The Macroeconomic Stabilization of Tariff Shocks: What is the Optimal Monetary Response?

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Motivation

- Brexit and the Trump trade wars raise debate over macroeconomic effects of tariff shocks.
- This paper studies the monetary dimension:

  price stickiness means monetary policy affects real exchange rate, and alters effect of tariffs on international relative prices.
- Central banks looking for guidance on approp-riate monetary policy responses to Brexit and Trump tariff wars.

Related literature

- Most of macro literature on tariffs focuses on real models; not consider monetary policy role.
- The papers with monetary models tend to assume standard Taylor rule, not optimal policy. (Barrattieri et al. (2017), Erceg et al. (2018), Caldara et al. (2018), Linde and Pescatori (2019))
- Auray, et al (2020) consider strategic interaction of optimal exchange rate and tariff policies; we study optimal response to an exog. tariff shock,
- and we include several key features from trade models…

Preview of Results

- We use a calibrated theoretical monetary DSGE model with trade features to study effects of tariff, and optimal monetary policy response.
- Monetary expansion to induce exchange rate depreciation can blunt effects of a tariff shock.
- Even in case of a symmetric trade war, where exchange rate cannot help, coordinated monetary expansion can blunt fall in global output.
- Ramsey optimal policy is opposite of standard Taylor policy rule prescription in the latter case.

Outline of Model

Two county dynamic stochastic general eqm. model

Two tradable sectors:

1) Differentiated manufacturing sector (D):

- monopolistic competition
- firm entry with sunk cost
- Iceberg trade cost
- sticky prices: Rotemberg cost of price adjustment in producer currency units.

2) Non-differentiated sector (N), perfectly competitive, flexible prices, frictionless trade.

Ad valorem tariffs in model can affect either sector, but here focus on differentiated sector.

Outline of Model, cont'd

- Production requires labor and intermediates;
- Endogenous labor supply (leisure affects utility).
- Trade in bonds permits non-zero trade balance.
- Shocks: ad-valorem tariff subject to AR shocks, calibrated to Trump trade war.
- Solve for second-order approximation around deterministic steady state.
- Compute conditional welfare including transition.
- Monetary policy: study standard rules as well as computing Ramsey optimal (cooperative) policy.

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Goods market structure

Home consumption index, C, includes

- n varieties h of the differentiated good (D) produced in Home country,
- n^* varieties f produced in Foreign,
- home-country-specific (nondifferentiated) good (H)
- A foreign-country-specific good (F).

$$C_t \equiv C_{D,t}^{\theta} C_{N,t}^{1-\theta}$$

where

$$C_{D,t} \equiv \left(\int_0^{n_t} c_t(h)^{\frac{\phi-1}{\phi}} dh + \int_0^{n_t^*} c_t(f)^{\frac{\phi-1}{\phi}} df \right)^{\frac{\phi}{\phi-1}}$$

$$C_{N,t} \equiv \left(\nu^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\nu)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

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<u>Differentiated (Manufacturing) Goods</u>

- Production uses labor and composite of other differentiated goods, with sector productivity shock, α_{Dt}

$$y_t(h) = \alpha_{D,t} \left[G_t(h)\right]^{\zeta} \left[l_t(h)\right]^{1-\zeta}$$

- Manufacturing firms
  - <u>prepay a one-time sunk entry cost</u>, K_t, in units of combined labor and differentiated goods index.
  - <u>set prices subject to Rotemberg adjustment cost</u> in domestic currency units (producer currency pricing); output demand determined.
  - Face <u>trade cost</u> τ_D in selling in foreign market.

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Firm Entry

- Managers maximize firms' discounted value:

$$v_t(h) = E_t\left\{\sum_{s=0}^{\infty}\left(\beta(1-\delta)\right)^s \frac{\mu_{t+s}}{\mu_t}\pi_{t+s}(h)\right\}$$

Subject to exit shock, δ, where $\mu_t = P_t C_t^{\sigma}$ and profits are:

$$\pi_t(h) = p_t(h)d_t(h) + e_t p_t^*(h)d_t^*(h) - mc_t y_t(h) - P_t AC_{p,t}(h)$$

$$mc_t = \zeta^{-\zeta}(1-\zeta)^{\zeta-1} P_{D,t}{}^{\zeta} W_t^{1-\zeta} / \alpha_{D,t} \text{ is marginal cost.}$$

- Optimal choice of inputs:

$$\frac{P_{D,t}G_t(h)}{W_t l_t(h)} = \frac{\zeta}{1-\zeta}$$

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Firm Entry, cont.

- Firms enter until the point that firm value equals the entry cost:

$$v_t\left(h\right) = P_{Dt} K_t$$

- Sunk cost subject to congestion externality:

$$K_t = \overline{K}\left(ne_t / ne_{t-1}\right)^{\chi}$$

function of number of new firm entrants (ne).

$$n_{t+1} = \left(1-\delta\right)\left(n_t + ne_t\right)$$

skip

Non-differentiated Good Production

- Production linear in labor, subject to own shocks:

$$y_{H,t} = \alpha_{N,t} l_{H,t}$$

- Firms perfectly competitive, price takers:

$$p_{H,t} = W_t / \alpha_H$$

- Trade subject to iceberg trade cost:

$$p^*_{H,t} = p^*_{H,t} \left(1 + \tau_N\right) / e_t$$

Tariffs

- Ad-valorem tariff imposed by importing country on price of imported differentiated goods.
- Can affect either sector, but we focus on differentiated goods tariffs.
- Tariff revenue rebated to households.
- Distorts the relative price between domestic and imported goods faced by consumers

$$c_t(f) = \left(p_t(f) T_{D,t} / P_{D,t} \right)^{-\phi} C_{D,t}$$

skip

Households Problem

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{1-\sigma} C_t^{1-\sigma}{}_t + \chi \ln \frac{M_t}{P_t} - \frac{1}{1+\psi} l_t^{1+\psi} \right]$$

$$P_t C_t = W_t l_t + \int_0^{n_t} \pi_t(h)\, dh - W_t q + M_t - M_{t-1} + B_t - (1+i_{t-1}) B_{t-1} - T_t$$

- Utility from consumption, real money balances (M/P); disutility from labor (l).
- Income from labor earnings at wage rate W, interest (i) on domestic bonds (B), profits from ownership of firms (π). Pay lump sum tax (T).
- Implies standard Household FOCs for Consumption Euler, labor supply, money demand

Experiments

Two types of tariff shocks on D sector:

1. Unilateral Tariff imposed on one country.
2. Symmetric Tariff (full retaliation).

Objects of study for each shock:

- Dynamics: impulse responses of single shock
- unconditional means: effect of uncertainty in full stochastic simulation
- Conditional welfare

Three alternative money policy responses:

- No policy (constant money growth)
- Standard Taylor policy stabilizing inflation
- Ramsey cooperative optimal policy

