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ABSTRACT

What is the optimal monetary policy response to tariffs? This paper explores this question within an open-economy New Keynesian model and shows that the optimal monetary policy response is expansionary, with inflation rising above and beyond the direct effects of tariffs. This result holds regardless of whether tariffs apply to consumption goods or intermediate inputs, whether the shock is temporary or permanent, and whether tariffs address other distortions.

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1 Introduction

The prospect of rising tariffs in the US has sparked a debate about their inflationary consequences and the appropriate response of the Federal Reserve. A prevalent view is that the Federal Reserve should "look through" the price increases driven by tariffs. The argument is that tariffs induce a one-off change in the price level, and thus, the central bank should keep its monetary stance unchanged.[1]

In this paper, we investigate the optimal monetary policy response to a tariff shock. Contrary to the prevailing view, we argue that the optimal monetary policy response may be *expansionary*. The argument is as follows: When a tariff is imposed, households and firms perceive the cost of importable goods to be higher than the social cost. This discrepancy arises because individual agents fail to internalize that higher imports generate additional tariff revenue, which, in equilibrium, raises household income. As a result, imports decline more than is socially optimal. To counteract the substitution effect of tariffs and mitigate the contraction of imports, the optimal monetary policy stimulates employment and aggregate income.

Our framework is a dynamic, open economy New Keynesian model that features home-produced and importable goods. Our baseline model assumes that imported goods are final consumption goods and that international relative prices are exogenously given; however, we also extend our results to cases where imports serve as intermediate inputs and where international prices vary with domestic output. In the absence of tariffs, the optimal policy follows the canonical prescription of New Keynesian models, where the monetary authority is able to achieve an allocation with zero inflation and a zero output gap. The introduction of tariffs distorts trade by inefficiently reducing imports, as households substitute home goods for foreign goods. We show that the Ramsey optimal policy overheats the economy, raising employment above the efficient level and inflation. The idea is that starting from an allocation with zero inflation and a zero output gap, stimulating the economy entails no first-order costs. However, the resulting increase in aggregate income boosts demand for imports, generating strictly positive first-order gains. This makes it optimal for the monetary authority to tolerate some overheating.

Our analysis challenges the conventional wisdom on the effects of tariffs on exchange rates and capital flows. The dominant view, rooted in the Mundell-Fleming framework, holds

[1] See, for example, the speech by Governor Chris Waller, where he stated: "If, as I expect, tariffs do not have a significant or persistent effect on inflation, they are unlikely to affect my view of appropriate monetary policy."

that tariffs lead to an appreciation of the exchange rate and have no effect on the trade surplus when the tariff is permanent. In contrast, our model shows that under the optimal monetary policy, the nominal exchange rate depreciates following the imposition of tariffs, and even permanent tariffs result in an increase in the trade surplus. This occurs because an expansionary monetary policy depreciates the exchange rate and the higher short-run level of employment leads households to accumulate foreign assets.

We begin our analysis by characterizing how tariffs on imported consumption goods affect employment. In a flexible-price benchmark, we show that the employment response is ambiguous. Unlike a standard consumption tax, tariffs generate two distinct substitution effects: (i) between labor and foreign consumption and (ii) between domestic and foreign consumption. The direction of the employment response depends on the relative magnitudes of the intertemporal elasticity of substitution and the trade elasticity, as well as the size of the tariff. Specifically, when the intertemporal elasticity exceeds the trade elasticity—implying that goods are Hicksian substitutes—employment rises for sufficiently high tariffs. However, we show that, starting from zero tariffs, a marginal tariff increase necessarily reduces employment, and for empirically plausible values of elasticities and tariffs, employment contracts. This implies that a "look-through policy" that maintains zero producer price index (PPI) inflation and a zero output gap results in an employment contraction.

We then turn to optimal policy, and characterize analytically the optimal response in a version of the model in which firms face price adjustment costs, which are rebated to households. we show that employment is necessarily higher than under the flexible price allocation. Moreover, under the optimal policy, employment increases (decreases) in response to a tariff if the intertemporal elasticity of substitution is lower (higher) than one. Furthermore, the optimal policy is characterized by a positive level of inflation. That is, unlike a traditional cost-push shock in the New Keynesian literature—where the optimal policy results in positive inflation and output below the efficient level—tariffs generate both inflation and a positive output gap simultaneously.

The optimal monetary response to a tariff shock fundamentally differs from the optimal response to a terms-of-trade shock. As highlighted by Aoki (2001) and subsequent literature, when faced with a terms-of-trade shock—such as a rise in food prices—optimal policy fully stabilizes PPI and keeps output at potential, while allowing the consumer price index (CPI) to experience a one-time jump. In this case, a look-through policy is optimal. In contrast, the key distinction with a tariff shock is that, while the private cost of importing rises due to tariffs, the social cost remains unchanged. In essence, tariffs inefficiently weaken private incentives to consume imported goods. To mitigate this distortion, the monetary authority must stimulate the economy, allowing PPI to rise, boosting aggregate income, and sustaining higher consumption of imported goods.

Our quantitative simulations indicate that the monetary authority finds it optimal to deviate significantly from the allocation with zero inflation and a zero output gap. We consider a 10% uniform tariff. Under a look-through policy, we find that employment falls, although the output gap remains at zero as the monetary authority targets PPI inflation.[2] We find that under the optimal policy employment stays roughly constant and the labor wedge becomes negative. In addition, PPI inflation reaches 0.4%, raising inflation above and beyond the effect of tariffs on foreign goods.

We explore various extensions of the baseline framework, including different durations of the tariff hike, incorporating imported intermediate inputs, and examining the potential for tariffs to mitigate initial distortions. Across all these cases, we find that the optimal monetary policy remains expansionary, with inflation rising above and beyond the direct effects of tariffs. However, we argue that the anticipation of tariffs can exacerbate the trade-offs faced by the monetary authority because adopting an expansionary monetary policy raises inefficiently imports before the tariff hike takes place. Additionally, we analyze a scenario in which labor taxes are inefficiently high and tariff revenue is used to reduce them. In this case, we find that tariffs raise employment and also welfare under optimal monetary policy.

Literature. This paper contributes to the literature on the macroeconomic implications of tariffs. The analysis of tariffs as a macroeconomic policy tool dates back to Keynes (1937), who argued that under fixed exchange rates, tariffs could serve as a policy tool to help stabilize employment. In contrast, Mundell (1961) argued that tariffs are likely to be contractionary under flexible exchange rates. His argument—which continues to influence many current policy discussions—is that tariffs lead to an appreciation of the exchange rate and depress demand (see also Krugman, 1982). Our analysis offers a new perspective, highlighting that under optimal monetary policy, tariffs are expansionary.

Several recent studies have also examined tariffs as a macroeconomic policy tool within dynamic open economy models (Eichengreen, 2019; Barattieri, Cacciatore and Ghironi, 2021; Comin and Johnson, 2021; Auray, Devereux and Eyquem, 2022, 2024a,b; Jeanne, 2021; Erceg,

[2] Our analytical results show that starting from zero tariffs, employment falls in response to tariffs, but the general effect is ambiguous.

Prestipino and Raffo, 2023; Lloyd and Marin, 2024).[3] Our paper differs in that it assesses the optimal monetary response to an exogenous tariff policy. In this regard, the closest paper to ours is Bergin and Corsetti (2023), which examines Ramsey optimal cooperative monetary policy. They find that, to correct the misalignment from tariffs, the cooperative policy prescribes a neutral or contractionary stance in the country imposing tariffs and an expansionary policy in the country whose exports are targeted. In contrast, we analyze the optimal policy from the perspective of the country imposing tariffs and show that it is expansionary.

Our paper also contributes to the literature on optimal monetary policy. In particular, we share with a subset of studies a focus on steady-state distortions, such as those arising from markups or domestic taxes (see, e.g., Galí, 2015 and Woodford, 2010, for textbook treatments).[4] For instance, in the absence of a subsidy to offset firms' market power, optimal monetary policy induces positive short-run inflation to reduce the labor wedge. In our case, a tariff represents a tax on the consumption of imported goods rather than a broad-based consumption tax, like a VAT. This distinction is crucial because as we demonstrate in our open economy model, a tariff does not act as a cost-push shock. Instead, under the optimal policy, it *simultaneously* induces inflation and a positive output gap.

Finally, our paper is also related to the literature on post-COVID inflationary dynamics– in particular, papers emphasizing sectoral considerations.[5] Relative to these papers, ours considers the inflationary consequences of trade policy and the implications for optimal monetary policy.

Outline. The remainder of the paper is organized as follows. Section 2 presents the model, and Section 3 presents the theoretical results. Section 4 presents the baseline quantitative results. Section 5 analyzes extensions of the baseline model. Section 6 concludes.

[3] For additional work at the intersection of trade policy and international macroeconomics, see, e.g., Barbiero et al. (2017), Lindé and Pescatori (2019), and Costinot and Werning (2019) for Lerner symmetry, Steinberg (2019), Caldara, Iacoviello, Molligo, Prestipino and Raffo (2020), and Alessandria, Khan, Khederlarian, Ruhl and Steinberg (2025) for the implications of trade policy uncertainty, and Ambrosino, Chan and Tenreyro (2024) for the inflationary consequences of trade fragmentation. On the trade side, see Bagwell and Staiger (2016); Caliendo and Parro (2022) for surveys of the literature on trade policy.

[4] See also Afrouzi, Halac, Rogoff and Yared (2023) for a recent example in a dynamic non-linear framework where the central bank lacks commitment.

[5] See, e.g., Baqaee, Farhi and Sangani (2024); Guerrieri, Lorenzoni, Straub and Werning (2021, 2022); Woodford (2022); Gagliardone and Gertler (2023); di Giovanni, Kalemli-Özcan, Silva and Yildirim (2023); Bernanke and Blanchard (2023); Fornaro and Romei (2023); Bianchi and Coulibaly (2024); and Bianchi, McKay and Mehrotra (2024).

2 Model

We present an open economy framework with home-produced and importable goods, subject to nominal rigidities. Specifically, we consider a small open economy (SOE) that faces an exogenous terms of trade and a world interest rate. There is a government in the SOE, which sets tariffs, and a monetary authority, which chooses optimal monetary policy.

2.1 Households

The SOE is populated by a continuum of identical households with preferences given by

$$\sum_{t=0}^{\infty} \beta^t \left[U(c_t) - v(\ell_t)\right],$$

where

$$U(c_t) = \frac{c_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}, \quad v(\ell_t) = \omega \frac{\ell_t^{1+\psi}}{1+\psi}.$$

The term c_t is a composite between home and foreign consumption goods:

$$c_t = \left[\omega (c_t^h)^{1-\frac{1}{\gamma}} + (1-\omega)(c_t^f)^{1-\frac{1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}},$$

where $\omega \in (0,1)$ represents the preference weight for home goods, $\gamma \geq 0$ is the elasticity of substitution between home and foreign goods, and $\sigma \geq 0$ is the intertemporal elasticity of substitution.

We take the domestic currency as our numeraire. Let e_t denote the price of foreign currency in domestic terms—a higher e_t implies a depreciation of the domestic currency. Denote by P_t^h the price of the home good in domestic currency and by P_t^f the pre-tariff price of the foreign good, also expressed in domestic currency. The relative price of foreign goods in terms of home goods is given by $p = \frac{P_t^f}{P_t^h}$.

We assume that the country is small with respect to both production and consumption of these goods, so the relative price p is exogenous. This assumption allows us to abstract from any incentives for manipulating the terms of trade.[6] Under this framework, tariffs fully pass through to import prices at the border, a result that is consistent with recent empirical

[6]Following Gali and Monacelli (2005), it is common to assume that each country is a monopolist of a tradable good, which gives it market power to affect the terms of trade and create scope for optimal tariffs. Our assumption about exogenous terms of trade can be endogeneized by allowing multiple countries to produce the same good. In Section 5.2, we examine the case with endogenous terms of trade.

findings for the U.S. economy (Amiti, Redding and Weinstein, 2019; Fajgelbaum, Goldberg, Kennedy and Khandelwal, 2020; Cavallo, Gopinath, Neiman and Tang, 2021). Moreover, without loss of generality, we assume that the prices of both home and foreign goods are constant in foreign currency, with the home good's price normalized to one. The law of one price is assumed to hold for both domestic and foreign goods (before tariffs).

Households can trade bonds denominated in domestic currency and foreign currency. Domestic currency bonds are denoted by B_{t+1} and yield a nominal return R_t, which is set by the central bank. Foreign currency bonds are denoted by b_{t+1} and yield a nominal return R^*, which is exogenous to the SOE. Given the assumption of constant prices in foreign currency, R^* represents the world real interest rate. The households' budget constraint is given by

$$P_t^h c_t^h + P_t^f (1+\tau_t) c_t^f + \frac{e_t b_{t+1}}{R^*} + \frac{B_{t+1}}{R_t} = e_t b_t + B_t + W_t \ell_t + T_t + D_t,$$

where τ_t denotes the tariff, D_t denotes firms' profits, and T_t corresponds to lump-sum transfers.

