Could Tariffs Provide a Stimulus? Simple Analytics of Tariffs and the Macro Economy

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Abstract

This paper shows the stimulus effects of temporary tariff policies in a sticky-price environment. Tariff shocks enter into open economy IS and Phillips curves. Having constrained monetary policy and a flat Phillips curve through inputs in production amplified the inflation from tariffs. Unilaterally imposing tariffs on imports may both divert consumption toward domestic goods and promote exports through depreciating terms of trade, ultimately stimulating domestic output. These stimulus effects apply to both small and large economies. When the input share in production is large enough, a large country's unilateral trade policy may benefit the domestic economy without adverse impacts on foreign consumption or output.

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1. Introduction

Can tariffs be used as a policy tool to stimulate consumption or output without begging thy neighbor? Recently, many countries impose tariffs or threat using them to achieve domestic objectives, including managing recession and improving trade balances or employment. Policymakers often associate tariffs with a beggar-thy-neighbor nature, and negative spillovers affecting foreign consumption or output may also elicit foreign retaliation. Moreover, empirical and theoretical literature still debate to what degree tariffs benefit the domestic economy.

This paper examines the above question in a simple open economy sticky price framework. The model is kept simple to isolate key transmission mechanisms in a sticky-price environment. Any anticipated future changes of temporary tariffs induce inter-temporal trade motives and affect the current consumption. Changes in inter-temporal substitution and expected inflation/deflation is distinct from all the static trade models of permanent tariffs and dynamic trade models without nominal frictions.

The effect of tariffs on domestic economy and its spillover nature depend on whether or not the monetary policy actively manages inflation and the slope of the Phillips curve. Tariff shocks enter into both open economy IS and Phillips curves. Having a constrained monetary policy and a flat Phillips curve amplify the expected inflation from tariffs and allow tariffs to increase global consumption and output.

Barattieri et al. (2018) recognize the importance of inflation and the role of constrained monetary policy for tariffs. However, they could not find any cases where temporary tariffs improve consumption even when monetary policy is constrained due to temporary risk premium shocks. However, they missed an important point that the anticipated lower future tariffs matter for the demand side and affect inter-temporal consumption switching. This effects could be strong for temporary trade protections. This important point is recognized in Erceg et al. (2022), which talks about the effects of tariffs policy reversal, the short notes by Lorenzoni (2019) in a stylized two-period model, and even undergraduate textbook Schmitt-Grohé et al. (2022). However, they do not connect to supply-side inflationary pressure from tariffs and analyze channels amplifying tariff-

induced expected inflation and potentially reversing negative conclusions related to tariffs. Auray et al. (2020a) shows that tariffs may stimulate consumption but still depress output. This paper also complements Auray et al. (2020a) by analyzing the possibility of tariffs improving both domestic consumption and/or output.

Auray et al. (2020a) focuses on using tariffs as a policy tool in response to various shocks. They show that in response to a reduction in the home country's household discount factor β, a tariff war increases home households' welfare (Figure 7 in their paper). Moreover, the IRF in Figure 10 shows the home country's persistent tariffs increase home households' welfare and consumption, though they are begging thy neighbor. From the same group of authors, Auray et al. (2020b) show that tariffs under non-cooperative tariff wars decrease the consumption and welfare even when the monetary policy is constrained. This paper argues that self-oriented home country's tariffs may benefit foreign county's and/or output. Therefore, non-cooperative tariffs may improve global consumption. The likelihood of monetary policy being constrained in the future is a key determinant on tariff spillovers and hence the outcome of non-cooperative tariff wars.

Eggertsson et al. (2016) don't discuss tariffs directly, but they mention that policies reducing global integrations on trade or capital accounts aimed at improving net foreign asset positions are welfare improving. Erceg et al. (2022) discuss how intra-temporal and intertemporal elasticities govern whether or not output increases in response to tariffs. They also examine the implication of anticipated policy changes. Erceg et al. (2022), like all other recent papers analyzing tariffs in an open economy New Keynesian framework, implements a computational approach to analyzing tariffs. This paper is the first to analyze temporary tariffs in an analytical sticky-price environment, and it provides a transparent framework to compare and reconcile a range of results from simulations.

Caballero et al. (2021) discuss tariffs when the global economy is potentially permanently stuck at the zero lower bound. They conclude tariffs at the ZLB are begging thy neighbor and tariff wars return the global economy to autarky. Tariffs in their framework without endogenous labor supply have no employment and inflationary effects, and tariffs only operate through the expenditure

switching channel: relative price changes reallocate home and foreign output. Although monetary policy is temporarily constrained, this paper nests Caballero et al. (2021)'s results[1].