Case 1: Unilateral tariff shock

Figure 1. Unilateral foreign tariff on home exports

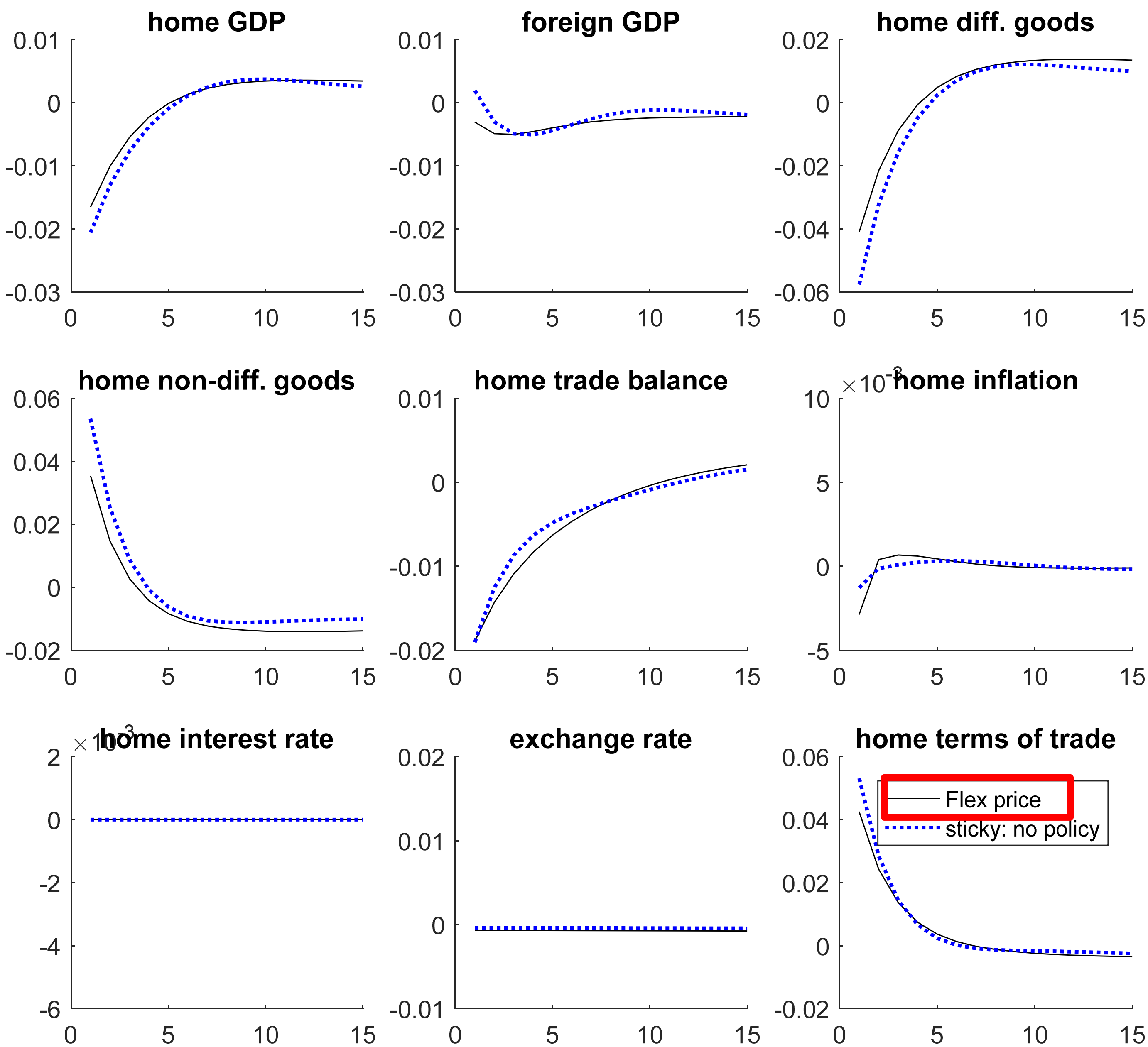
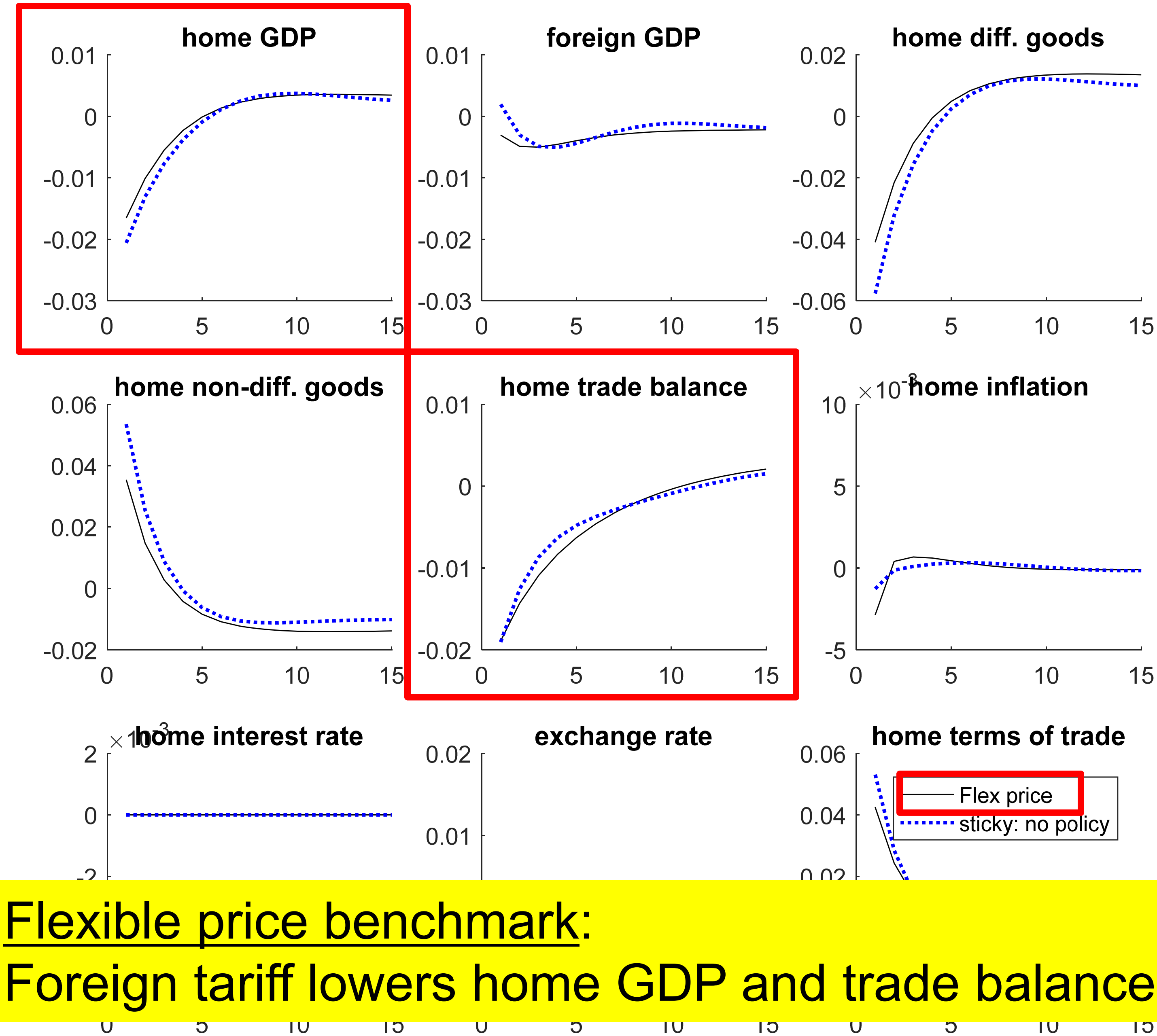
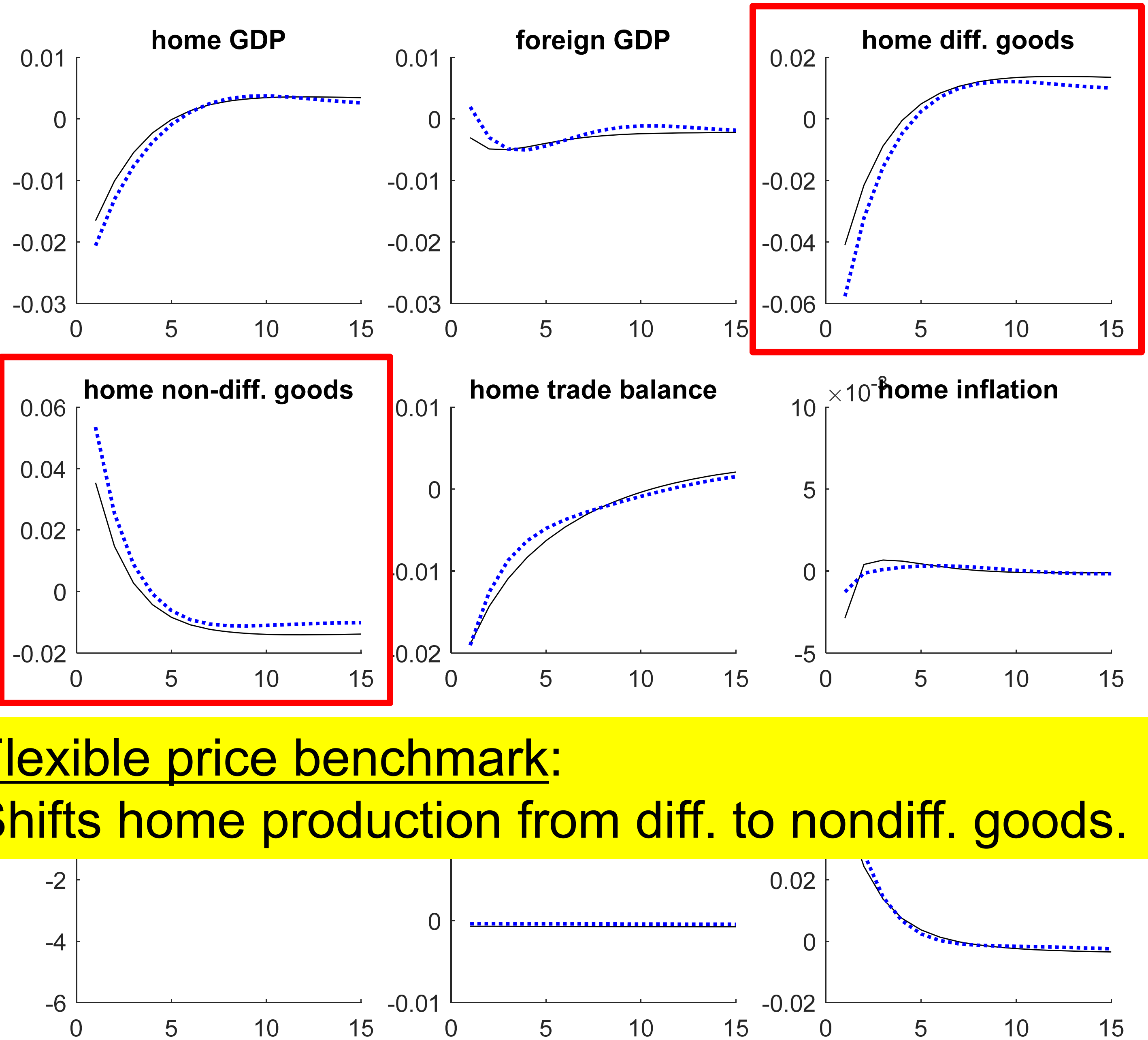


Figure 1. Unilateral foreign tariff on home exports



Flexible price benchmark:
Foreign tariff lowers home GDP and trade balance.

Figure 1. Unilateral foreign tariff on home exports

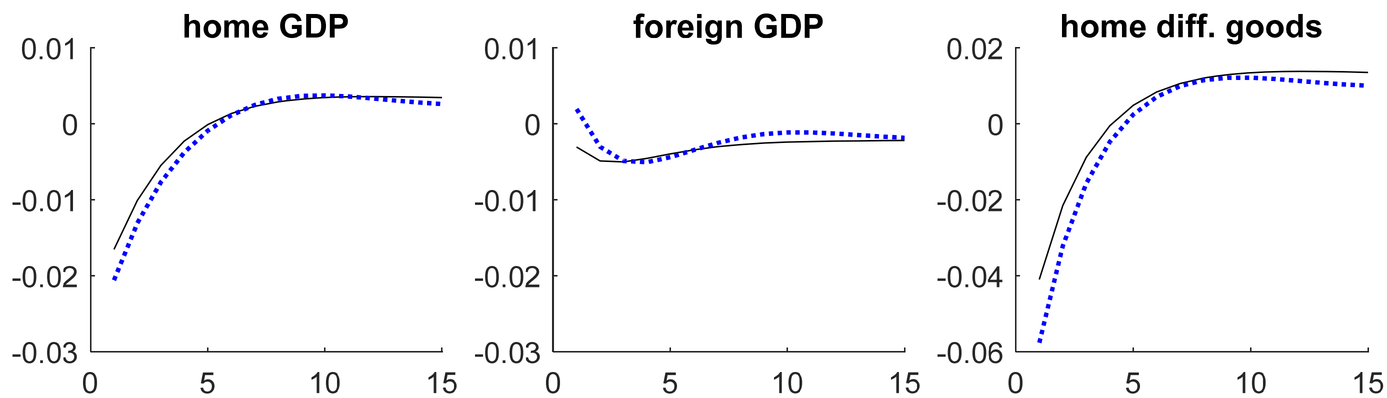


Flexible price benchmark:
Shifts home production from diff. to nondiff. goods.