The household problem is to choose a sequence $\left\{c_t^h, c_t^f, \ell_t, b_{t+1}, B_{t+1}\right\}$ to maximize their utility, subject to their budget constraint and a no-Ponzi-game condition.[7] The first-order conditions yield the following:

$$\frac{W_t}{P_t^h} u_h(c_t^h, c_t^f) = \omega \ell_t^{\psi}, \tag{1}$$

$$\frac{1-\omega}{\omega} \left(\frac{c_t^h}{c_t^f}\right)^{\frac{1}{\gamma}} = p(1+\tau_t), \tag{2}$$

$$u_h(c_t^h, c_t^f) = \beta R^* u_h(c_{t+1}^h, c_{t+1}^f), \tag{3}$$

$$R_t = R^* \frac{e_{t+1}}{e_t}, \tag{4}$$

where we use $u(c_t^h, c_t^f)$ to denote the utility as a function of the two consumption goods and u_h and u_f to denote the respective partial utilities.

Condition (1) represents the labor supply decision. Condition (2) determines the optimal split between home goods and foreign goods, by equating the marginal rate of substitution (MRS) to the relative price after tariffs. Condition (3) is an Euler equation that determines savings and the intertemporal path for consumption. Condition (4) is the uncovered interest parity condition (UIP), which equates the expected return on the two bonds expressed in the same currency. We note that given the absence of uncertainty, the gross asset positions of households across currencies are undetermined. For simplicity, we assume henceforth that

[7] We use $\{x_t\}$ to refer to the sequence $\{x_t\}_{t=0}^{\infty}$.

$B_0 = 0$ to abstract from initial valuation effects.

2.2 Firms

There are two types of firms: intermediate and final good producers. Final good producers produce the home good using a CES production function given by:

$$y_t = \left(\int_0^1 y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

where y_{jt} represents varieties of intermediate inputs, and ε denotes the elasticity of substitution across varieties. Final good producers are competitive and take as given the price of the home good and the price of inputs. Cost minimization yields the following downward-sloping demand for intermediate inputs: $y_{jt} = \left(\frac{P_{jt}}{P_t^h}\right)^{-\varepsilon} y_t$. In addition, in equilibrium, we must have that $P_t^h = \left(\int P_{jt}^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}$.

Intermediate goods are produced out of labor according to $y_{jt} = \ell_{jt}$. We assume a quadratic cost from changing prices, as in Rotemberg (1982). The problem of an intermediate good firm is

$$\max_{\{y_{jt}, \ell_{jt}, P_{jt}\}} \sum_{t=0}^{\infty} \Lambda_{t+1} \left[(1+s) P_{jt} y_{jt} - W_t y_{jt} - \frac{\varphi}{2} \left(\frac{P_{jt}}{P_{j,t-1}} - 1 \right)^2 P_t^h y_t \right], \tag{5}$$

subject to

$$y_{jt} = \left(\frac{P_{jt}}{P_t^h} \right)^{-\varepsilon} y_t,$$

where $\Lambda_{t+1} \equiv \beta \frac{u_h(t+1)}{u_h(t)} \frac{P_t^h}{P_{t+1}^h}$ is the nominal discount factor and $s = \frac{1}{\varepsilon-1}$ is a standard subsidy on production to correct the markup distortion. Using optimality and symmetry ($P_{jt} = P_t^h$ for all j), we obtain the standard dynamic New Keynesian Phillips curve:

$$(1+\pi_t)\pi_t = \frac{\varepsilon}{\varphi} \left[\frac{W_t}{P_t^h} - 1 \right] + \beta \frac{u_h(c_{t+1}^h, c_{t+1}^f)}{u_h(c_t^h, c_t^f)} \frac{\ell_{t+1}}{\ell_t} (1+\pi_{t+1})\pi_{t+1}, \tag{6}$$

where $\pi_t \equiv P_t^h / P_{t-1}^h - 1$ represents the inflation rate of home-produced goods, or, equivalently, PPI inflation.

Total firms' profits transferred to households are given by

$$\frac{D_t}{P_t^h} = (1+s) y_t - \frac{W_t}{P_t^h} \ell_t - \Upsilon \frac{\varphi}{2} \pi_t^2 y_t.$$

We allow for the possibility that only a fraction of the cost of price adjustments results in deadweight losses. Specifically, Υ represents the fraction of price adjustment costs that constitute deadweight losses, while $1-\Upsilon$ is the portion rebated to households. The benchmark case in the New Keynesian model, which will be our primary focus, corresponds to $\Upsilon = 1$.

2.3 Government

The government collects the tariffs and rebates them lump-sum to households (net of the production subsidy). That is, the government budget constraint satisfies

$$\tau_t P_t^f c_t^f = T_t + s\, P_t^h y_t. \tag{7}$$

2.4 Competitive Equilibrium

We are now ready to define a competitive equilibrium.

Definition 1. Given initial bonds b_0, terms of trade p, a government policy $\{\tau_t, s, T_t\}$, and monetary policy $\{R_t\}$, a competitive equilibrium is a set of allocations $\left\{b_{t+1}, c_{t+1}^f, c_{t+1}^h\right\}$ and prices $\left\{P_{t+1}^f, P_{t+1}^h, e_t, W_t\right\}$ such that

i) households maximize their utility; that is, (1)-(4) hold;

ii) firms maximize profits; that is, (6) holds;

iii) labor markets clear; that is, $\ell_t = \int_0^1 \ell_{jt} dj$;

iii) the government budget constraint holds.

Combining the households' and the government's budget constraints, and the expression for profits, and using the law of one price, we arrive at a balance of payments condition:

$$\underbrace{\left(1 - \Upsilon \frac{\varphi}{2} \pi_t^2\right) \ell_t - c_t^h}_{\text{exports}} - \underbrace{p c_t^f}_{\text{imports}} = \underbrace{\frac{b_{t+1}}{R^*} - b_t}_{\text{capital outflows}} .$$

This condition equates the trade surplus to capital outflows.

2.5 Efficient Allocation

We conclude the description of the model with a characterization of the efficient allocation. Given b_0, the planner chooses consumption allocations and bonds to maximize households' welfare:

$$\max_{\left\{b_{t+1},c_t^f,c_t^h,\ell_t\right\}} \sum_{t=0}^{\infty} \beta^t[u(c_t^h,c_t^f)-v(\ell_t)],$$

subject to

$$c_t^h+pc_t^f+\frac{b_{t+1}}{R^*} = b_t+\ell_t. \tag{8}$$

Optimality implies that

$$u_h(c_t^h,c_t^f)=\omega\ell_t^{\psi}, \tag{9}$$

$$\frac{1-\omega}{\omega}\left(\frac{c_t^h}{c_t^f}\right)^{\gamma}=p, \tag{10}$$

$$u_h(c_t^h,c_t^f)=\beta R^* u_h(c_{t+1}^h,c_{t+1}^f). \tag{11}$$

These three conditions indicate that the planner equates: (i) the marginal utility benefit from one extra unit of labor to the marginal utility cost from working, (ii) the marginal rate of substitution between home and foreign goods to the relative international price, (iii) and the marginal utility benefits from raising one unit of foreign good consumption to the marginal benefit from saving in bonds and consuming one additional unit next period.

Comparing the efficient allocation with the competitive equilibrium, we can see two distortions introduced by nominal rigidities and tariffs. First, from (6), we can see that nominal rigidities potentially imply that the wage deviates from the marginal product of labor, which implies a deviation from (9). Second, comparing (2) and (10) indicates that the tariff distorts the optimal consumption mix between home and foreign goods.

3 Optimal Monetary Policy

In this section, we provide an analytical characterization of the optimal monetary policy response to tariffs. We consider the case with government commitment. The Ramsey optimal monetary policy consists of choosing the competitive equilibrium that maximizes welfare. We can write the problem as follows:

$$\max_{\left\{b_{t+1},\pi_t,\ell_t,c_t^f,c_t^h\right\}} \sum_{t=0}^{\infty} \beta^t \left[u(c_t^h, c_t^f) - \omega \frac{\ell_t^{1+\psi}}{1+\psi} \right], \tag{12}$$

subject to

$$c_t^h + pc_t^f + \frac{b_{t+1}}{R^*} = b_t + \left[1 - \Upsilon \frac{\varphi}{2} \pi_t^2\right] \ell_t, \tag{13}$$

$$(1+\pi_t)\pi_t = \frac{\varepsilon}{\varphi} \left[\frac{\omega \, \ell_t^{\psi}}{u_h(c_t^h, c_t^f)} - 1 \right] + \frac{1}{R^*} \frac{\ell_{t+1}}{\ell_t} (1+\pi_{t+1})\pi_{t+1}, \tag{14}$$

$$\frac{1-\omega}{\omega} \left(\frac{c_t^h}{c_t^f} \right)^{\gamma} = p(1+\tau_t), \tag{15}$$

$$u_h(c_t^h, c_t^f) = \beta R^* u_h(c_{t+1}^h, c_{t+1}^f). \tag{16}$$

We define a look-through policy as a policy that targets PPI inflation.

Definition 2 (Look-through policy)**.** *A look-through policy is a policy that keeps $\pi_t = 0$ for all t.*

This definition is consistent with the notion of targeting the level of inflation excluding those goods affected by tariffs, as emphasized in the policy discussions. In addition, a policy of targeting PPI inflation is optimal or close to optimal under a variety of shocks in standard open economy New Keynesian models (see e.g., Gali and Monacelli, 2005). In line with this, a first result is that in the absence of tariffs, a monetary authority that follows a look-through policy achieves the efficient allocation. In other words, divine coincidence holds.

Proposition 1 (Efficiency)**.** *If $\tau_t = 0$ for all t, the solution to the Ramsey problem* (12) *coincides with the efficient allocation.*

Proof. Setting $\tau_t = 0$ and $\pi_t = 0$ in the implementability constraints (13)-(16), we arrive at (8)-(11), the conditions characterizing the efficient allocation. □

In the presence of positive tariffs, however, the efficient allocation is no longer feasible. Setting $\pi_t = 0$ for all t, we see that the three conditions in the planner's problem: (8), (9), and (11) are satisfied, but comparing (10) and (15) indicates that the ratio of home to foreign consumption is too high relative to what the planner would choose under *any* monetary policy.

We will study below how the monetary authority finds it optimal to depart from targeting PPI inflation in the presence of tariffs. Throughout, we will focus on a situation where

$\beta R^* = 1$, $b_0 = 0$, which imply that in the absence of tariffs, there is a constant path for consumption and that the trade balance is zero in every period. Moreover, in this section on a constant path for tariffs.

3.1 Analytical Example with $\Upsilon = 0$

In this section, we consider the case where price adjustment costs are rebated back to households (i.e., $\Upsilon = 0$), an assumption that allows us to obtain closed-form solutions for the optimal policy. Note that although inflation does not generate resource losses, it still affects firms' employment decisions and, consequently, the labor wedge.

As defined above, the monetary authority keeps PPI inflation at zero, and thus lets CPI inflation rise in response to the introduction of tariffs. Notice that the level of employment under look-through corresponds to the flexible price allocation which features a zero labor wedge. Setting $\pi_t = 0$ in (13)-(16) yield constant allocations in this case.

For the optimal policy, note that in problem (12), with $\Upsilon = 0$ we have that π_t appears only in the Phillips curve, and thus we can drop constraint (14) as an implementability constraint. Moreover, constant tariffs and $\beta R^* = 1$ imply that home and foreign consumption are constant. Replacing c^f using (15) and iterating forward in the country budget constraint, we can write the central bank problem as

$$\max_{c^h, \{\ell_t\}} \sum_{t=0}^{\infty} \beta^t \left[\frac{(\omega \Theta_\tau)^{\frac{\gamma(\sigma-1)}{\sigma(\gamma-1)}}}{1-\sigma^{-1}} \left(c^h\right)^{1-\frac{1}{\sigma}} - \omega \frac{\ell_t^{1+\psi}}{1+\psi} \right] \tag{17}$$

subject to

$$\frac{\Theta_\tau + \tau}{1+\tau} c^h = (1-\beta) \sum_{t=0}^{\infty} \beta^t \ell_t,$$

where

$$\Theta_\tau \equiv 1 + \left(\frac{1-\omega}{\omega}\right)^{\gamma} (p(1+\tau))^{1-\gamma} > 1.$$

In effect, this optimal monetary policy problem is equivalent to the problem of a planner choosing labor in behalf of households and letting households choose the mix of consumption. Notice also the Ramsey problem is time consistent in this case.

The proposition below establishes that the level of employment is strictly higher under optimal policy than under look-through.

Proposition 2. *Assume that $\beta R^* = 1$, $\Upsilon = 0$, $\tau_t = \tau > 0$. Then, the level of employment* *under look-through policy and optimal policy is given respectively by*

$$\ell_t^{look}(\tau) = \left[\frac{\Theta_\tau + \tau}{1+\tau}\left(\omega\Theta_\tau\right)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}},$$

$$\ell_t^{opt}(\tau) = \left(\frac{1+\tau}{1+\Theta_\tau^{-1}\tau}\right)^{\frac{\sigma}{1+\sigma\psi}}\left[\frac{\Theta_\tau + \tau}{1+\tau}\left(\omega\Theta_\tau\right)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}} > \ell_t^{look}(\tau).$$

In addition,

$$c_t^{h,j}(\tau) = \frac{1+\tau}{\Theta_\tau + \tau}\ell_t^j(\tau), \qquad c_t^{h,j}(\tau) = \frac{\Theta_\tau - 1}{p\left(\Theta_\tau + \tau\right)}\ell^j(\tau), \quad \textit{for } j \in \{look, opt\} \tag{18}$$

and the constant level of inflation consistent with the optimal allocation is positive.