The idea of tariff stabilization is not new. Dixit and Norman (1980) talks about tariffs "at fixed wage, increase employment and hence income". This paper clearly shows the possibility of tariff stabilization and complements old narratives in a modern setting.

Jeanne (2018) analyzes multiple policy games including tariffs when the global economy has constrained monetary policy for one period. In Appendix D, he shows that increasing tariffs reduces consumption and improves the trade balance deflated by the global price level. Since welfare is measured on the level of consumption, his results in Table D2 imply that tariffs increase domestic consumption when IES ¡1=Armington elasticity and that the home country's tariffs always depress global and foreign consumption. This result directly implies that a global cooperative policy would not impose any positive tariffs and he argues that the global policymaker indeed set tariffs at a negative level. This paper complements Jeanne (2018) by showing that the effects of tariffs depend on how likely monetary policy remains constrained in the future.

Auclert et al. (2021) show the real income channel is not present in representative agent open economy New Keynesian model under complete asset market and contribute little to the response of output to exchange rate shocks under incomplete asset market. Similarly, although higher import prices directly increase the price level and directly reduce the real wage, direct real income reduction contribute little to the reduce fin the consumption. This happens because temporary tariffs alter the path of consumption, which deepens on the path of the real interest rate and ultimately return to the flexible price steady state. Therefore, the observed reduce in consumption is not as some papers claimed (Bergin and Corsetti (2021) and Barattieri et al. (2018)) to coming from reducing in real income from lower real wages.

[1]In their paper, increasing the global tariffs does not change the global output or consumption. This point can be seen by combining equations 40a and 40b and assuming symmetric countries with exchange rate=1. In this symmetric setting, global demand is irrelevant to global tariff rates.

2. How do temporary tariff shocks propagate when nominal frictions exist?

To clarify the main transmission mechanism in tariff-imposing countries, this section presents a small open economy New Keynesian model. I include tariff shocks and intermediate input to a textbook-style model. This model conveys two messages: 1) permanent tariffs reduce consumption by depressing real wages in real income channel. Whether tariffs stimulate the output or not depends on trade elasticity and inter-temporal elasticity of substitution. 2) temporary tariffs are inflationary on the supply side because they raise the marginal cost and compress the markup under sticky prices. Tariffs are deflationary on the demand side because households expect CPI to be lower in the future as tariffs go away. Hence, the overall response of consumption in general equilibrium main operate through the real interest channel where monetary policy and the slope of the Phillips curve affect the expected inflation and hence the real interest rate. The response of output in turn depends on the level of expenditure and the expenditure switching channel, coming from the direct effect of tariffs and indirect effect of terms of trade response. Throughout the model, lower case variables denote log deviation from the deterministic steady state.

Households' lifetime utility is $E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$. For $\sigma = 1$, $U(C_t, N_t) = log(C_t) - \frac{N_t^{1+\psi}}{1+\psi}$ and for $\sigma \neq 1$, $U(C_t, N_t) = \frac{C^{1-\sigma}-1}{1-\sigma} - \frac{N_t^{1+\psi}}{1+\psi}$. Home-biased final consumption consists of home and foreign goods according to $C_t = \left((1-\nu)^{\frac{1}{\eta}} C_{H,t}^{\frac{1-\eta}{\eta}} + \nu^{\frac{1}{\eta}} C_{F,t}^{\frac{1-\eta}{\eta}}\right)^{\frac{\eta}{\eta-1}}$, where $\nu \in (0, 0.5)$ and $\eta \geq 1$. This CES aggregator implies the price index $p_t = (1-\nu)p_{H,t} + \nu(p_{F,t} + \tau_t)$, where τ_t is the tariff shock, $p_{H,t}$ is the domestic producer price and $p_{F,t}$ is the tariff-exclusive price of imported goods in local currency. Tariff revenues T_t are transferred to households. Under a complete asset market, households save in state-contingent bonds D_{t+1} whose price is Q_t. Households face the following budget constraint

$$P_t C_t + E(Q_t D_{t+1}) = D_t + W_t N_t + T_t + \Pi_t$$

Households' labor choice is $\sigma c_t + \psi n_t = w_t - p_t$. To facilitate interpreting the result of tariff shocks on output, I consider perfectly elastic labor supply, that is $\psi \to 0$. Households' labor

supply becomes $\sigma c_t = w_t - p_t$. Log-linearized household Euler equation is

$$c_t = E(c_{t+1}) - \frac{1}{\sigma}(i_t - E(\pi_{t+1}) - r^n)$$

where the natural real interest rate $r^n = -log(\beta)$.