Figure 1. Unilateral foreign tariff on home exports

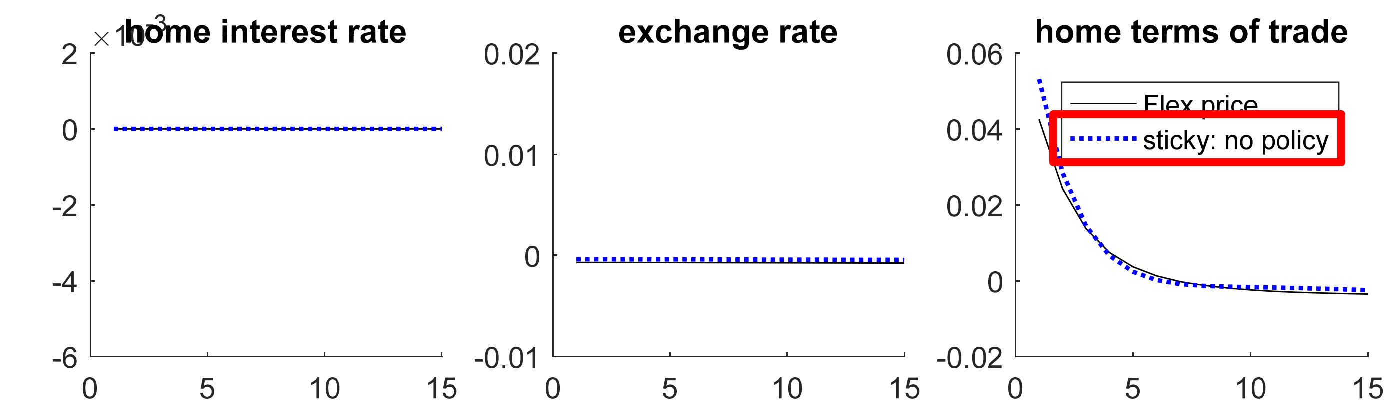
Flexible price benchmark:
Small effect on equilibrium exchange rate.

Figure 1. Unilateral foreign tariff on home exports



<u>Sticky prices</u>:
Amplify effects of tariff on relative prices and quantities.

Because firms cannot lower prices to offset tariff or reflect lower wage costs.



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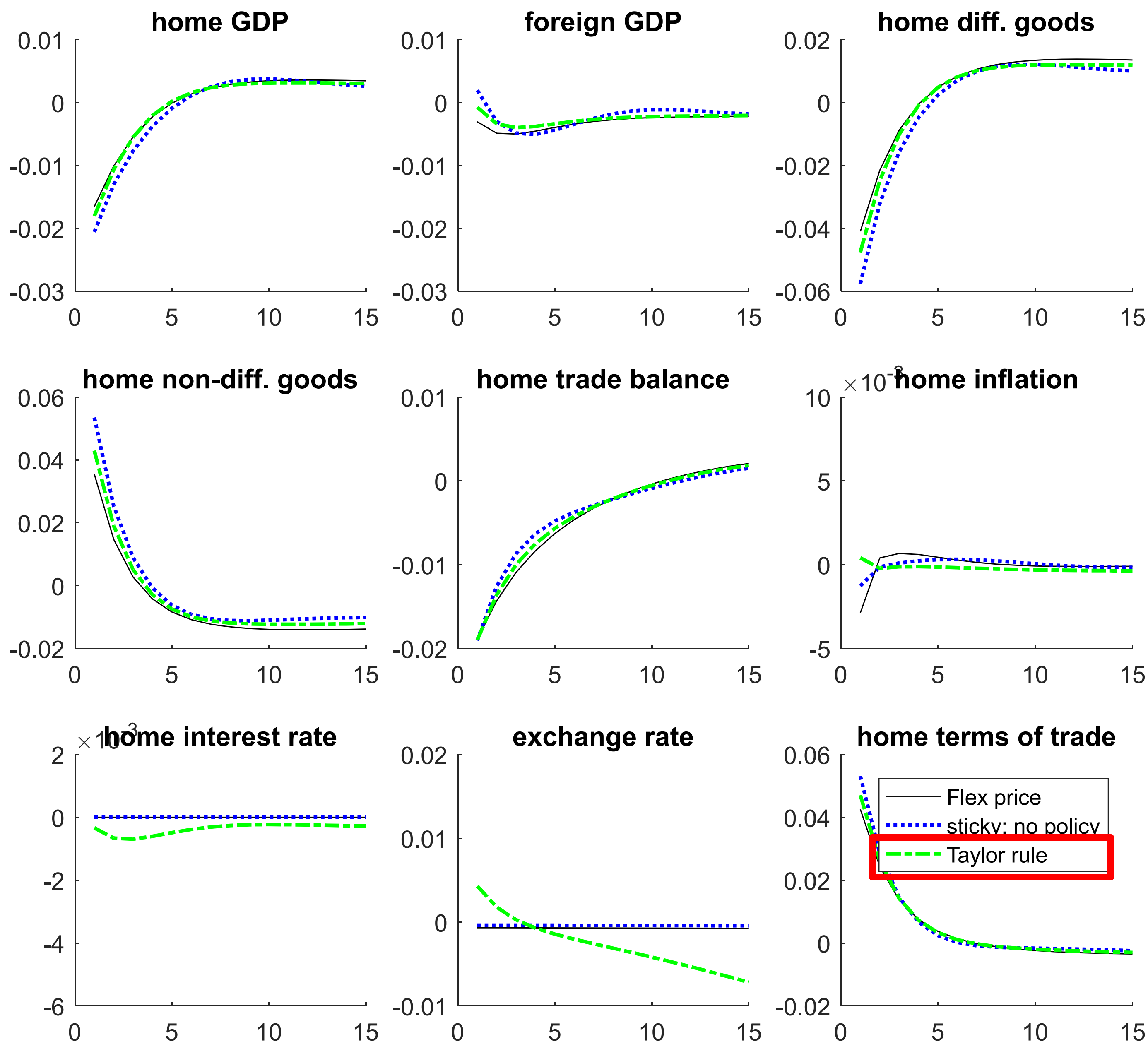

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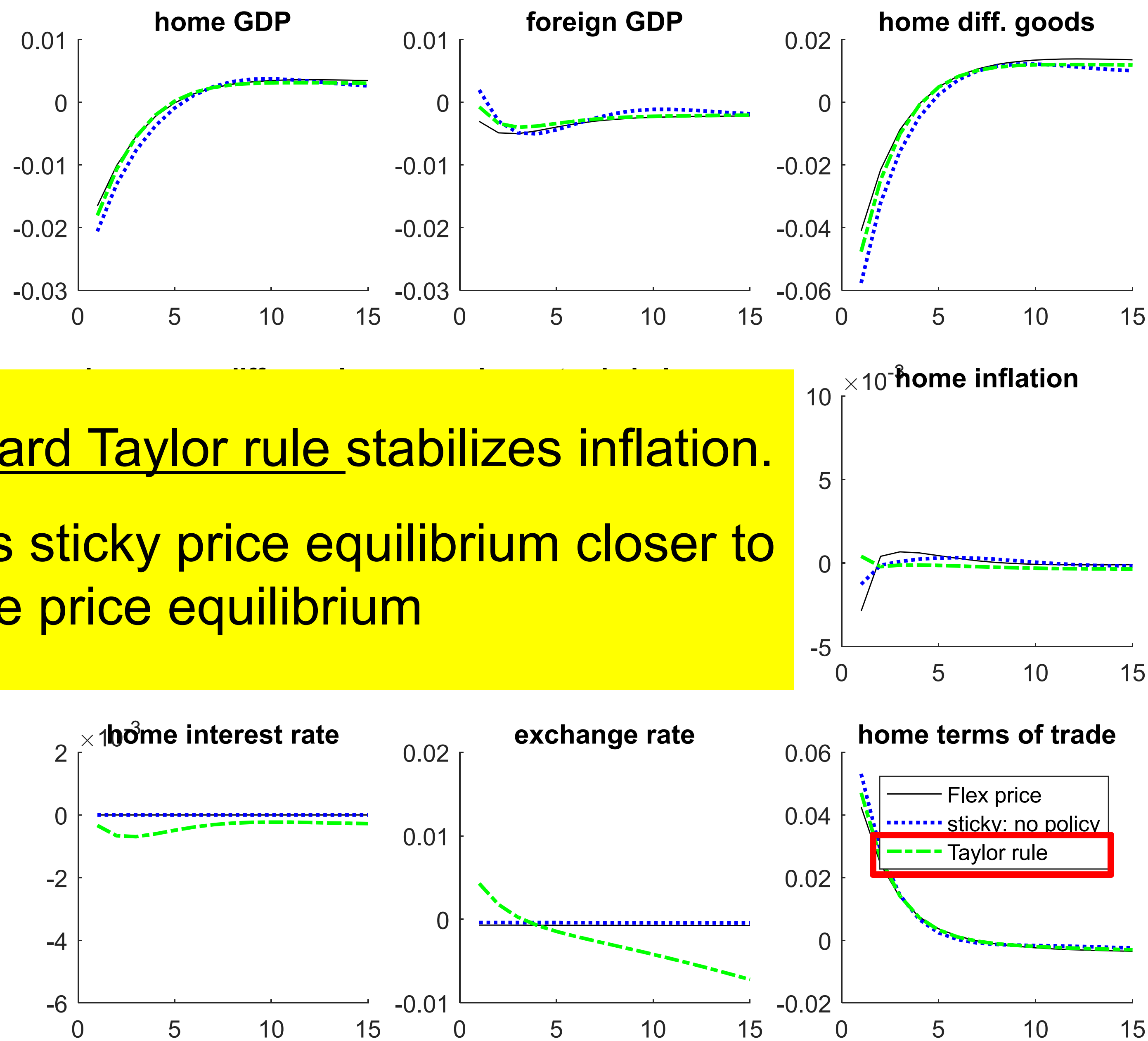
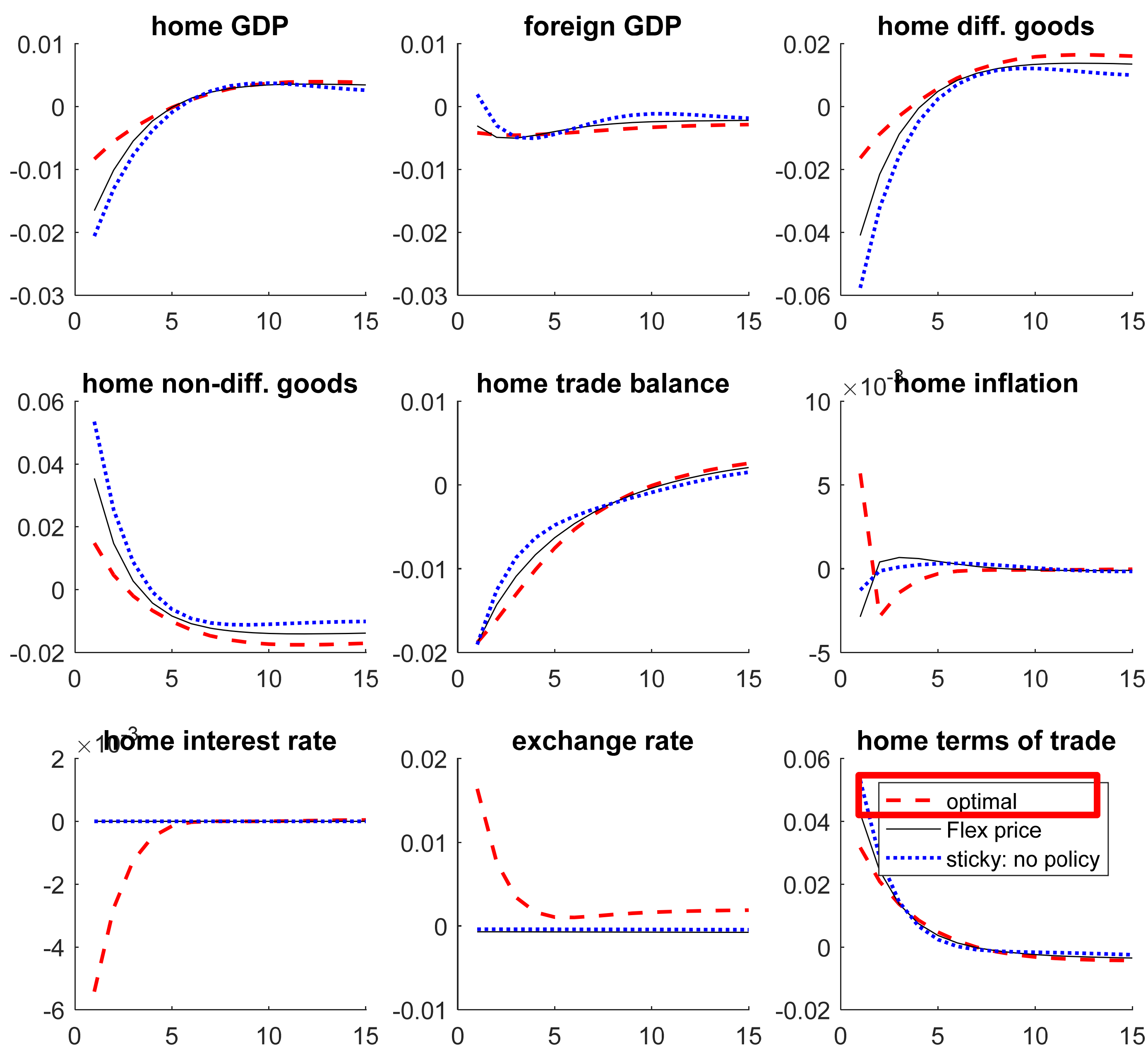


