t \frac{\pi^\Pi_t}{1-\pi^\Pi_t}\frac{\pi^V_t}{1-\pi^V_t} P_{FH,t}Q_{FH,t}$. The last term reflects the compounding effect of the border adjustment associated with VAT and C-BAT.

to the former case as the C-BAT. In fact, for the neutrality analysis it is inessential whether the profit tax rate τ_t^Π changes itself at t_0 or that there is simply a switch from a no C-BAT to a C-BAT profit tax system.

We introduce the following notion of C-BAT neutrality:

Definition 1 (C-BAT Neutrality) *Border adjustment associated with the corporate profit tax is neutral if the equilibrium path of all real macroeconomic variables does not depend on whether the border adjustment is implemented or not, that is whether $\iota_t = 0$ or $\iota_t = 1$.*

The neutrality concerns only real macro variables, and does not concern prices, exchange rates and distributional outcomes across agents or between the private and public sector, a topic to which we return in Section 3.2. The C-BAT neutrality property means that the choice of whether to implement the profit tax with or without the border adjustment is immaterial for the equilibrium path of the economy.

We introduce two additional definitions that prove useful below. First, as we will see, the border adjustment is often associated with an exchange rate appreciation. In particular, we call this appreciation *complete* if:

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

Recall that a fall in $\mathcal{E}_t$ corresponds to an appreciation of the home currency, as fewer units of the home currency are needed to buy one unit of the foreign currency. Therefore, Definition 2 implies an appreciation in the home currency proportional to the size of the profit tax τ_t^Π when the profit tax is implemented together with the border adjustment. Alternatively, for a given value of the profit tax $\tau_t^\Pi = \tau^\Pi$ for all t, a reform can involve a switch from no border adjustment $\iota_t = 0$ for $t < t_0$ to a C-BAT $\iota_t = 1$ for $t \geq t_0$ at some date t_0, which triggers an exchange rate appreciation at t_0 proportional to the existing level of the profit tax τ^Π.

The final definition concerns the *short-run* response of border prices, both to the border tax and to the exchange rate. It turns out to be convenient to use foreign currency border prices for this definition, namely $P_{ij,t}^{b*}(\omega) = P_{ij,t}^b(\omega)/\mathcal{E}_t$ for $i, j \in \{H, F\}$ and $i \neq j$, where $P_{ij,t}^b(\omega)$ are the home-currency border prices defined in Table 1. Therefore, $P_{ij,t}^{b*}(\omega)$ corresponds to the net foreign-currency price paid/received by foreigners for cross-border transactions. The corresponding effective home prices (producer price for exports and consumer price for imports) in the home currency are:

$$P_{HF,t}^p(\omega) = \frac{\mathcal{E}_t}{1-\iota_t\pi_t^\Pi} P_{HF,t}^{b*}(\omega) \qquad \text{and} \qquad P_{FH,t}^c(\omega) = \frac{\mathcal{E}_t}{1-\iota_t\pi_t^\Pi} P_{FH,t}^{b*}(\omega).$$

The reason for this focus on $P^{b*}_{ij,t}(\omega)$ is that C-BAT neutrality requires, among other things, that foreign relative prices remain unchanged. Hence, we define:

Definition 3 (Symmetric short-run pass-through) *During the period of price stickiness, the response of border prices is symmetric for the C-BAT $\iota_t\tau^\Pi_t$ and the exchange rate $\mathcal{E}_t$:*

$$\frac{\partial \log P^{b*}_{ij,t}(\omega)}{\partial \log \mathcal{E}_t} = -\frac{\partial \log P^{b*}_{ij,t}(\omega)}{\partial \log(1-\iota_t\tau^\Pi_t)}, \qquad i,j \in \{H,F\}, \quad i \neq j. \tag{21}$$

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 notable cases in which short-run pass-through is symmetric. The first case is that of PCP pricing, in which the firm fixes the net of tax home-currency price (namely, $P^p_{HF,t}$ and $P^{p*}_{FH,t} = P^{b*}_{FH,t}$). In this case, any change 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 second case is that of LCP, where the firm fixes the export market consumer price in foreign currency (namely, $P^{c*}_{HF,t} = P^{b*}_{HF,t}$ and $P^c_{FH,t}$). In this case, a change in taxes or exchange rates both have a zero short-run pass-through into the consumer price, and again the symmetry assumption holds. 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, in which the home-currency border prices $P^b_{ij,t}$ are inflexible, and hence $P^{b*}_{ij,t}$ are fully responsive to the exchange rate, but have a zero pass-through to the C-BAT in the short run.

With these definitions in hand, we now introduce the following set of assumptions and prove our main neutrality result below:

Assumptions:

A1. Border prices are either flexible or exhibit a symmetric short-run pass-through (according to Definition 3).

A2. The monetary policy rule depends only on the output gap and the effective CPI inflation (or its expectation), as in (20), 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, i.e. $B_t \equiv 0$ for the home-currency bonds.

A4. The border adjustment tax is a one-time permanent and unanticipated policy shift, with no (expectation of) retaliation by foreign country.

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

Proposition 1 *When Assumptions A1-A5 are satisfied, the border adjustment tax C-BAT 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 fixed exchange rate regime. FGI demonstrate that, under a fixed exchange rate regime, an equivalent fiscal policy to the border adjustment tax has the same effect as a nominal devaluation. In contrast, when the 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.

We now describe the logic behind the proof, which is presented in Appendix A.3. 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, $\mathcal{E}_t^1 = (1-\tau_t^{\Pi})\mathcal{E}_t^0$ 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 run. Indeed, the pass-through is symmetric in the short run, and firms have no incentives to change prices later, when they have the opportunity to do so. This can be seen by investigating the optimal price setting equations from Section 2.3: since the costs of the firms remain unchanged, they have no incentive to adjust their producer prices. Assumption A2 then ensures that the monetary policy stance is also unchanged, despite the appreciation, and hence so is 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 and the associated nominal appreciation. Indeed, this can be observed from the country budget constraint (18), which in this case can be rewritten as:

$$B_{t+1}^{*} - (1+i_t^{*})B_t^{*} = P_{HF,t}^{b*}Q_{HF,t}^{*} - P_{FH,t}^{b*}Q_{FH,t}.,$$

with the foreign-currency border prices $P_{ij,t}^{b*}$ following the same equilibrium path irrespectively of the border adjustment, due to Assumption A1. Therefore, we conclude that the same macroeconomic allocation (consumption, output, trade flows, effective 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 3.3, 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 government budget consequences of this policy when neutrality holds.

3.2 Government budget revenues

We consider here the case when Assumptions A1–A5 and hence Proposition 1 hold, and therefore the C-BAT is neutral for macroeconomic outcomes. Nonetheless, this does not exclude the possibility of the distributional effects, for example between borrowers and lenders, which in our model have no macroeconomic consequences. 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 $\Delta_t^\Pi = -\frac{\iota_t\tau_t^\Pi}{1-\tau_t^\Pi}NX_t$, as follows from the expression for the profit tax revenues TR_t^Π in (16) and the definition of net exports NX_t in (19). 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.

Over the long run, the net present value of these transfers depends on the initial net foreign asset position of the country, which from the intertemporal budget constraint is equal to the present value of future trade surpluses and deficits:

$$B_t^* = -\sum_{s\geq t}\frac{\mathcal{E}_s NX_s}{\prod_{j=0}^{s-t}(1+i_{t+j}^*)}. \tag{22}$$

Therefore, the present value of the government budget surplus from a C-BAT reform at t_0 is $\Sigma_{t_0}^\Pi = \frac{\tau^\Pi}{1-\tau^\Pi}B_{t_0}^*\mathcal{E}_{t_0}^1$, or equivalently $\Sigma_{t_0}^\Pi = \tau^\Pi B_{t_0}^*\mathcal{E}_{t_0}^0$ if evaluated under at the pre-reform value of the exchange rate.[11] Note that for the home households, who face an unchanged price level P_t under C-BAT neutrality, this nominal transfer also corresponds to the real loss/gain in household wealth, which is transferred over time to/from the government as the country runs trade deficits/surpluses along the future equilibrium path.

[11] Two clarifications are in order. First, by Assumption A4, the C-BAT is one-time permanent change, so that $\iota_t\tau_t^\Pi = 0$ for all $t < t_0$ and $\iota_t\tau_t^\Pi = \tau^\Pi$ for all $t \geq t_0$. Second, by Assumption A3, $B_{t_0} = 0$, and therefore the non-zero NFA are entirely in foreign currency, $B_{t_0}^* \neq 0$.

We summarize these results in:

Proposition 2 *Under assumptions A1-A5 ensuring C-BAT neutrality, the border adjustment is associated with a lump-sum transfer Δ_t^{Π} from the private sector to the government in periods of trade deficit, and vice versa. The net present value of these transfers $\Sigma_{t_0}^{\Pi}$ towards the government is proportional to the initial net foreign asset position of the country. In particular,*

$$\Delta_t^{\Pi} = -\frac{\tau^{\Pi}}{1-\tau^{\Pi}} NX_t \quad \textit{for} \quad t \geq t_0 \qquad \textit{and} \qquad \Sigma_{t_0}^{\Pi} = \frac{\tau^{\Pi}}{1-\tau^{\Pi}} B_{t_0}^{*} \mathcal{E}_{t_0}^{1}, \tag{23}$$

where τ^{Π} is the profit tax rate after the C-BAT reform at t_0.[12]

What is the nature of this transfer? Consider a representative household holding $B_t^* > 0$ of foreign-currency assets at $t = t_0$. 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 home-currency value of the assets $B_t^* \mathcal{E}_t$ declines. Similarly, it reduces the purchasing power of B_t^* in terms of foreign goods in the home market, $B_t^*(1-\tau_t^{\Pi})/P_{FH,t}^{b*}$, but not in terms of the pre-border-tax prices, $B_t^*/P_{FH,t}^{b*}$. (Recall that the foreign-currency price paid to foreigners, $P_{FH,t}^{p*} = P_{FH,t}^{b*}$, 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.[13] The net present value of this gap is exactly $\tau^{\Pi} B_{t_0}^*$, in terms of foreign-currency purchasing power. This capital loss on the asset position of households is realized gradually as households unwind it by purchasing foreign goods and running trade deficits. Trade deficits result in the transfer of funds to the government that pockets the difference in the trade prices, which emerged at the border. The opposite happens in the case of a negative foreign asset position, $B_t^* < 0$, and the government looses revenues to the households.[14]

Why is this transfer non-distortionary? Indeed, we refer to it as a lump-sum transfer because it is associated with no change in relative prices and macroeconomic allocations, as follows from Proposition 1. The reason is that the combination of the border adjustment on both import and export flows with the complete offsetting exchange rate movement ensures that no relevant relative price is affected. Perhaps surprisingly, while home households now pay more for imports then foreign exporters receive due to the border adjustment wedge, this wedge however does not alter the relative price of the home- and foreign-produced goods for

[12]The profit tax reform may or may not involve a change in the profit tax rate itself. What is essential for Proposition 2 is that ι_t switches from 0 to 1 at t_0. This analysis can also be extended in a straightforward way to the changes in the profit tax rate while the border adjustment is in effect throughout.

