The Optimal Monetary Policy Response to Tariffs*

Javier Bianchi
Federal Reserve Bank of Minneapolis

Louphou Coulibaly
University of Wisconsin-Madison
and NBER

December 11, 2024

Link to Latest version

Abstract

What is the optimal monetary policy response to a tariff shock? This paper explores this question in the context of an open economy New Keynesian model. We show that the optimal monetary policy response to a rise in domestic tariffs is expansionary. Specifically, the monetary authority should stimulate the economy, allowing inflation to rise above and beyond the direct effects of tariffs. Our analysis also suggests that tariffs can significantly exacerbate the time inconsistency problem of monetary policy.

Keywords: Tariffs, optimal monetary policy, inflation

JEL Codes: E24, E44, E52, F13, F41

*PRELIMINARY AND INCOMPLETE. First Draft, December 6, 2024. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1 Introduction

The prospect of rising tariffs in the US has sparked a debate about their inflationary consequences and how the Federal Reserve should respond. A prevalent view is that tariffs would generate a one-time increase in the price of imported goods and that the Federal Reserve should "look through," which implies that it would stay focused on stabilizing inflation of home produced goods.[1]

In this paper, we investigate the optimal monetary policy response to a tariff shock. Our framework is a dynamic, open economy New Keynesian model with home-produced and importable goods. In contrast to the view outlined above, we argue that the optimal monetary policy response is *expansionary*. The logic for this result stems from a fiscal externality created by tariffs. When a tariff is in place, households perceive a higher cost of importable goods compared to the social cost; that is, to the extent that tariff revenue is rebated, households' individual income increases with aggregate imports. Therefore, tariffs lead to an inefficient reduction of imports relative to home-produced goods. Given that monetary policy cannot change the price of importable goods relative to home-produced ones, the optimal policy turns out to be to overheat the economy, which raises total production and income and, through this channel, increases import consumption.

The optimal monetary response to a tariff shock contrasts with the optimal response to a terms-of-trade shock, such as a rise in oil prices. As highlighted by Aoki (2001), in an environment with imported consumption goods, the monetary authority should focus on stabilizing producer price inflation (PPI). Thus, in response to a shock that raises prices of imports, the central bank should refrain from tightening; instead, it should let the consumer price index (CPI) rise and stabilize PPI. However, in the case of tariffs, while the private cost for households increases, the social cost does not. Hence, our argument is that the optimal monetary policy response to a tariff is to keep consumption of imports high, which requires an expansionary monetary policy.

In a nutshell, the idea is that tariffs inefficiently reduce private incentives to consume imported goods. To counteract this effect, the monetary authority needs to stimulate the economy, raising aggregate income and leading to higher consumption of imported goods.

In response to a permanent tariff, our simulations show that inflation of home-produced goods rises initially under the optimal policy, accompanied by a depreciation of the dollar. However, over time, inflation returns to zero, and the exchange rate stabilizes at a higher value. Simultaneously, the economy experiences an increase in output and runs a persistent

[1] See the September 2018 Federal Reserve Tealbook for model simulations under the "look-through policy".

trade surplus. These results contrast with the "look-through policy" that keeps inflation of home produced goods at zero where the trade balance remains unchanged.

Literature. This paper contributes to the literature on the macroeconomic implications of tariffs. Several papers have studied monetary frameworks and analyze the extent to which tariffs may serve as a macroeconomic stabilization tool (Barattieri, Cacciatore and Ghironi, 2021; Auray, Devereux and Eyquem, 2022, 2024a,b; Jeanne, 2021; Erceg, Prestipino and Raffo, 2023).[2] The goal of our paper is different, in that we assess the optimal monetary response to an exogenous tariff policy. In this regard, the closest paper to ours is Bergin and Corsetti (2023) who study a two-country model with cooperative monetary policy. Different from us, they find that optimal policy prescribes a monetary contraction in the country imposing tariffs (and an expansion in the country whose exports are targeted). The key distinction is that under optimal cooperative policy, the central bank in the home country should appreciate the exchange rate to mitigate the fall in imports by the foreign country. We analyze instead optimal monetary policy from the perspective of a single economy that imposes tariffs on imports and find that the optimal response is expansionary.[3]

Our paper is also related to the extensive literature on optimal monetary policy. Specifically, we share with a subset of studies the implications of steady-state distortions, in particular because of markups or domestic taxes (see e.g. Galí, 2015 and Woodford, 2010 for textbook treatments and Afrouzi, Halac, Rogoff and Yared, 2023 for a recent example in the context of a dynamic non-linear framework). One important distinction here is that the distortion is not on production decitions but it instead applies to the relative consumption of two goods, one of which is produced domestically and one abroad. In contrast to existing results on cost-push shocks, we show that a tariff shock generates both a positive output gap and inflation under the optimal policy. Moreover, our paper is also related to the literature on post-COVID inflationary dynamics, in particular papers emphasizing sectoral considerations.[4] Relative to

[2]For additional work at the intersection of trade policy and international macroeconomics, see, e.g., Barbiero, Farhi, Gopinath and Itskhoki (2017), Lindé and Pescatori (2019), and Costinot and Werning (2019) for Lerner symmetry, Caldara, Iacoviello, Molligo, Prestipino and Raffo (2020) and Steinberg (2019) 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.

[3]Bergin and Corsetti (2023) also present a simple framework with full-risk sharing where the equilibrium with cooperative monetary policy coincides with the Nash equilibrium. In that framework with full risk-sharing, home policy responds to foreign tariffs, but not to tariffs levied by the home government.

[4]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).

these papers, we consider the inflationary consequences of trade policy and the implications for optimal monetary policy.