Firms employ labor and use inputs X_t according to $Y_t = N_t^{1-\alpha} X_t^{\alpha}$. These inputs come from combining home and foreign final output using the same aggregation function for consumption bundles. Therefore, the price of inputs is the same as the final consumption goods. Firms also face Calvo nominal frictions. Firms reset the optimal prices $\bar{P}_t$ with a probability $1-\theta$ each period, where $\bar{P}_{H,t} = (1-\beta\theta)E\sum_{j=t}^{\infty}(\beta\theta)^{j-t}[MC_j]$. The marginal cost $MC_t = \frac{W_t^{1-\alpha}P_t^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}$. Firms' optimal labor demand is $W_t N_t = (1-\alpha)MC_t Y_t$, and the optimal demand for inputs is $P_t X_t = \alpha MC_t Y_t$.

Goods market clearing condition is $Y_t = C_{H,t} + X_{H,t} + C_{F,t} + X_{F,t}$. In the steady state, terms of trade defined as $S_t = P_{H,t}/P_{F,t}$ is one and $C/Y = 1-\alpha$ when a subsidy is applied to eliminate steady-state markups. The log-linearized goods market condition is

$$y_t = (1-\nu)((1-\alpha)c_t + \alpha x_t) + \nu(2-\nu)\eta s_t + \nu\eta(1-\nu)\tau_t$$

The linearized risk-sharing condition is $c_t = \frac{1}{\sigma}(p_{F,t} - p_t)$. It can be represented using terms of trade s_t as

$$\sigma c_t = \frac{\nu}{1-\alpha}(s_t - \tau_t)$$

Finally, to close the model, the monetary authority sets the nominal interest rate.

2.1 Permanent tariffs

Nominal frictions in the above model do not play any role in permanent tariffs. The effects of tariffs are pinned down by labor market clearing condition $\sigma c_t = -(1-\nu)s_t - \nu\tau_t$ and risk sharing condition $\sigma(1-\alpha)c_t + \nu\tau_t - \nu s_t = 0$. The solutions are $c_t = -\frac{\nu}{\sigma(1-(1-\nu)\alpha)}$ and $s_t = \frac{\nu\alpha}{(1-(1-\nu)\alpha)}$.

Permanent tariffs always depress consumption in a Neoclassical model because tariffs increase the domestic price level by raising the price of imports and lowering the real wage and hence the labor demand. In other words, permanent tariffs operate through household real income channel. However, tariffs have positive effects on terms of trade if inputs are used in production. The larger the input share in production, the larger tariffs raise the terms of trade. The response of output is

$$y_t = \frac{\nu}{\sigma(1-(1-\nu)\alpha)^2}[(1-\nu)(\eta\sigma-(1-\alpha))-\sigma\alpha(\eta+1-\alpha)]\tau_t \tag{1}$$

The response of output to tariff shocks depends on changes in expenditure levels from consumption and reallocation of consumption between home and foreign goods from terms of trade. Without inputs in production, tariffs directly raise output by inducing households to consume more domestic goods through expenditure switching. As a result of lower consumption, tariffs indirectly lower the output. Expenditure switching effects dominate when $\eta > \frac{1}{\sigma}$. With inputs, tariffs improve domestic terms of trade and hence marginally reduce the output by reducing the domestic export to the rest of the world, and therefore a larger trade elasticity is required to amplify the expenditure switching effect directly from tariffs so that permanent tariffs stimulate output.

2.2 Temporary tariffs under PPI targeting monetary policy rule

This section focuses on the transmission of temporary tariff shocks under nominal frictions. Monetary policy targeting PPI inflation $\pi_{H,t} = p_{H,t} - p_{H,t-1}$ is $i_t = max(0, r^n + \phi_\pi \pi_{H,t})$.

The log-linearized model around the steady state can be summarized by open economy New Keynesian Phillips and IS curves and a monetary policy rule targeting domestic PPI inflation. Given exogenous tariff shocks τ_t, equations 2-4 define the equilibrium dynamics of consumption c_t, PPI inflation $\pi_{H,t}$, and nominal interest rate i_t.

$$\pi_{H,t} = \beta E(\pi_{H,t+1}) + \lambda\left(\sigma(\frac{1}{1-\nu}-\alpha)c_t + \frac{\nu}{1-\nu}\tau_t\right) \tag{2}$$

$$c_t = E(c_{t+1}) - \frac{1-\nu}{\sigma}\big(i_t - E(\pi_{H,t+1}) - \frac{\nu(2-\nu)}{1-\nu}E(\Delta\tau_{t+1}) - r^n\big) \tag{3}$$

$$i_t = \max\{0, r^n + \phi_\pi \pi_{H,t}\} \tag{4}$$

where λ comes from Calvo sticky prices and governs the slope of the Phillips curve. ϕ_π governs the response of monetary policy to domestic PPI inflation.