[13]A symmetric gap emerges for US exports, where the US private sector receives more than what is paid by foreigners.

[14]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 (e.g., the central bank), there is no distributional gain or loss for the government.

domestic households due to the home currency appreciation. Furthermore, due to the Ricardian equivalence, this distributional consequence of the C-BAT does not alter the equilibrium allocations determined by the combined wealth of home households and the home government. This combined wealth remains unchanged when the assumptions underlying C-BAT neutrality (in particular assumption A3) are satisfied, ensuring no wealth transfers across the border.

Implications for the United States What are the implications of Proposition 2 for the proposed C-BAT reform in the United States? The United States currently holds a large accumulated net foreign asset deficit against the rest of the world, and simultaneously runs persistent trade deficits. Under these circumstances, the intertemporal budget constraint (22) requires that the US trade deficits eventually convert into trade surpluses in the long run. Therefore, Proposition 2 suggests that a C-BAT reform in the US would generate government surplus in the short run, government deficits in the long run when the trade balance reverses. Over the long run, a C-BAT reform would create a net transfer away from the government budget in proportion with the current US net foreign liabilities.

There are two caveats to this conclusion. First, our analysis here assumes a single international bond, which in particular implies a common rate of return on both the US foreign assets and foreign liabilities. The analysis however can be immediately extended to a richer asset market structure (as we do in FGI), which allows for the case where the US holds a riskier foreign asset portfolio commanding a higher expected rate of return relative to the rest of the world (consistent with the empirical patterns documented by Gourinchas and Rey 2007, Curcuru, Thomas, and Warnock 2013). In this case, Proposition 2 still applies, and in particular expression (23) for $\Sigma_{t_0}^{\Pi}$ still holds, but now in terms of the risk-adjusted net present value using the stochastic discount factor. In other words, the higher returns on the US foreign assets reflect their higher risk, and hence have to be discounted more heavily, while without adjusting for risk, the US would indeed run an average trade deficit over time.[15]

Second, there is an issue of mis-measurement of the US NFA position, both due to imprecise valuation of the US assets abroad (e.g., the understated capital gains on FDI and portfolio investment abroad) and the transfer pricing by the US importers, which inflated the value of the past trade deficits by overstating the value of the imported goods (see e.g. Guvenen, Mataloni, Rassier, and Ruhl 2017). In this case, again, Proposition 2 applies, but the value of B_t^* used in the calculation of the transfer in (23) needs to be corrected. If transfer pricing is

[15]The matter is different, however, if the higher rate of return on the US portfolio reflects financial market imperfections rather than the equilibrium price of risk, which e.g. could be the case if the US has a monopoly power in supplying international safe assets. In this case, the US indeed can run a permanent trade deficit even in the risk adjusted terms, and hence it is possible to have $\Sigma_t^{\Pi} > 0$ even with a negative initial NFA position.

indeed the concern, the C-BAT has an added benefit of reducing incentives for transfer pricing and hence increasing the base of the corporate profit tax at home (as discussed in e.g. Auerbach, Devereux, Keen, and Vella 2017).

3.3 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 the case when the pass-through assumption A1 does not hold. In particular, assume that instead of PCP or LCP, the DCP regime applies. In this case 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 C-BAT pass-through). Import prices are set in home currency (zero pass-through), but the border adjustment tax is paid by home importers (complete pass-through). We view this as a likely scenario for the US. In this case, even if the exchange rate appreciates fully, the relative price of imported and domestic goods will be distorted in the short run, before prices adjust, and therefore 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 a full appreciation 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 a low degree of trade openness as is the case for the U.S. and relative price and wage stickiness, a complete exchange rate appreciation on impact of C-BAT provides a reasonable approximation even when C-BAT neutrality does not hold. Under DCP and with a nearly complete appreciation, border prices increase on impact of the reform — due to the dollar appreciation for exports and due to the border adjustment for imports — and are only gradually adjusted back down. As a result, both exports and imports are depressed in the short run, as we further explore in the next section.

Next consider the case when assumption A2 fails, and the foreign country targets a particular value of the exchange rate $\bar{\mathcal{E}}_t$, so as to prevent its own currency depreciating excessively relative to the dollar. This could arise for instance if the banking system in the foreign country has net liabilities in dollars, and the central bank has an incentive to avoid a negative shock to banks balance sheets. This would lead the foreign central bank to raise it's interest rates, resulting in a reduction in foreign demand for both foreign- and home-produced goods, possibly triggering a recession.

Assumption A3 is violated when home holds net foreign assets in home currency, that is $B_t > 0$. Due to the home currency appreciation, there is a capital gain on the home-currency NFA position. In particular, if the appreciation is complete (recall Definition 2), home receives a capital gain equal to $B_t\big(\frac{\mathcal{E}_t^0}{\mathcal{E}_t^1} - 1\big) = \frac{\tau^\Pi}{1-\tau^\Pi} B_t$, which would be a net transfer from the foreign and would improve the budget constraint of home as a country. As a result, 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 generates a large net transfer from the US to the rest of the world, as we discuss quantitatively in the next section.

If border adjustment is anticipated (assumption A4 fails), then the movement of the currency takes place prior to the policy implementation, at least in part, resulting in extra short run dynamics prior to the reform, which would be absent under a reform featuring no C-BAT. If the policy is expected to be reversed, then appreciation is likely to be incomplete on impact, affecting the relative price of traded goods and therefore trade flows. Whether this stimulates or hinders net exports becomes then a quantitative matter, which we address in the next section.

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 on certain products, but not others. For example, assumption A5 is violated if some businesses can avoid border adjustment tax on imports as they are not subject to the corporate tax, but instead pay the personal income tax (e.g., as the S-corps do 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 United States. Once exact neutrality fails, analytical results in a dynamic environment become largely infeasible. This is why, in Section 4, we turn to a quantitative exploration of a calibrated model to assess the likely consequences of a border adjustment tax in practice.

3.4 The value-added tax

We close this section with a brief analysis of an alternative tax reform, which also features the border adjustment, namely the VAT reform. In the long run, with flexible prices and wages, the VAT is a distortionary tax, which unlike the profit tax creates a *labor wedge* in the economy, depressing equilibrium employment. When combined with the labor subsidy, the VAT has the same effects as the border adjustment associated with the corporate profit tax (the C-BAT).

Therefore, our above results for C-BAT also apply to a tax reform that jointly increases VAT and reduces the payroll tax, as we study in FGI. Here instead we consider an alternative reform which only increases the VAT rate τ_t^V at some date t_0, without an associated reduction in the payroll tax.

Due to the induced labor wedge, such VAT policy reform cannot be neutral in general. Nonetheless, in the special case where the equilibrium employment allocation is not sensitive to the VAT labor wedge, the VAT is neutral. For example, in one such special case wages are infinitely sticky and employment is demand determined given the constant nominal wage $\bar{W}$. The other special case features fully inelastic labor supply $\bar{N}$ and wages of arbitrary degree of flexibility. Furthermore, the neutrality in this case requires no exchange rate adjustment, provided the VAT pass-through into prices is complete and instantaneous for all products subject to the VAT — an assumption we adopt here and relax quantitatively later in Section 4.2. We summarize these result in (see Appendix A.4 for a formal proof):

Proposition 3 *Assume:*

(i) wages are infinitely sticky at some $\bar{W}$ or labor supply is inelastic at some $\bar{N}$;

(ii) the pass-through of VAT into prices is complete in the short run; and

(iii) the monetary policy rule does not respond to a one time-time jump in the price level.

Then a one-time unanticipated VAT reform is neutral for the real macroeconomic allocation (consumption, output, trade flows), triggers a one-time instantaneous increase in the consumer price level and an associated reduction in the real wage, and no adjustment in the nominal exchange rate.

How can a VAT reform remain neutral for consumption, output and international trade, even when it results in a large jump in the price level and a reduction in the home real wage. Consider for concreteness the case with infinitely sticky wages, and the case with infinitely inelastic labor supply is similar. With unchanged wages, home producers have no incentive to change producer prices, while consumer prices instantaneously increase by the magnitude of the VAT (see Table 1). Similarly, if foreigners do not adjust their producer prices, the price of imported goods at home also increase by the size of the VAT. As a result, the consumer price P_t instantaneously jumps by the same amount.[16] However, because the VAT is reimbursed on intermediate input purchases, the marginal cost of the home producers are not affected (see (5)). Export prices are also unaffected, since export sales are not subject to the VAT, and therefore there is no reallocation of purchasing power across the international border. There is, however, a distributional effect within home — the government collects VAT and the households become poorer in real terms due to the jump in the price level. Yet, again, this does not affect

[16] Note that the monetary policy stance is not affected as long as this is a one-time jump in the price level resulting in no inflation thereafter.

aggregate wealth and consumption in the home economy, due to Ricardian equivalence. However, if wages are not fully sticky and labor supply not fully inelastic, the reduction in the real wage associated with the VAT triggers an adjustment akin to that to a negative productivity shock, and the VAT reform is no longer neutral.

The stark difference of this result from the C-BAT neutrality in Proposition 1 is the lack of the exchange rate appreciation following a VAT reform. This is the case because the VAT by itself introduces no asymmetry in the treatment of domestically- and internationally-produced goods — both home and foreign goods are subject to the VAT when they are purchased for domestic final consumption, but not for intermediate use, and home goods are not subject to the VAT when they are exported. Therefore, VAT introduces *no* wedge in the relative price of home and foreign goods in the absence of any exchange rate movements. This is not the case for C-BAT, which treats home- and foreign-produced goods differentially, and hence requires an exchange rate adjustment to maintain constant the relative prices of foreign goods. While Proposition 3 applies to a much narrower set of circumstances then the earlier BAT neutrality result, we find nonetheless that the prediction for the lack of the exchange rate adjustment is a rather robust feature of VAT reforms, as we show in the following quantitative section.

4 Quantitative Analysis of Border Adjustment Taxes

In this section we numerically evaluate the impact of border adjustment taxes, for the case of corporate tax reform (C-BAT) and for the case of VAT. In Section 3, we described conditions under which neutrality is obtained. Here we explore the short-term and long-term implications when we depart from neutrality by presenting impulse response functions within the model environment described in Section 2. We calibrate to the United States economy and consequently refer to the home country as the US and the home currency as the dollar.