<u>Standard Taylor rule</u> stabilizes inflation.

Moves sticky price equilibrium closer to flexible price equilibrium

Figure 1. Unilateral foreign tariff on home exports



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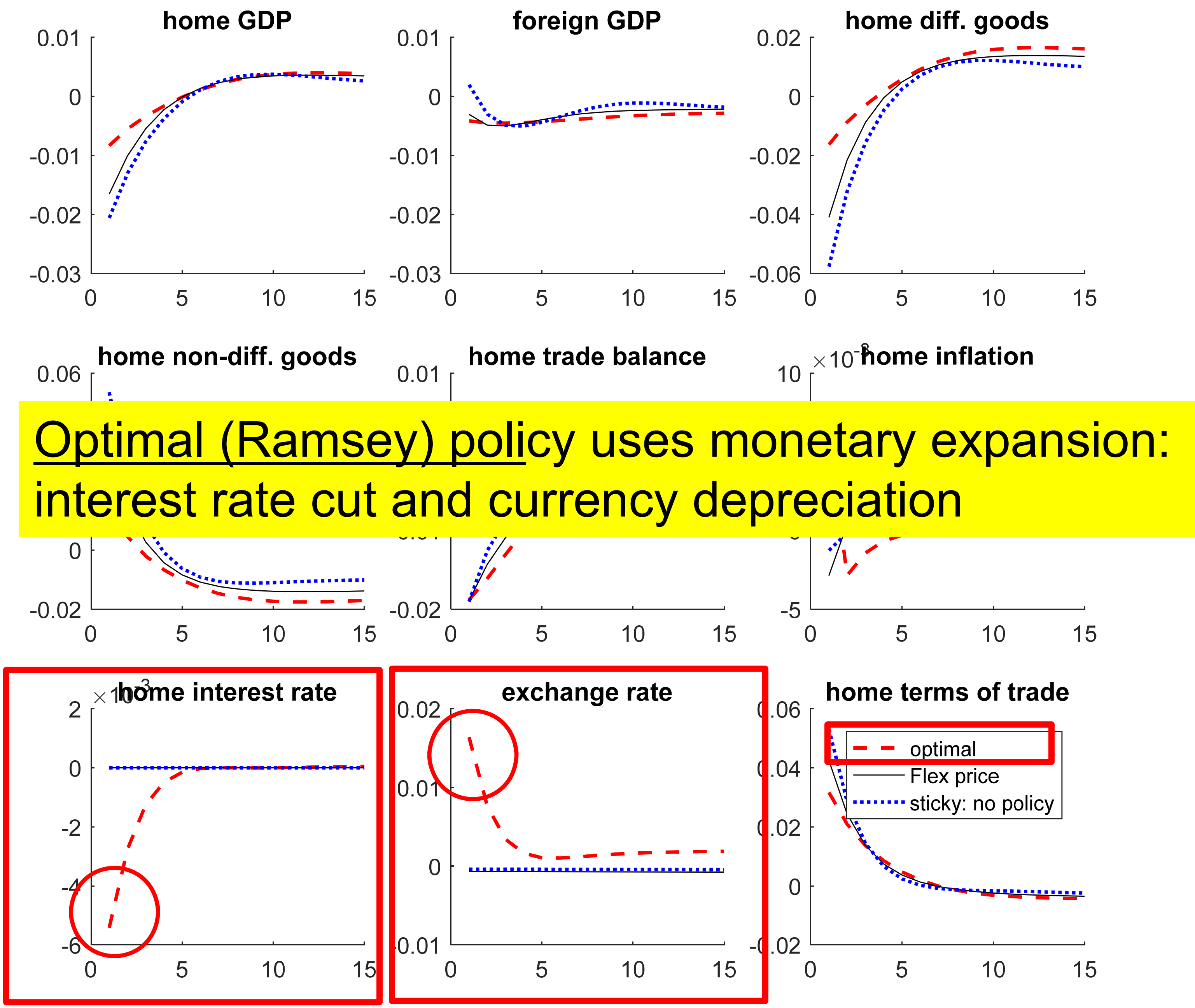

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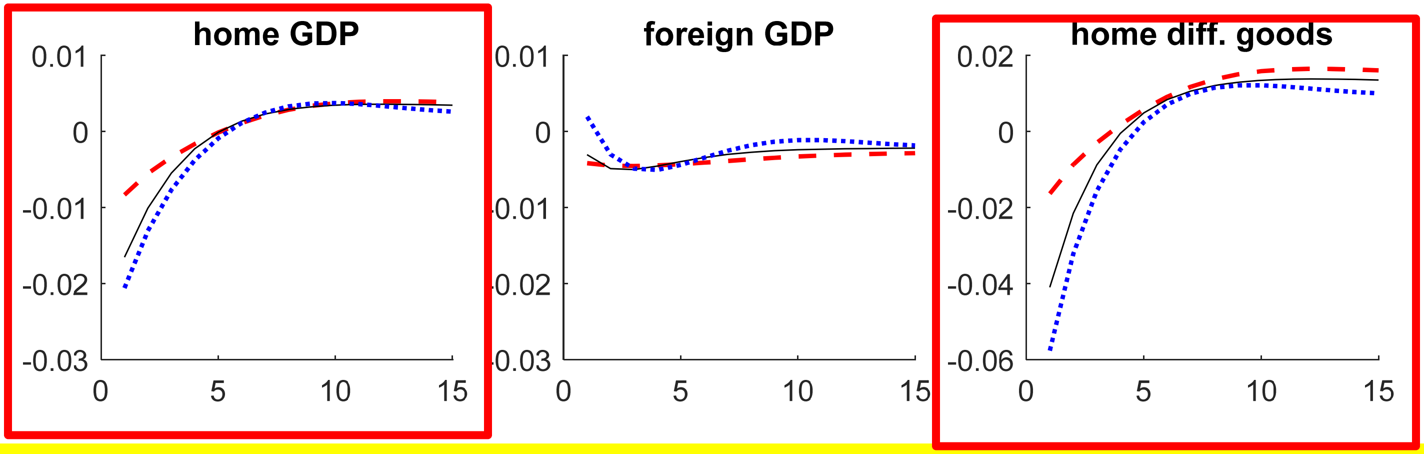
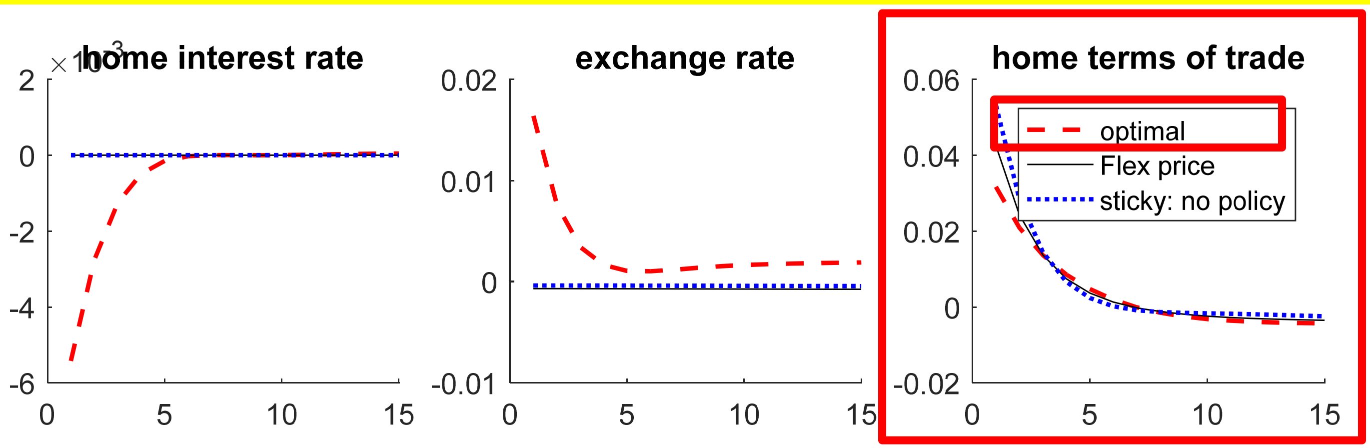


Does not replicate flexible price equilibrium to eliminate the sticky price distortion;

Instead uses sticky prices to affect real exchange rate to help offset tariff effect on rel. prices and production.



Effect of tariff shock uncertainty

- Stochastic simulation with stochastic shocks to tariffs in both countries.
- Solve with second order perturbation methods
- for unconditional means of variables, and
- for effect of suboptimal policy on conditional welfare (discounted stream of utility from a common starting point), in consumption units.
- Report results under standard Taylor rule relative to optimal Ramsey policy.