Two competing forces for tariff shocks exert on inflation through New Keynesian Philips and IS curves respectively. Different from commonly seen shocks only affecting either the supply or the demand side, the level of tariffs enters into the New Keynesian Philips curve (eq 2), and expected tariffs enter into the IS curve (eq 3). On the supply side, tariffs generate inflation. On the demand side, an expected drop in tariffs lowers the expected inflation and hence raises the consumption-based natural real interest rate and depresses the current consumption.

The effects of tariffs crucially depends on $E(\Delta\tau_{t+1})$. The following two types of tariff shocks have identical effects: 1) any temporary tariff shocks following an AR(1) mean-reverting process where the persistence is ρ; 2) tariffs shocks with a probability ρ to revert to previous levels. The central message is that as long as the future tariffs to lower, a trade policy meant to be permanent affects inflation expectation in general equilibrium. For example, before China's admission to WTO, the US's import tariffs on Chinese goods were reviewed regularly, implying that expected inflation also affects the impact of the US's trade policy towards China. Moreover, Trump's tariffs on Chinese goods are kept for many years, and Trump's tariff shocks do not follow a mean reverting process. However, the public is uncertain about whether or not Trump's tariffs will be in place forever.

In general equilibrium, tariffs may or may not generate inflation, despite a negative response to consumption. Domestic PPI inflation is

$$\frac{d\pi_{H,t}}{d\tau_t} = \frac{\nu\lambda(1-\rho)}{\mathcal{M}}\Big\{(2-\nu)\alpha - 1\Big\}, \text{ where } \mathcal{M} = (1-\beta\rho)(1-\rho) + \lambda(\phi_\pi - \rho)(1-\alpha(1-\nu)) > 0 \tag{5}$$

Whether tariffs are inflationary or not depend on $(2-\nu)\alpha - 1$. Tariffs necessarily increase the

real interest rate and depress consumption from the demand side, and to what extent this generates deflation depends on the slope of the Philips curve. It is flattened when the share of inputs in production rises.

The response of consumption to tariffs in general equilibrium is:

$$\frac{dc_t}{d\tau_t} = -\frac{\nu\sigma^{-1}}{\mathcal{M}}\Big\{\lambda(\phi_\pi - \rho) + (2-\nu)(1-\rho)(1-\beta\rho)\Big\} < 0 \tag{6}$$

Tariffs always depress consumption. The direct response of consumption to anticipated lower tariffs is the dominant force independent of household inter-temporal consumption motives (i.e. σ does not affect the sign of consumption response to tariffs). This unique result occurs because any small IES would imply a small direct response of current consumption on the demand side, but a small IES also implies a large substitution between consumption and labor supply and hence a steeper Phillips curve and larger expected deflation from tariffs. In general equilibrium, the supply- and the demand-side effect from household inter-temporal consumption smoothing motives cancel out. Therefore, σ does not enter eq 6.

Moreover, monetary policy responses to domestic PPI inflation, reduce the expected inflation from tariffs and further amplifies the negative effects of tariffs on consumption. Due to the simplifying assumption of perfectly elastic labor supply, the impact of tariffs on output depends on the aggregate consumption, and the expenditure switching effects from terms of trade and direct response of tariffs, that is $\frac{dy_t}{d\tau_t} = (1-\nu)(1-\alpha)(1+\alpha\sigma)c_t - \nu\eta(2-\nu)s_t + \nu\eta\tau_t$. Tariffs improve terms of trade and hence the expenditure switching effects directly from tariffs are the only source for the output to increase.

$$\frac{dy_t}{d\tau_t} = \frac{\nu}{(1-\nu)(1-\alpha(1-\nu))}\big\{\eta - [(1-\nu)^2(1-\alpha)(\sigma^{-1}+\alpha+\eta\nu(2-\nu)]\tilde{M}\big\} \tag{7}$$

where $\bar{M} = \frac{(2-\nu)(1-\rho)(1-\beta\rho)+\lambda(\phi_\pi-\rho)}{(1-\beta\rho)(1-\rho)+\lambda(\phi_\pi-\rho)(1-\alpha(1-\nu))} > 1$. It is possible that tariff raise output when trade elasticity is large.

2.3 Temporary tariffs under alternative monetary policy conditions

This section analyzes the effect of tariffs when monetary policy is either a fixed real-rate or fixed nominal-rate policy. When monetary policy adjusts to maintain a constant real interest rate, it stabilizes consumption, generates terms of trade appreciation and worsens the output.