Benchmark Specification Our benchmark specification is one of a small open economy in that we keep all foreign variables unchanged except for the prices at which they sell to the home market. We allow for both sticky wages and sticky prices. For the pricing environment we choose DCP as the benchmark given the extensive evidence of the dominant role of the US dollar in trade invoicing for US imports and exports (see Goldberg and Tille 2008, Gopinath and Rigobon 2008, Gopinath, Itskhoki, and Rigobon 2010). Under DCP all border prices are assumed to be sticky in dollars.

In the benchmark case international asset markets are assumed to be incomplete with only bonds denominated in foreign currency traded, an assumption we later relax. The world interest rate faced by domestic households depends on the amount borrowed by the country

Table 2: Parameter Values

	Parameter	Value
Household Preferences		
Discount Factor	β	0.99
Risk aversion	σ_c	2.00
Labor Frisch elasticity	$1/\varphi$	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.

as a whole. Specifically:

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

where $\bar{B}^*$ is the exogenously-specified steady-state level of foreign currency assets held by households and $i^* = 1/\beta - 1$. This assumption ensures that the model is stationary in a log-linearized environment.

For Kimball demand, that gives rise to strategic complementarities in pricing, we adopt the functional form in Klenow and Willis (2006). This gives rise to the following demand for individual varieties:

$$Q_{FH,t}(\omega) = \gamma_F\big(1 - \epsilon \ln Z_{FH,t}(\omega)\big)^{\sigma/\epsilon} Q_t$$

where $Z_{FH,t}(\omega) \equiv \frac{P_{FH,t}(\omega)}{P_t}\frac{\sigma D_t}{\sigma-1}$, with P_t and D_t 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 desired mark-up are given by:

$$\sigma_{FH,t}(\omega) = \frac{\sigma}{1-\epsilon\ln Z_{FH,t}(\omega)} \quad \text{and} \quad \Gamma_{FH,t}(\omega) \equiv -\frac{\partial \log \frac{\sigma_{FH,t}(\omega)}{\sigma_{FH,t}(\omega)-1}}{\partial \log Z_{FH,t}(\omega)} = \frac{\epsilon}{\sigma - 1 + \epsilon \ln Z_{FH,t}(\omega)}.$$

In a symmetric steady state $Z_{ij,t}(\omega) = 1$ for all i, j and ω, 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 case with elasticity σ.

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 average price duration is one year, and hence $\delta_p = 0.75$. The steady state elasticity of substitution between home and foreign varieties and between varieties within the home region are assumed to be the same and set to $\sigma = 2$ following Casas, Diez, Gopinath, and Gourinchas (2016). We set $\epsilon = 1$ so as to generate a steady state mark-up elasticity of $\Gamma = 1$ consistent with the estimate by Amiti, Itskhoki, and Konings (2016). The foreign bond holdings are set to $\bar{B}^* = -2.6$, 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.

4.1 C-BAT reform

At time $t = 0$, the economy is in its non-stochastic steady state with a corporate tax of 20%. In the first quarter ($t_0 = 1$) border adjustment tax is implemented. Consequently, export sales become fully deductible for home good producers, while home bundlers face a 20% tax increase on imported goods, which they pass on as a cost to consumers and home good producers. Unless otherwise specified, the shock is assumed to be unanticipated and permanent.

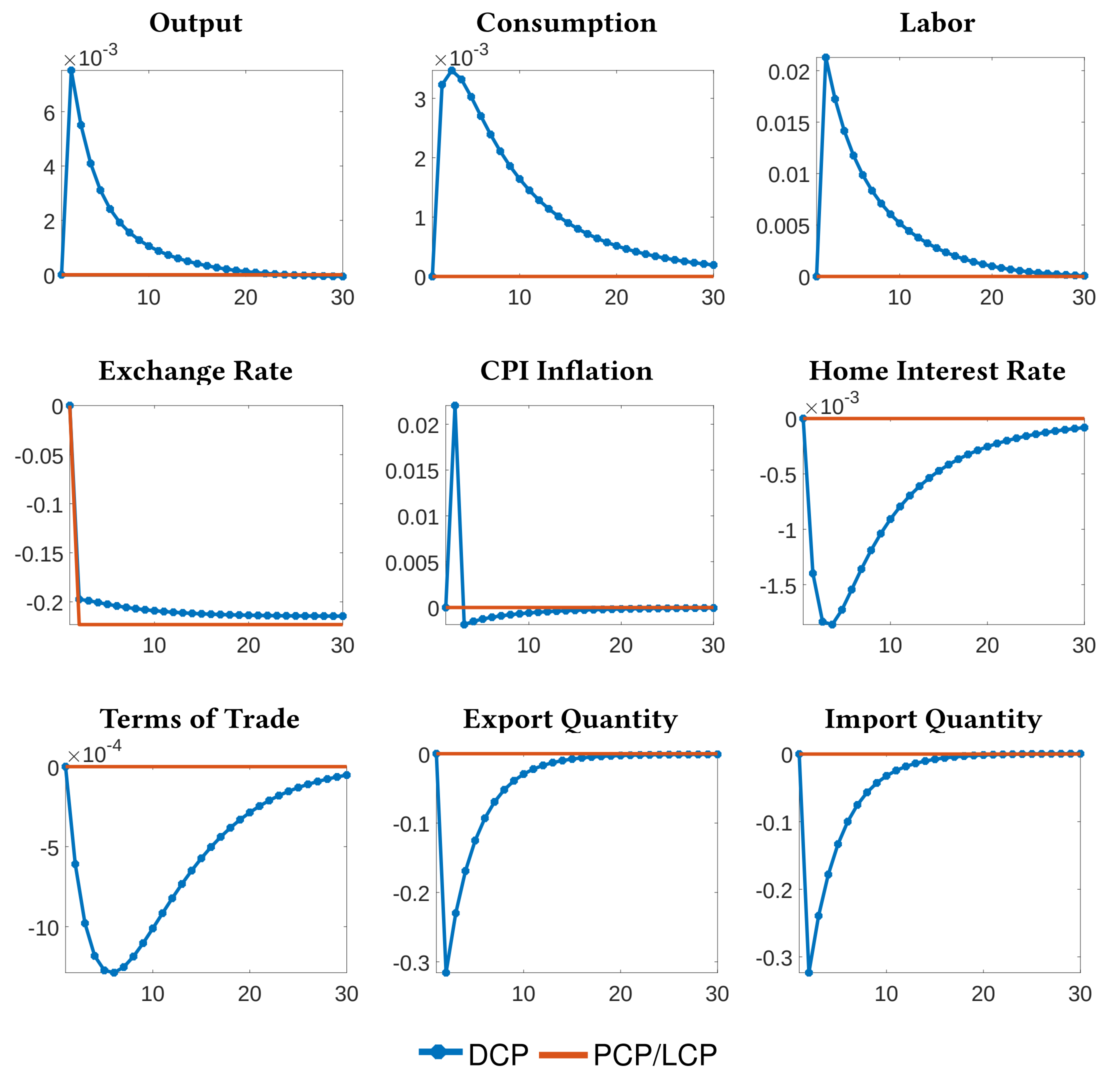
The Impact of Pricing Regimes Figure 2 plots the impulse responses to the permanent introduction of a C-BAT under producer currency pricing (PCP), local currency pricing (LCP) and dominant currency pricing (DCP). In the long-run, when prices and wages are flexible, the tax is neutral in our benchmark specification, therefore, we focus on the short-run effects.

First, consider the response under the PCP and LCP regimes. Consistent with Proposition 1, the dollar instantaneously appreciates by the full amount of the border tax reform and there is no effect on real variables or on inflation.[17] The symmetry in pass-through of border taxes and exchange rates into buyers prices neutralizes the impact of the tax reform. In the absence of an output gap or inflation, policy rates are unchanged, which under 'uncovered interest parity' (UIP) is consistent with a one-time permanent exchange rate appreciation.

In the more realistic case of DCP, prices are sticky in dollars for both US exporters and foreign exporters to the US. In this case the sharp dollar appreciation is associated with a decline

[17]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 2: Response to a Border Adjustment Tax across Pricing Regimes



in imports and in exports. This is because under DCP import prices at-the-dock are sticky in dollars and respond minimally to the exchange rate appreciation in the very short-run. On the other hand the bundlers pass-through the C-BAT to their buyers fully. Consequently from the perspective of producers and households there is an increase in the relative price of imports to home goods resulting in a 30% drop in demand for imports. On the export side the sticky export price in dollars does not respond to the C-BAT and consequently the nearly complete (18%) dollar appreciation raises the price of U.S. exports in foreign currency and leads to a drop in exports of almost 30% as foreign buyers switch away from home goods. The DCP case effectively implies a significant decrease in trade compared to PCP and LCP. The terms of trade remains stable as border prices in dollars adjust sluggishly, and the trade balance remains stable due to the counterbalancing effects on imports and exports.

The increase in the consumer price of imported goods generates a transitory spike in CPI inflation in the first quarter that turns slightly negative due to the gradual negative adjustment of import prices in response to the dollar appreciation.[18] Given that the monetary policy rule reacts to the persistent components of inflation as opposed to the highly transitory short term inflation, the central bank cuts interest rates (negligibly) to mitigate the expected deflation triggered by import price adjustment. 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. Overall the impact on output and consumption is small and this is owed to the low level of openness of the U.S. economy. This is also then consistent with a close to one-time appreciation of the dollar as interest rates remain broadly unchanged.