Proof. In Appendix A. □

The intuition for why the optimal employment is higher than the look-through is as follows. The monetary authority internalizes that when households work more, they consume more imports and raise tariff revenue, therefore raising aggregate income for all households. Because tariffs depress inefficiently the level of imports, the monetary authority induces a negative labor wedge, which implies that employment exceeds the level in the look-through policy.

The proposition also highlights that the optimal policy induces a positive level of inflation. Intuitively, given that employment under the optimal policy exceeds the level associated with the zero-inflation allocation, implementing this higher level of consumption requires higher inflation to stimulate the economy.

What is the effect of tariffs on employment? To examine the effect, we differentiate the employment function derived in Proposition 2. Under look-through, we have

$$\frac{d\ell^{look}(\tau)}{d\tau} = -\frac{\Theta_\tau - 1}{\left(\Theta_\tau + \tau\right)\Theta_\tau}\frac{\sigma\Theta_\tau + (\sigma-\gamma)\tau}{(1+\sigma\psi)(1+\tau)}\ell^{look}(\tau). \tag{19}$$

Notice that tariffs do not necessarily have monotonic effects on employment. While the first term is negative, the second term has an ambiguous sign. Therefore, depending on parameter values, it is possible to obtain that a higher tariff either increases or decreases employment. One may have expected that tariffs operate as a tax on consumption, and thus indirectly as a tax on labor supply, thereby always depressing employment. In particular, a tax on labor income depresses labor supply and to the extent that the tax is rebated, this mutes a wealth effect and reduces unambiguously labor supply. However, this equivalence does not extend to the case where there are multiple goods and the tax applies to only one consumption good.

The ambiguity arises because tariffs affect two key relative prices: the price between foreign and home goods and the price between foreign goods and labor. These shifts induce two distinct substitution effects. The first one is that a tariff reduces the real wage in terms of foreign consumption goods, leading to a substitution away from labor. The second one is that when $\gamma > \sigma$, we have that for a sufficiently large level of tariff an increase in the tariff at the margin induces an increase in labor supply. The intuition for this perhaps surprising result is as follows. When the elasticity of substitution between home and foreign consumption exceeds the intertemporal elasticity of substitution, home and foreign goods are Hicksian substitutes, which implies that a lower foreign consumption leads to an increase in the marginal utility of home goods (i.e., $u_{h,f} < 0$). As a result, a tariff that depresses c^f may lead households to increase their labor supply given the higher marginal utility value associated to c^h.

Nonetheless, evaluating (19) at $\tau = 0$ indicates that an increase in tariffs always reduces employment under the look-through policy. That is, a small tariff necessarily reduces employment under the look-through policy. We also note that for the parameterizations and tariff magnitudes considered, tariffs will reduce employment in our quantitative analysis, suggesting that on net tariffs do induce a tax-like effect on labor supply.

Under optimal policy, the effect of tariffs on employment is given by

$$\frac{d\ell^{opt}(\tau)}{d\tau} = \frac{1-\sigma}{1+\sigma\psi} \frac{\gamma\tau\left(\Theta_\tau - 1\right)}{\Theta_\tau\left(\Theta_\tau + \tau\right)(1+\tau)} \ell^{opt}(\tau) \tag{20}$$

Notice that now the sign of the employment response is determined by the intertemporal elasticity of substitution. For $\sigma < 1$, employment increases and for $\sigma > 1$, employment decreases. As discussed above, a lower σ makes home and foreign goods more substitutes (in the Hicksian sense), and monetary policy becomes more effective at preventing a larger drop in imports.

A case that is especially simple is $\gamma = \sigma = 1$ and $\psi \to 0^+$. Specializing Proposition 2 to this case and setting $\tau = 0$, we obtain that the efficient allocation yields

$$\ell^\star = \frac{1}{\omega}, \quad c^{h,\star} = 1, \quad c^{f,\star} = \frac{1-\omega}{\omega p},$$

while the look-through and optimal policy are given by

$$\ell^{look} = \left(\frac{1+\omega\tau}{1+\tau}\right)\frac{1}{\omega}, \quad c^{h,look} = 1, \quad c^{f,look} = \left(\frac{1}{1+\tau}\right)\frac{1-\omega}{\omega p},$$

$$\ell_t^{opt} = \frac{1}{\omega}, \quad c^{h,opt} = \frac{1+\tau}{1+\omega\tau}, \quad c^{f,opt} = \left(\frac{1}{1+\omega\tau}\right)\frac{1-\omega}{\omega p},$$

In this simple example, we obtain that under look-through policy, home consumption equals the efficient level and employment is decreasing in tariffs. Under the optimal policy, employment remains equal to the efficient level of employment and home consumption is increasing in tariffs.

The main takeaway from this section is that the optimal monetary policy calls for overheating the economy, raising employment and inflation beyond the look-through policy.

3.2 General Setting with $\Upsilon > 0$

A simplifying assumption in the analytical case above is that inflation does not induce any social costs (i.e., changing prices is only privately costly for the firms). When $\Upsilon > 0$, however, this is not the case, and the Ramsey planner faces the Phillips curve as an implementability constraint. Let us set $\Upsilon = 1$ and maintain the assumptions that $\beta R^* = 1, \tau_t = \tau$ and $\gamma = \sigma = 1$. Under these assumptions, we have that (15) and (16) imply that c_t^f and c_t^h are constant. We can therefore write the problem as

$$\max_{\{c^h, c^f, \ell_t, \pi_t\}} \sum_{t=0}^{\infty} \beta^t \left[\omega \log\left(c^h\right) + (1-\omega)\log(c^f) - \omega \frac{\ell_t^{1+\psi}}{1+\psi}\right], \tag{21}$$

subject to

$$(1+\pi_t)\pi_t = \frac{\varepsilon}{\varphi}\left[c^h \ell_t^{\psi} - 1\right] + \beta\frac{\ell_{t+1}}{\ell_t}(1+\pi_{t+1})\pi_{t+1}, \qquad [\eta_t] \tag{22}$$

$$c^f \leq \frac{1-\omega}{\omega p(1+\tau)} c^h, \qquad [\xi] \tag{23}$$

$$b_0 \geq \sum_{t=0}^{\infty} \beta^t \left[c^h + pc^f - \left(1 - \frac{\varphi}{2}\pi_t^2\right)\ell_t\right], \qquad [\lambda] \tag{24}$$

with Lagrange multipliers in brackets. We note that while the implementability constraints (23) and (24) hold with equality at the optimum, we express them with inequality to reflect the direction in which the constraint binds for $\tau > 0$. In addition, we express the Lagrangian so that a higher η_t reflects a positive marginal gain from lowering the left-hand side of (21) (i.e., lowering inflation).

Optimality with respect to c^h yields

$$\frac{\omega}{c^h} + \frac{c^f}{c^h}\xi = \lambda + \frac{\varepsilon}{\varphi}(1-\beta)\sum_{t=0}^{\infty}\beta^t \ell_t^{\psi}\eta_t, \tag{25}$$

Condition (25) equates the marginal utility benefits from consumption to the marginal costs. The benefits are given by the sum of the direct utility from one extra unit of home consumption plus the gains from relaxing the implementability constraint equating the MRS to the relative price, (23). That is, since the constraint effectively imposes a lower bound on c^h/c^f, a rise in c^h helps relax the constraint. The costs are given by the shadow value of resources plus the present discounted value of the inflationary cost captured by the marginal effect on the Phillips curve constraint (22).

Optimality with respect to c^f yields:

$$\frac{1-\omega}{c^f} - \xi_t = \lambda p, \tag{26}$$

Relative to the previous first-order condition, we can see now that an increase in c^f tightens (23). Combining (25) and (26), we obtain

$$\xi = \frac{p(1+\tau)}{(1+\omega\tau)c^h}\left[\tau + \frac{\varepsilon}{\varphi}(1-\beta)\sum_{t=0}^{\infty}\beta^t \ell_t^{\psi}\eta_t\right] \tag{27}$$

This expression indicates that to the extent that the tariff tightens the relative price-MRS constraint (23), the monetary authority will tend to face a positive Lagrange multiplier on the PC constraint (in present discounted terms).

The first-order condition with respect to $\{\ell_t\}$ yields

$$\omega\ell_t^{\psi} + \frac{\varepsilon}{\varphi}\Big((\psi+1)\,c^h\,(\ell_t)^{\psi} - 1\Big)\frac{\eta_t}{\ell_t} - (1+\pi_t)\pi_t\left(\frac{\eta_t}{\ell_t} - \frac{\eta_{t-1}}{\ell_{t-1}}\right) = \left(1 - \frac{\varphi}{2}\pi_t^2\right)\lambda, \tag{28}$$

which equates the marginal cost from one more unit of labor (including the marginal effect on current and future Phillips curve constraints) to the marginal value of the additional resources. Finally, we have the following first-order condition with respect to $\{\pi_t\}$:

$$\frac{\pi_t}{1+2\pi_t} = \frac{1}{\varphi\lambda}\left(\frac{\eta_t}{\ell_t} - \frac{\eta_{t-1}}{\ell_{t-1}}\right). \tag{29}$$

for $t > 0$ while for $t = 0$, we have

$$\frac{\pi_0}{1 + 2\pi_0} = \frac{\eta_0}{\varphi \lambda \ell_0}. \tag{30}$$

The difference between these conditions is that that the monetary authority perceives a higher cost from inflation far in the future. This is because through the forward-looking Phillips curve, higher inflation in the future leads to higher inflation today.

We note that $1 + 2\pi_0 > 0$.[8] Condition (30) then implies that π_0 and η_0 have the same sign. Intuitively, when inflation is positive, the monetary authority recognizes that relaxing the Phillips curve (by allowing for lower inflation) would strictly improve welfare by reducing inflation costs and increasing available resources.

We proceed next to argue that $\pi_0 > 0$. In particular, we show formally that if the monetary authority were to ensure price stability for $t \geq 1$, then the monetary authority would deviate from price stability today and set $\pi_0 > 0$. Under the assumption that $\pi_t = 0$ for all $t \geq 1$, we have from (29) that

$$\frac{\eta_t}{\ell_t} = \frac{\eta_0}{\ell_0} = \varphi \lambda \frac{\pi_0}{1 + 2\pi_0}$$

Next, we combine (25) and (26) to get

$$\frac{1 + \omega \tau}{1 + \tau} \lambda = \left[1 - \frac{\varepsilon}{\varphi} (1 - \beta) \sum_{t=0}^{\infty} \beta^t c^h \ell_t^{\psi} \eta_t \right] \frac{\omega}{c^h}$$

and using the Phillips curve (14) with $\pi_{t+1} = 0$, we can rewrite (28) at $t = 0$ as

$$\left[\frac{\varphi}{\varepsilon} (1 + \pi_0) + \frac{\Xi_0}{1 + 2\pi_0} \left((1 + \pi_0)\pi_0 + \frac{\varepsilon}{\varphi} \psi c^h \ell_0^{\psi} \right) \right] \pi_0 = \left[1 + \frac{1}{1 + 2\pi_0} \frac{\varphi}{2} \pi_0^2 \right] \Xi_0 - 1 \tag{31}$$

where we defined

$$\Xi_0 \equiv \frac{1 + \tau}{1 + \omega \tau} \left[1 - \frac{\varepsilon}{\varphi} (1 - \beta) \sum_{t=0}^{\infty} \beta^t c^h \ell_t^{\psi + 1} \frac{\eta_0}{\ell_0} \right]$$

Note that $\Xi_0 > 1$ for $\eta_0 \leq 0$ or equivalently $\pi_0 \leq 0$ following the argument above. If $\pi_0 \leq 0$, we would have that the left hand side of (31) is negative while the right hand side is positive. Therefore, it must be $\pi_0 > 0$.

[8] The argument for why $1 + 2\pi_0 > 0$ is as follows. We observe that $\pi_0(1 + \pi_0)$ has a minimum at $\pi_0 = 0.5$. Moreover, for any $\pi_0 < -0.5$, we can find $\pi_0 < 0$ such that the PC holds and we have the same ℓ and higher c^f and c^h. Thus, any allocation with $\pi_0 < -0.5$ is dominated.

The intuition for this result parallels the earlier case where inflation costs were absent. A tariff inefficiently depresses demand for imports. Starting from an allocation with zero inflation and a zero output gap, stimulating the economy does not create first-order costs, while the resulting increase in imports generates strictly positive first-order gains. This makes overheating a desirable outcome for the monetary authority.

In the next section, we calibrate the model and quantitatively assess the extent to which the monetary authority finds it optimal to overheat the economy.

4 Quantitative Analysis

4.1 Calibration

We calibrate the model to the US economy at a quarterly frequency and solve it using a global non-linear algorithm.[9] Table 1 presents the values for the parameters.