Money policy could be inactive because this small open economy has an exchange rate peg or it suffers from a large demand shocks so that the monetary policy faces the zero lower bound constraint. I adopt the approach used for analyzing the fiscal spending multiplier under the zero lower bound by Woodford (2011). The effect on consumption is

$$\frac{dc_t}{d\tau_t} = -\frac{\nu(2-\nu)}{\sigma}\frac{(1-\beta\rho)(1-\rho)-\lambda\rho\frac{1}{(2-\nu)}}{\mathcal{N}} \tag{8}$$

The stability requires that $\mathcal{N} = (1-\beta\rho)(1-\rho)-\lambda\rho((1-\nu)(1-\alpha)+\nu) > 0$. There is an upper bound $\bar{\rho} < 1$ such that $\rho < \bar{\rho}$. As long as $(1-\nu)(1-\alpha)+\nu < \frac{1}{2-\nu}$, there exists ρ such that consumption rises. To see this, any small deviation from $\bar{\rho}$ implies that $\mathcal{N} > 0$ and $(1-\beta\rho)(1-\rho)-\lambda\rho\frac{1}{(2-\nu)} < 0$ if $(1-\nu)(1-\alpha)+\nu < \frac{1}{2-\nu}$.

Tariffs increase consumption by generating expected inflation and lowering the natural real interest rate in equilibrium. Since monetary policy is inactive, a high probability of tariffs remaining in palace is required to generate enough expected inflation to offset negative effects from anticipated future lower tariffs (expected deflation).

The derivation in this section clarifies results in Barattieri et al. (2018). They recognize tariffs as being inflationary and negative effects of monetary policy, but they don't articulate clearly the direct effect of anticipated lower tariffs due to the shock process being AR(1) on distorting intertemporal consumption. The negative anticipated effects of tariffs also carry to their analysis for constrained monetary policy. What they didn't recognize is that tariffs may stabilize consumption and output in a small open economy as the likelihood of monetary policy being constrained in the future increases.

Moreover, the complete asset market risk sharing implies that terms of trade worsen when

tariffs rise consumption. Hence, regardless parameters, output increases due to higher consumption and expenditure switching toward home goods for home consumers and larger exports due to lower terms of trade.

3. Could coordinated tariffs improve global welfare?

This section focuses on tariffs imposed by countries that affect international prices. As before, lower case variables are the log deviation from the steady state. Superscript W denotes variables of world aggregate.

For permanent tariffs, world labor and goods markets clearing conditions to pin down world aggregate consumption c_t^W. $\frac{dc_t^W}{d\tau_t^W} = -\frac{\nu}{\sigma}$. An increase in world tariff rates reduces global consumption (output) due to the negative employment effects of higher real wages.

With nominal frictions and a monetary policy rule targeting PPI inflation, the equilibrium for the world can be defined as the following.

$$\pi_t^W = \beta E(\pi_{t+1}^W) + \lambda(\sigma(1-\alpha)c_t^W + \nu\tau_t^W), \text{ where } \pi_t^W = \pi_{H,t} + \pi_{F,t}^* \tag{9}$$

$$c_t^w = E(c_{t+1}^w) - \frac{1}{\sigma}(i_t^W - E(\pi_{t+1}^w) - \nu E(\Delta\tau_{t+1}^W) - r^W) \tag{10}$$

$$i_t^W = \max\{0, r^W + \phi_\pi \pi_t^W\}, \text{ where } i_t^W = i_t + i_t^* \tag{11}$$

$$y_t^W = (1 + \alpha\sigma)c_t^W \tag{12}$$

Similar to the small open economy case, tariff shocks enter both the New Keynesian Phillips curve and the IS curve. Tariffs increase the worldwide current and expected PPI inflation, and hence also put downward pressure on the natural real interest rate and boost current consumption. However, in the presence of monetary policy targeting inflation, monetary policy reacts to a rise in current inflation. Therefore, the effect of tariffs boosting current consumption and output is mitigated by the monetary policy. Moreover, any trade policy eliciting an expectation of lower

future tariffs increases the natural real interest rate and depresses current consumption. The effects of world tariffs on global consumption are

$$\frac{dc_L^w}{d\tau_L^w} = -\frac{\nu}{\sigma} \times \frac{(1-\rho)(1-\beta\rho) + \lambda(\phi_\pi - \rho)}{(1-\rho)(1-\beta\rho) + \lambda(\phi_\pi - \rho)(1-\alpha)} < 0 \tag{13}$$

When monetary policy is inactive, tariffs are reversed to the steady state level with a probability of $1-\rho$. The effect of tariffs on global consumption is:

$$\frac{dc_L^w}{d\tau_L^w} = -\frac{\nu}{\sigma} \times \frac{(1-\rho)(1-\beta\rho) - \lambda\rho}{(1-\rho)(1-\beta\rho) - \lambda\rho(1-\alpha)} \tag{14}$$

where the existence of a solution requires $(1-\rho)(1-\beta\rho) - \lambda\rho(1-\alpha) > 0$, and there is an upper bound $\bar{\rho} < 1$ to satisfy this. The term $\lambda\rho$ governs the expected inflation from tariffs, while the term $(1-\rho)(1-\beta\rho)$ governs the expected deflation from anticipated lower tariffs once the economy returns to the steady state. When these two terms offset each, the state of the economy is similar to what Caballero et al. (2021) picture: tariffs are zero-sum.