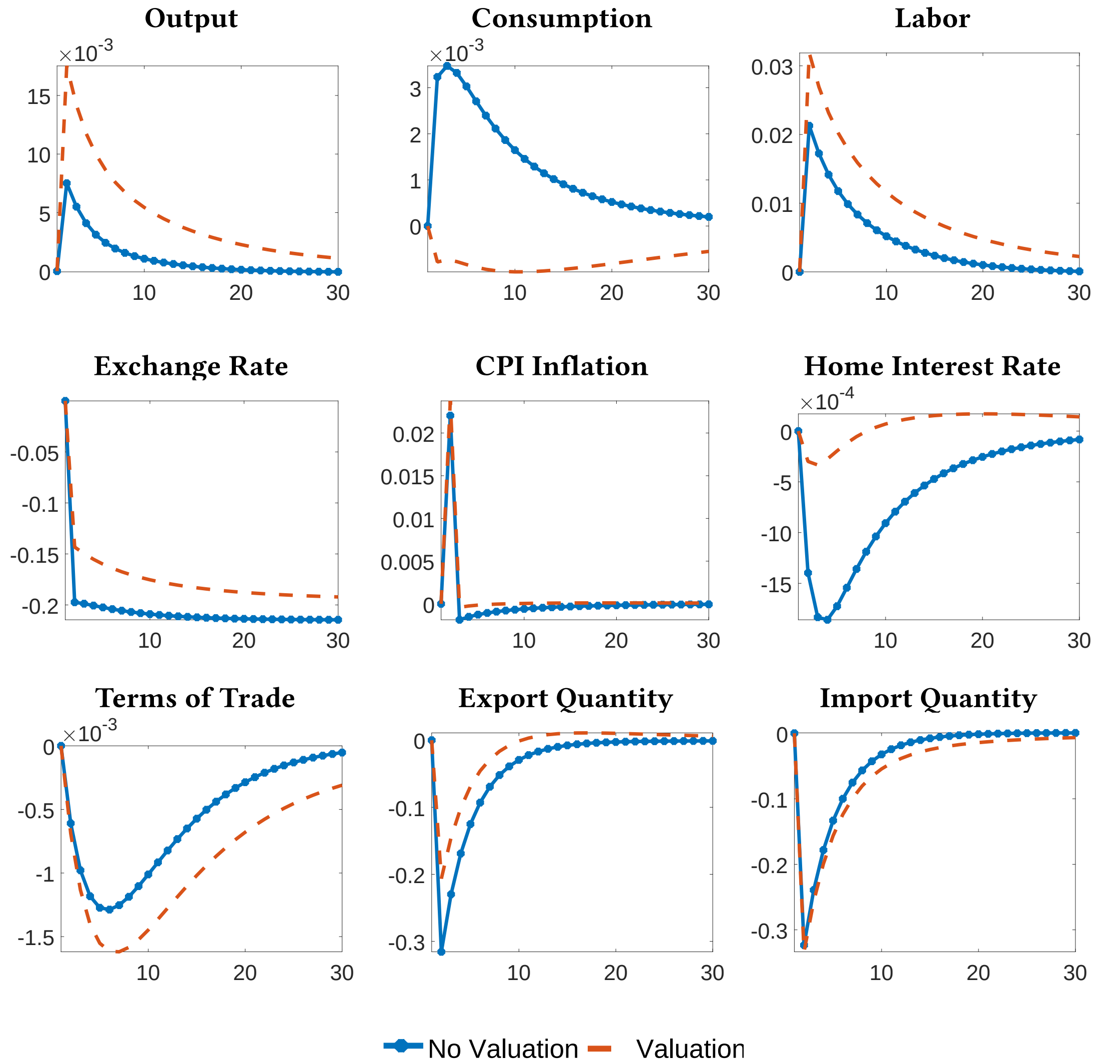
Valuation Effects We now discuss the case where the home country holds debt in both foreign currency and home currency. In the benchmark case, when debt is fully denominated in foreign currency, the exchange rate appreciation is not associated with wealth transfers across countries, despite the possible redistribution effects within countries (see Proposition 2). In contrast, when debt is partially owed in home currency, the home currency appreciation triggers a capital loss and generates a net transfer from the debtor to the lender country. If the home country is a debtor, like the U.S., 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, the net foreign asset position in dollars is $B_0/GDP_0 = 0.82 \cdot 1.8 - 0.32 \cdot 1.2 = 1.09$, and we simulate an economy with a negative valuation effect of $B_0 \cdot (1 - \mathcal{E}_1/\mathcal{E}_0)$, or 15% of GDP.

Figure 3 plots simulation results when the debt is partially held in dollars, under the benchmark simulation along with the baseline DCP pricing. In this case neutrality is violated both in the short-run and in the long-run. As depicted in Figure 3 the exchange rate also appreciates instantaneously to (almost) its long-run value, however compared to the case without valuation effects the size of this appreciation is smaller for reasons discussed in Section 3.3. The negative wealth effect that results in a transfer from the US to the rest of the world alongside the dollar appreciation results in a decline in imports as U.S. consumption demand declines and imports become relatively more expensive. Despite the smaller appreciation of the dollar relative to the case of no-valuation effects, the lower demand arising from negative wealth effects generates a combined quantitative decline that is similar to the case with no-valuation effects. On the other hand, the smaller appreciation of the dollar mutes the negative impact

[18] The results are qualitative the same for various degrees of strategic complementarity in price setting, as captured by ϵ and Γ, as we explore in Appendix A.5 and Figure 9. In particular, the CES case ($\Gamma = 0$) is almost indistinguishable from our baseline case with $\Gamma = 1$.

Figure 3: Valuation Effects

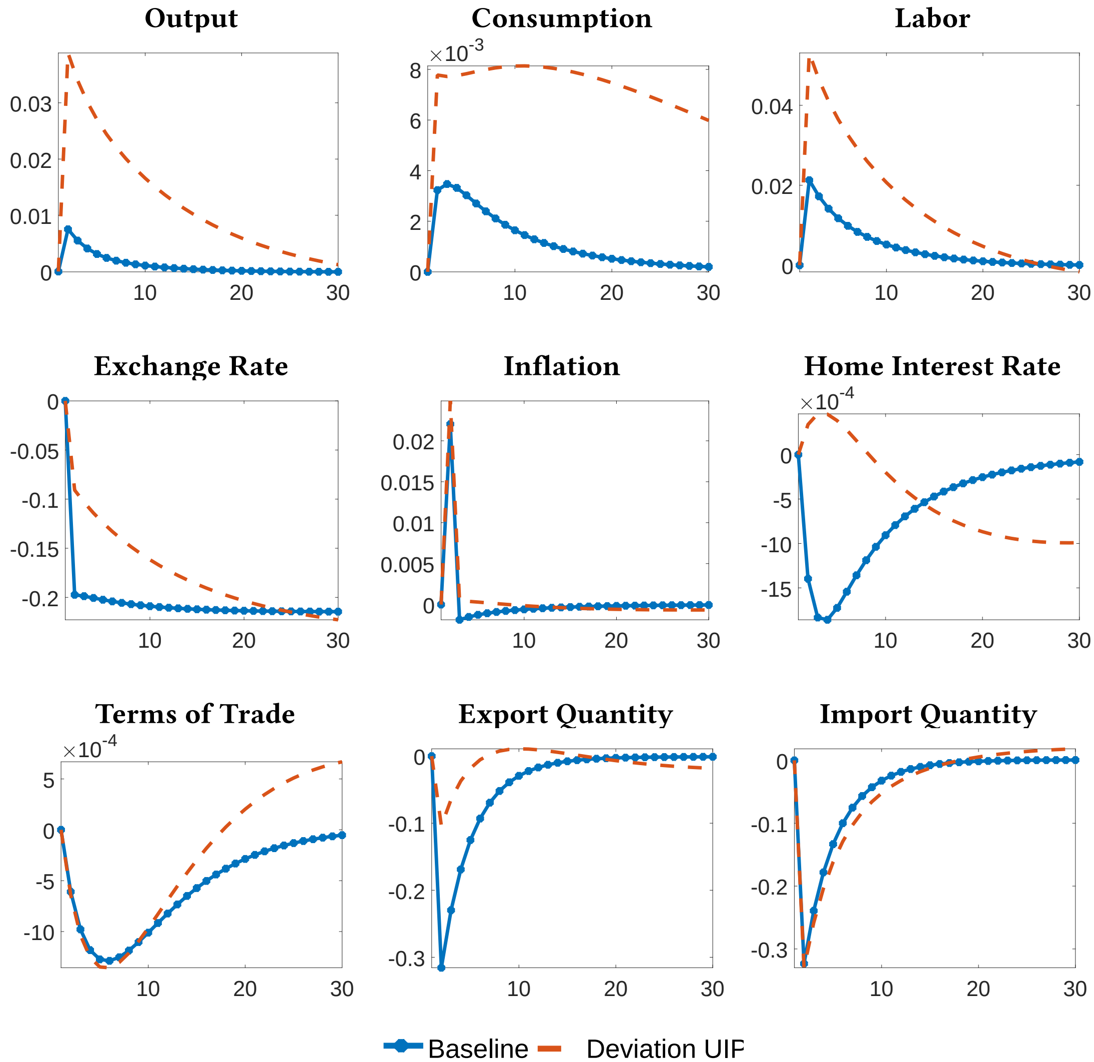


of the C-BAT on exports and on net the trade balance, and output increases. The quantitative difference from the no-valuation-effect case is however not very large, as the transfer to the rest of the world, while large as a fraction of annual GDP, is still small relative to home wealth.

Retaliation/shocks to UIP We now consider the impact of retaliation from the rest of the world, modeled in an admittedly stylized way. In particular, we model this as a shock to the UIP condition that occurs alongside the imposition of C-BAT and prevents the dollar from appreciating by the extent of the tax. This can occur when countries try to prevent a large depreciation of their currency relative to the dollar.[19] The UIP shock is calibrated to have a half-life of two years and to reduce the impact effect of the C-BAT on the exchange rate by

[19]This can also capture a risk-premium or an expectation shock to the UIP (see Itskhoki and Mukhin 2017).

Figure 4: Deviation from UIP



half. Figure 4 depicts the results in this case.

The calibration imposes the benchmark values along with DCP. In this case long-run neutrality and a long-run appreciation of the dollar that offsets the tax completely continues to hold. However, short-run dynamics are significantly different as the dollar appreciates by half of its long-run value in the short-run and then gradually appreciates over time to its long-run value, consistent with the UIP shock fed in. The smaller appreciation of the dollar leads to a significantly smaller drop in exports as export prices in destination currency rise by less. On the other hand imports decline by almost as much as in the case without the UIP shock in the short-run. This is because under DCP short-run exchange rate pass-through is low and consequently the weaker dollar appreciation makes little difference to the level of import demand. The combined effect of aweaker drop in exports and a similar decline in imports (as compared to the case without the UIP shock) results in a larger improvement in the trade balance and through the expenditure switching effect on output.

Non-uniform implementation of C-BAT We now model the possibility that a fraction of importers are not subject to the border adjustment. The C-BAT may not be universal whenever exemptions apply to certain industries, such as tourism, or when some companies engage in tax avoidance. We call such companies *X-Corps*.

Figure 5 compares the simulation results when the import tax applies to all imports and when X-Corps make up 50% of imports, that is half of bundlers are exempted from C-BAT. When X-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 but by a smaller amount because of the weaker appreciation of the dollar in the case of exports and the exemption of half of importers from the C-BAT in the case of imports.