Table 1: means and welfare under unilateral tariff shocks

	benchmark	substitutes
Unconditional means (% change from Ramsey case):		
GDP	0.091	0.808
Employment	0.070	2.540
Consumption	-0.058	-2.883
Firm entry		
Investment	-0.641	-15.662
Welfare (% change from Ramsey case, C units):		
	-0.155	-0.293

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For benchmark calibration,
suboptimal Taylor rule in presence of tariff shocks:

- reduces consumption and leisure (raising employment and GDP), which lowers welfare,
- and lowers investment in firm creation.

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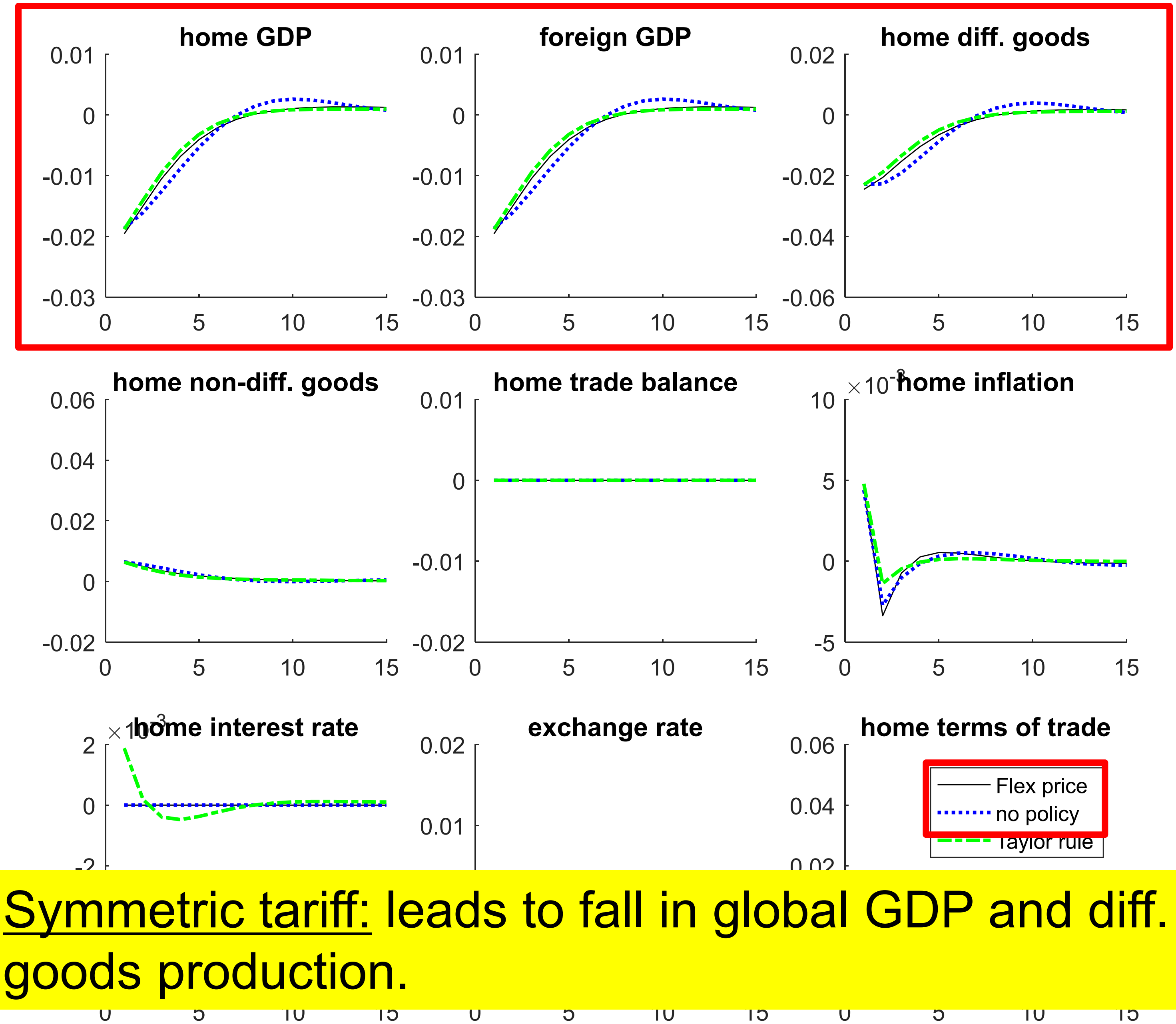
Welfare (% change from Ramsey case, C units):		
	-0.155	-0.293

For higher substitutability between sectors (elast 1.4):
All effects amplified, including on welfare.

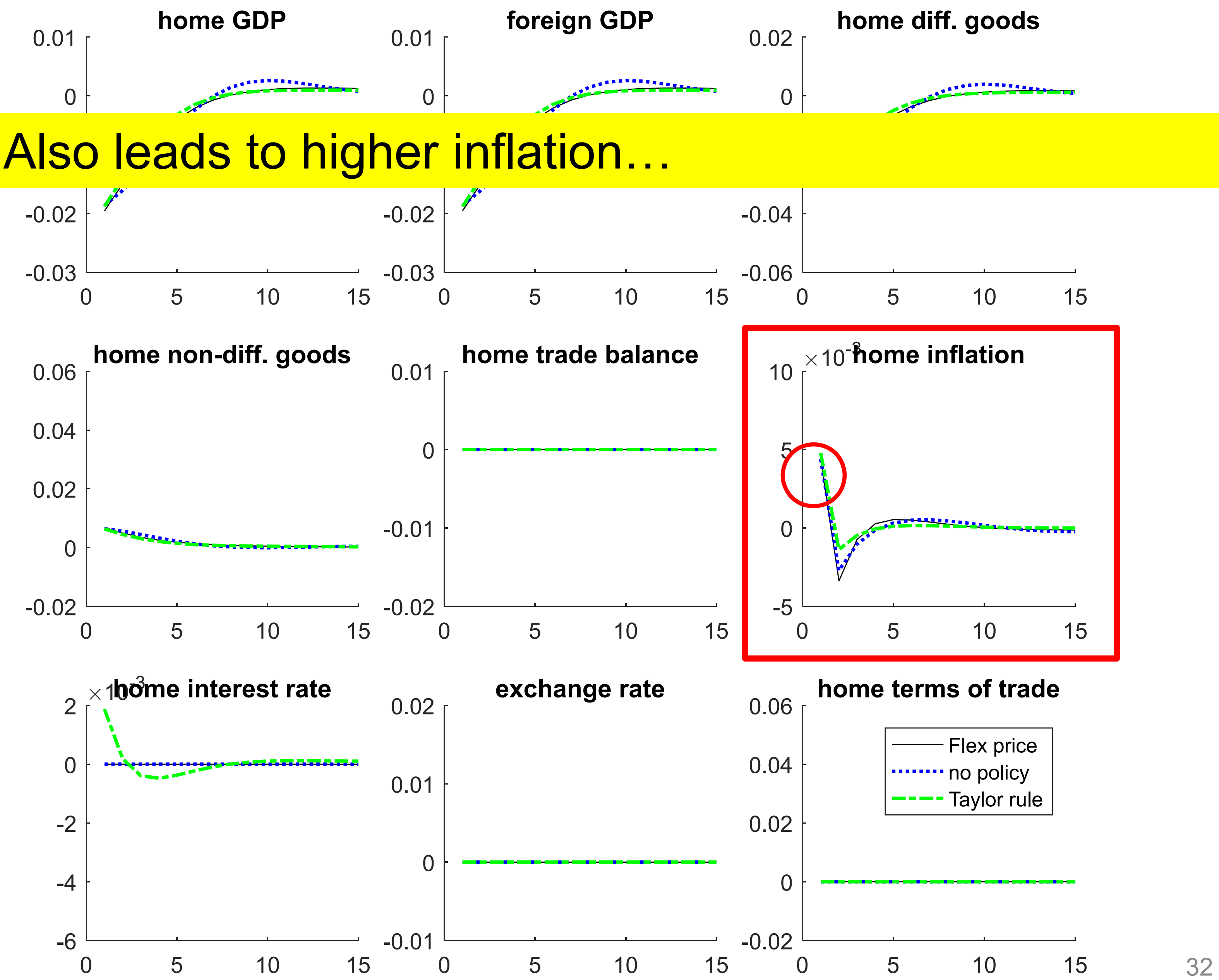
Case 2: Symmetric tariff shock (full retaliation case)

Figure 2. Symmetric tariff shock



Symmetric tariff: leads to fall in global GDP and diff. goods production.