The discount factor is set to $\beta = 0.99$, which implies an annual risk-free rate of 4%, given that $R^* = 1/\beta$. We set the Frisch elasticity of labor supply to $\psi = 1$, in line with the estimates of Kimball and Shapiro (2008). As in Gali and Monacelli (2005), we set the elasticity of substitution between differentiated goods to $\varepsilon = 6$, which implies a price markup of 20%. We normalize the terms-of-trade p to 1 and calibrate the preference weight on home goods to ω to 0.35, which matches the ratio of imports to tradable GDP of 15.5%. The intertemporal elasticity of substitution is set to $\sigma = 2$.

Table 1: Calibration

Description	Value	Source/Target
Discount factor	$\beta = 0.99$	Real rate=4% (annual)
Trade elasticity	$\gamma = 2$	Baseline
Intertemporal elasticity	$\sigma = 2$	Baseline
Preference weight	$\omega = 0.35$	Imports to tradable-GDP = 15.5%
Frisch elasticity parameter	$\psi = 1$	Kimball and Shapiro (2008)
Elasticity of subs. varieties	$\varepsilon = 6$	Gali and Monacelli (2005)
Price-adjustment cost	$\varphi = 1636$	Slope of Phillips curve =0.005

The two remaining parameters are the price adjustment cost, φ, and the elasticity of

[9] A challenge for local solution methods is that an incomplete market economy like ours is non-stationary. That is, any shock results in a permanent shift in the net foreign asset position and in the long-run allocations.

substitution between home and foreign goods, γ. These parameters are crucial because they determine, respectively, the effectiveness of monetary policy and the welfare effects of tariffs. We calibrate φ so that the slope of the linearized Phillips curve equals 0.005, following the estimate from Hazell et al. (2022). We set γ equal to 2, which lies within the empirical range (see Boehm, Levchenko and Pandalai-Nayar, 2023; Caliendo and Parro, 2022).

4.2 Baseline Results

We will assume throughout that the economy is initially at a steady state where $b_0 = 0$ and there are no tariffs. We first study the optimal response to a permanent increase in tariffs. For each experiment, we will present the simulation path for the following variables: home-goods inflation, the labor wedge, the price level, the exchange rate, consumption of home goods, imports, employment, the consumer price index (CPI), net foreign asset (NFA), and the trade balance. We express the trade balance and the NFA as a fraction of GDP, and consumption of home goods, employment, the price level, and the exchange rate are expressed as a percentage deviation from the pre-tariff allocation. The CPI, which we refer to as the price level, is defined as $\mathcal{P}_t = \left[P_t^h \left(\omega^\gamma + (1-\omega)^\gamma (p(1+\tau_t))^{1-\gamma}\right)^{\frac{1}{1-\gamma}}\right]$. For reference, the black dotted line denotes the pre-tariff allocation.

Figure 1 presents the simulations in response to a permanent tariff of $\tau = 10\%$.[10] We compare the optimal policy (blue solid line) with the "look-through" policy (red, dashed line). Recall that the look-through policy stabilizes inflation for home-produced goods (i.e., $\pi_t = 0$) while allowing the CPI to jump following the one-time increase in import prices. As the figure illustrates, under the look-through policy, the exchange rate, trade balance, and the NFA remain constant at their pre-tariff levels (panels f, h, and i). Moreover, consumption of home goods is permanently higher (panel d), and consumption of foreign goods is permanently lower (panel e), reflecting the increase in the price of the latter. Finally, employment declines (panel c). As discussed in Section 3.1, tariffs effectively act as a tax on labor, which tends to depress labor supply.

Under the optimal policy, inflation rises in the short-run (panel a) as the monetary authority seeks to stimulate employment and aggregate income. Over time, inflation falls and converges to zero in the long-run. The long-run allocation corresponds to the flexible-price allocation characterized by a zero labor wedge (panel e)—but with a higher NFA position

[10] This is one of the original proposals suggested by the Trump administration. Recent measures have included differential tariffs on Mexico, Canada, China, and other countries. Although we focus on uniform tariffs across all imports for simplicity, our analysis can be extended to differential tariffs by introducing multiple foreign goods.

and higher levels of consumption relative to the pre-tariff levels. A key result in line with the theoretical analysis is that the stimulative monetary policy results in a smaller decline in imports than under the look-through policy.

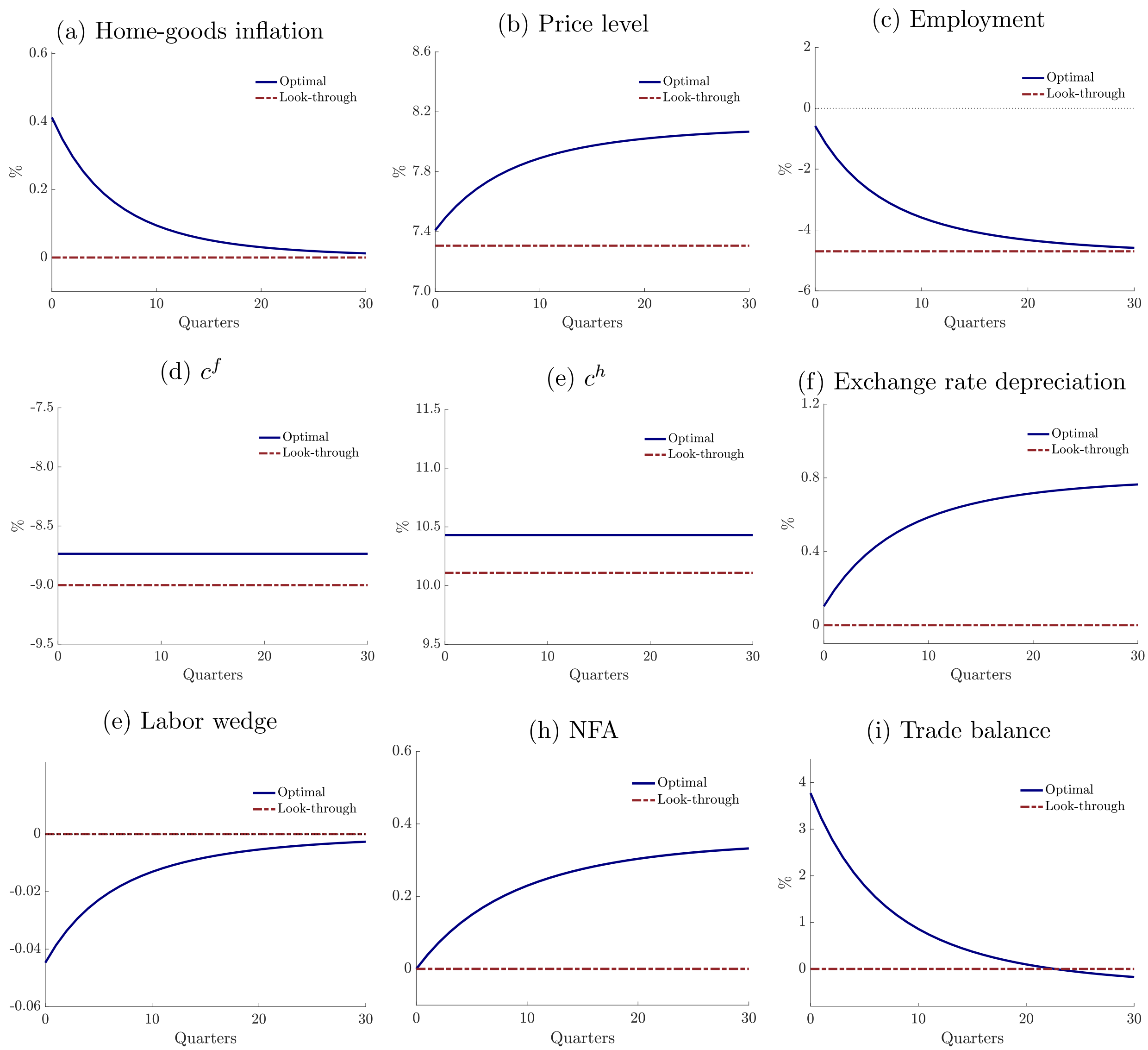

Figure 1: Baseline response to a permanent tariff

Note: The tariff is set to $\tau_t = 10\%$ for all t. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

4.3 Tariffs vs. Terms-of-Trade Shocks

We next show that the optimal monetary response to tariffs fundamentally differs from that to a deterioration in the terms of trade. From the perspective of an individual household, whether the price of foreign goods rises due to a tariff or a terms-of-trade (TOT) shock has the same implications. However, at the aggregate level, tariffs differ because households receive a lump-sum rebate from the government. To highlight the role of tariff revenue, consider a scenario in which tariff revenue is effectively "thrown into the ocean." In this case, the monetary authority's problem in (12) faces the following intertemporal budget constraint

$$b_0 = \sum_{t=0}^{\infty} \beta^t \left[c^h + p(1+\tau)c^f - \left(1 - \frac{\varphi}{2}\pi_t^2\right) \ell_t \right]$$

instead instead of (24). This formulation shows that the solution to this problem yields the efficient allocation, with the price adjusted to $p(1+\tau)$ and optimal inflation $\pi_t = 0$. Figure 2 compares the impulse response to a tariff shock (when revenue is rebated lump-sum) to that of a TOT shock. We assume that p increases by 10%, ensuring that the price of imports faced by households is identical in both cases. As shown in panel (b), the TOT shock leads to a larger decline in imports compared to the tariff shock, and home goods consumption increases less under the TOT shock. The lower level of consumption under a TOT shock arises because the higher price of imports tightens the intertemporal budget constraint, reducing households' purchasing power. In addition, monetary policy remains neutral under a TOT shock while it is expansionary under a tariff-shock.[11]

Figure 2 compares the impulse response to a tariff shock (when the revenue is rebated lump-sum). We assume that p goes up by 10% so that the price of imports faced by households is the same in the economy with the tariff shocks as it is in the economy with the terms-of-trade (TOT) shock. As shown in panel (b), the TOT shock leads to a higher decline in imports compared to the tariff shock, and consumption of home goods increases less under the TOT shock. The lower consumption in the case of TOT shock follows from the higher p tightens the intertemporal budget constraint and the different monetary policy response.

[11] Bergin and Corsetti (2023) highlight the distinction between a rise in marginal cost driven by lower productivity—in which case there is no monetary policy tradeoff—and tariffs. In their cooperative two-country setting, the optimal policy prescribes PPI deflation in the foreign country when imposing tariffs unilaterally (see Figure 4).

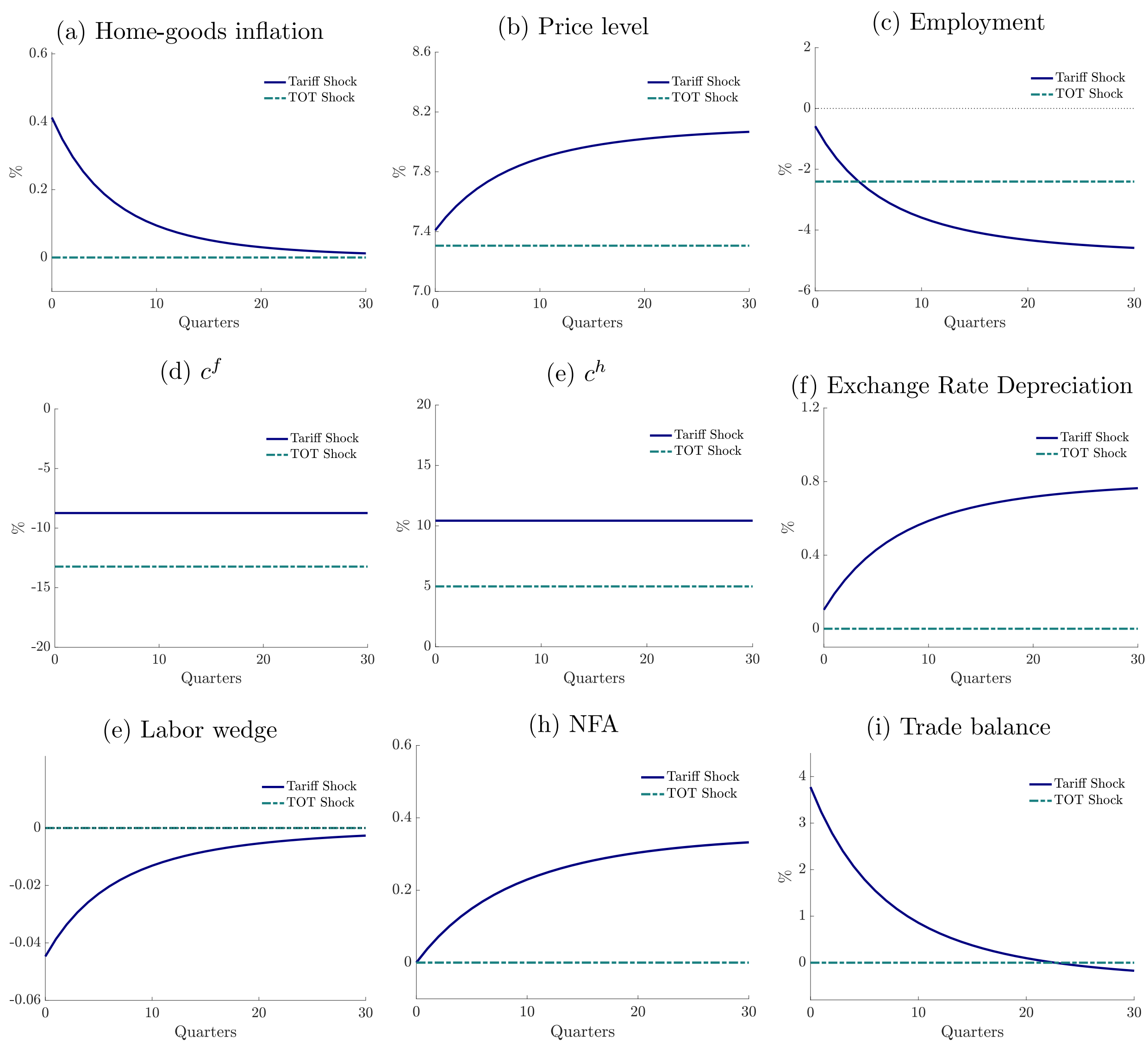

Figure 2: Tariff shock vs. terms-of-trade shock

Note: For the tariff shock, we set $\tau = 10\%$ and for the TOT shock, we assume a 10% increase in p. In both cases, we consider optimal monetary policy. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

4.4 Temporary vs. Permanent Tariffs

In this section, we consider a temporary shock to tariffs. In particular, we assume that tariffs follow an autoregressive process $\tau_t = \rho\tau_{t-1}$, with $\tau_0 = 10\%$ and $\rho = 0.976$, so that the half-life of the shock is 4 years.