2 Model

We analyze an open economy framework with home-produced and importable goods, subject to nominal rigidities. We consider a small open economy (SOE); specifically, we assume that the relative price of exportable to importable goods and that the foreign interest rate are exogenous to the small open economy. There is a government in the SOE that sets a policy for tariffs $\{\tau_t\}$ and a monetary authority that chooses optimally monetary policy.

2.1 Households

There is a continuum of identical households with preferences given by

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

where

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

Consumption 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 ω is the preference weight for home goods, γ is the elasticity of substitution between the two goods and σ is the intertemporal elasticity of substitution.

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, where R_t 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.

We use the domestic currency as the numeraire. We denote by e_t the price of foreign currency in terms of domestic currency (with a higher e_t indicating a depreciation of the domestic currency), P_t^h the price of the home good in domestic currency, and P_t^f the price of the foreign good in domestic currency before tariffs. The law of one price holds for the

domestic good, $P_t^h = P_t^{h,*} e_t$, where $P_t^{h,*}$ is the price of the home good in foreign currency, which we assume is constant and normalized to one. The law of one price also holds for the foreign good before tariffs, so that $P_t^f = P_t^{f,*} e_t$, where $P_t^{f,*}$ is the price of the foreign good in foreign currency, assumed to be constant. Because the country is small in terms of both production and the consumption of the two goods, the relative price of foreign goods is exogenous and given by $\frac{P_t^{*,f}}{P_t^{*,h}} = p$.[5]

The budget constraint is given by

$$P_t^h c_t^h + P_t^f (1+\tau_t) c_t^f + \frac{e_t b_{t+1}}{R^*} + \frac{B_{t+1}}{R_t} = e_t b_t + B_t + W_t \ell_t + T_t + D_t, \tag{2}$$

where D_t denotes firms' profits, τ_t denotes the tariff, and T_t represents lump-sum transfers, both in domestic currency.

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 (1) subject to (2) and a no-Ponzi-game condition. The first-order conditions yield the following:

$$\frac{W_t}{P^h} u_h(c_t^h, c_t^f) = v_\ell(\ell_t), \tag{3}$$

$$\frac{1-\omega}{\omega}\left(\frac{c_t^h}{c_t^f}\right)^{\frac{1}{\gamma}} = p(1+\tau_t), \tag{4}$$

$$\frac{u_f(c_t^h, c_t^f)}{1+\tau_t} = \beta R^* \frac{u_f(c_{t+1}^h, c_{t+1}^f)}{1+\tau_{t+1}}, \tag{5}$$

$$R_t = R^* \frac{e_{t+1}}{e_t}, \tag{6}$$

where we use u_h and u_f to denote the partial derivatives of the utility function with respect to c^h and c^f.

Condition (3) represents the labor supply decision. Condition (4) 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 (5) determines savings and the intertemporal path for consumption. Finally, (6) is the uncovered interest parity condition (UIP) that 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 is undetermined. For simplicity, we assume $B_0 = 0$ to abstract from initial valuation effects.

[5] For our purpose, an advantage of this assumption is that we can abstract from terms of trade externalities.

2.2 Firms

There are two types of firms. One set of firms produces the home good with a CES production function,

$$y_t^h = \left(\int_0^1 y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{7}$$

where y_{jt} represents varieties of intermediate inputs and ε is the elasticity of substitution.

Final good producers take as given the price of the home good and the prices of intermediate inputs. Cost minimization implies the following downward sloping demand for intermediate inputs: $y_{jt} = \left(\frac{P_t^h}{P_{jt}}\right)^{\varepsilon} y_t^h$. 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 $y_{jt} = z\ell_{jt}$, with productivity normalized to $z = 1$. We assume a quadratic cost from changing prices, as in Rotemberg (1982). The problem of the intermediate good firm is

$$\begin{aligned} \max_{\{y_{jt},\ell_{jt},p_{jt}\}} & \sum_{t=0}^{\infty} \Lambda_{t+1} \left[p_{jt} y_{jt} - W_t(1-s)\ell_t - \frac{\varphi}{2} \left(\frac{P_{jt}}{P_{j,t-1}} \right)^2 y_{jt} \right], \\ & \text{subject to} \\ & y_{jt} = \ell_{jt}, \\ & y_{jt} = \left(\frac{P_t^h}{P_{jt}} \right)^{\varepsilon} y_t^h, \end{aligned} \tag{8}$$

where s is the standard subsidy on the wage bill to correct the markup distortion, and $\Lambda_{t+1} = \beta \frac{u_h(t+1)}{u_h(t)} \frac{P_t^h}{P_{t+1}^h}$ is the discount factor for the firm.

Optimality and using symmetry, $P_{jt} = P_t^h$ for all j, yields the standard NK dynamic Phillips curve:

$$(1+\pi_t)\pi_t = \frac{\varepsilon - 1}{\varphi} \left[\frac{W_t}{P_t^h} - 1 \right] + \beta \frac{u_h(c_{t+1}^h, c_{t+1}^f)}{u_h(c_t^h, c_t^f)} \frac{\ell_{t+1}}{\ell_t} (1+\pi_{t+1})\pi_{t+1}, \tag{9}$$

where $\pi_t \equiv P_t^h / P_{t-1}^h - 1$ represents the inflation rate of home produced goods, which we often refer as inflation for short.

In addition, total firms' profits transferred to households are given by

$$D_t = (P_t^h - W_t(1+s)) y_t^h - \Upsilon \frac{\varphi}{2} \pi_t^2. \tag{10}$$

Notice that in (10), we allow for a fraction of the cost of price changes to be rebated back to households. In particular, Υ represents the fraction of price adjustment costs that are deadweight losses. The benchmark case in the New Keynesian model is $\Upsilon = 1$, which will be our main focus.

2.3 Government

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

$$\tau_t P_t^f c_t^f = T_t - sW_t\ell_t. \tag{11}$$

2.4 Competitive equilibrium

We are now ready to define a competitive equilibrium.