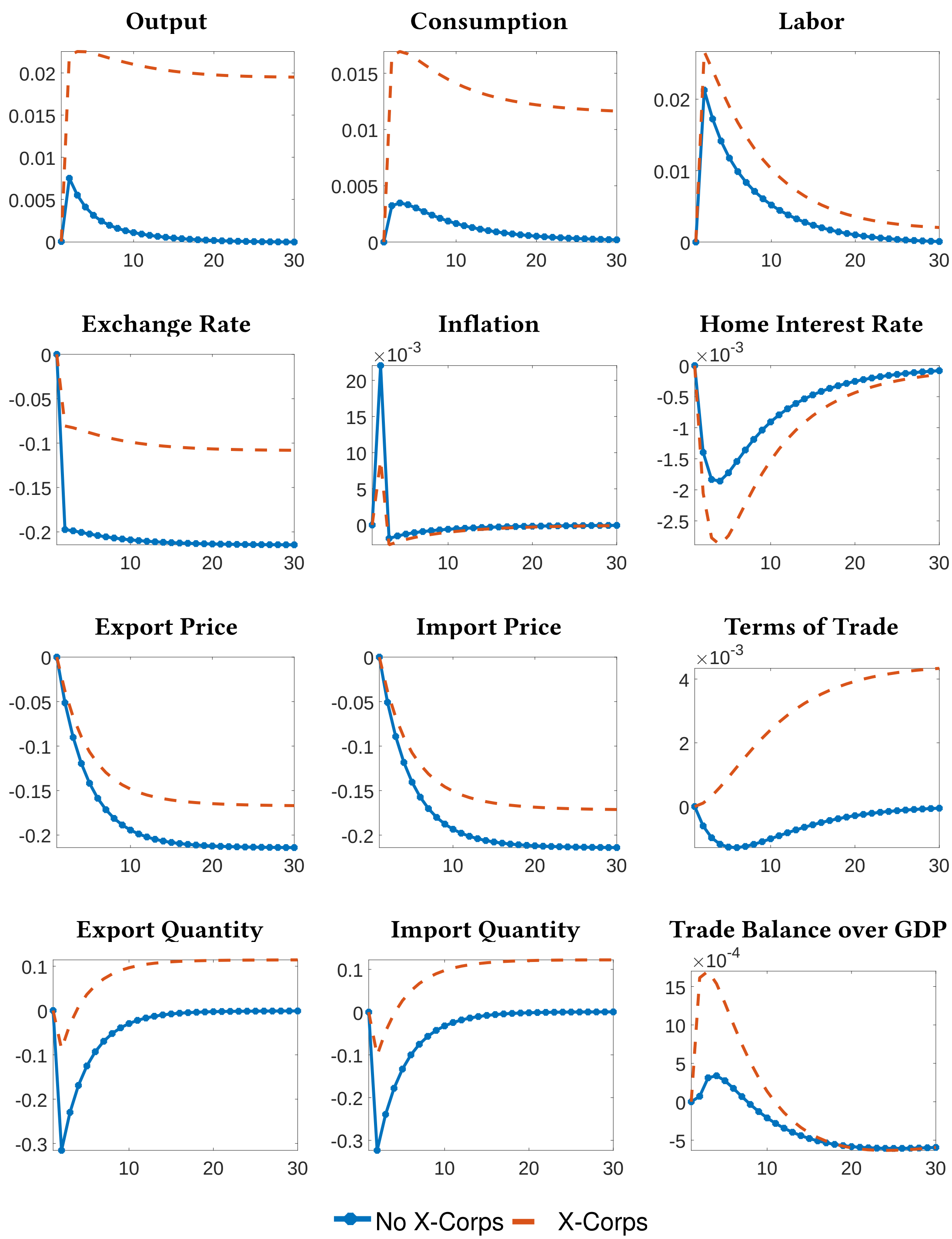
4.2 VAT reform

In this section we numerically evaluate the implementation of a 20% VAT in the US economy. The model is specified and calibrated in the same way as before. In Section 3, we demonstrated that under the assumption of a full pass-through of the tax and inelastic labor supply, the VAT is neutral and the value of the dollar remains unchanged. In this section we explore the importance of assumptions on pricing, labor supply elasticity, and tax pass-through on the neutrality of VAT both in the short-run and in the long-run.

At time 0, the economy is in its non-stochastic steady state, with zero value added or border adjustment taxes. Figure 6 depicts the response to an unexpected and permanent onset of a 20% VAT tax in the first quarter. The VAT is levied on all goods sold in the domestic market and rebated back for the purchase of intermediaries. The VAT is not levied on exports to the rest of the world. When introduced, the tax is assumed to be fully passed-through to domestic and import prices. In other words, firms do not absorb the VAT into their short-run profit margins. Figure 6 presents the case with DCP and PCP producers facing elastic labor supply, and we contrast that to the case with inelastic labor supply.

When labor is inelastically supplied, VAT has no impact on employment and output by construction and the tax is neutral both in the short-run and in the long-run. The introduction of the VAT results in an instantaneous increase in the price of domestic goods and of imports by 20% given our assumption of full pass-through and dollar export prices remain unchanged

Figure 5: X-Corps



as they are exempt from the VAT. Consequently, there are no expenditure switching effects either at home or in the rest of the world. Aggregate demand is also unaffected as all revenues are returned lump-sum to households. The decline in real wages takes place entirely through the increase in prices and nominal wages remain unchanged. Though the price of intermediate inputs faced by domestic producers increases by 20% it is fully offset by the VAT deduction. Because nominal marginal costs of domestic producers stay fixed domestic firms do not desire to update their prices. Even though the VAT includes a border adjustment feature, unlike the case of the C-BAT, neutrality is associated with no exchange rate appreciation. This is because all relative prices (inclusive of taxes) remain unchanged even without a dollar adjustment, which is not the case under C-BAT. With nominal marginal costs unchanged for domestic producers and no change in the dollar's value neither domestic producers nor foreign exporters have a desire to change their pre-tax price and consequently the choice of currency of invoicing is irrelevant in the case with perfectly inelastic labor supply.

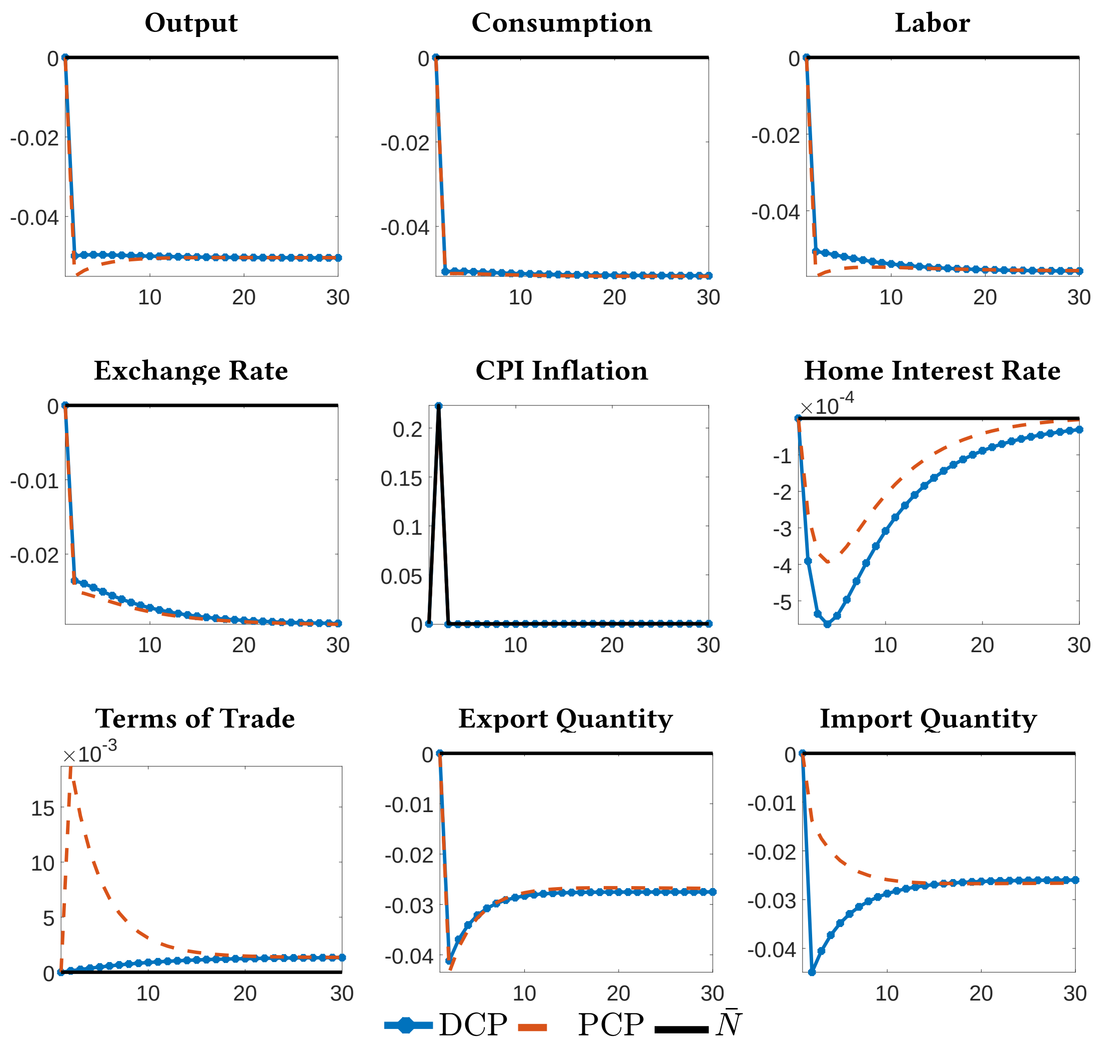
Next, we consider the realistic case of elastic labor supply with a benchmark Frisch elasticity of 0.5. In this case we no longer have long-run neutrality and this is the case with either PCP or DCP. In either case the decrease in real wages is associated with a decline in labor supply. The general equilibrium effect is around a 5% decrease in output, consumption and labor. The instantaneous full pass-through of the VAT makes nominal marginal costs relatively stable at their initial level. As a consequence, inflation is negligible in the quarters after the VAT introduction. The decline in output generates a cut in interest rates that is associated with an expected appreciation of the dollar. On impact the exchange rate appreciates, but not nearly as much as the magnitude of the VAT tax or the response documented in Section 4 for a C-BAT of the same size.

The effects under dominant and producer currency pricing are similar because of the low dollar appreciation, and because both cases assume the same tax pass-through. One exception is with regard to import quantities that take a larger hit under DCP because import prices do not instantaneously pass-through the effect of the dollar appreciation.