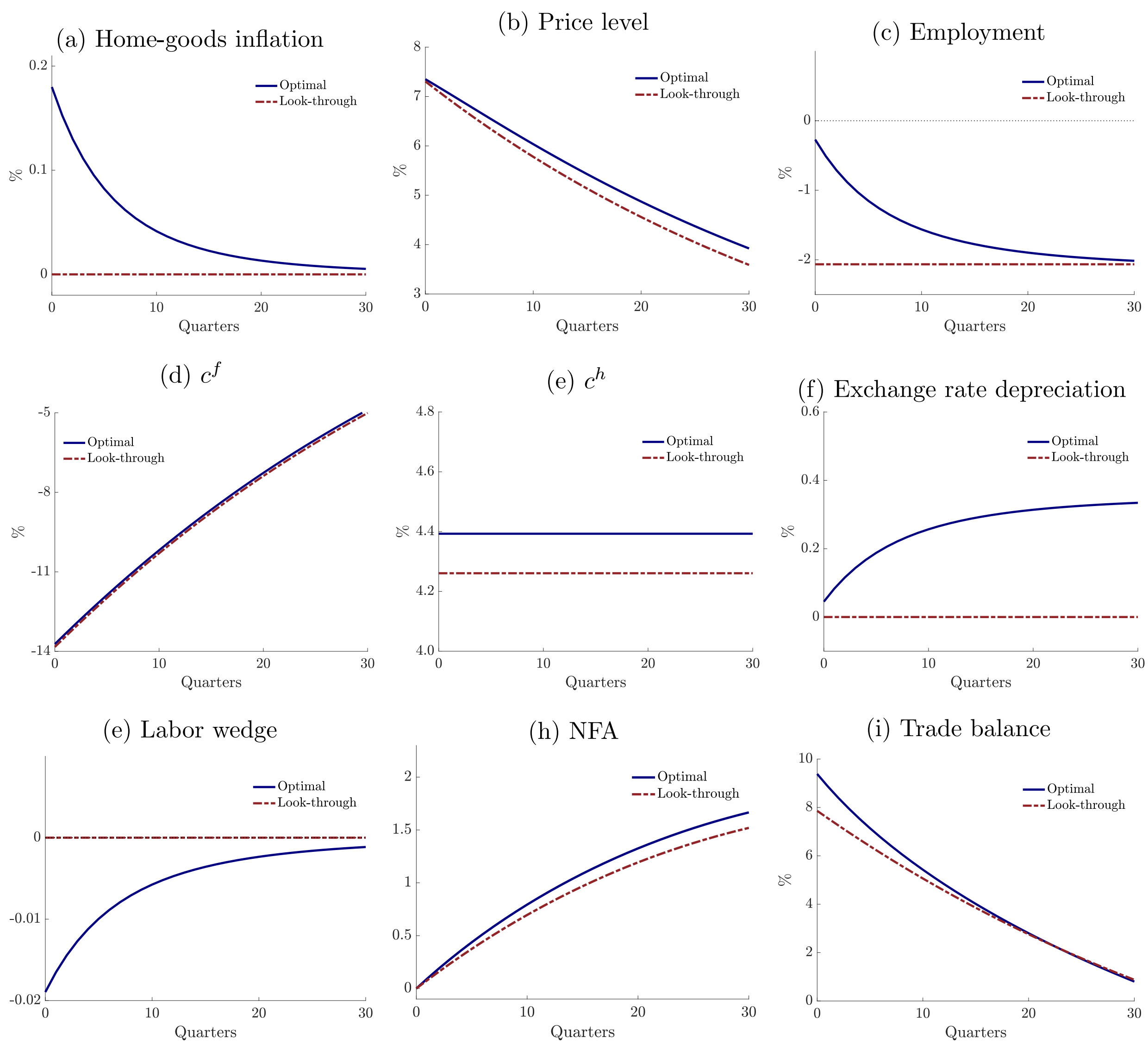

Figure 3: Response to a temporary tariff

Note: We assume the tariff follows $\tau_t = \rho\tau_{t-1}$, with $\tau_0 = 10\%$ and $\rho = 0.976$. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

Figure 3 presents the results. When tariffs are temporary, households anticipate that the cost of consuming imported goods will decline in the future, increasing the marginal benefit of saving to shift consumption toward the future. As a result, a trade surplus emerges under the look-through policy, while the surplus is even larger under the optimal policy. In panel (e), we can see that home consumption stays constant because the assumption of $\gamma = \sigma$ implies that preferences are separable between home and foreign consumption.

It is useful to note that the economy does not return to its initial allocation in the long run, even if the shock is temporary. This occurs because, in an incomplete market model, any temporary shock has permanent effects on the NFA position, resulting in different long-run allocations. Furthermore, the optimal policy features a promise of deflation after the shock subsides (although the magnitude is modest and not apparent in the figure). The idea is that by committing to deflation in the future, the monetary authority can stimulate output when tariffs are high and tame current inflation. The result is similar to the case of a temporary markup shock: once the shock subsides, generating deflation has second-order costs, while the benefits of reducing inflation costs in earlier periods are first-order.[12] However, the case of a temporary tariff differs from a markup shock in that, the optimal monetary policy induces both inflation and a positive output gap (or a negative labor wedge, as can be seen in panel e). A key takeaway is that, as in the case of a permanent tariff, the monetary authority lets the exchange rate depreciate to stimulate the economy.

4.5 Anticipated Tariff

We now assume that tariffs are announced at $t = 0$, implemented at $t = 4$, and remain constant thereafter. Figure 4 presents the results of this simulation. The tariff announcement leads to a trade deficit and a decrease in the NFA position, as agents increase their consumption of foreign goods before the price hike occurs. We argue that the anticipation of tariffs generates a more delicate trade-off for the monetary authority. Like before, stimulating the economy at $t = 0$ helps to raise aggregate income and overall consumption. However, we also have now an inefficient increase in imports before the tariff hike takes place. As a result, the monetary authority implements an expansionary monetary policy but relatively softer compared to the unanticipated case.

[12]When the shock is permanent, as considered above, the distortion persists, and generating deflation is not optimal for any t.

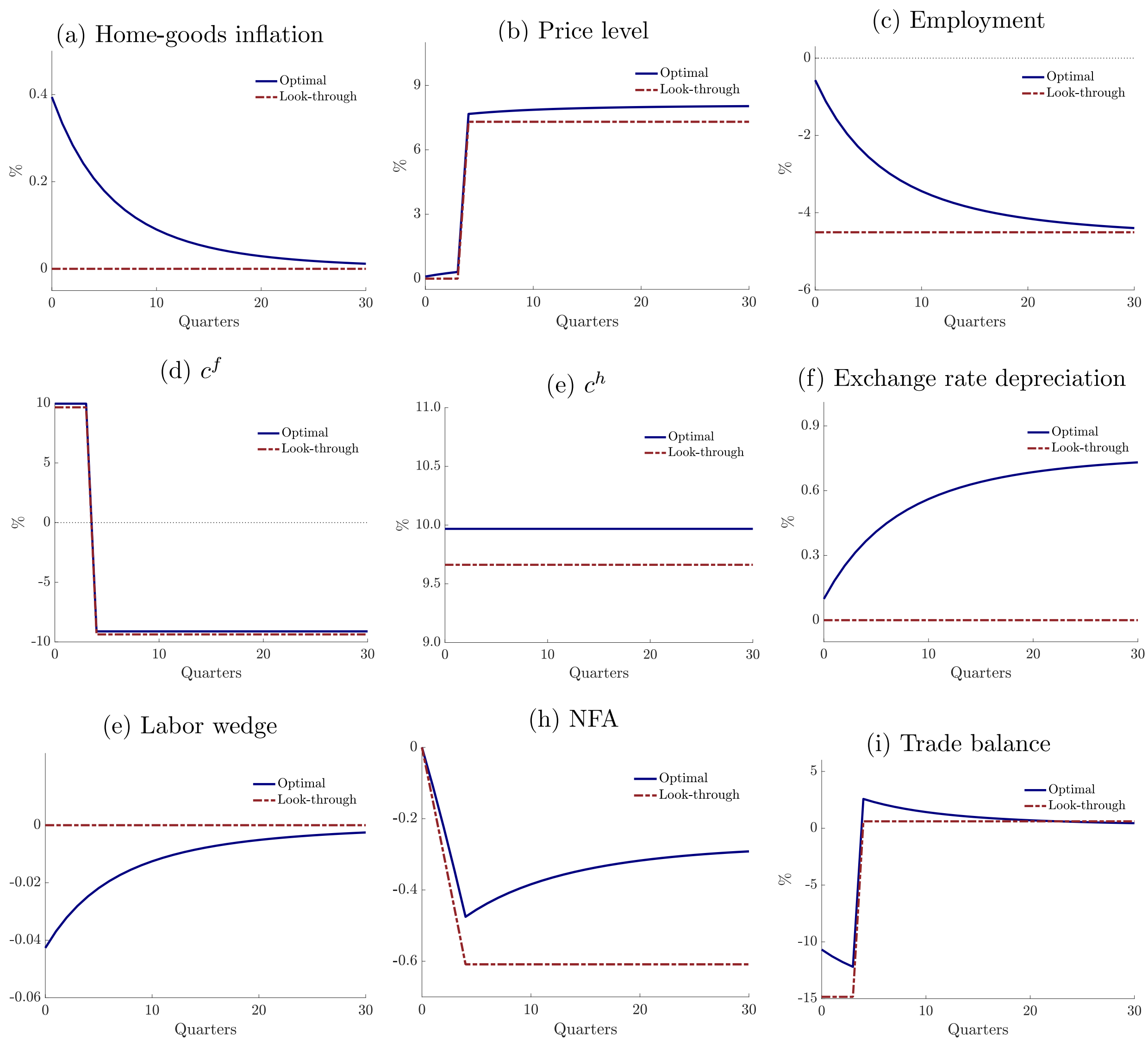

Figure 4: Response to an anticipated permanent tariff

Note: A permanent tariff of 10% is announced at $t = 0$ and imposed at $t = 4$. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

5 Extensions and Further Analysis

5.1 Distorted Steady State

Until now, we have analyzed an initial scenario in which the economy operates at the efficient level in the absence of tariffs. This result hinges on the key assumption that the government has access to a constant labor subsidy that offsets the markup distortion.