Definition 1. Given initial bonds b_0, terms of trade p, prices of goods in foreign currency $\left\{P^{h,*}, P^{f,*}\right\}$, a goverment policy $\{\tau_t, T_t\}$, 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, (3)-(6) hold;

ii) firms maximize profits; that is, (9) holds;

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

iii) the government budget constraint (11) 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:

$$\underbrace{(1 - \Upsilon\frac{\varphi}{2}\pi^2)z\ell_t - c_t^h}_{\text{exports}} - \underbrace{c_t^f p}_{\text{imports}} = \underbrace{p\left(\frac{b_{t+1}}{R} - b_t\right)}_{\text{capital outflows}} \tag{12}$$

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:

$$\max_{\{b_{t+1},c_t^f,c_t^h,\ell_t\}} \sum_{t=0}^{\infty} \beta^t [u(c_t^h, c_t^f) - v(\ell_t)], \tag{13}$$

subject to

$$c_t^h + pc_t^f + \frac{b_{t+1}}{R^*} = b_t + \ell_t. \tag{14}$$

Optimality implies that

$$u_h(c_t^h, c_t^f) = v_\ell(\ell_t), \tag{15}$$

$$\frac{1-\omega}{\omega}\left(\frac{c_t^h}{c_t^f}\right)^{\gamma} = p, \tag{16}$$

$$u_f(c_t^h, c_t^f) = \beta R^* u_f(c_{t+1}^h, c_{t+1}^f). \tag{17}$$

That is, the planner equates the marginal utility benefit from one extra unit of labor to the marginal utility cost from working, the marginal rate of substitution between home and foreign goods to the relative international price, 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 three distortions introduced by sticky prices and tariffs. First, from (9), nominal rigidities potentially imply that the wage deviates from the marginal product of labor, which implies a deviation from (15). Second, the tariff distorts the optimal consumption mix between home and foreign goods. Finally, to the extent that the tariff varies over time, there is a distortion in the incentives to save and borrow.

3 Optimal Monetary Policy

We now address the question of how monetary policy should respond when the government introduces tariffs. We consider first the case with commitment. The Ramsey optimal monetary

policy consists of choosing the competitive equilibrium that maximizes welfare:

$$\max_{\{b_{t+1},\pi_t,\ell_t,c_t^f,c_t^h\}} \sum_{t=0}^{\infty} \beta^t \left[u(c_t^h, c_t^f) - \omega \frac{\ell_t^{1+\psi}}{1+\psi} \right], \tag{18}$$

subject to

$$c_t^h + p c_t^f + \frac{b_{t+1}}{R^*} = b_t + \left[1 - \Upsilon \frac{\varphi}{2} \pi_t^2 \right] \ell_t \tag{19}$$

$$(1+\pi_t)\pi_t = \frac{\varepsilon - 1}{\varphi} \left(c_t^h \left(\ell_t \right)^{\psi} - 1 \right) + \beta \frac{u_h(c_{t+1}^h, c_{t+1}^f)}{u_h(c_t^h, c_t^f)} \frac{\ell_{t+1}}{\ell_t} \pi_{t+1}, \tag{20}$$

$$\frac{1-\omega}{\omega} \left(\frac{c_t^h}{c_t^f} \right)^{\gamma} = p(1+\tau_t), \tag{21}$$

$$u_f(c_t^h, c_t^f) = \beta R^* \left(\frac{1+\tau_t}{1+\tau_{t+1}} \right) u_f(c_{t+1}^h, c_{t+1}^f). \tag{22}$$

We note that in the absence of tariffs, $\tau_t = 0$ for all t, a monetary policy that stabilizes prices achieves the efficient allocation. This can be seen by noting that by setting $\tau_t = 0$ and $\pi_t = 0$ in the implementability constraints in problem (18), we arrive at (14)-(17), the conditions characterizing the efficient allocation.

However, in the presence of positive tariffs, the efficient allocation is not feasible. In particular, (21) indicates that the ratio of home to foreign consumption becomes too high relative to what the planner for any monetary policy would choose. Implementing $\pi_t = 0$ for all t would then imply from (19) and (20) that consumption of home goods would be too high and consumption of foreign goods be too low. Departing from $\pi_t = 0$ for all t leads to a zero first-order loss of resources, while (20) and (21) suggest that introducing positive inflation can have a first-order gain in welfare by strictly relaxing (21), thus enabling higher consumption of imported goods.

Analytical example. To simplify the analysis, let us assume that $\beta R^* = 1$, $\Upsilon = 0$, $\psi = 0$,$\tau_t = \tau$ and $\gamma = \sigma = 1$. These assumptions imply, respectively, that (i) domestic households are as impatient as foreign ones, (ii) price adjustment costs are fully rebated to households, (iii) the disutility of labor is linear, (iv) tariffs are constant, and (v) the utility function is separable between home and foreign goods (with unitary elasticities across time and goods).

Under these conditions, the efficient allocation yields $c^h = 1$ and $c^f = \frac{1-\omega}{\omega p}$, as can be seen by replacing these parametric assumptions in (14)- (17). Notice also that if the monetary authority were to implement $\pi_t = 0$, we would have $c^h = 1$ and $c^f = \frac{1-\omega}{\omega p(1+\tau)}$, and thus an

inefficiently low level of imports. As we will see next, keeping zero inflation will not be optimal.

To solve for the optimal monetary policy, we can use the fact that $\Upsilon = 0$ implies that π_t appears only in the Phillips curve, and thus we can drop constraint (20). Moreover, constant tariffs and $\beta R^* = 1$ imply that that home and foreign consumption are constant. Under these assumptions, we can therefore write the central bank problem as

$$\max_{\{b_{t+1},\ell_t,c^h\}} \sum_{t=0}^{\infty} \beta^t \big[\log(c^h) - \omega \ell_t \big], \tag{23}$$

subject to

$$\left(\frac{1+\omega\tau}{\omega+\omega\tau} \right) c^h + \frac{b_{t+1}}{R^*} = b_t + \ell_t, \tag{24}$$

where notice we have replaced c^f using (21) in the resource constraint and in the objective function.