Sensitivity to elasticity of labor supply We demonstrate here that the low response of the exchange rate remains even as we increase the elasticity of labor supply or the size of the demand elasticity parameter or the measure of relative risk aversion. Figure 7 plots the impulse responses to a 20% VAT rise, under four different parametrizations. The first case corresponds to the calibration in Table 2: Frisch elasticity $\varphi^{-1} = 0.5$, risk aversion $\sigma_c = 2$, and elasticity of substitution between varieties $\sigma = 2$. The other three cases test the effect of changing these parameters to stimulate a larger appreciation.

Changing the Frisch elasticity from 0.5 to 2 almost doubles the effect on output and labor

Figure 6: Impulse Response after the introduction of a 20% value added tax



but the dollar appreciates only by 3% because relative import and export prices move again closely to the benchmark case. Decreasing the risk aversion parameter from 2 to 1 implies a change to the Walrasian labor elasticity, and the effects are similar to the high Frisch elasticity case. Finally, making demand more inelastic by setting $\sigma = 1.5$ can cause a somewhat larger dollar appreciation but the general equilibrium effect is again similar to the benchmark case.

Sensitivity to VAT Pass-through We now discuss the case where we relax the assumption of instantaneous pass-through of the VAT into consumer prices. Under partial pass-through, both the short-term output drop and the appreciation of the dollar are amplified. Moreover, the slow dynamics of inflation imply that the assumptions on monetary policy response start to matter.

Figure 7: Impulse Response after a 20% VAT, with DCP under different parametrizations

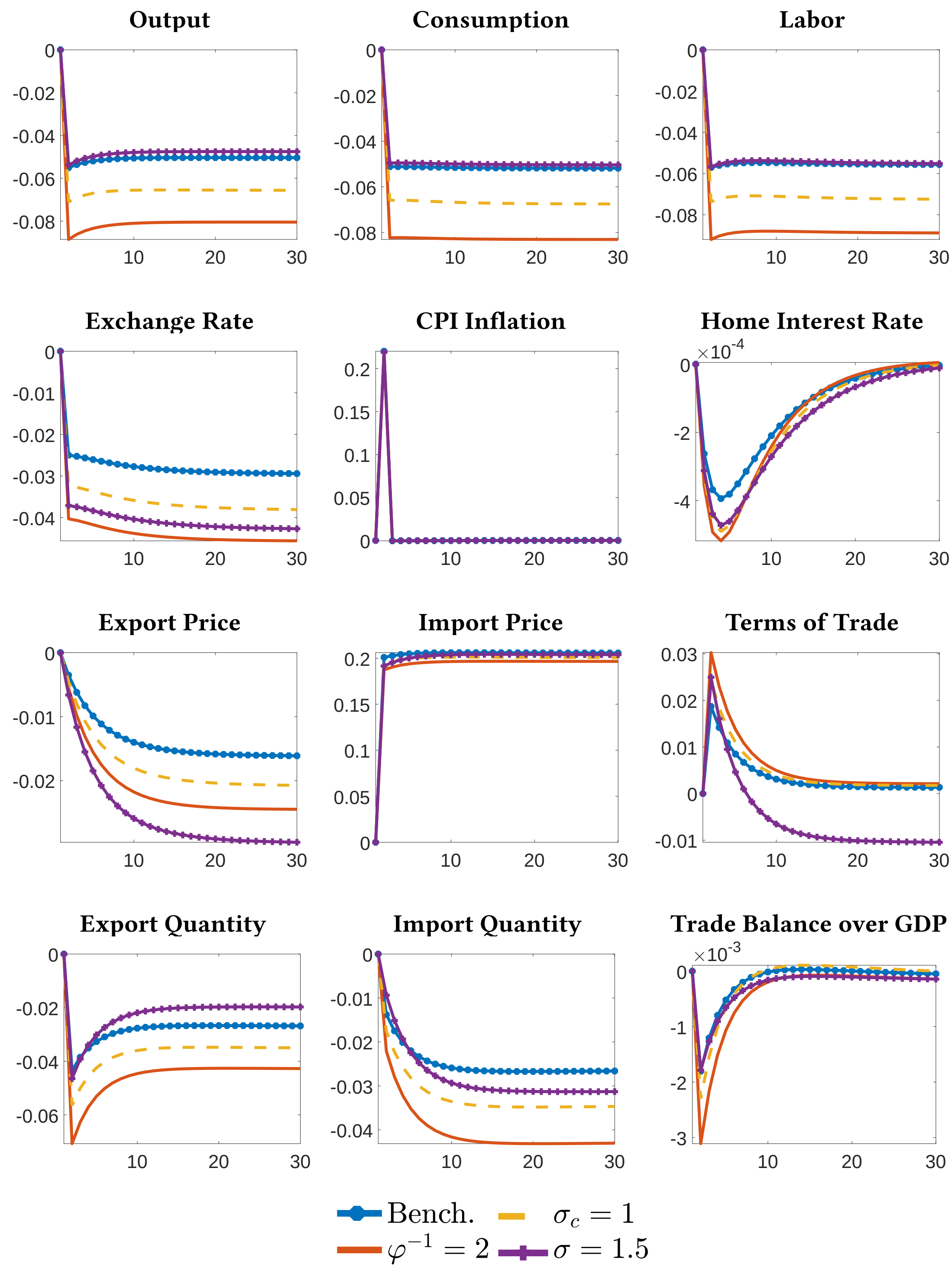


Figure 8: Impulse Response after a 20% VAT with DCP under full and partial pass-through

We present the results only under dominant currency paradigm (DCP). Using the notation in Table 1, partial pass-through can be introduced by assuming that only a fraction $\lambda \in [0, 1]$ is passed-through instantaneously into the consumer prices:

$$P^b_{FH,t} = (1 - \tau^V_t)^\lambda P_{FH,t}$$
$$P^p_{HH,t} = (1 - \tau^V_t)^\lambda P_{HH,t}$$

As a consequence, a fraction $1 - \lambda$ of the VAT will be absorbed into the short-term profit margins of importers and domestic producers.

Figure 8 depicts the effect of a 20% VAT introduction when $\lambda = 1$ (the benchmark case in Figures 6 and 7) and $\lambda = 0.5$. When the VAT is passed through 50%, the import and aggregate price levels only rise by 10% in the first quarter. The rest of the tax is absorbed by foreign exporters and domestic producers with sticky prices. Firms start updating their prices in the following quarters to offset the 10% tax incidence on their margins. This generates expected positive inflation that the central bank responds to. In this case, we assume that the Taylor rule fights expected inflation but not the output gap. And the implied boost in interest rate leads to a larger dollar appreciation and a more intense recession. The large dollar appreciation causes export sales to drop by 20% in the short-term. Import quantities are less responsive because prices are sticky in dollars and the tax pass-through between domestic goods and imported goods is symmetric.

In conclusion, with a partial VAT pass-through, assumptions on price stickiness and monetary policy response count. Under a BAT, the calibration of the Taylor rule is of second-order importance because the inflation and the output responses are small, as the BAT only affects international prices. Instead, a VAT with partial pass-through affects inflation dynamics of both imports and domestically produced goods, which entails a sharp response of monetary policy that can generate a large short-term appreciation as in Figure 8.

5 Conclusion

Our analysis of border adjustment taxes demonstrates that the *Lerner (1936) symmetry* result holds only under very special circumstances that are unlikely to hold up in reality. As discussed, the C-BAT is unlikely to be neutral either in the short-run or in the long-run once we recognize that there is a differential pass-through of taxes and exchange rates into the prices buyers face, that the accompanying exchange appreciation can lead to large valuation effects and net transfers to the rest of the world and or if the policy triggers retaliation from the rest of the world. In the case of the VAT, neutrality breaks down under weaker conditions. There are other important differences between a VAT and C-BAT. For the U.S. a VAT generates only a weak exchange rate response while a C-BAT generates a strong exchange rate response and consequently strong valuation effects. On the other hand, a VAT is far more distortionary to output as compared to a C-BAT. While there is some empirical evidence that confirms the theoretical predictions of a VAT for the exchange rate much less is known empirically about the impact of a C-BAT or its equivalent of a VAT-payroll tax swap and so this remains an avenue for future research.

A Appendix

A.1 Price Setting

Consider the profit maximization by the home firms:

$$\max \mathbb{E}_t \sum_{s=t}^{\infty} \delta_p^{s-t} \Theta_{t,s} \Pi_s(\omega),$$

where $\Pi_s(\omega)$ is defined in (7), and subject to production

$$Y_s(\omega) = e^{a_s} L_s(\omega)^{1-\alpha} X_s^{\alpha} = Q_{HH,s}(\omega) + Q^*_{HF,s}(\omega)$$

and demand constraints:

$$Q_{HH,s}(\omega) = \gamma_H \psi \left(\frac{P_{HH,s}(\omega)}{P_s/D_s} \right) Q_s \qquad \text{and} \qquad Q^*_{HF,s}(\omega) = \gamma^*_H \psi \left(\frac{P_{HF,s}(\omega)/\mathcal{E}_s}{P^*_s/D^*_s} \right) Q^*_s.$$

Under PCP, maximization is with respect to preset producer prices $\bar{P}^p_{HH,t}(\omega)$ and $\bar{P}^p_{HF,t}(\omega)$, such that:

$$P_{HH,s}(\omega) = \frac{\bar{P}^p_{HH,t}(\omega)}{1-\tau^V_s} \qquad \text{and} \qquad P_{HF,s}(\omega) = (1-\iota_s \tau^{\Pi}_s) \bar{P}^p_{HF,t}(\omega).$$

Under LCP, maximization is with respect to preset consumer prices $\bar{P}^c_{HH,t}(\omega)$ and $\bar{P}^{c*}_{HF,t}(\omega)$, such that:

$$P_{HH,s}(\omega) = \bar{P}^c_{HH,t}(\omega) \qquad \text{and} \qquad P_{HF,s}(\omega) = \mathcal{E}_s \bar{P}^{c*}_{HF,t}(\omega).$$

Under DCP, maximization is with respect to preset export border price in dollars $\bar{P}^b_{HH,t}(\omega)$, such that:

$$P_{HF,s}(\omega) = \bar{P}^b_{HF,t}(\omega).$$

Formal differentiation results in price setting equations in the text upon simplification, in particular using the definition of demand elasticity $\sigma_{Hj,s}(\omega)$ and marginal cost $\mathcal{MC}_s$. Similar formulation applies to the price setting by foreign firms, and making use of the definitions of prices in Table 1.