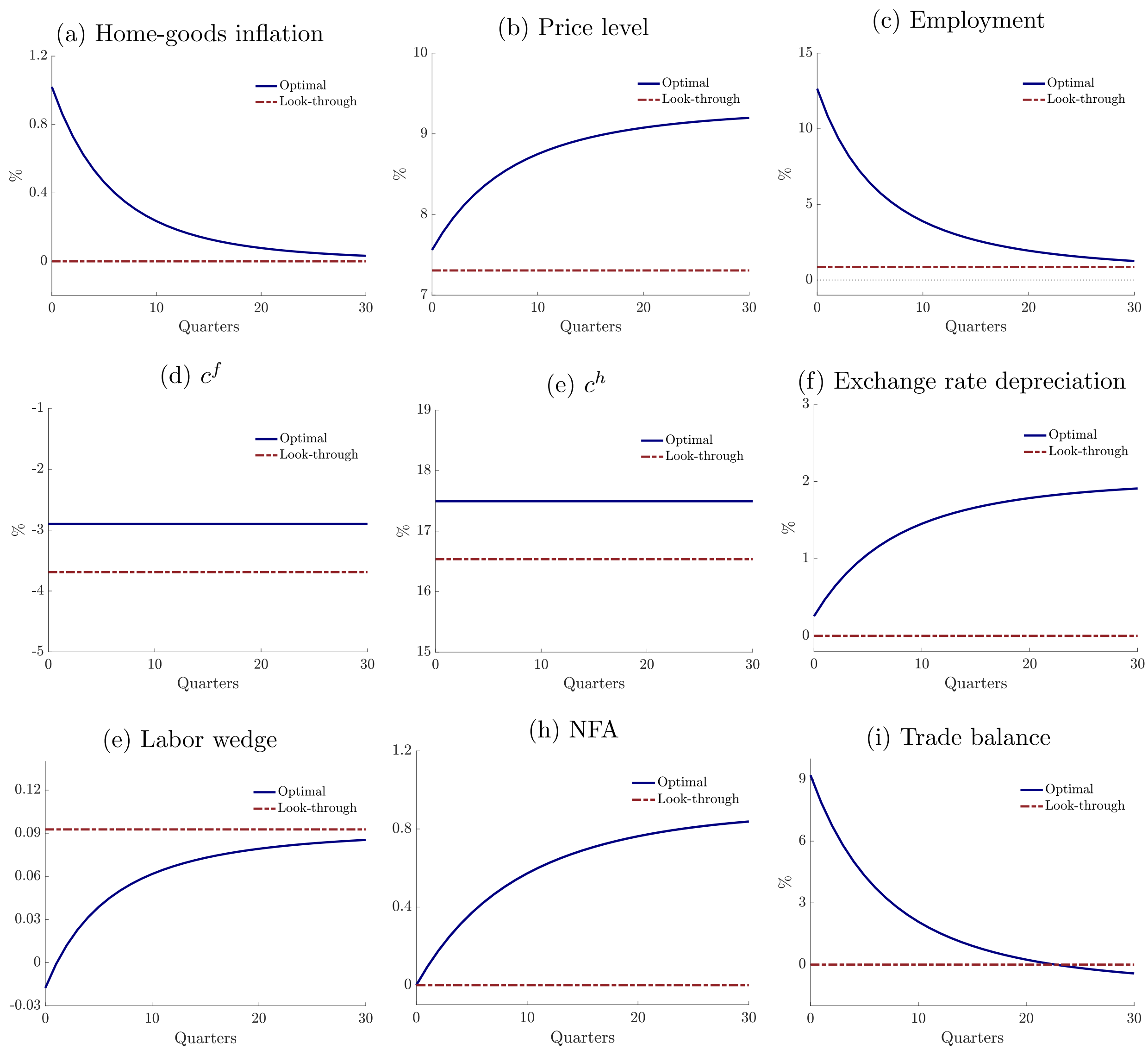

Figure 5: Response to a permanent tariff shock of 10% with an inefficient steady state

Note: The initial allocation has an inefficient steady state ($s = 0$). We assume that tariff revenue collected subsidizes the wage bill: $P_t^f \tau_t c_t^f = s_t W_t \ell_t$. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

We now consider the case where no such subsidy is in place ($s = 0$), meaning the economy starts from a distorted steady state in the absence of tariffs. Importantly, we assume that tariff revenue is used to subsidize the wage bill. That is, the government budget constraint is now given by

$$P_t^f \tau_t c_t^f = s_t W_t \ell_t$$

Crucially, now tariffs help mitigate the markup distortion. This aligns with one of the common arguments for tariff proposals: the revenue collected can be used to reduce other distortionary taxes.

Figure 5 presents the results of this simulation. As shown in panel (e), the labor wedge declines and employment rises under the look-through policy due to the lower markup. Under the optimal policy, the monetary authority provides stimulus to further reduce the labor wedge in the short run, and in the long run, employment converges to a permanently higher level than in the pre-tariff allocation. Compared to the case with an efficient steady state, we observe qualitatively similar differences between the look-through and optimal policies. However, as we will see below, these policies result in significant welfare differences.

5.2 Endogenous Terms of Trade

In our baseline model, the international price of home and foreign goods is exogenous. The assumption enables us to abstract from a terms-of-trade manipulation incentive to focus on demand stabilization. We now extend our analysis to a situation where domestic production affects the relative price in the international goods market. We assume, in particular, an isoelastic demand for the home good such that

$$p_t = A\left(y_t\right)^{\frac{1}{\theta}}, \tag{32}$$

where $\theta \geq 0$ denotes the foreign demand elasticity for home goods and $A > 0$ captures an overall level of foreign demand for home goods. Our baseline model is a particular case where $\theta = \infty$. In the simulations below, we calibrate this elasticity to $\theta = 5$ and set A so that $p_t = 1$ in the efficient allocation. Notice that now achieving the efficient allocation requires a lower wage subsidy to take into account the terms of trade externality that arises because of the downward-sloping demand for home goods.[13]

Figure C.1 compares the optimal response to a tariff shock in the baseline model with that in the extended version featuring endogenous terms of trade. Compared to the baseline, the monetary authority still stimulates the economy, though to a lesser extent because now the monetary authority internalizes that a higher output of home goods lowers the price of the domestic good (raises p) and further lowers imports. Quantitatively, however, we can see

[13] It is possible to extend the model to allow the relative price to depend on exports of home goods, in which case the demand for exports becomes an increasing function of p (i.e., decreasing in the relative price of the home good). In that case, a positive tariff is necessary to implement the efficient allocation. To the extent that the tariff set is higher than the one that implements the efficient allocation, the motive for expansionary monetary policy in our model would remain.

that the level of employment (and inflation) is very close to the baseline. One difference with respect to the baseline is that because of the upward path for p_t, we observe that consumption of foreign goods falls on impact but then rises over time.

5.3 Intermediate Inputs

Our analysis thus far has focused on imports of final consumption goods. We now extend the analysis to allow for imported intermediate inputs. We assume that the production of domestic intermediate goods requires inputs imported from abroad in addition to labor. In particular, the production function is given by $y_{jt} = \ell_{jt}^{1-\nu} x_{jt}^{\nu}$. In addition, the country's budget constraint becomes

$$c_t^h + pc_t^f + \frac{b_{t+1}}{R^*} = b_t + \left(1 - \frac{\varphi}{2}\pi_t^2\right) y_t - p_t x_t^f, \tag{33}$$

where the last term on the right-hand side represents the cost of imported intermediate inputs.

The firm's problem differs from the one described in (5) in that the firm now has a choice about the use of alternative factors of production, labor, and inputs. Moreover, the marginal cost now depends on both wages and the price of imported inputs, inclusive of tariffs (see Appendix B for details). Consequently, tariffs raise the marginal cost of production and lower output for given monetary policy. However, a similar insight to our baseline carries over. Tariffs induce firms to perceive an inefficiently high cost of imports, which the monetary authority counteracts by stimulating the economy.

Figure 6 presents the results of a permanent tariff that applies to both consumption goods and inputs.[14] We calibrate the output elasticity with respect to imported inputs to match that half of imports correspond to intermediate inputs, which results in $\nu = 0.39$ (and recalibrate ω to continue to match the import-GDP ratio). As the figure shows, under the look-through policy, output falls both because of the reduction in employment and intermediate inputs. Under the optimal policy, the stimulus effect on employment (panel c) exceeds the contraction in imported inputs (panel k), and thus GDP expands (panel l).

Our modeling of the look-through policy in the version with imported inputs mirrors the baseline model without inputs. That is, we assume that the monetary stance remains unchanged in response to a tariff shock and the monetary authority keeps zero inflation of

[14] Figures B.1 and B.2 present the cases where tariffs apply only to consumption goods or intermediate inputs.

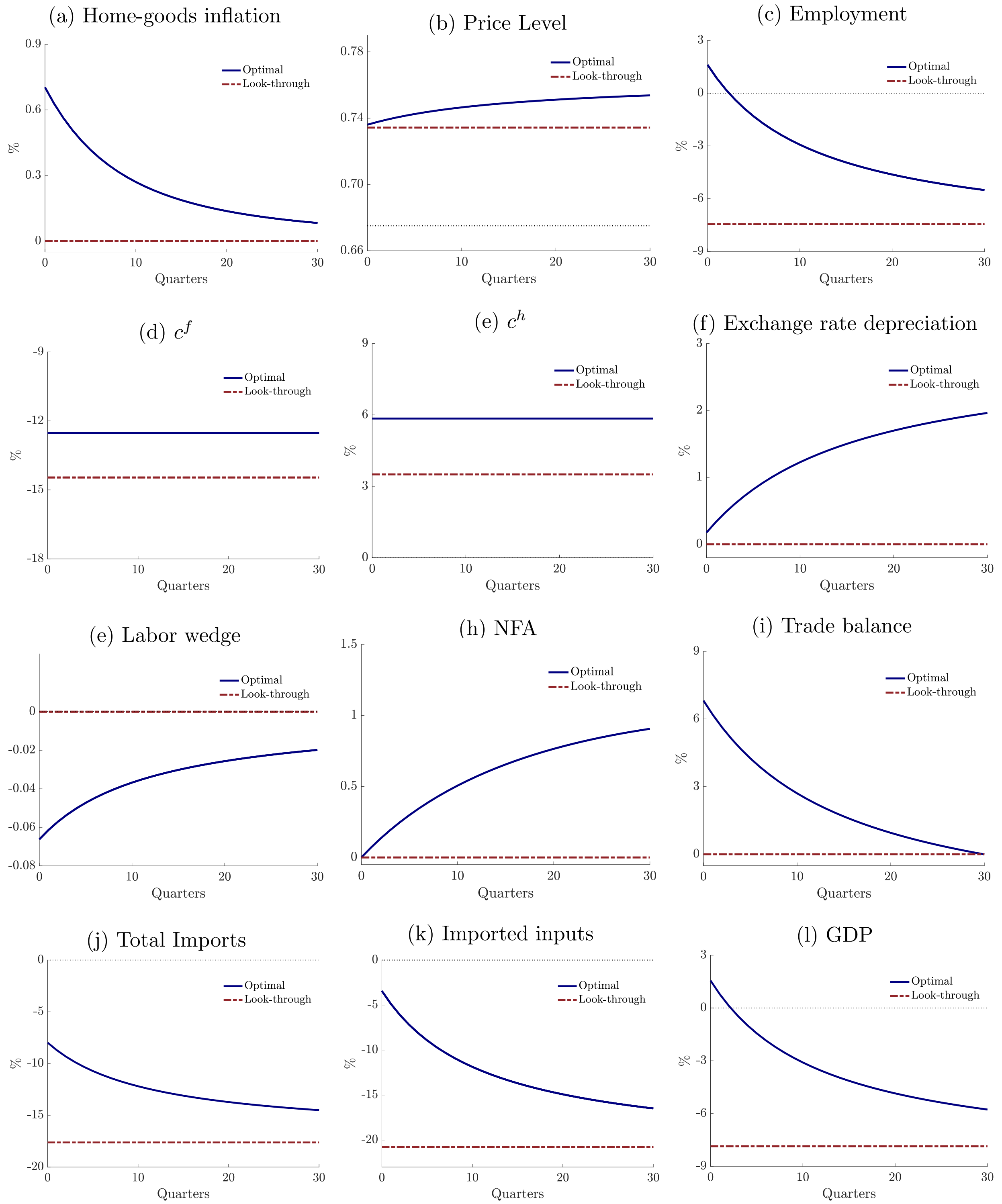

Figure 6: Response to a tariff shock in the model with imported inputs.

Note: The tariff is imposed on imported consumption goods and intermediate inputs with $\tau_t = 10\%$ for all t. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

home goods, $\pi_t = 0$. However, there is a key difference in how tariffs affect the CPI compared to the baseline model. When tariffs apply only to consumption goods, they directly raise the price of final consumption goods. In that case, under the look-through policy, the CPI experiences a one-time jump, with inflation returning to zero thereafter. In contrast, when tariffs apply to imported inputs, the price of final consumption goods remains unchanged unless monetary policy responds. As a result, when tariffs apply *only* to imported inputs, a look-through policy is equivalent to CPI inflation targeting, as illustrated in Figure B.1 in the appendix.

Additionally, just as in the baseline model, there is a fundamental difference in how monetary policy responds to tariffs and terms-of-trade shocks. A TOT shock to the price of intermediate inputs calls for maintaining PPI inflation at zero while allowing output to decline because of the increase in production costs (see Figure B.3).[15] By contrast, in response to a tariff on imported inputs, the optimal monetary policy is expansionary.

5.4 Welfare

Table 2: Welfare Implications

	Gain Optimal Policy	Losses from Tariffs	
		Optimal Policy	Look-through
Baseline	0.013	0.32	0.34
Endogenous TOT	0.013	0.32	0.34
Anticipated tariffs	0.012	0.33	0.34
Distorted steady state	0.086	-0.06	0.03
Model w/ imported inputs			
Tariffs on c and x	0.312	0.78	1.10
Tariffs on c	0.026	0.30	0.33
Tariffs on x	0.162	0.38	0.55

Note: Welfare corresponds to permanent consumption equivalence and is expressed in percentage.