The solution to this problem yields

$$c^h = \frac{1+\tau}{1+\omega\tau} > 1, \quad c^f = \frac{1-\omega}{\omega p(1+\omega\tau)}, \tag{25}$$

which imply total consumption expenditures given by Notice that replacing the solution for c^h in (20) and substituting $\psi = 0$ shows that $\pi_t > 0$. Intuitively, given that consumption exceeds the level associated with the zero inflation allocation, implementing this higher level of consumption requires higher inflation to stimulate the economy. That is, in this simple case considered here, the optimal monetary policy response to a constant tariff is to raise permanently the level of inflation.

Case with inflation costs. 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 $\Upsilon = 1$, while allowing for $\psi > 0$ and maintaining the other simplifying assumptions that $\beta R^* = 1, \tau_t = \tau$ and $\gamma = \sigma$. Under these assumptions, we have that (22) implies that c_t^f is constant, and thus from (21), we also

have that c_t^h is constant. We can therefore write the problem as

$$\max_{\{b_{t+1},c^h,c^f,\ell_t,\pi_t\}} \sum_{t=0}^{\infty} \beta^t \left[\omega \log\left(c^h\right) + (1-\omega)\log(c^f) - \omega \frac{\ell_t^{1+\psi}}{1+\psi} \right], \tag{26}$$

subject to

$$b_0 = \sum_{t=0}^{\infty} \beta^t \left[c^h + pc^f - \left[1 - \frac{\varphi}{2}\pi_t^2\right] \ell_t \right], \qquad [\lambda_t] \tag{27}$$

$$(1+\pi_t)\pi_t = \frac{\varepsilon - 1}{\varphi}\left(c^h \ell_t^{\psi} - 1\right) + \beta \frac{\ell_{t+1}}{\ell_t}(1+\pi_{t+1})\pi_{t+1}, \qquad [\eta_t] \tag{28}$$

$$\frac{1-\omega}{\omega}\left(\frac{c^h}{c^f}\right) \geq p(1+\tau), \qquad [\xi] \tag{29}$$

with Lagrange multipliers in brackets. We note that while the constraints hold with equality at the optimum, we express them with inequality to reflect the direction in which the constraint binds for $\tau > 0$. That is, we proceed to characterize the results under the presumption that the Lagrange multipliers λ_t, η_t and ξ are positive.[6]

Optimality with respect to c^h yields

$$\left[1 + \xi p(1+\tau)\right] \frac{\omega}{c^h} = \lambda + \frac{\varepsilon - 1}{\varphi}(1-\beta) \sum_{t=0}^{\infty} \beta^t \ell_t^{\psi} \eta_t, \tag{30}$$

where we have used that λ_t is constant given that $\beta R^* = 1$. Condition (30) 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 restriction that equates the MRS to the relative price, (29). The costs are given by the shadow value of resources plus the inflationary cost captured by the marginal effect on the Phillips curve constraint (28). Optimality with respect to c^f yields:

$$\left[1 - \xi p(1+\tau)\right] \frac{1-\omega}{c^f} = \lambda. \tag{31}$$

where now a higher c^f tightens (29).

In addition, the first-order condition with respect to $\{\ell_t\}$ (and combining with the Phillips

[6] Notice that if at the optimum $(1+\pi_t)\pi_t > \frac{\varepsilon-1}{\varphi}\left(c^h \ell_t^{\psi} - 1\right) + \beta \frac{\ell_{t+1}}{\ell_t}(1+\pi_{t+1})\pi_{t+1}$ for some t, given consumption and employment, a lower π_t would help relax the country budget constraint (14) at time t.

curve) yields

$$\omega\left(\ell_t\right)^{\psi}+\frac{\varepsilon-1}{\varphi}\left(\left(\psi+1\right)c^{h}\left(\ell_t\right)^{\psi-1}-1\right)\eta_t-\left(1+\pi_t\right)\pi_t\left(\frac{\eta_t}{\ell_t}-\frac{\eta_{t-1}}{\ell_{t-1}}\right)=\left(1-\frac{\varphi}{2}\pi_t^2\right)\lambda \quad (32)$$

which equates the marginal cost from one more unit of labor (including the distulity cost and the cost from tightening the Phillips curve) to the marginal value of the additional resources.

For $t>0$, we have the following optimality with respect to $\{\pi_t\}$:

$$\pi_t=\frac{1+2\pi_t}{\varphi\lambda}\left(\frac{\eta_t}{\ell_t}-\frac{\eta_{t-1}}{\ell_{t-1}}\right) \quad (33)$$

while for $t=0$, we have

$$\pi_0=\frac{1+2\pi_0}{\varphi\lambda\ell_0}\eta_0 \quad (34)$$

Comparing to (33), this equation shows that the monetary authority perceives a higher cost from future inflation because through the forward-looking Phillips curve, this generates more inflation today.

This last condition indicates that if $\pi_0>0$, we then have that $\eta_0>0$. Intuitively, for the central bank to face higher inflation, it must be that the Phillips curve constraint is binding. To see why deviating from zero inflation is optimal, suppose that $\pi_t=0$ for all t. Then from (28) , $l_t^{\psi}=1/c^h$. Then, (31), (32) and the fact that $\xi>0$, yield $c^h<\ell^{-\psi}$, a contradiction.