Figure 2. Symmetric tariff shock



Also leads to higher inflation…

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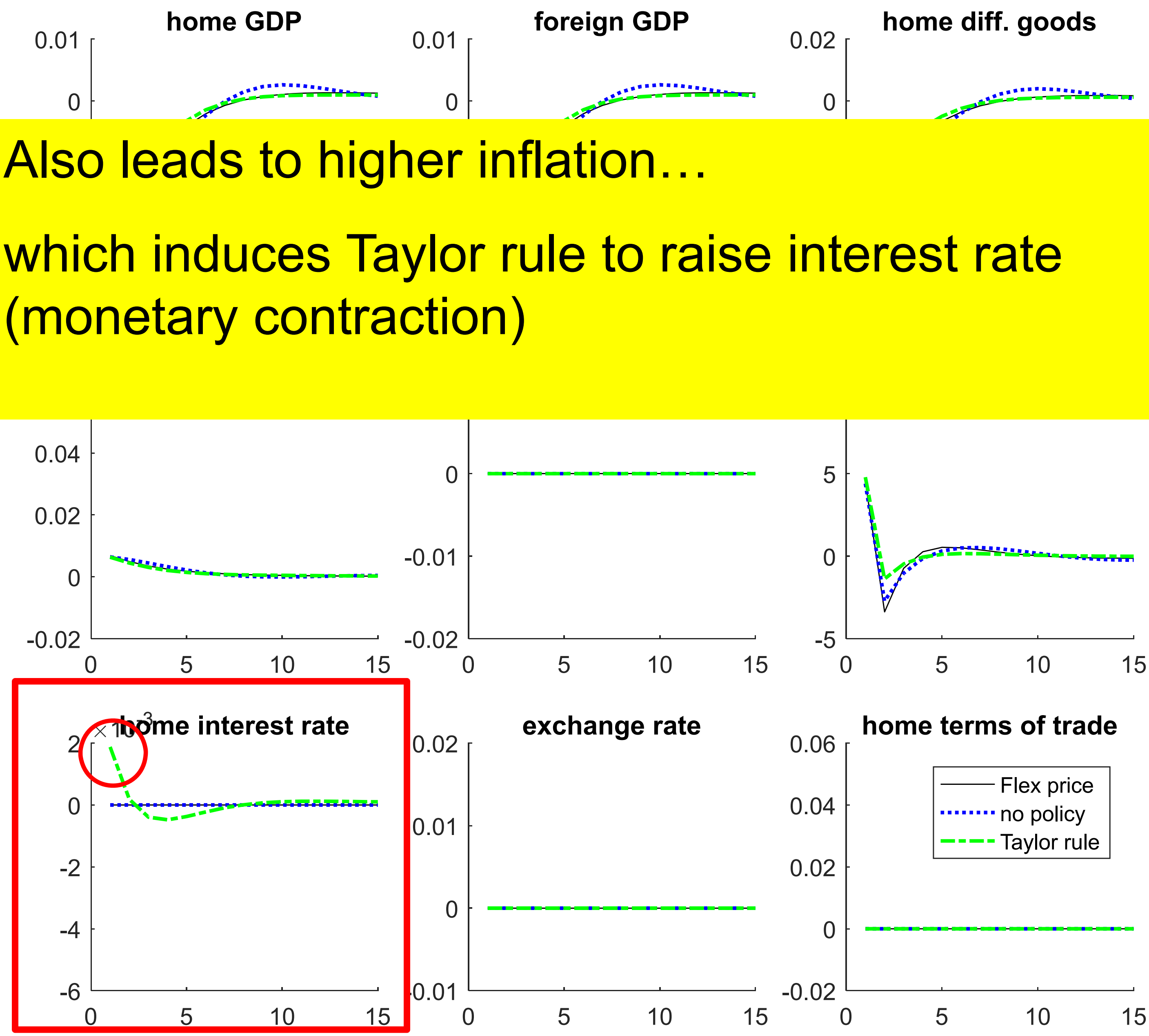
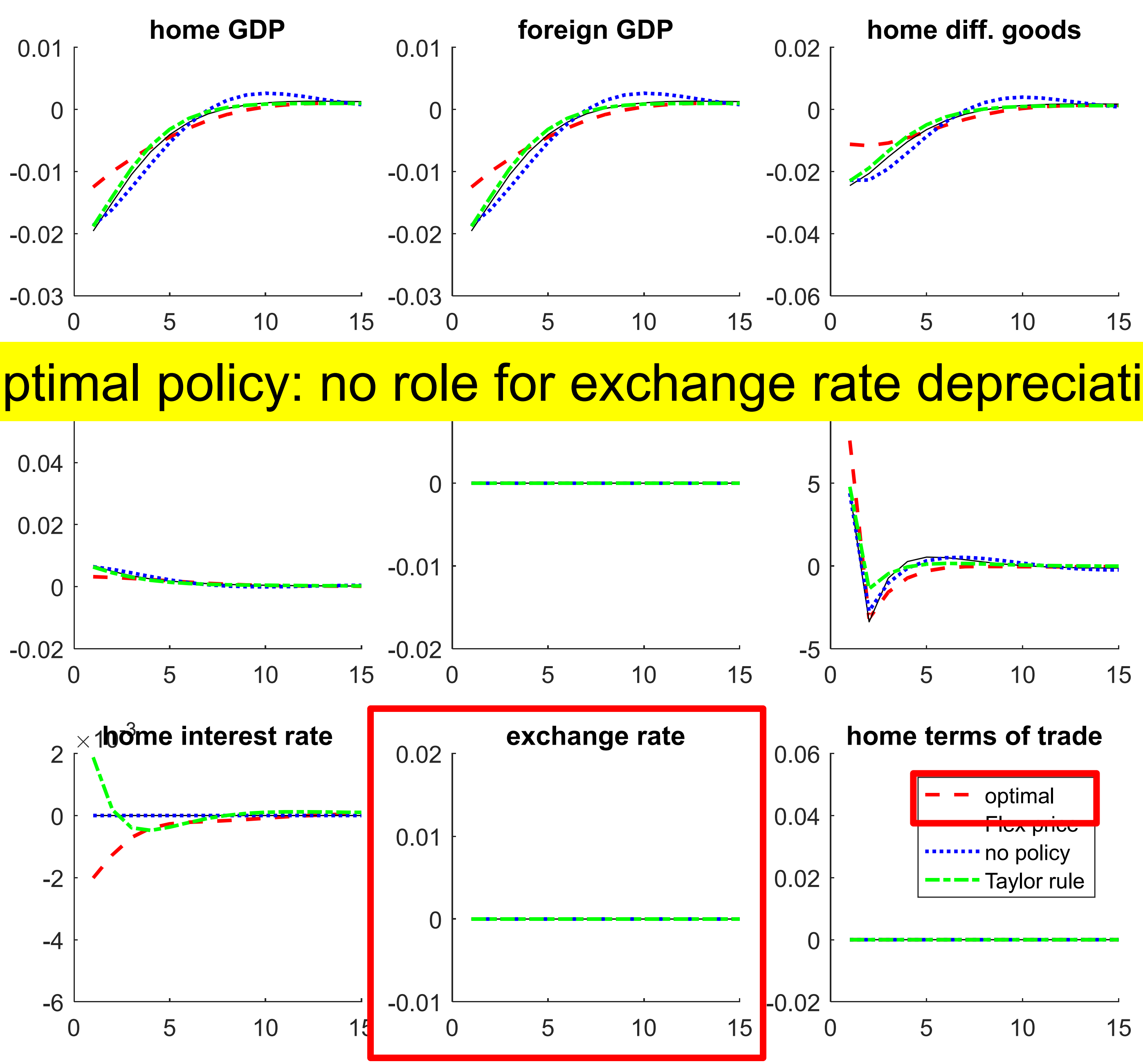


Also leads to higher inflation…

which induces Taylor rule to raise interest rate (monetary contraction)

Figure 2. Symmetric tariff shock



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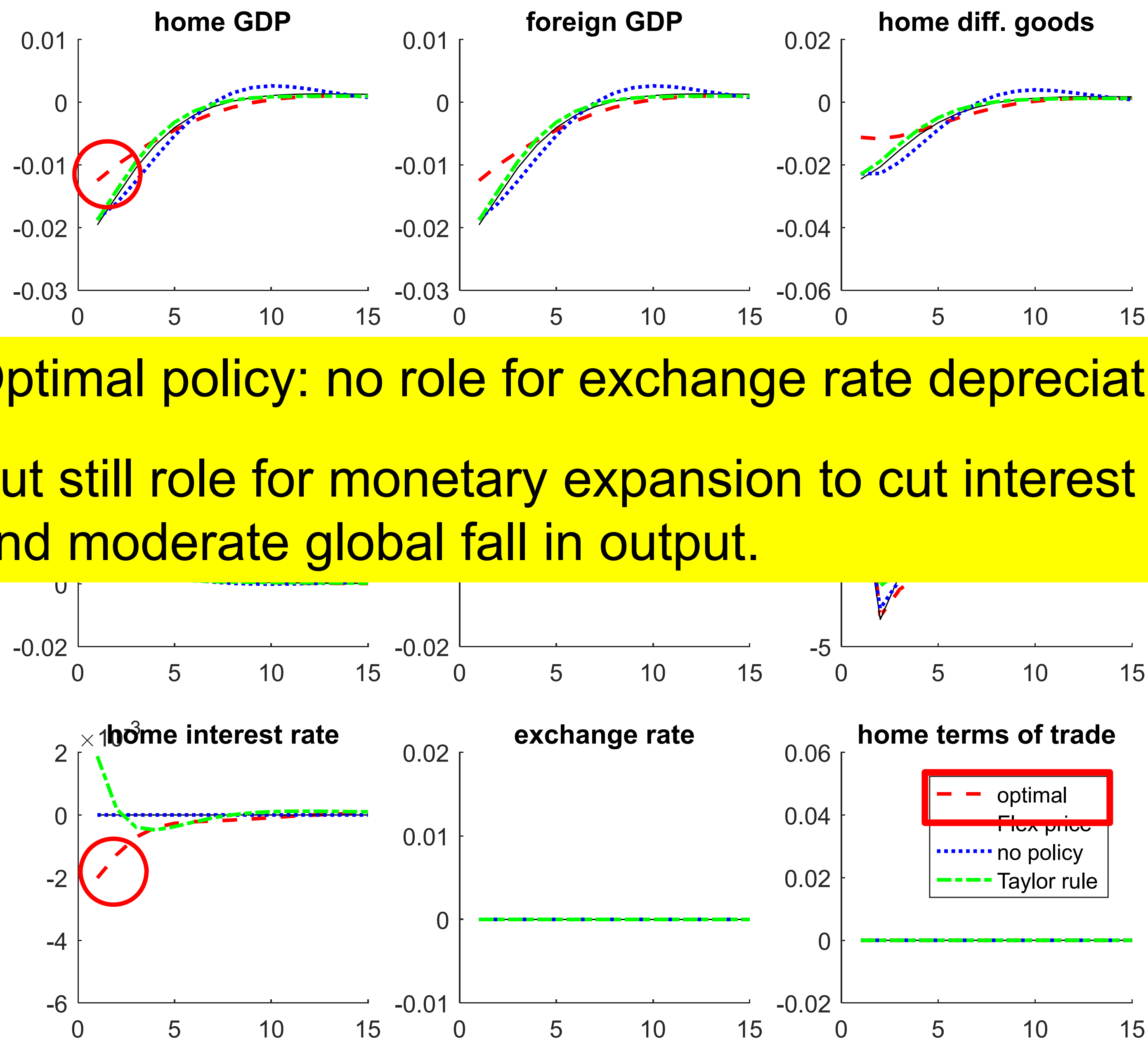

Optimal policy: no role for exchange rate depreciation...

But still role for monetary expansion to cut interest rate and moderate global fall in output.

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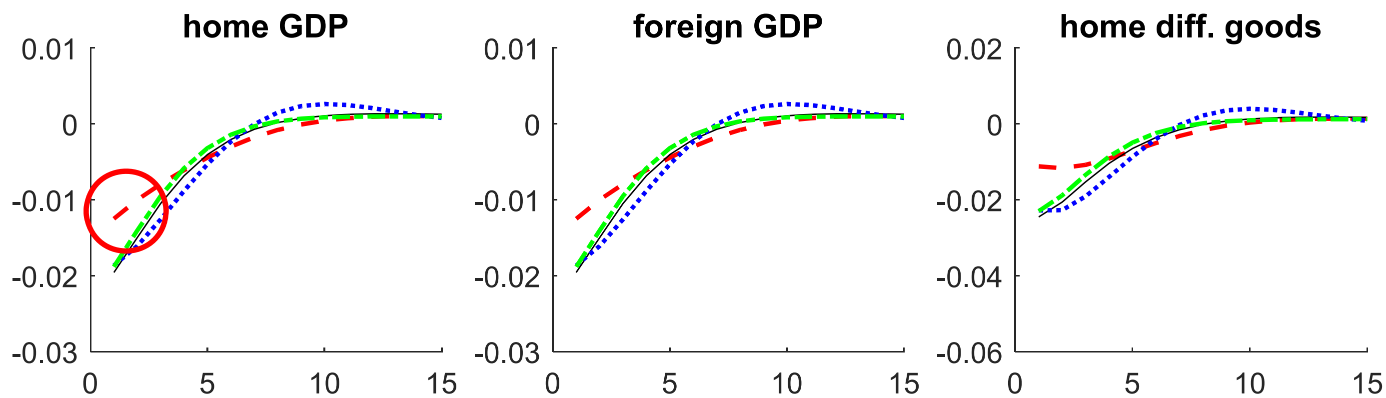

Optimal policy: no role for exchange rate depreciation...

