Global Networks, Monetary Policy and Trade

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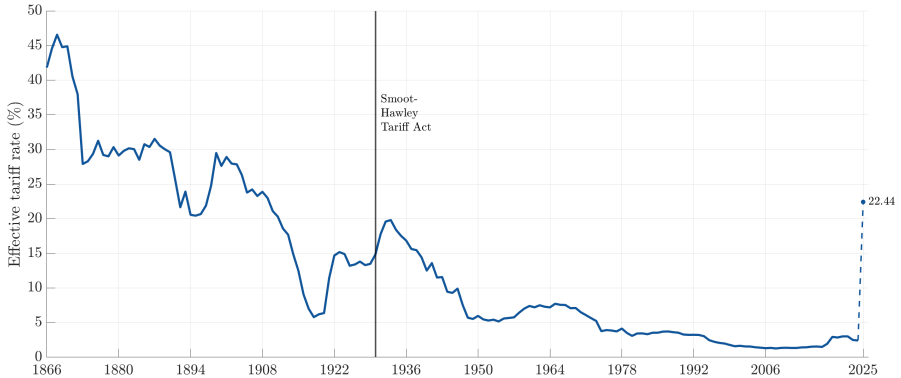
May 2025

2025 “De-Globalization” Shock

Figure 1: Effective Tariff Rate (%, Historic and Estimated)



NOTE: Effective tariff rate stands for customs duty revenue as a proportion of goods imports. Data from *Historical Statistics of the United States* Ea424-434, *Monthly Treasury Statement*, Bureau of Economic Analysis. Estimated effective tariff rate of 22.44% provided by Yale Budget Lab using the GTAP Model v7.

Classic Question, Different Approaches

- **Classic question (Hume, 1752)**: How do trade barriers affect prices and output?
  - Modern Trade: Real models, long-run focus on productivity, inequality and welfare + important role for GVCs
  - Modern Macro: Short-run. Trade barriers lead to higher prices and efficiency loss but no recessions; open economy focus on expenditure switching and TOT manipulation.
- Trade do not emphasize the role of **aggregate demand and monetary policy**
- Macro do not emphasize **country asymmetry and sector heterogeneity**

Liberation Day Shock: Needs Both

Paul Krugman, April 5th:

"There's a funny thing here, which is that ordinarily I would say that while tariffs are bad, they don't cause recessions. It makes the economy less efficient. You turn to higher-cost domestic sources for stuff, instead of lower-cost foreign sources, and foreigners turn away from the stuff you can produce cheaply. But that's a reduction in the economy's efficiency, not a shortfall in demand. What's unique about this situation is that the protectionism is unpredictable and unstable. And it's that uncertainty that is the recessionary force."

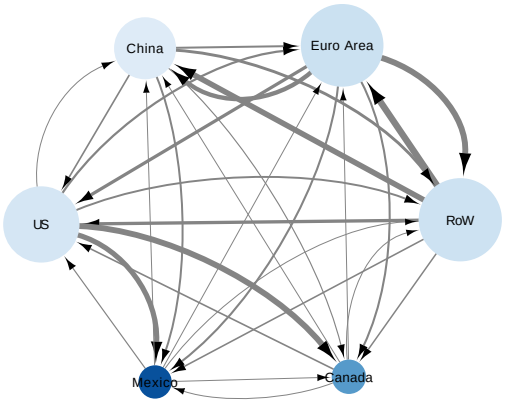
Treasury Secretary Bessent, April 6th:

"I see no reason that we have to price in a recession."

FED Chair Powell, April 16th:

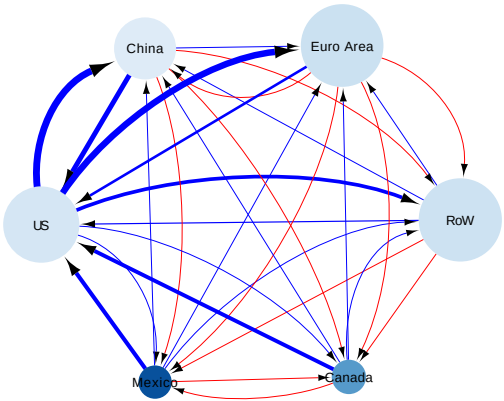
"We may find ourselves in the challenging scenario in which our dual-mandate goals are in tension."

Supply Chain Trade: Before January 2025



Size: World GDP shares (0.6% to 13.7%).
Darker color: Higher imported input shares (8.6% to 31%).
Thicker arrow: Share of the inputs from the source country among all imported inputs (0.6% to 58%).