3.1 Quantitative Simulations

Calibration. We calibrate the model to the U.S. economy at a quarterly frequency and solve it non-linearly.[7] Table 1 presents the values for the parameters. We set the elasticity of substitution between home and foreign goods equal to $\gamma=2$, which is in line with empirical estimates (see e.g., Boehm, Levchenko and Pandalai-Nayar, 2023). In addition, we assume an elasticity of intertemporal elasticity such that $\sigma=\gamma=2$, which is in the range of empirical estimates (e.g., Gruber, 2013) and simplifies the numerical solution by having preferences separable between the two goods. We calibrate the home bias parameter ω to 0.80, which implies a ratio of imports to GDP of 15.5%, which corresponds to the value for the U.S. in 2022. In line with evidence by Kimball and Shapiro (2008), the Frisch elasticity of labor

[7]Notice that a challenge for local methods is that the economy is non-stationary, implying that any shock leads to a permanent change in the long-run allocations.

supply ψ is set to 1. The discount factor is set to $\beta = 0.995$, which implies an annual risk-free rate of 2%, given that $R^* = 1/\beta$. 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. Finally, we calibrate the price adjustment cost parameter φ so that the slope of the linearized Phillips curve corresponds to the one in the Calvo model. In line with Nakamura and Steinsson (2008), we set the adjustment cost so that it is consistent with prices adjusting on average every 3 quarters.

Table 1: Calibration

Description	Value	Source/Target
Discount factor	$\beta = 0.995$	Real rate=2% (annual)
Elasticity of substitution of c^h, c^f	$\gamma = 2$	Boehm et al. (2023)
IES	$\sigma = 2$	Gruber (2013)
Home bias parameter	$\omega = 0.80$	Imports to GDP ratio = 15.5%
Frisch elasticity parameter	$\phi = 1$	Kimball and Shapiro (2008)
Elasticity of subs. varieties	$\varepsilon = 6$	Gali and Monacelli (2005)
Price-adjustment cost	$\varphi = 872.5$	Frequency price adjustment=3 quarters

Results. Figure 1 presents the optimal monetary policy response to a permanent increase in tariffs. The experiment begins with an initial steady state where $b_0 = 0$ and $\tau = 0$ and introduces a tariff of $\tau = 10\%$, which is the across-the-board tariff proposed by the incoming Trump administration.[8]

We evaluate the optimal policy and compare it against the "look-through policy," which stabilizes inflation of home-produced goods (i.e., $\pi_t = 0$). The look-through policy, represented by the red-dashed line, shows that while employment, consumption of imports, and the exchange rate remain at their initial steady-state values, imports fall. Furthermore, CPI inflation rises immediately due to the increase in the price level of imports.[9]

Under the optimal policy, home-good inflation and employment both increase on impact, with π increasing by 0.5% and employment by 3% (see panels [a] and [f]). Over time, inflation returns to zero, and the exchange rate stabilizes at a higher value (panel [c]). Meanwhile, employment falls below the efficient level in the long-run. This is because tariffs represent a tax on consumption, which effectively reduces the marginal benefits from working.

[8]There have been also specific proposals for differential tariffs on Mexico, Canada and China and with different tariffs across goods. Here we focus on the across-the-board tariff.

[9]CPI inflation is given by $(1 + \pi_t)\left(\frac{1+\tau_t}{1+\tau_{t-1}}\right)^{1-\omega}$.

The stimulative monetary policy leads to a larger increase in the CPI than the one emerging purely from the effect of tariffs on imported goods, as can be seen in panel (b). Moreover, while imports fall relative to the initial steady state under the optimal policy, they decrease less than under the look-through policy (panel [c]). Finally, the trade increases on impact under the optimal policy as output raises more than consumption (panel [h]). On the other hand, under the look-through policy, exports and imports fall in the same magnitude and the trade balance therefore remains unchanged.