A.2 Country budget constraint

Define $\Delta^{NFA} = B_{t+1} + \mathcal{E}_t B^*_{t+1} - (1+i_t)B_t - (1+i^*_t)\mathcal{E}_t B^*_t$. Then we reproduce (1), (7), (10) and (15) as the following system:

$$
\begin{aligned}
\Delta^{NFA} &= W_t L_t + \Pi_t + T_t - P_t C_t, \\
\Pi_t &= (1-\tau^\Pi_t)\left[(1-\tau^V_t)\big(P_{HH,t}Q_{HH,t} - P_t X_t\big) + \frac{P_{HF,t}Q^*_{HF,t}}{1-\iota_t\tau^\Pi_t} - W_t L_t\right], \\
0 = \Pi^B_{Ht} &= (1-\tau^V_t)(1-\tau^\Pi_t)\left[P_t Q_t - P_{HH,t}Q_{HH,t} - \frac{1}{1-\iota_t\tau^\Pi_t}P_{FH,t}Q_{FH,t}\right], \\
T_t + P_t G_t &= TR^V_t + TR^\Pi_t = TR_t,
\end{aligned}
$$

where

$$
\begin{aligned}
TR_t &= \tau^V_t\left[P_{HH,t}Q_{HH,t} + P_{FH,t}Q_{FH,t} - P_t X_t\right] \\
&\quad + \tau^\Pi_t\left[(1-\tau^V_t)(P_{HH,t}Q_{HH,t} - P_t X_t) - W_t L_t\right] + (1-\iota_t)\tau^\Pi_t P_{HF,t}Q^*_{HF,t} \\
&\quad + \tau^\Pi_t(P_t Q_t - P_{HH,t}Q_{HH,t}) - (1-\iota_t)\tau^\Pi_t P_{FH,t}Q_{FH,t}.
\end{aligned}
$$

Using the definitions of profits, we simplify the expression for tax revenues:

$$
TR_t = \tau^V_t\left[P_{HH,t}Q_{HH,t} + P_{FH,t}Q_{FH,t} - P_t X_t\right] + \frac{\tau^\Pi_t}{1-\tau^\Pi_t}\Pi_t - \frac{\iota_t\tau^\Pi_t}{1-\tau^\Pi_t}\left[P_{HF,t}Q^*_{HF,t} - P_{FH,t}Q_{FH,t}\right],
$$

which corresponds to (16) and (17) in the text.

Finally, we combine the government and the household budget constraints (using $Q_t = C_t + G_t + X_t$) to arrive at the country budget constraint (18) in the text:

$$
\begin{aligned}
\Delta^{NFA} &= W_t L_t + \Pi_t + TR_t - P_t(C_t + G_t) \\
&= P_{HH,t}Q_{HH,t} + \frac{P_{HF,t}Q^*_{HF,t}}{1-\iota_t\tau^\Pi_t} - P_t Q_t + \tau^V_t P_{FH,t}Q_{FH,t} - \frac{\iota_t\tau^\Pi_t}{1-\tau^\Pi_t}\left[P_{HF,t}Q^*_{HF,t} - P_{FH,t}Q_{FH,t}\right] \\
&= P_{HF,t}Q^*_{HF,t} - (1-\tau^V_t)P_{FH,t}Q_{FH,t} = NX_t,
\end{aligned}
$$

where net exports

$$
NX_t = P_{HF,t}Q^*_{HF,t} - (1-\tau^V_t)P_{FH,t}Q_{FH,t},
$$

as defined in (19) in the text.

A.3 Proof of C-BAT neutrality Proposition 1

Consider an equilibrium path of macro variables at home $\mathbf{Z} \equiv \{P_t, W_t, C_t, L_t, Q_t, Q_{iH,t}\}_{t\geq 0}$ in an economy without border adjustment, $\iota_t = 0$ for all t, and also an associated equilibrium path of the nominal exchange rate $\{\mathcal{E}^0_t\}$. We prove that the same path of variables at home and abroad ($\mathbf{Z}^*$) remains an equilibrium in an economy with a one-time unanticipated C-BAT reform at $t_0 > 0$ at home, that is $\iota_t = \mathbf{1}_{\{t \geq t_0\}}$ with $\tau_t^{\Pi} = \tau^{\Pi}$ for all $t \geq t_0$, with a new equilibrium path of the exchange rate given by:

$$\mathcal{E}_t^1 = (1 - \iota_t \tau_t^{\Pi})\mathcal{E}_t^0.$$

Assuming this is the case, we check in turn:

1. That the relative consumer prices in every period are unaffected. C-BAT and exchange rate do not directly affect $P_{HH,t}$ and $P^*_{FF,t}$, so we only need to check the international prices. Under Assumption A1, the path of consumer prices $P^c_{FH,t} = \frac{P^{b*}_{FH,t}\mathcal{E}_t^1}{1-\iota_t\tau_t^{\Pi}}$ and $P^{c*}_{HF,t} = P^{b*}_{HF,t}$ is unchanged on impact, as $\frac{\mathcal{E}_t^1}{1-\iota_t\tau_t^{\Pi}} = \mathcal{E}_t^0$, and pass-through into $P^{b*}_{FH,t}$ and $P^{b*}_{HF,t}$ is symmetric (see Definition 2). With this (and with Assumption A5), P_t, P_t^* and consumer demand $Q_{iH,t}$ and $Q^*_{iF,t}$ remain unaffected on impact of the reform.

2. That firms do not want to change the path of their price changes at all dates. This follows directly from the price setting equations in Section 2.3 for the PCP and LCP cases since either $\mathcal{E}_t$ and ι_t do not enter at all or enter jointly as $\mathcal{E}_t^1/(1 - \iota_t\tau_t^{\Pi})$, and hence there is no change to the price setting outcome relative to the economy without border adjustment. This confirms that the path of all prices and product demand remains the same for all t.

3. Given demand for goods, the demand for labor and intermediate goods remains unchanged. Therefore, the wage setting remains unchanged. These equations do not feature either $\mathcal{E}_t$ or ι_t. This means that W_t, L_t and Q_t follow the same path with and without border adjustment.

4. Next we confirm that Euler equations continue to hold for the same path of C_t. This is indeed the case since consumer price level P_t follows the same path, and so does the interest rate set by monetary policy in the absence of changes to the path of inflation and output gap (Assumptions A2 and A4).

5. Lastly, we check that the country budget constraint (18) continues to hold under the same allocation. This is indeed the case under Assumption A3 ($B_t \equiv 0$), as we can rewrite (18):

$$B^*_{t+1} - (1 + i_t^*)B_t^* = \frac{P_{HF,t}}{\mathcal{E}_t}Q^*_{HF,t} - \frac{P_{FH,t}}{\mathcal{E}_t}Q_{FH,t} = P^{b*}_{HF,t}Q^*_{HF,t} - P^{b*}_{FH,t}Q_{FH,t},$$

   with the path of border prices unaffected (see point 1 above).

This confirms that $\mathbf{Z}$ remains an equilibrium path of macro variables in an economy with border adjustment. ■

A.4 Proof of VAT neutrality Proposition 3

The proof of VAT neutrality follows the same steps as that of the C-BAT neutrality above, with the difference that now $\mathbf{Z}^V \equiv \{\mathcal{E}_t, W_t, C_t, L_t, Q_t, Q_{iH,t}\}_{t \geq 0}$ is the path of macro variables (including nominal exchange rate), which remains unchanged after the introduction of a VAT, while the consumer price level jumps on impact of the VAT reform by the magnitude of the tax:

$$P_t^1 = \frac{P_t^0}{1-\tau_t^V} \quad \text{for} \quad t \geq t_0.$$

As a result, the real wage W_t/P_t falls on impact by the same magnitude. Assuming this is the case, we verify:

1. The relative prices do not change on impact, since $P_{HH,t}^1 = P_{HH,t}^0/(1-\tau_t^V)$ and $P_{FH,t}^1 = P_{FH,t}^0/(1-\tau_t^V)$, i.e. both increase by value of the VAT due to the complete pass-through assumption, resulting in a jump in P_t as described above. The prices in the foreign are unaffected by VAT and there is no exchange rate movement, so the relative prices there are also unchanged. As a result, the quantities of the products demanded are unchanged on impact.

2. The marginal costs (due to VAT reimbursement on intermediate inputs), producer prices, sales and profits of the firms remain unchanged, and therefore they do not change their price setting behavior when they adjust prices.

3. Since there is a one-time jump in the price level and no change to the following path of inflation, there is no change in the monetary policy, and consumption-saving decisions remain unchanged.

4. There is no change to the border prices paid/received by the foreigners, and therefore the country budget constraint remains unchanged.

5. It only remains to verify that the old path of $\{W_t, L_t\}$ is consistent with equilibrium. If wages are infinitely sticky, $W_t \equiv \bar{W}$ in both cases, and the path of L_t is demand determined, and product demand did not change, therefore equilibrium L_t is unchanged. If labor is in perfectly inelastic supply at some $L_t \equiv \bar{N}$, then we need to verify that the equilibrium path of wages W_t remains unchanged. This is the case because the firm would demand the same amount of labor $\bar{N}$ only if wages do indeed remain unchanged.

This completes the proof of the proposition. ■

A.5 Extensions

Strategic complementarities and incomplete pass-through Figure 9 plots the impulse response for the DCP case with different values of markup elasticity, $\Gamma \in \{0, 1, 6\}$, with the $\Gamma = 1$ case corresponding to the baseline and $\Gamma = 0$ corresponding to the CES (constant markups). A larger value of Γ corresponds to a lower pass-through of marginal costs into prices, or equivalently stronger strategic complementarities in the price setting (see Amiti, Itskhoki, and Konings 2016). The figure indicates only very mild differences between our baseline and the constant markup case. Raising $\Gamma = 6$, an implausibly high value empirically, still results in about the same exchange rate movement, but leads to more protracted future deflation, triggering a larger monetary policy response and hence a bigger swing in consumption and output.