As long as inputs are used in the production (i.e. $1 > \alpha > 0$), there exists $\rho < \bar{\rho}$ such that tariffs potentially raise global consumption and output. Households expect tariffs to be lower once preference shocks end and anticipated lower future tariffs depress the current consumption and generate an expected deflation through the Phillips curve. However, when the Phillips curve is flat, the expected deflation is small. Self-oriented tariffs increase global demand through increasing world inflation.

In terms of the welfare, I focus on a specific case where monetary policies around the world are constrained by the zero lower bound. The welfare analysis focuses on this cases because monetary policy (or even fiscal policy) are able to manage the demand when tariffs as a tool cannot do better. When monetary policy is unable to stimulate the demand, tariffs may be a source of generating expected inflation and allow the economy the escape the liquidity trap. However, Jeanne (2018) does not support this argument and he shows that the optimal coordinated tariffs under global liquidity trap is actually negative. Here, I use a two state economy and assume that the economy

is expected to return to the steady state in the next period with a probability ρ. Tariffs are imposed whenever the global economy is in the liquidity trap. I future assume that the demand shock is large enough so that tariffs along does not escape the economy from the liquidity trap. I show that using tariffs or not depends on the production structure and the expected persistence of tariffs (or the economy remains at the liquidity trap).

To do the welfare analysis, I first compute the optimal consumption and labor supply from the global social planner point of view and then use a second order approximation of the world utility functions around the social optimal.

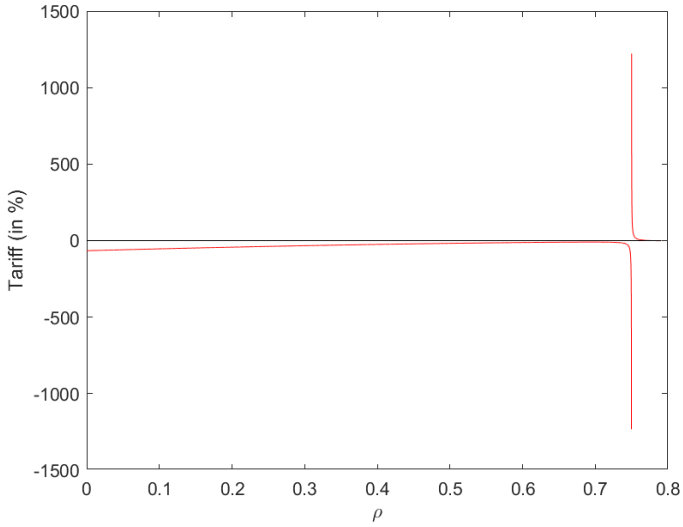
The welfare the global social planner optimizes is

$$W = \frac{1}{1-\beta\rho}\Big(\frac{2(1+\alpha\phi+\alpha)}{1+\alpha\phi}c_L^W - \frac{\epsilon}{4\lambda(1+\alpha\phi)}\pi_L^{W2} - \frac{(1+\phi)(1+2\alpha+\phi\alpha)^2}{4}c_L^{W2}\Big) \tag{15}$$

where ϵ is the elasticity of substitution among differentiated varieties. ϕ is the inverse of the Frisch labor supply elasticity.

The lower script "L" denote the value under the global liquidity trap. Their response to tariffs are identical to the case under inactive monetary policy described above. It can be shown that if $dc_L^W/d\tau_L < 0$, then optimal tariffs must smaller than zero. In other words, under global liquidity trap, social planners would subsidize imports instead of imposing import tariffs. Moreover, this must be the case when the production does not use the intermediate inputs (i.e. $\alpha = 0$). Figure 1 depicts the value of optimal world tariffs by the social planners. It show that when the persistence of the liquidity trap is low, optimal tariffs are negative. When the persistence is large enough, there are cases for the positive tariffs from the perspective of social planner. Overall, the usage of the tariffs even under the global liquidity by the social planner depends on the anticipated length of the liquidity trap and the global production structure. It is possible that coordinated tariffs improve welfare in a global liquidity trap.

Figure 1: Optimal coordinated tariffs



Notes: The parameters used to generate this figure are: $\beta = 0.99$, $\nu = 0.2$, $\eta = \sigma = \phi = 1$, $\alpha = \frac{2}{3}$, and $\epsilon = 6$.