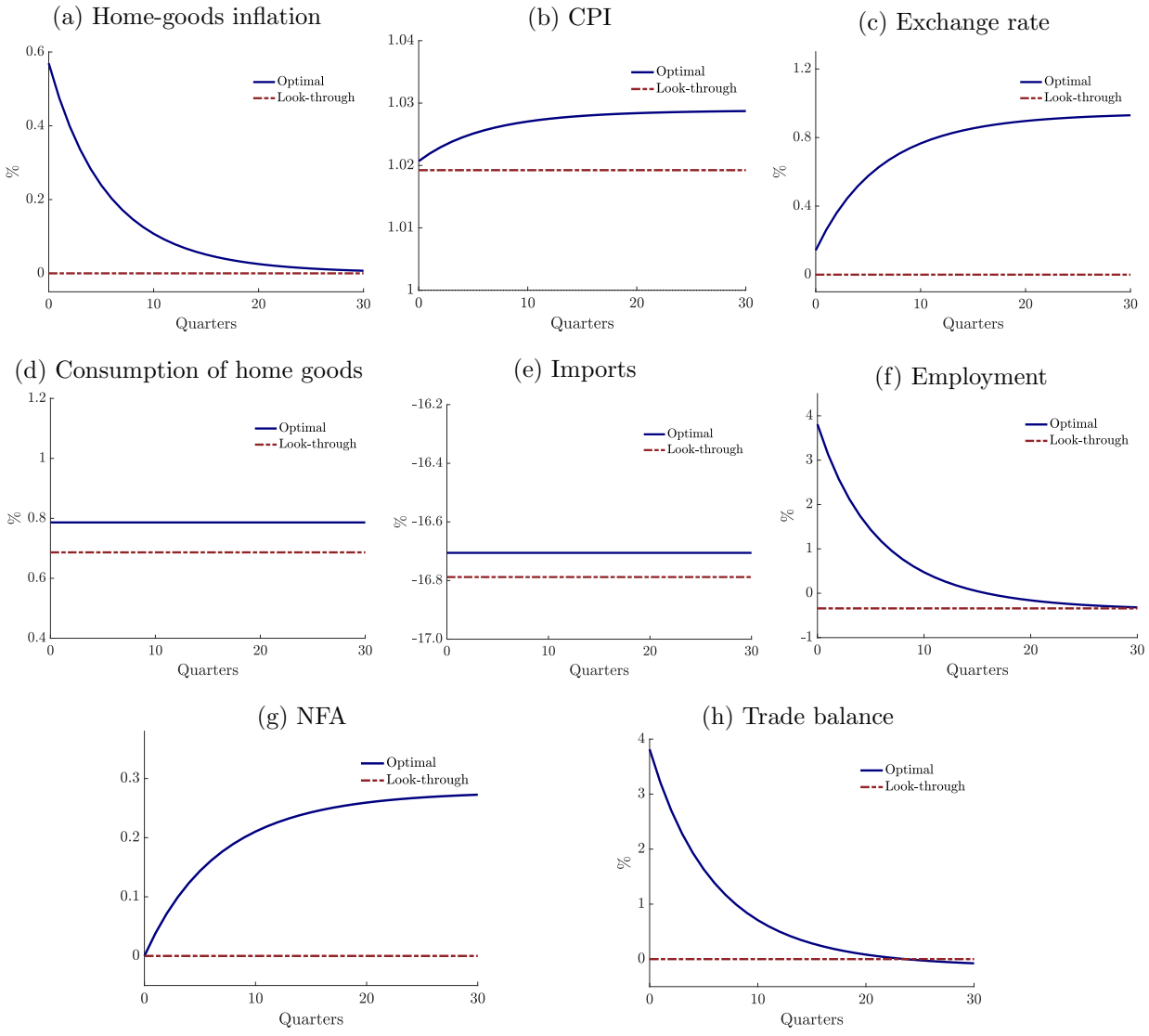


Figure 1: Response to a permanent tariff of $\tau = 10\%$.

Note: The trade balance and the net foreign asset position (NFA), represented by b, are expressed as a fraction of GDP. Consumption and employment are expressed as percentage deviation from the efficient allocation. The gray line in panel (b) denotes the normalized CPI in the efficient allocation.

3.2 Tariffs vs. terms-of-trade shocks

In Figure 2, we compare the responses to a tariff shock and a terms-of-trade (TOT) shock, both under the assumption of optimal monetary policy. Notably, in the case of the TOT shock, the optimal policy involves stabilizing home goods inflation at zero.

We assume a permanent increase in the price of imports, specifically that p rises by $1+\tau$, ensuring the relative price of home and foreign goods faced by households is the same under both shocks. As shown in panel (b), the increase in p leads to a larger decline in imports under the TOT shock compared to the tariff shock. Similarly, consumption of home goods decreases more in response to the TOT shock than under the tariff shock. Finally, the TOT shock leads to a jump in the CPI because of the direct effect on the price of imports, but after that the CPI remains constant. This contrasts with the tariff shock where the increase in the price of home-goods contribute to a further and persistent rise in the CPI.

The difference in the response to the two shocks emerges because of the different implications for of fiscal revenues. Namely, tariffs generate fiscal revenues that are rebated back to households, whereas a rise in the international price of imports results in a transfer to the rest of the world. In other words, when the economy faces an adverse TOT shock, the price of imports rises for both individual households and the economy as a whole. In contrast, with tariffs, the relative price of imported goods increases for individual households but remains unchanged for the aggregate economy. As a result, under a TOT shock, the central bank lets imports fall and keeps home-goods inflation at zero, whereas in in the case of tariffs, the central bank stimulates the economy to moderate the decline in imports.[10]

We note that we have focused our analysis on imported consumption goods. However, the main insight extends to the case of imported intermediate inputs. For instance, an increase in the price of intermediate inputs like oil raises marginal costs, prompting the monetary authority to stabilize the price of domestically produced goods and allow output to fall. Similarly to our setup involving trade in consumption goods, when tariffs are present, optimal policy would stimulate the economy more aggressively compared to a terms-of-trade shock, aiming to mitigate the decline in imports.

[10] Notice that if tariffs are not rebated the constraint (27) would be modified with an intertemporal budget constraint $b_0 = \sum_{t=0}^{\infty} \beta^t \left[c^h + p(1+\tau)c^f - \left[1 - \frac{\varphi}{2}\pi_t^2\right] \ell_t \right]$. One can then see that then this is the only constraint binding in problem (26), and the solution yields the efficient allocation.