Alternative LCP formulation Figure 10 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 2 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 11 quantifies the importance of trade openness and wage stickiness for the extent of dollar appreciation under DCP, when BAT neutrality fails. Specifically, Figure 11 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 3.3, 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 9: Dominant Currency Pricng with Strategic Complementarities

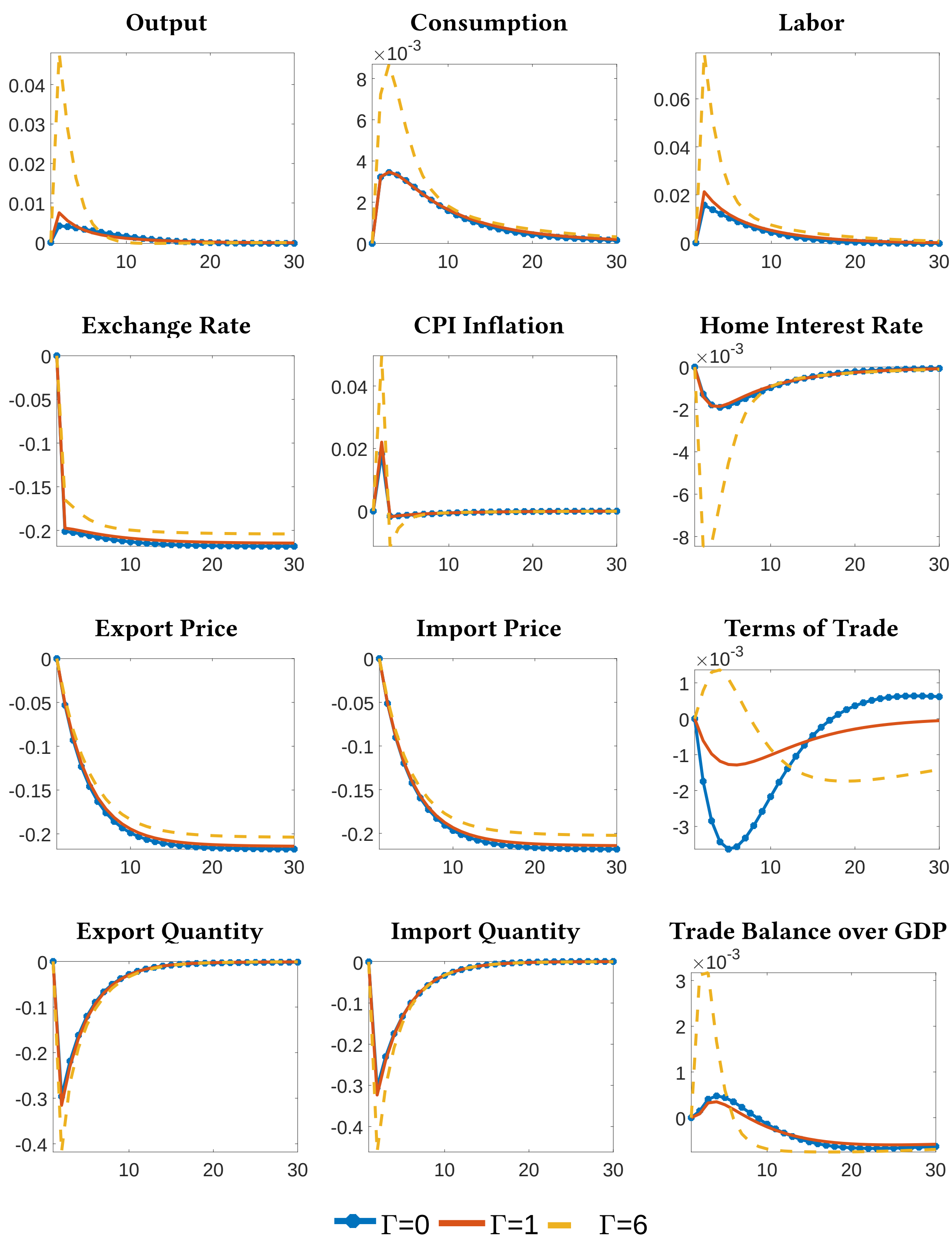


Figure 10: Response to a Border Adjustment Tax across Pricing Regimes

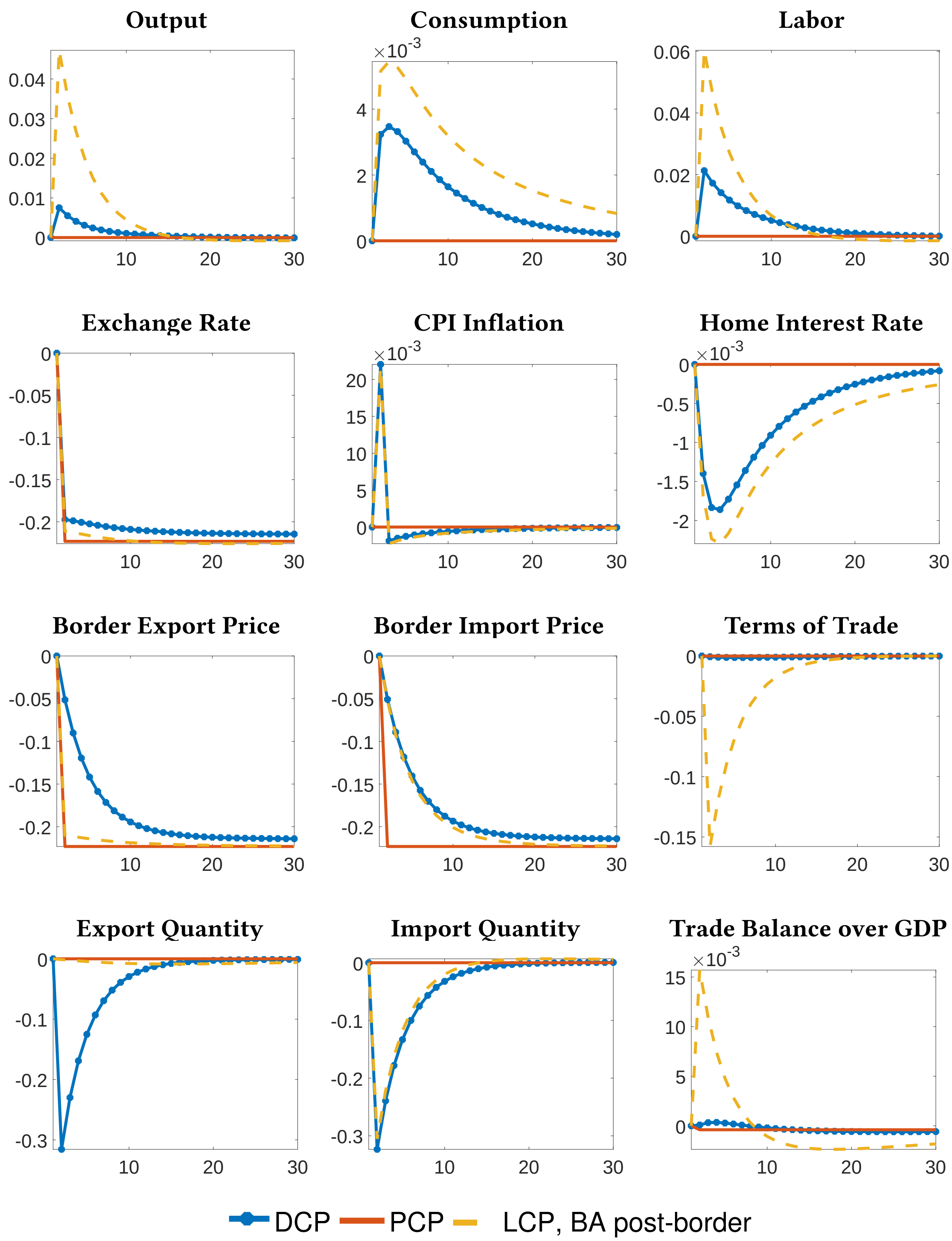
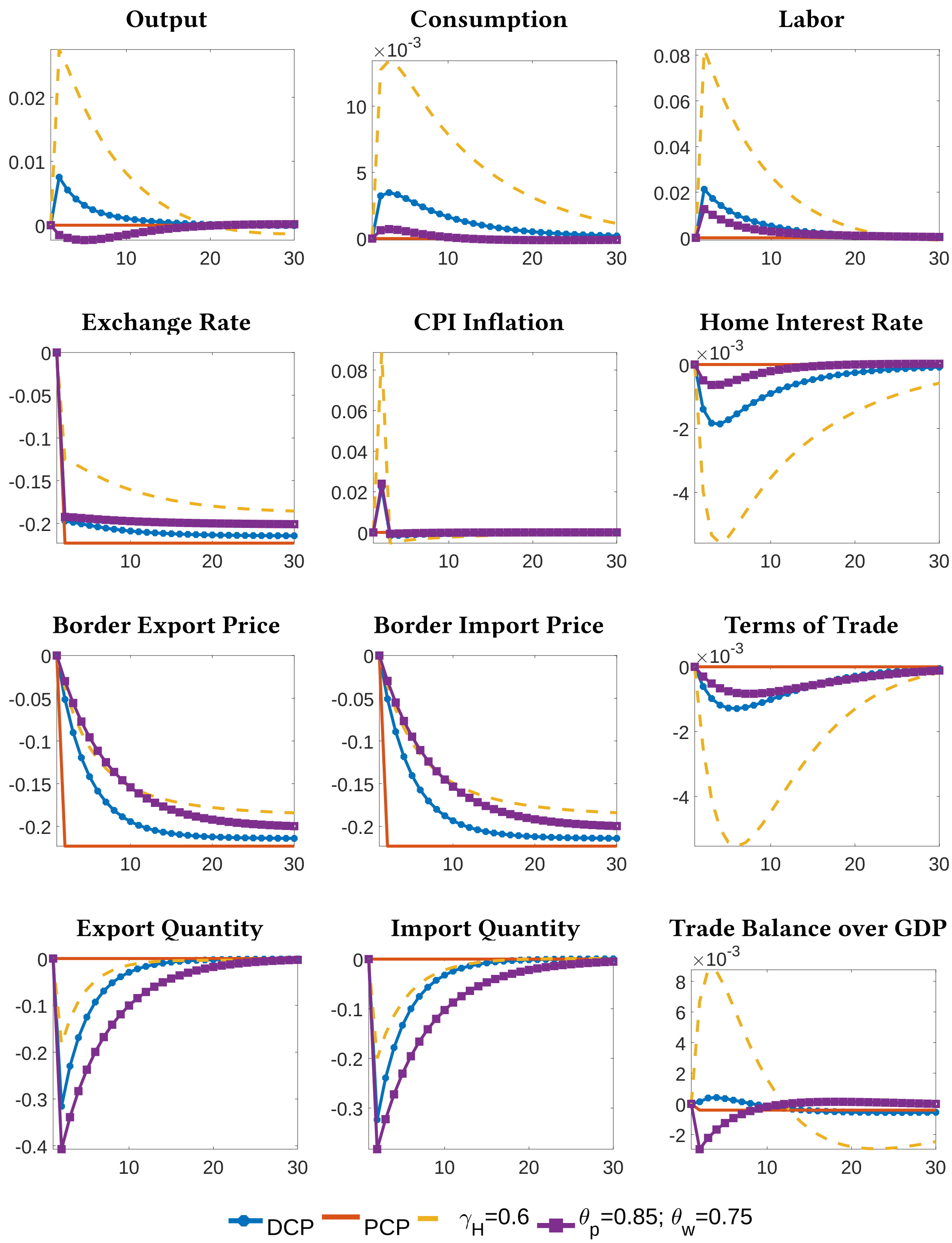


Figure 11: Dynamics under different openness and stickiness assumptions



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