In this section, we evaluate the welfare implications of tariffs and optimal monetary policy. Table 2 presents the results, where welfare is measured in terms of permanent consumption

[15] In other words, divine coincidence holds in our model for TOT shocks to imported inputs. Other studies such as Bodenstein, Guerrieri and Kilian (2012) study the response to oil price shocks with wage rigidities and find that a rise in PPI inflation is desirable.

equivalence. The table reports that in our baseline calibrated model, tariffs result in a sizable welfare loss of 0.25% under the look-through policy. Moreover, optimal policy improves welfare by 0.015% relative to the look-through policy. Interestingly, the extension with intermediate inputs reveals that the welfare costs of tariffs on inputs exceed the welfare costs of tariffs on consumption, despite their roughly equal shares.

The welfare analysis in the case of a distorted steady state deserves some discussion. When the labor subsidy is zero, the economy operates with a positive labor wedge in steady state. In this setting, even thought the tariff distorts the relative consumption, it may improve welfare by lowering the labor wedge. Under the baseline calibration, the table shows that tariffs improve welfare when the monetary authority follows the optimal policy.

6 Conclusion

Tariffs are back as a policy tool. In this paper, we provide a simple theory of how a monetary authority should respond to the introduction of tariffs. We show that in our model, the optimal monetary policy is expansionary, leading to a rise in inflation above and beyond the direct effects of tariffs on imported goods. In essence, tariffs inefficiently reduce private incentives to import foreign goods. The optimal monetary response is to stimulate the economy, raising aggregate income and boosting demand for imported goods.

We conclude by noting that our model is intentionally stylized and abstracts from several important considerations. In particular, we have abstracted from trade wars, as well as strategic and geopolitical factors. Incorporating these elements and investigating how they shape the optimal conduct of monetary policy represents an exciting direction for future research.

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A Proof of Proposition 2

Proof. Using $\beta R^* = 1$ and b_0, (13)-(16), we have that

$$c_t^h = c^h, \tag{A.1}$$

$$c^f = \left(\frac{1-\omega}{\omega p(1+\tau)}\right)^{\gamma} c^h, \tag{A.2}$$

$$(1+\pi_t)\pi_t = \frac{\varepsilon}{\varphi}\left[(\omega\Theta_\tau)^{\frac{\gamma-\sigma}{\sigma(\gamma-1)}}\left(c^h\right)^{\frac{1}{\sigma}}\ell_t^{\psi} - 1\right] + \beta\frac{\ell_{t+1}}{\ell_t}(1+\pi_{t+1})\pi_{t+1}, \tag{A.3}$$

$$b_0 = \sum_{t=0}^{\infty}\beta^t\left[c^h + pc^f - \ell_t\right] \tag{A.4}$$

Note that to obtain (A.1), we first use (15) to get

$$u_h\left(c_t^h, c_t^f\right) = \omega\left(\omega\mathcal{M}_t\right)^{\frac{\sigma-\gamma}{\sigma(\gamma-1)}}\left(c_t^h\right)^{-\frac{1}{\sigma}}$$

Plugging it into (16), that is $u_h(c_t^h, c_t^f) = u_h(c_{t+1}^h, c_{t+1}^f)$, we arrive at $c_t^h = c_{t+1}^h$ for all t.

Under the look-through policy $\pi_t = 0$ for all t and the allocation is

$$\ell^{look} = \left[\frac{\Theta_\tau+\tau}{1+\tau}(\omega\Theta_\tau)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}},$$

$$c^{h,look} = \frac{1+\tau}{\Theta+\tau}\left[\frac{\Theta_\tau+\tau}{1+\tau}(\omega\Theta_\tau)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}},$$

$$c^{f,look} = \frac{\Theta_\tau-1}{p(\Theta+\tau)}\left[\frac{\Theta_\tau+\tau}{1+\tau}(\omega\Theta_\tau)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}}$$

Under the optimal policy, the Ramsey planner solves (17). Denoting by λ the Lagrange multiplier on (18), the first-order condition for ℓ_t and c^h are respectively given by

$$\omega\ell_t^{\psi} = \lambda, \quad \text{and} \quad (\omega\Theta_\tau)^{\frac{\gamma(\sigma-1)}{\sigma(\gamma-1)}}\left(c^h\right)^{-\frac{1}{\sigma}} = \lambda\frac{\Theta_\tau+\tau}{1+\tau}, \tag{A.5}$$

which imply that ℓ is constant. Using (18) and (A.5), we arrive at

$$\ell = \left[\left(\frac{1+\tau}{1+\Theta_\tau^{-1}\tau}\right)^{\sigma}\frac{\Theta_\tau+\tau}{1+\tau}(\omega\Theta_\tau)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}},$$

$$c^h = \frac{1+\tau}{\Theta+\tau}\left[\left(\frac{1+\tau}{1+\Theta_\tau^{-1}\tau}\right)^{\sigma}\frac{\Theta_\tau+\tau}{1+\tau}(\omega\Theta_\tau)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}},$$

$$c^f = \frac{\Theta_\tau-1}{p(\Theta+\tau)}\left[\left(\frac{1+\tau}{1+\Theta_\tau^{-1}\tau}\right)^{\sigma}\frac{\Theta_\tau+\tau}{1+\tau}(\omega\Theta_\tau)^{\frac{\sigma-\gamma}{\gamma-1}}\right]^{\frac{1}{1+\sigma\psi}}$$

In addition, given that $\Theta_\tau > 1$, we have that

$$\frac{1+\tau}{1+\Theta_\tau^{-1}\tau} > 1,$$

Using this inequality, we obtain $\ell > \ell^{look}$, $c^h > c^{h,look}$ and $c^f > c^{f,look}$. Finally, we use (A.3) and (A.5), to get $\ell_{t+1} = \ell, c_t^h = c^h$. Solving for a constant level of inflation $\pi_t = \pi$, we obtain

$$\begin{aligned}(1+\pi)\pi &= \frac{\varepsilon}{\varphi}\sum_{t=0}^{\infty}\beta^t\left[(\omega\Theta_\tau)^{\frac{\gamma-\sigma}{\sigma(\gamma-1)}}(c^h)^{\frac{1}{\sigma}}\ell^{\psi}-1\right]\\ &= \frac{\varepsilon}{\varphi(1-\beta)}\frac{\Theta_\tau-1}{1+\tau} > 0 \end{aligned} \tag{A.6}$$

where the inequality follows from $\Theta > 1$. Given that a root with $\pi < -1$ is not feasible, the optimal policy therefore implies $\pi > 0$. □

B Appendix to the Model with Imported Inputs

The household problem is identical to the baseline model. As in Section 2, there are two types of firms: intermediate and final good producers. The problem of final good producers remain the same. The intermediate producer firm produces a variety j out of labor ℓ_{jt} and intermediate inputs x_{jt} according to $y_{jt} = (\ell_{jt})^{1-\nu}(x^f_{jt})^{\nu}$. Cost minimization requires that firms optimally split expenditures on labor and imported inputs according to

$$p(1+\tau^x_t)x^f_{jt} = \frac{\nu}{1-\nu}\,\frac{W_t}{P^h_t}\ell_{jt}.$$

The problem of the firm is analogous to (5). To ensure that the steady state is efficient, we assume now a subsidy on production, instead of the wage bill. We have the following dynamic Phillips curve

$$(1+\pi_t)\pi_t = \frac{\varepsilon}{\varphi}\left[mc_t - 1\right] + \beta\frac{u_h(c^h_{t+1}, c^f_{t+1})}{u_h(c^h_t, c^f_t)}\frac{y_{t+1}}{y_t}(1+\pi_{t+1})\pi_{t+1},$$

where the real marginal cost of production is given by

$$mc_t = \left(\frac{W_t}{(1-\nu)P^h_t}\right)^{1-\nu}\left(\frac{p(1+\tau^x_t)}{\nu}\right)^{\nu},$$

where τ^x_t is the tariff on imported inputs.

Firms' profits transferred to households are now given by

$$\frac{D_t}{P^h_t} = (1+s)y_t - \frac{W_t}{P^h_t}\ell_t - p(1+\tau^x_t)x^f_t - \frac{\varphi}{2}\pi^2_t\, y_t.$$

The government budget constraint satisfies

$$P^f_t(\tau^c_t c^f_t + \tau^x_t x^f_t) = T_t + s\,P^h_t y_t.$$

Combining the last two conditions with the households' budget constraint, we arrive to (33).

Optimal Monetary Policy. Taking as given the sequence of tariffs for inputs and consumption goods $\{\tau^x_t, \tau^c_t\}$, the monetary authority chooses the competitive equilibrium that maximizes social welfare. We can write the problem as follows:

$$\max_{\left\{b_{t+1},\pi_t,\ell_t,x_t,c_t^f,c_t^h\right\}} \sum_{t=0}^{\infty} \beta^t \left[u(c_t^h, c_t^f) - \omega \frac{\ell_t^{1+\psi}}{1+\psi}\right], \tag{B.1}$$

subject to

$$c_t^h + pc_t^f + px_t^f + \frac{b_{t+1}}{R^*} = b_t + \left[1 - \Upsilon \frac{\varphi}{2} \pi_t^2\right] \ y_t$$

$$(1+\pi_t)\pi_t = \frac{\varepsilon}{\varphi}\left[\kappa\left(\frac{\omega \ell_t^{\psi}}{u_h(c_t^h, c_t^f)}\right)^{1-\nu}\Big(p(1+\tau_t^x)\Big)^{\nu} - 1\right] + \beta \frac{u_h(c_{t+1}^h, c_{t+1}^f)}{u_h(c_t^h, c_t^f)} \frac{y_{t+1}}{y_t}(1+\pi_{t+1})\pi_{t+1},$$

$$c_t^f = \frac{1-\omega}{\omega p(1+\tau_t^c)} c_t^h,$$

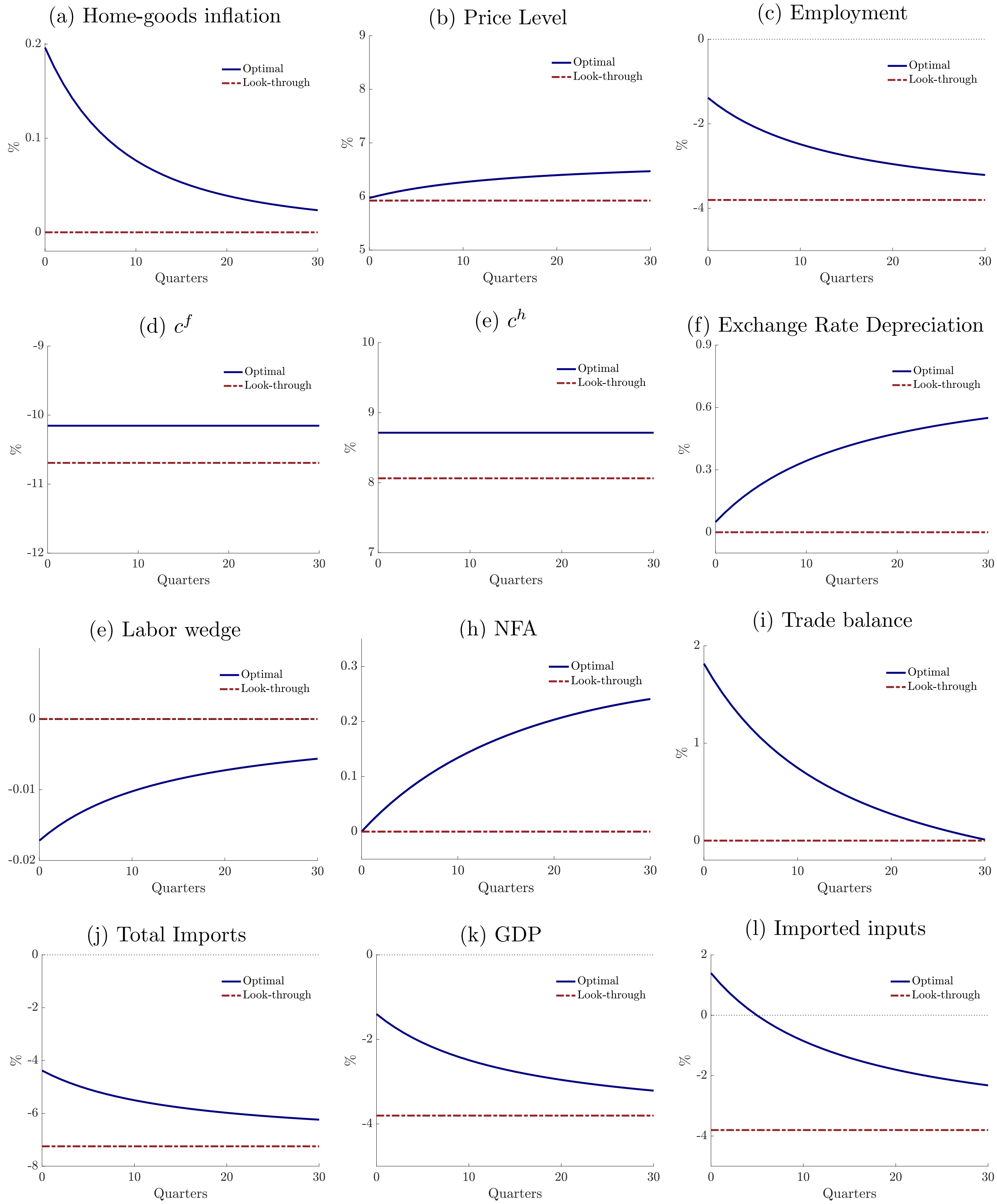
$$x_t^f = \frac{\nu}{1-\nu} \frac{c_t^h \ \ell_t^{\psi+1}}{p(1+\tau_t^x)}$$