But still role for monetary expansion to cut interest rate and moderate global fall in output.

(Opposite response to Standard Taylor rule)

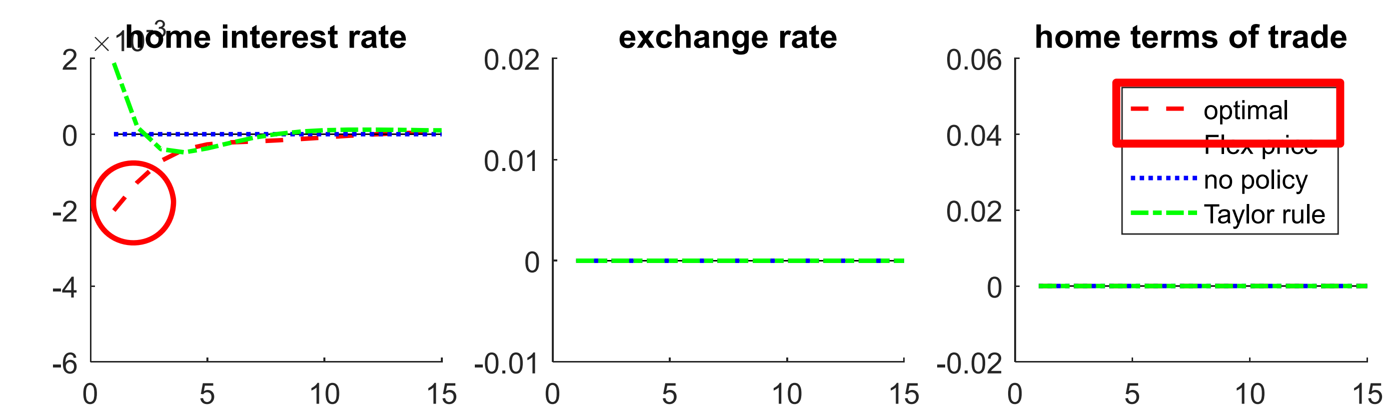

Table 2: means and welfare under symmetric tariff

Unconditional means (% change from Ramsey case):	
GDP	0.016
Employment	0.014
Consumption	-0.010
Firm entry	
Investment	-0.086
Welfare (% change from Ramsey case, C units):	
	-0.053

For tariff war shocks, smaller welfare loss from suboptimal monetary policy than unilateral tariff shocks.

Other results

- Alternative LCP (local currency) version of price stickiness:
  - No effect on tariff transmission.
  - But exchange rate depreciation not matter for relative prices; optimal policy looks more like standard Taylor rule policy.
- Single sector (macro) model: Similar results as above, since tariffs still have effect via changes in trade balance even if not trade composition.

Conclusions

- There is a role for monetary policy to ease the costs of tariff shocks.
- Monetary expansion to induce greater exchange rate depreciations can help blunt the effects of a unilateral tariff.
- Even in the case of a symmetric trade war where exchange rates cannot help, monetary expansion can blunt fall in global output.
- Optimal policy is opposite of standard Taylor rule in the latter case.

Extra Slides: Model Equations

Corresponding price indexes and demands:

$$P_t \equiv \frac{P_{D,t}^{\theta} P_{N,t}^{1-\theta}}{\theta^{\theta}\left(1-\theta\right)^{1-\theta}}$$

$$P_{D,t} = \left(n_t p_t\left(h\right)^{1-\phi} + n_t^*\left(p_t\left(f\right)T_{D,t}\right)^{1-\phi}\right)^{\frac{1}{1-\phi}}$$

$$P_{N,t} = \left(\nu P_{H,t}{}^{1-\eta} + \left(1-\nu\right)\left(P_{F,t}T_{N,t}\right)^{1-\eta}\right)^{\frac{1}{1-\eta}}$$

$$C_{D,t} = \theta\left(P_{D,t} / P_t\right)^{-\xi} C_t \qquad C_{N,t} = C_{D,t} = \left(1-\theta\right)\left(P_{N,t} / P_t\right)^{-\xi} C_t$$

$$c_t(h) = \left(p_t\left(h\right)/P_{Dt}\right)^{-\phi} C_{Dt} \qquad C_{Ht} = \nu\left(P_{Ht}/P_{Nt}\right)^{-\eta} C_{Nt}$$

$$C_{H,t} = \nu\left(P_{H,t}/P_{N,t}\right)^{-\eta} C_{N,t} \qquad C_{Ft} = \left(1-\nu\right)\left(P_{Ft}/P_{Nt}\right)^{-\eta} C_{Nt}$$

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Price setting

- Price changes subject to Rotemberg adjustment cost:

$$AC_t(h) = \frac{\psi_P}{2}\left(\frac{p_t(h)}{p_{t-1}(h)} - 1\right)^2 p_t(h)\, y_t(h)$$

- Optimal price setting:

$$p_t(h) = \frac{\phi}{\phi-1} mc_t + \frac{\psi_P}{2}\left(\frac{p_t(h)}{p_{t-1}(h)} - 1\right)^2 p_t(h) - \psi_P \frac{1}{\phi-1}\left(\frac{p_t(h)}{p_{t-1}(h)} - 1\right)\frac{p_t(h)^2}{p_{t-1}(h)}$$
$$+\frac{\psi_P}{\phi-1} E_t\left[\beta \frac{\Omega_{t+1}}{\Omega_t}\left(\frac{p_{t+1}(h)}{p_t(h)} - 1\right)\frac{p_{t+1}(h)^2}{p_t(h)}\right]$$

Where
$$\Omega_t = \left[\left(\frac{p_t(h)}{P_{D,t}}\right)^{-\phi}\left(C_{D,t} + G_t + ne_t(1-\theta_K)K_t + AC_{P,D,t} + AC_{B,D,t}\right)\right.$$
$$\left. + \left(\frac{(1+\tau_D)p_t(h)}{e_t P^*_{D,t}}\right)^{-\phi}(1+\tau_D)\left(C^*_{D,t} + G^*_t + ne^*_t(1-\theta_K)K^*_t + AC^*_{P,D,t} + AC^*_{B,D,t}\right)\right] \Big/ \mu_t$$

Household Problem Implies

Defining $\mu_t = P_t C_t^{\sigma}$,

Consumption Euler: $$\frac{1}{\mu_t} = \beta(1+i_t)E_t\left[\frac{1}{\mu_{t+1}}\right]$$

Labor supply: $$W_t = l_t^{\psi}\mu_t$$

Money demand: $$M_t = \mu_t\left(\frac{1+i_t}{i_t}\right)$$

Interest rate parity:

$$\mathrm{E}_{\mathrm{t}}\left[\frac{\mu_{\mathrm{t}}}{\mu_{\mathrm{t+1}}}\frac{e_{\mathrm{t+1}}}{e_{\mathrm{t}}}\left(1+\mathrm{i}_{\mathrm{t}}^{*}\right)\left(1+\psi_{\mathrm{B}}\left(\frac{e_t B_{ft}}{p_{Ht}y_{Ht}}\right)\right)\right]=\mathrm{E}_{\mathrm{t}}\left[\frac{\mu_{\mathrm{t}}}{\mu_{\mathrm{t+1}}}\left(1+\mathrm{i}_{\mathrm{t}}\right)\right]$$

Market clearing

- Labor: $$\int_0^{n_t} l_t(h)dh + l_{H,t} = l_t$$
- Bonds: $$B_{Ht} + B^*_{Ht} = 0$$
$$B_{Ft} + B^*_{Ft} = 0.$$
- Balance of Payments:

$$\int_0^{n_t} p_t^*(h)\left(d^*_t(h)\right)dh - \int_0^{n^*_t} p_t(f)\left(d_t(f)\right)df + P^*_{Ht}\left(C^*_{H,t} + AC^*_{P,H,t} + AC^*_{B,H,t}\right)$$
$$-P_{F,t}\left(C_{F,t} + AC_{P,F,t} + AC_{B,F,t}\right) - i_{t-1}B^*_{H,t-1} + e_t i^*_{t-1}B_{F,t-1} = \left(B^*_{H,t} - B^*_{H,t-1}\right) + e_t\left(B_{F,t} - B_{F,t-1}\right)$$

- Government budget constraint:

$$M_t - M_{t-1} + T_t = 0$$

Monetary Policy rules

1.No policy (constant money growth)

$$\frac{M_t}{M_{t-1}} = \upsilon$$

2. Ramsey optimal policy optimizes:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{1}{2}\left(\frac{1}{1-\sigma} C_t^{1-\sigma} - \frac{1}{1+\psi} l_t^{1+\psi} \right) + \frac{1}{2}\left(\frac{1}{1-\sigma} C_t^{*1-\sigma} - \frac{1}{1+\psi} l_t^{*1+\psi} \right) \right)$$

3. Taylor rule:

$$1 + i_t = (1 + i_{t-1})^{\gamma_i} \left[(1+\bar{i}) \left(\frac{p_t(h)}{p_{t-1}(h)} \right)^{\gamma_p} \left(\frac{Y_t}{\bar{\bar{Y}}} \right)^{\gamma_Y} \right]^{1-\gamma_i}$$

Includes output deviation.

$$Y_t = \left(\int_0^{n_t} p_t(h) y_t(h) dh + p_{Ht} y_{Ht} \right) / P_t$$

shocks

- Tariff shocks:

$$\begin{bmatrix} \log T_{D,t} - \log \overline{T_D} \\ \log T^*_{D,t} - \log \overline{T^*_D} \\ \log T_{N,t} - \log \overline{T_N} \\ \log T^*_{N,t} - \log \overline{T^*_N} \end{bmatrix} = \rho_T \begin{bmatrix} \log T_{D,t-1} - \log \overline{T_D} \\ \log T^*_{D,t-1} - \log \overline{T^*_D} \\ \log T_{N,t-1} - \log \overline{T_N} \\ \log T^*_{N,t-1} - \log \overline{T^*_N} \end{bmatrix} + \varepsilon_{Tt}$$