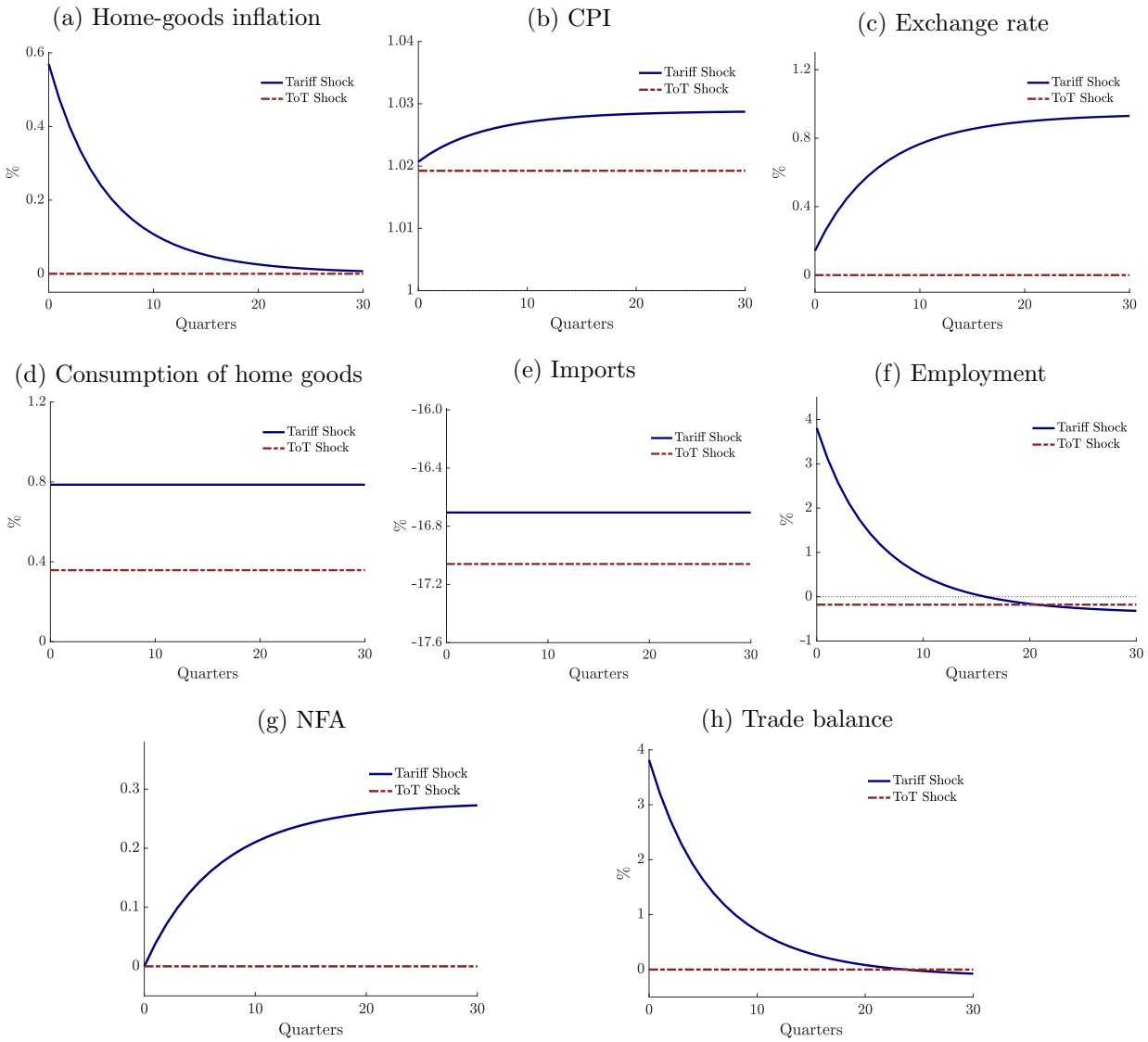


Figure 2: Tariffs vs. terms-of-trade shock

Note: The figure plots the response to a permanent tariff of $\tau = 10\%$ vs. a permanent ToT shock of 10%, both under the optimal monetary policy. Consumption and employment are expressed as percentage deviation from the efficient allocation. The trade balance and the net foreign asset position (NFA), represented by b, are expressed as a fraction of GDP.

3.3 Lack of Commitment

We now examine the problem of the monetary authority when it lacks commitment. We study a Markov perfect equilibrium (MPE). Given the expectation of future policies, the

monetary authority at any period t solves the following recursive problem:

$$V_t(b_t) = \max_{\{b_{t+1}, c_t^h, c_t^f, \ell_t, \pi_t\}} \left[\omega \log\left(c_t^h\right) + (1-\omega)\log(c_t^f) - \omega \frac{\ell_t^{1+\psi}}{1+\psi} \right] + \beta V_{t+1}(b_{t+1}), \tag{35}$$

subject to

$$c_t^h + p c_t^f + \frac{b_{t+1}}{R^*} \leq b_t + \left[1 - \frac{\varphi}{2}\pi_t^2\right] \ell_t, \tag{36}$$

$$(1+\pi_t)\pi_t \geq \frac{\varepsilon - 1}{\varphi}\left(c_t^h \ell_t^{\psi} - 1\right) + \beta \frac{\mathcal{C}_t(b_{t+1})\mathcal{L}_{t+1}(b_{t+1})}{\mathcal{C}_{t+1}(b_{t+1})\ell_t}(1 + \Pi_{t+1}(b_{t+1}))\Pi_{t+1}(b_{t+1}), \tag{37}$$

$$\frac{1-\omega}{\omega}\left(\frac{c_t^h}{c_t^f}\right) \geq p(1+\tau_t), \tag{38}$$

$$\frac{1}{c_t^f} = \beta R^* \left(\frac{1+\tau_t}{1+\tau_{t+1}}\right) \frac{1}{\mathcal{C}^f(b_{t+1})}. \tag{39}$$

The difference with problem (18) is that now the monetary authority cannot choose today future policies, because it cannot credibly promise to follow them in the future. As is standard in New Keynesian theory, the time inconsistency problem emerges from the forward-looking Phillips curve. In particular, the monetary authority would like to promise low inflation in the future so as to prevent costly price increases today. Crucially, this time inconsistency problem would not emerge in the absence of tariffs. This is because when $\tau_t = 0$, the monetary authority can implement the efficient allocation, and it has no incentives to deviate from this policy.[11]

4 Conclusion

Tariffs are back as an active policy tool. In this paper, we provide a simple model of how a monetary authority should respond optimally to the introduction of tariffs. We show that the optimal monetary policy is expansionary, leading to a rise in inflation above and beyond the direct effects from tariffs on imported goods. In essence, the key idea is that tariffs inefficiently reduce private incentives to consume imported goods. To counteract this effect, it is optimal for the monetary authority to stimulate the economy, thereby increasing aggregate income and boosting the consumption of imported goods.

Let us conclude with a few remarks. Our model is intentionally stylized and abstracts from several important considerations regarding tariffs. Notably, we have abstracted from

[11] A future version of this paper will evaluate quantitatively the Markov equilibrium.

terms of trade externalities and the potential for trade wars, as well as from strategic and geopolitical considerations. Integrating these factors, along with enhancing the quantitative aspects of the model, presents a promising direction for future research.