$$u_h(c_t^h, c_t^f) = \beta R^* u_h(c_{t+1}^h, c_{t+1}^f)$$

$$y_t = (\ell_t)^{1-\nu} (x_t^f)^{\nu}$$

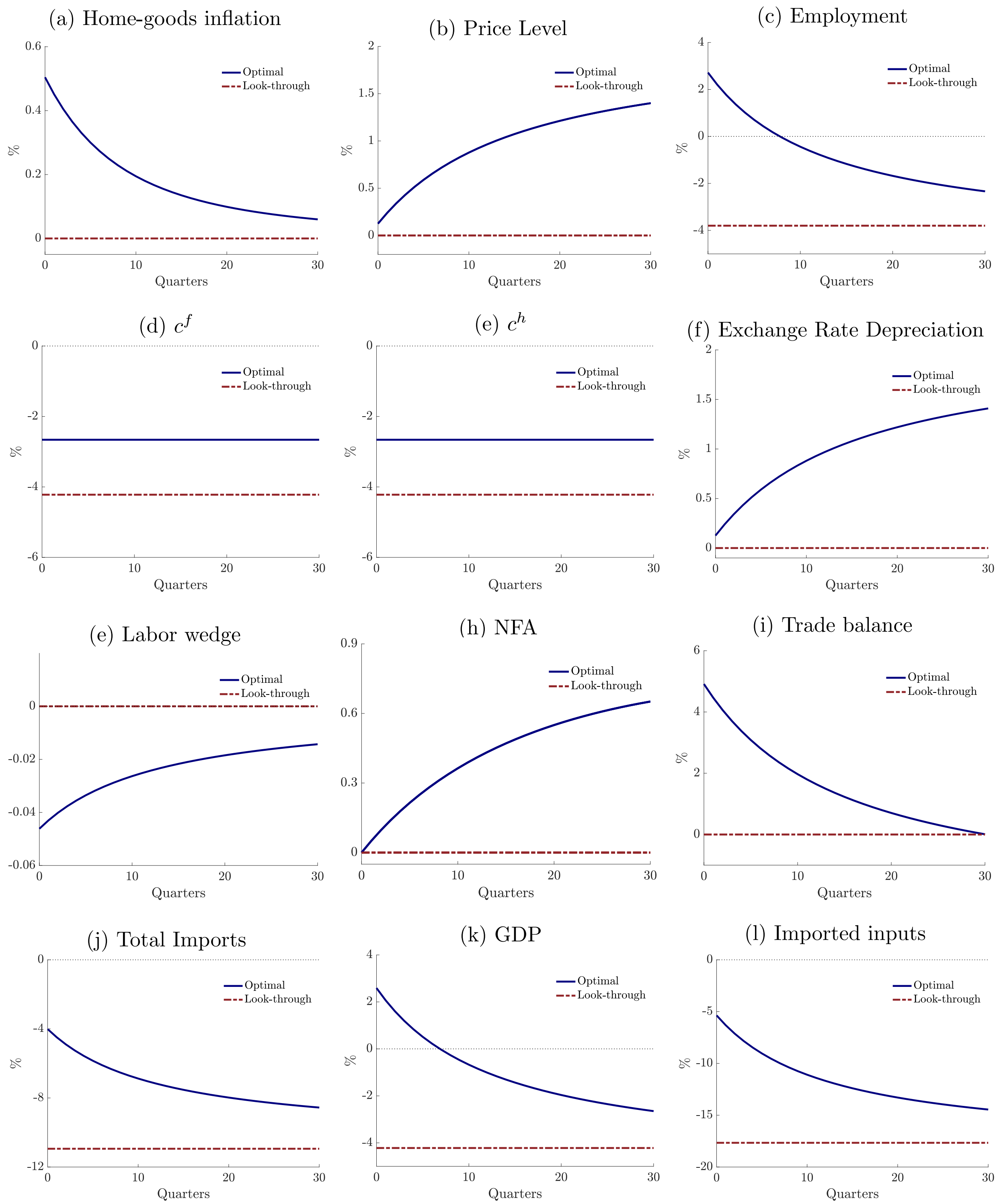
The simulation results of this policy problem are presented in Figures 6, B.1, and B.2.

Figure B.1: Tariff on foreign consumption goods in the model with imported inputs



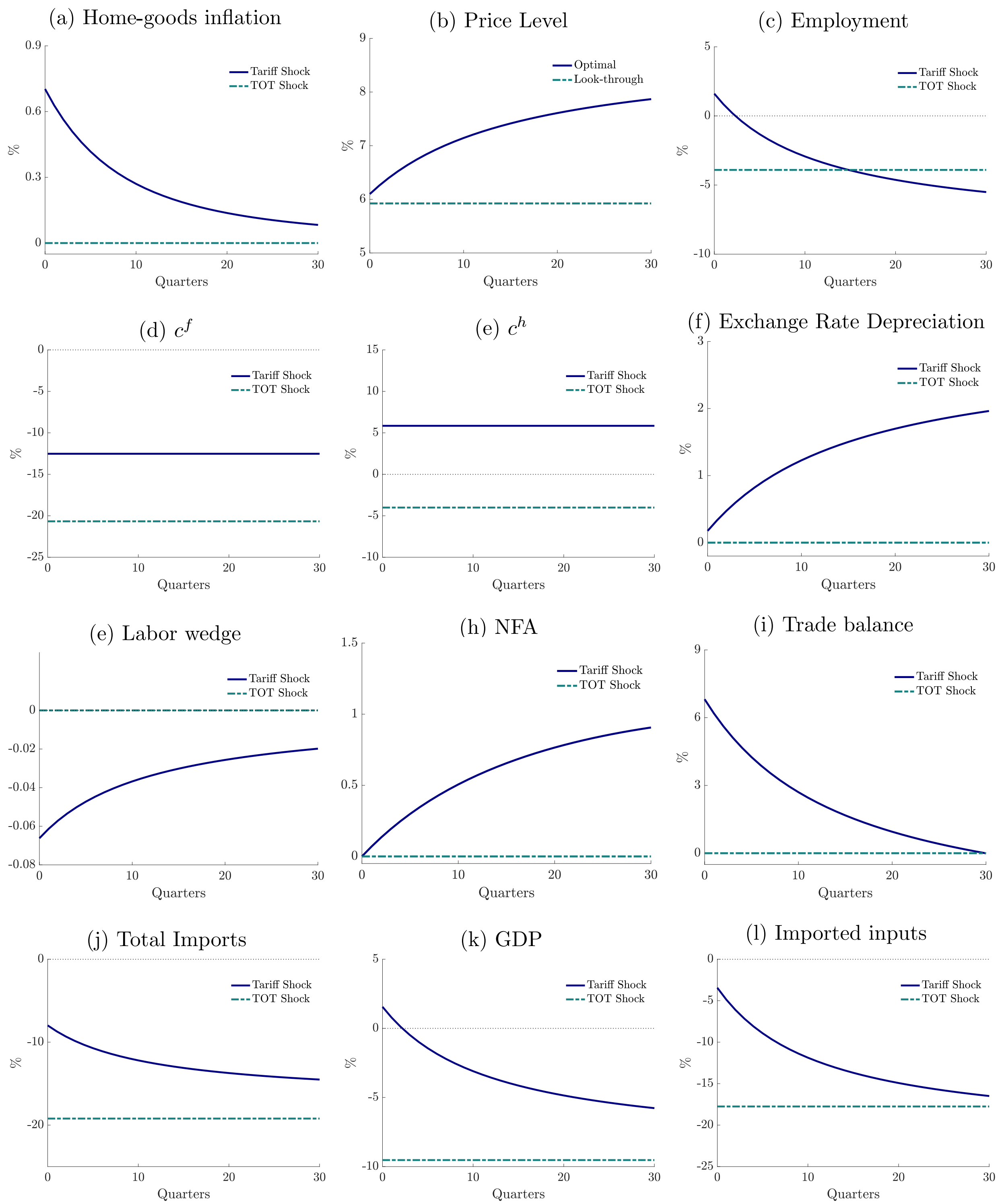
Note: The tariffs are set to $\tau_t^c = 10\%$ and $\tau_t^x = 0$. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

Figure B.2: Tariff on foreign inputs



Note: The tariffs are set to $\tau_t^x = 10\%$ and $\tau_t^c = 0$. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

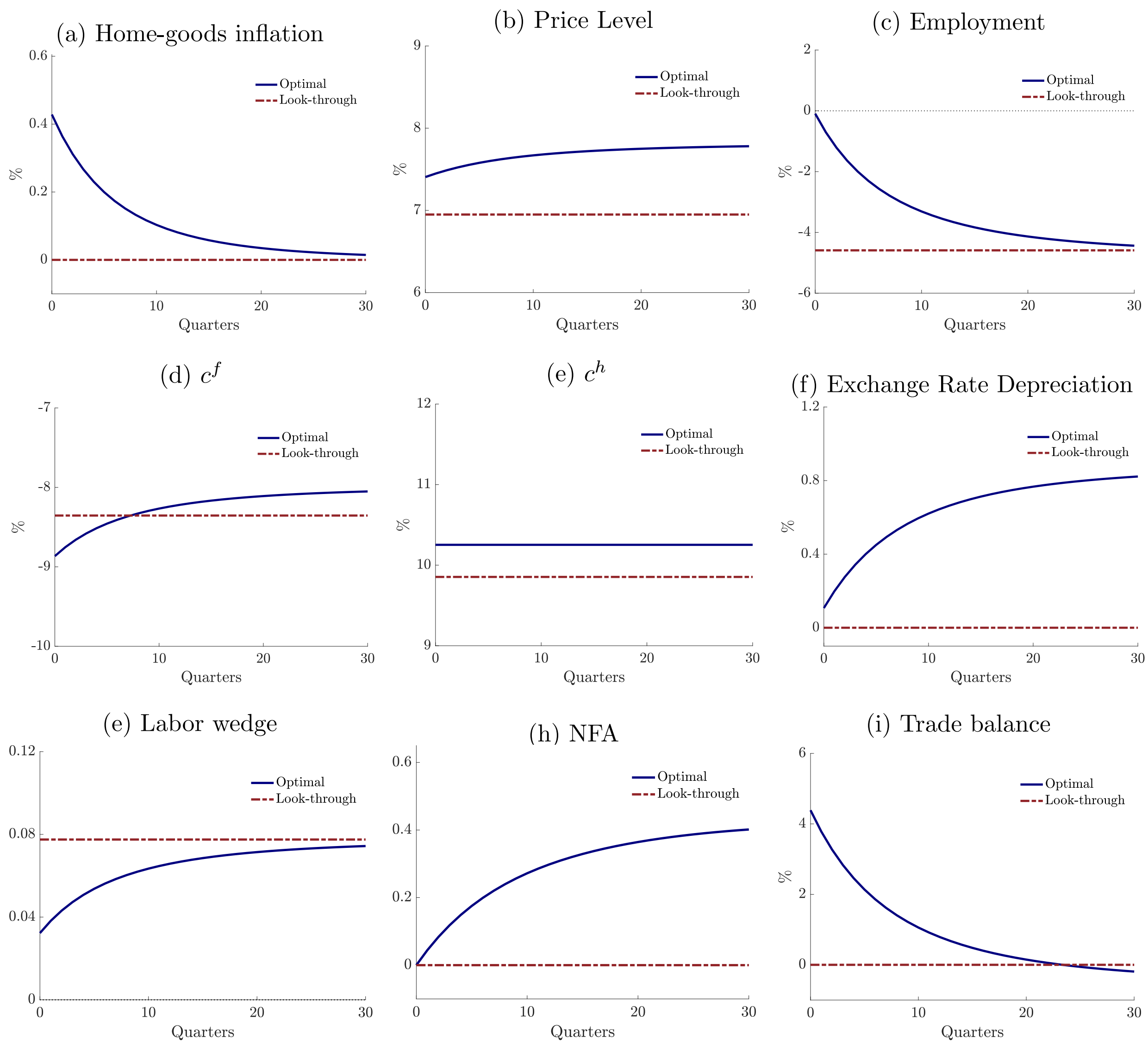
Figure B.3: Terms-of-trade shocks vs tariffs in the model with imported inputs



Note: We assume a permanent $\tau = 10\%$ for the tariff and a permanent increase in p of 10% in the case of TOT shocks. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.

C Additional Figures

Figure C.1: The case with endogenous terms of trade



Note: The figure displays the response to a permanent tariff of $\tau = 10\%$ when the relative price of imports is given by (32) and $\theta = 5$. The trade balance and the NFA position are expressed as a fraction of GDP. Consumption of home goods, employment, the exchange rate and the price level are expressed as percent deviation from the pre-tariff allocation.