4. Must tariffs be beggar-thy-neighbor?

To analyze the spillover effects of tariffs, I define variables in relative terms. Superscript R denotes variables of the home country relative to the foreign country.

$$y_t^R = \frac{(1+\alpha\sigma)(1-\alpha)}{1-\alpha+2\nu\alpha}(1-2\nu)c_t^R + \frac{2\nu\eta(1-\nu)}{1-\alpha+2\nu\alpha}\tau_t^R - \frac{4\eta\nu(1-\nu)}{1-\alpha+2\nu\alpha}s_t \tag{16}$$

$$\pi_t^R = \beta E(\pi_{t+1}^R) + \lambda((1-\alpha)\sigma c_t^R + \nu\tau^R - 2\nu s_t) \tag{17}$$

$$c_t^R = E(c_{t+1}^R) - \frac{1}{\sigma}(i_t^R - E(\pi_{t+1}^R) + 2\nu E(\Delta s_{t+1}) - \nu E(\Delta\tau_{t+1})) \tag{18}$$

$$s_t = -\frac{\sigma}{1-2\nu}c_t^R - \frac{\nu}{1-2\nu}\tau_t^R \tag{19}$$

$$i_t^R = \max\{0, \phi_\pi \pi_t^R\}, \text{ where } i_t^R = i_t - i_t^* \tag{20}$$

When the monetary policy is active, the relative consumption

$$\frac{dc_t^R}{d\tau_t} = -\frac{\nu}{\sigma} \times \frac{(1-\rho)(1-\beta\rho) + \lambda(\phi_\pi - \rho)}{(1-\rho)(1-\beta\rho) + \lambda(\phi_\pi - \rho)((1-\alpha)(1-2\nu) + 2\nu)} < 0 \tag{21}$$

Using the definition of c_t and c_t^*, I find that $\frac{dc_t}{d\tau_t} < 0$, but $\frac{dc_t^*}{d\tau_t} > 0$. Moreover, from the relative consumption, terms of trade appreciate when the home country imposes tariffs. For the relative output, lower home consumption relative to foreign depress the overall level of consumption, and terms of trade appreciations depress home country's export. Home country's output can only be beneficial from the expenditure switching effects directly from higher import prices due to tariffs. In the absence of inputs in production, if the trade elasticity is higher enough such that $\eta\sigma(1-\nu) > 1$, then this expenditure switching effect can induce a rise in home country's output relative to the foreign country, an increase in home output and a fall in foreign output. In other words, home country's tariffs are able to stabilize domestic production, though it depresses domestic consumption as well as foreign output.

When monetary policy is inactive, there exists $\bar{\rho}$ such that $(1-\rho)(1-\beta\rho) - \lambda\rho((1-\alpha)(1-2\nu) + 2\nu) > 0$ and for any $\rho < \bar{\rho}$,

$$\frac{dc_t^R}{d\tau_t} = -\frac{\nu}{\sigma} \times \frac{(1-\rho)(1-\beta\rho) - \lambda\rho}{(1-\rho)(1-\beta\rho) - \lambda\rho((1-\alpha)(1-2\nu) + 2\nu)} \tag{22}$$

Since $(1-\alpha)(1-2\nu) + 2\nu < 1$, there exists $\rho < \bar{\rho}$ such that $\frac{dc_t^R}{d\tau_t} > 0$ and tariffs could raise the home relative consumption. In fact, tariffs also increase home consumption at the cost of reducing foreign consumption. For the response of output, terms of trade depreciations facilitate increasing expenditure switching. Overall, the transmission of tariffs on home country's output is completely different depending on monetary policy.

When monetary policy actively manages inflation, the positive effect of tariffs on output comes from the direct effect of tariffs on expenditure switching and higher foreign consumption and hence the indirect effect of larger export demand. When monetary policy is inactive, in addition to previous direct effects of tariffs, tariffs indirectly reallocate the world demand from the foreign

country to the home country. Moreover, terms of trade depreciate in equilibrium, further facilitating the expenditure switching to domestic goods. For the foreign country, when monetary policy is inactive, home country's tariffs stimulate output by sacrificing foreign output.

Could tariffs improve the home country's consumption or output without begging thy neighbor? First of all, the necessary condition for a positive spillover effect of tariffs is that a rise in world aggregate tariffs raise the global demand. This could happen when monetary policy is inactive and a sufficiently large share of inputs in production.

I show that within this framework and with realistic parameters, home country's tariffs could stimulate both the home and foreign country's output. To demonstrate this, I first choose the following baseline parameters: risk aversion $\sigma = 1$, trade openness $\nu = 0.2$, input share in production $\alpha = \frac{2}{3}$, and trade elasticity $\eta = 1$. I change the value of one parameter while holding others at the baseline levels. In each sub-figure of Figure 2, I vary change the value of one parameter while holding others at the baseline level. I color shade ranges of parameters where output increases for both home and foreign countries in response to home country's tariffs under the constrained monetary policy.