References

Afrouzi, Hassan, Marina Halac, Kenneth S Rogoff, and Pierre Yared, "Monetary Policy Without Commitment," Technical Report, National Bureau of Economic Research 2023.

Ambrosino, Ludovica, Jenny Chan, and Silvana Tenreyro, "Trade Fragmentation, Inflationary Pressures and Monetary Policy," 2024. BIS Working Paper.

Aoki, Kosuke, "Optimal monetary policy responses to relative-price changes," *Journal of monetary economics*, 2001, *48* (1), 55–80.

Auray, Stéphane, Michael B Devereux, and Aurélien Eyquem, "Self-enforcing trade policy and exchange rate adjustment," *Journal of International Economics*, 2022, *134*, 103552.

_ , _ , and _ , "Trade Wars and the Optimal Design of Monetary Rules," Technical Report, NBER Working Paper No. 32451 2024.

_ , _ , and _ , "Trade wars, nominal rigidities, and monetary policy," *Review of Economic Studies*, 2024, p. rdae075.

Bagwell, Kyle and Robert W Staiger, "The design of trade agreements," in "Handbook of Commercial Policy," Vol. 1, Elsevier, 2016, pp. 435–529.

Baqaee, David R, Emmanuel Farhi, and Kunal Sangani, "The supply-side effects of monetary policy," *Journal of Political Economy*, 2024, *132* (4), 000–000.

Barattieri, Alessandro, Matteo Cacciatore, and Fabio Ghironi, "Protectionism and the business cycle," *Journal of International Economics*, 2021, *129*, 103417.

Barbiero, Omar, Emmanuel Farhi, Gita Gopinath, and Oleg Itskhoki, "The economics of border adjustment tax," *Harvard University and Princeton University (June)(unpublished manuscript)*, 2017.

Bergin, Paul R and Giancarlo Corsetti, "The macroeconomic stabilization of tariff shocks: What is the optimal monetary response?," *Journal of International Economics*, 2023, *143*, 103758.

Bernanke, Ben and Olivier Blanchard, "What caused the US pandemic-era inflation?," 2023. Peterson Institute for International Economics Working Paper.

Bianchi, Javier, Alisdair McKay, and Neil Mehrotra, "How Should Monetary Policy Respond to Housing Inflation?," 2024. Mimeo, Federal Reserve Bank of Minneapolis.

_ **and Louphou Coulibaly**, "Financial Integration and Monetary Policy Cooperation," 2024. NBER Working Paper 32009.

Boehm, Christoph E, Andrei A Levchenko, and Nitya Pandalai-Nayar, "The Long and Short (Run) of Trade Elasticities," *American Economic Review*, 2023, *113* (4), 861–905.

Caldara, Dario, Matteo Iacoviello, Patrick Molligo, Andrea Prestipino, and Andrea Raffo, "The economic effects of trade policy uncertainty," *Journal of Monetary Economics*, 2020, *109*, 38–59.

Caliendo, Lorenzo and Fernando Parro, "Trade policy," *Handbook of international economics*, 2022, *5*, 219–295.

Costinot, Arnaud and Iván Werning, "Lerner symmetry: A modern treatment," *American Economic Review: Insights*, 2019, *1* (1), 13–26.

di Giovanni, Julian, Sebnem Kalemli-Özcan, Alvaro Silva, and Muhammed A Yildirim, "Quantifying the Inflationary Impact of Fiscal Stimulus under Supply Constraints," 2023. NBER Working Paper No. 30892.

Erceg, Christopher, Andrea Prestipino, and Andrea Raffo, "Trade policies and fiscal devaluations," *American Economic Journal: Macroeconomics*, 2023, *15* (4), 104–140.

Fornaro, Luca and Federica Romei, "Monetary Policy in an Unbalanced Global Economy," 2023. Working Paper, Centre de Recerca en Economia Internacional.

Gagliardone, Luca and Mark Gertler, "Oil prices, monetary policy and inflation surges," 2023.

Galí, Jordi, *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*, Princeton University Press, 2015.

Gali, Jordi and Tommaso Monacelli, "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies*, 2005, *72* (3), 707–734.

Gruber, Jonathan, "A tax-based estimate of the elasticity of intertemporal substitution," *The Quarterly Journal of Finance*, 2013, *3* (01), 1350001.

Guerrieri, Veronica, Guido Lorenzoni, Ludwig Straub, and Iván Werning, "Monetary Policy in Times of Structural Reallocation," 2021. Economic Policy Symposium, Jackson Hole.

_ , _ , _ , and Iván Werning, "Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages?," *American Economic Review*, 2022, *112* (5), 1437–1474.

Jeanne, Olivier, "Currency Wars, Trade Wars, and Global Demand," Technical Report, National Bureau of Economic Research 2021.

Kimball, Miles and Matthew Shapiro, "Labor supply: are the income and substitution effects both large or both small," 2008. NBER Working Paper No. 14208.

Lindé, Jesper and Andrea Pescatori, "The macroeconomic effects of trade tariffs: Revisiting the Lerner symmetry result," *Journal of International Money and Finance*, 2019, *95*, 52–69.

Nakamura, Emi and Jón Steinsson, "Five Facts about Prices: A Reevaluation of Menu Cost Models," *Quarterly Journal of Economics*, 2008, *123* (4), 1415–1464.

Rotemberg, Julio, "Sticky Prices in the United States," *Journal of Political Economy*, 1982, *90* (6), 1187–1211.

Steinberg, Joseph B, "Brexit and the macroeconomic impact of trade policy uncertainty," *Journal of International Economics*, 2019, *117*, 175–195.

Woodford, Michael, "Optimal monetary stabilization policy," *Handbook of monetary economics*, 2010, *3*, 723–828.

_ , "Effective Demand Failures and the Limits of Monetary Stabilization Policy," *American Economic Review*, 2022, *112* (5), 1475–1521.