- Productivity shocks (when included):

$$\begin{bmatrix} \log \alpha_{D,t} - \log \overline{\alpha_D} \\ \log \alpha_{N,t} - \log \overline{\alpha_N} \end{bmatrix} = \rho_A \begin{bmatrix} \log \alpha_{D,t-1} - \log \overline{\alpha_D} \\ \log \alpha_{N,t-1} - \log \overline{\alpha_N} \end{bmatrix} + \varepsilon_{At}$$

Welfare

- computed in terms of consumption units that households would be willing to forgo to continue under the Ramsey policy regime:

$$\sum_{t=0}^{\infty} \beta^t \left(u\left(C_t^{alt.policy}, l_t^{alt.policy} \right) \right) = \frac{u\left[\left(1 + \frac{\Delta}{100} \right) \left(C_t^{Ramsey}, l_t^{Ramsey} \right) \right]}{1 - \beta}$$

- Impose identical initial conditions across different monetary policy regimes, using Ramsey allocation,
- we include transition dynamics in the computation to avoid spurious welfare reversals:

Numerical Simulations:

Calibrating differentiated sector

- Share of differentiated goods: Rauch (1999).
- Elasticities of Substitution: Broda and Weinstein (2006) 5.2 for differentiated goods (as defined by Rauch 1999); 15.3 for non-differentiated.
- Intermediate share from outside lit.: ς =1/3.
- Calibrate trade cost to match exports as share of GDP: $\tau_D = 0.33$
- Shocks: sectoral data from Groningen Growth and Development Centre, calibrate to U.S. data

Parameter Values

Preferences	
Risk aversion	$\sigma = 2$
Time preference	$\beta = 0.96$
Labor supply elasticity	$1/\psi = 1.9$
Differentiated goods share	$\theta = 0.61$
Non-differentiated goods home bias	$\nu = 0.5$
Differentiated goods elasticity	$\phi = 5.2$
Non-differentiated goods elasticity	$\eta = 15.3$
Technology	
Firm death rate	$\delta = 0.1$
Price stickiness	$\psi_P = 8.7$
Intermediate input share	$\varsigma = 0.33$
Differentiated goods trade cost	$\tau_D = 0.33$
Non-differentiated goods trade cost	$\tau_N = 0$
Mean sunk entry cost	$\overline{K} = 1$
Firm entry adjustment cost	$\lambda = 0.10$
Bond holding cost	$\psi_B = 0.001$

Parameter values continued

Monetary Policy (for the historical policy rule):

Interest rate smoothing	$\gamma_i = 0.7$
Inflation response	$\gamma_p = 1.7$
GDP response	$\gamma_Y = 0.1$

Shocks:

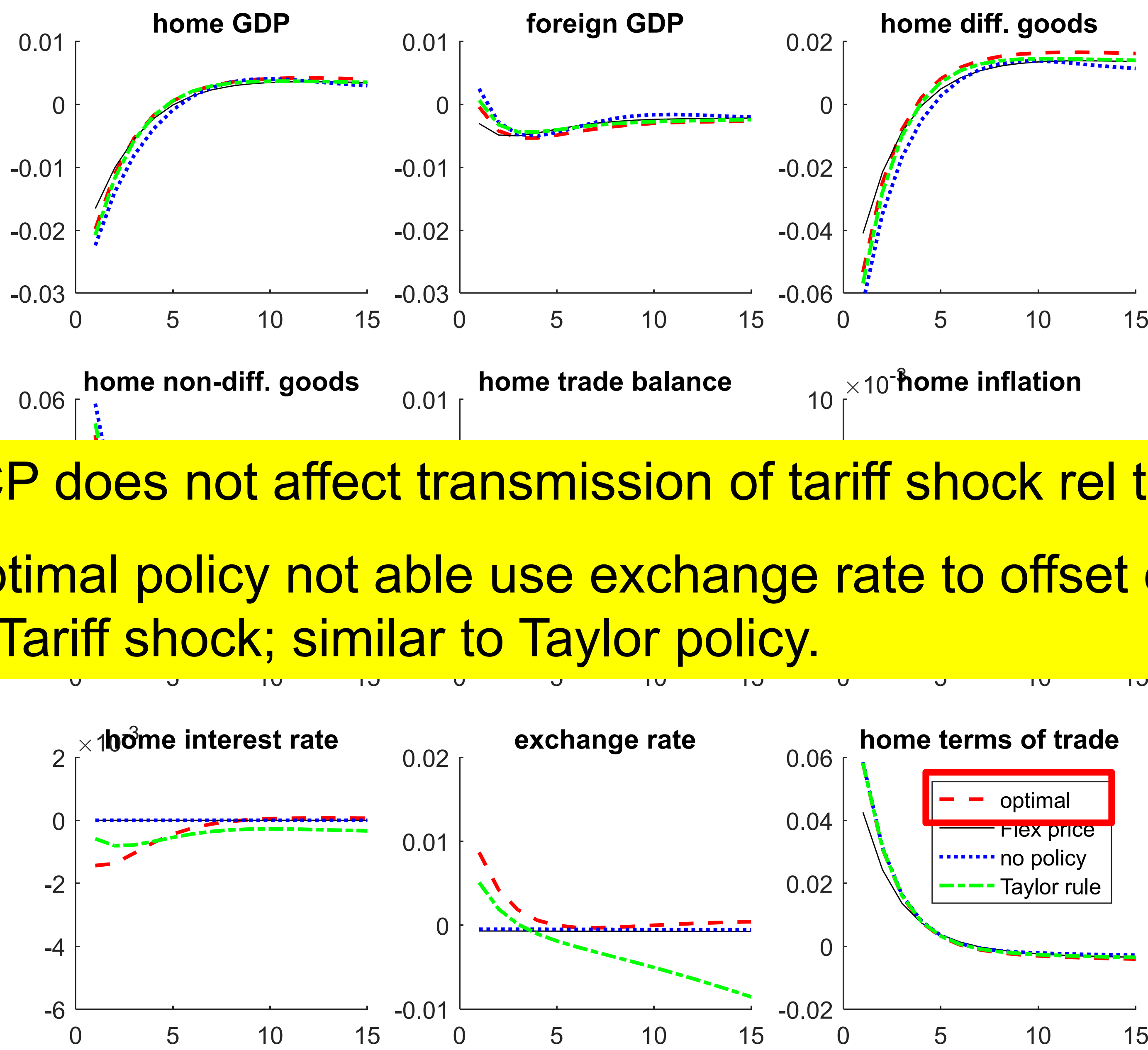
Tariff shocks:

Mean	1.02
Standard deviation	0.06
Autoregressive	0.56

Productivity shocks (when included):

Standard deviation	0.01
International corr.	0.25
Autoregressive, own	0.90
Autoregressive, int'l	0.09

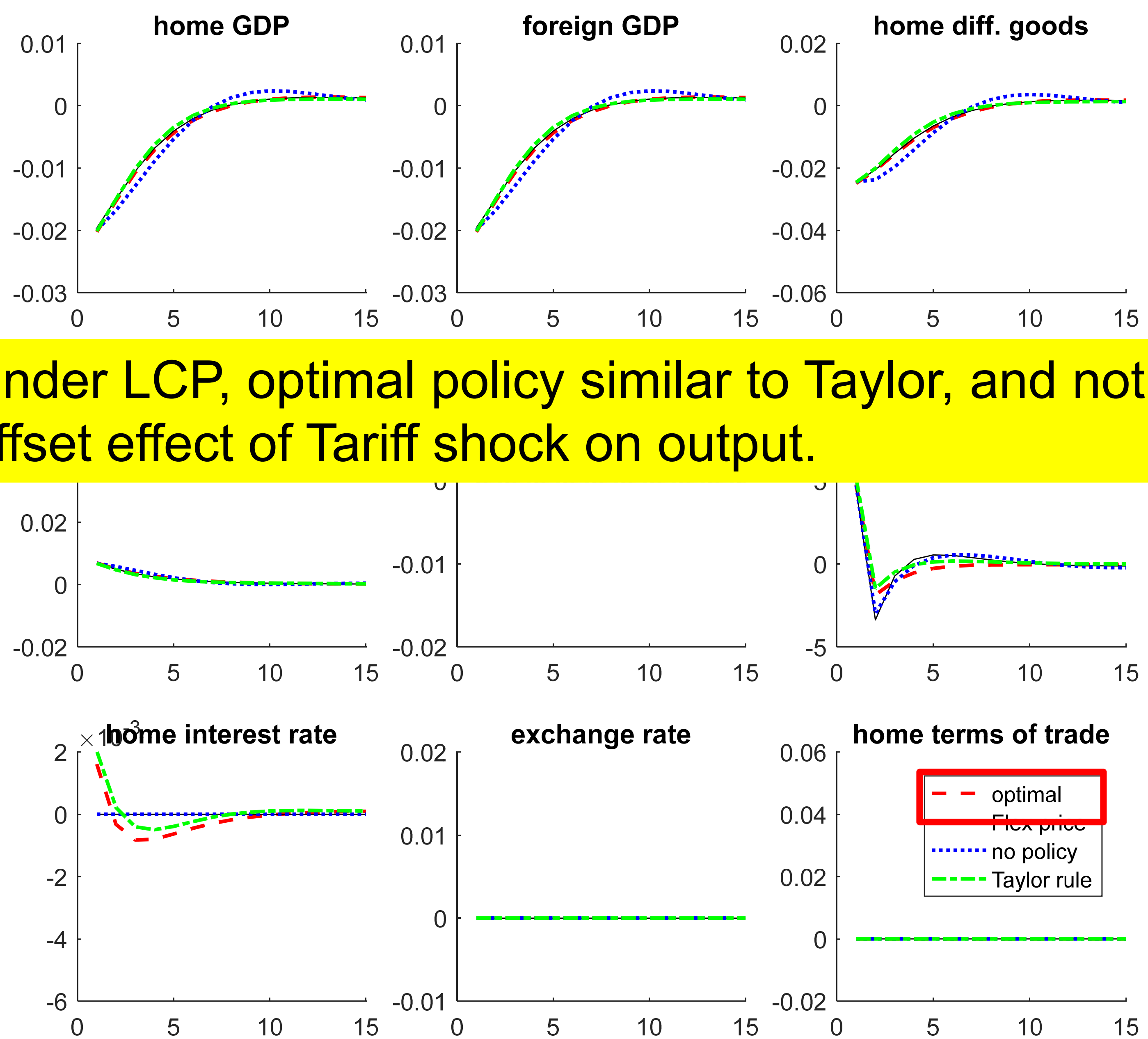
Figure 3. LCP: Unilateral tariff shock



LCP does not affect transmission of tariff shock rel to PCP.

Optimal policy not able use exchange rate to offset effect of Tariff shock; similar to Taylor policy.

Figure 4. LCP: Symmetric tariff shock



Under LCP, optimal policy similar to Taylor, and not able offset effect of Tariff shock on output.