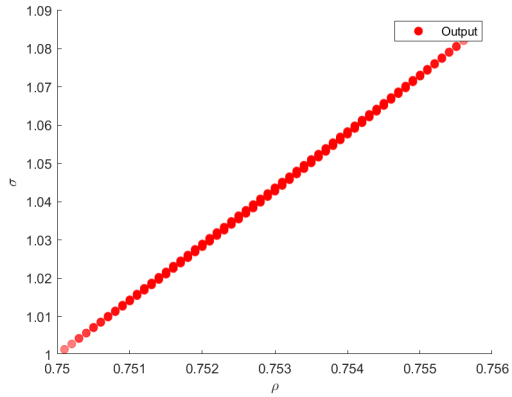
Once the home country imposes tariffs, tariffs generate terms of trade depreciation. This reallocate the world demand to the home country on top of the direct effect of tariffs. Consumption in both countries rises due to the rise in expected inflation globally and lower real interest rate. The positive expenditure switching effect and high expenditure level at the home country contribute to the rise in the home country's output. Positive expenditure switching effect for the home country works against foreign country and directly lower foreign output. However, higher global consumption generate positive force for the foreign output. Due to the presence inputs in production, high home country's production requires imports more from foreign country and boosts foreign output. Overall, the relative price changes reduce the foreign output, but its impact is overturned by higher expenditure level at the foreign country, higher import demand from the home country for consumption and production. In fact, home country's tariffs deteriorate its trade balances when it generate positive spillovers.

5. Conclusion

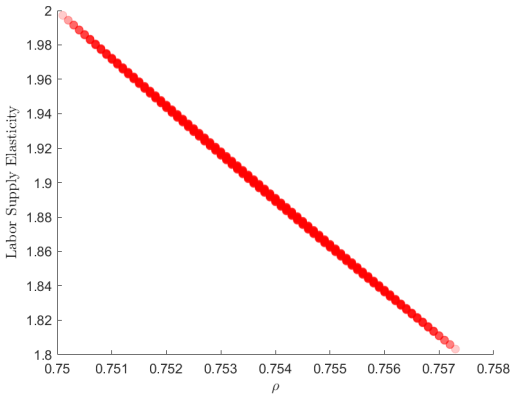
This paper examines temporary tariff policies in a sticky-price environment. It shows analytically how trade policy interacts with monetary policy and the importance of trade openness, inter-and intra-temporal trade elasticises, and intermediate inputs. Tariff shocks enter into both open economy IS and Phillips curves. Having inactive monetary policy and a flat Phillips curve through inputs in production amplifies the inflation from tariffs. A self-oriented trade policy by small open economies may raise domestic consumption, promoting exports through depreciating terms of trade, and ultimately stimulate output. These stimulus effects also apply for large economies but generally at the cost of foreign consumption or output. However, when inputs share in production is large enough, a large country's self-oriented trade policy may benefit domestic economy without begging thy neighbor on foreign consumption or output.

For a small open economy with currency pegs to the rest of the world, tariffs could help small open economies insulate foreign shocks and improve welfare. Tariffs are not necessarily beggar-thy-neighbor. Under inactive monetary policy, home country's tariffs could generate positive spillovers.

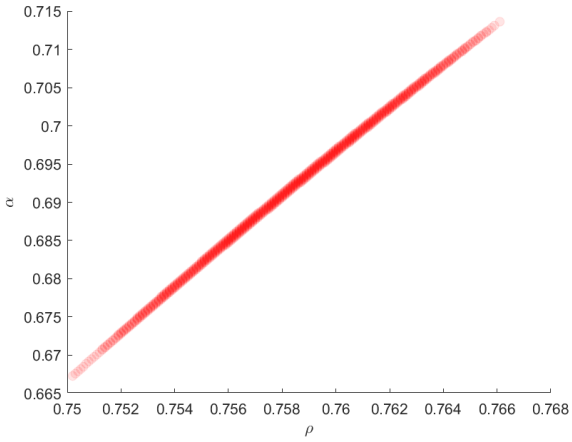
Figure 2: Positive effects of home tariffs on both home and foreign countries



(a) Varying σ



(b) Varying labor supply elasticity



(c) Varying α

Notes: This figure illustrates the possibility of home tariffs increasing both home and foreign countries' output. This positive spillovers of home tariffs depend on four key parameters and the probability of the economy staying with constrained monetary policy. The baseline key parameters are labor supply elasticity=0.5, $\nu = 0.2, \alpha = \frac{2}{3}, \eta = 1$. Each sub-figure varies the baseline parameter.

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