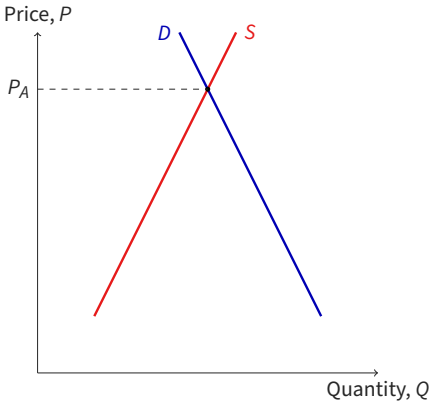
Projected: Liberation Day w/Retaliation



Link color: Decrease (blue) or increase (red) in trade.
Thicker arrow: Percent changes relative to the values before 2025 (from 0.1% to 31%).
Short run impact w/EOS<1, long run impact ↑ w/EOS>1.

Textbook Effects of Large Country Tariffs

- Autarky – No trade.



Adapted from Krugman, Obstfeld & Melitz (2022)

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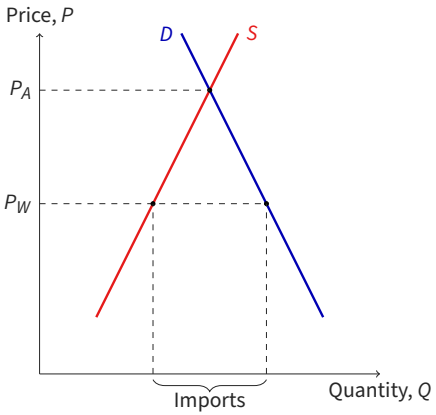

- Autarky – No trade.
- Opening up to trade – No tariffs.
  - World price is lower: $P_W < P_A$.
  - Country imports.

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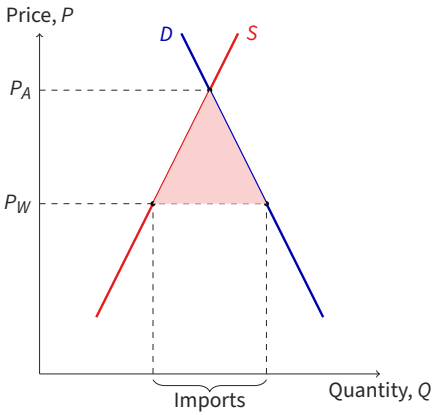

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  - Suppliers lose, consumers benefit.
  - Consumer benefits are larger $\Rightarrow$ Country as a whole is better off.

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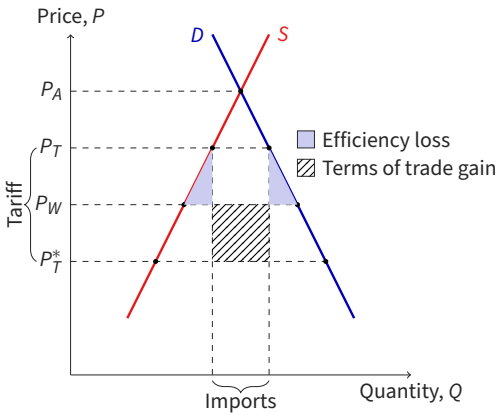

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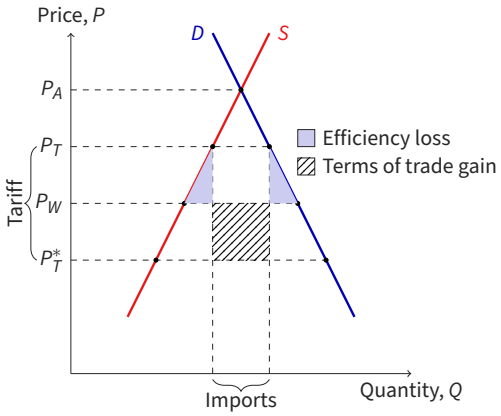
  - World price is lower: $P_W < P_A$.
  - Country imports.
  - Suppliers lose, consumers benefit.
  - Consumer benefits are larger $\Rightarrow$ Country as a whole is better off.
- Country imposes a tariff.
  - Price within the country appreciates: $P_T > P_W$.
  - If the country is large, its demand will be lower.
  - The price in the rest of the world depreciates: $P_T^* < P_W$ with Tariff = $P_T - P_T^*$.
  - Country imports less.
  - Inefficiencies both in supply and demand.
  - Gains from trade if tariff revenue compensates inefficiencies (Optimum tariff idea).

What do we learn if we add Macroeconomics?



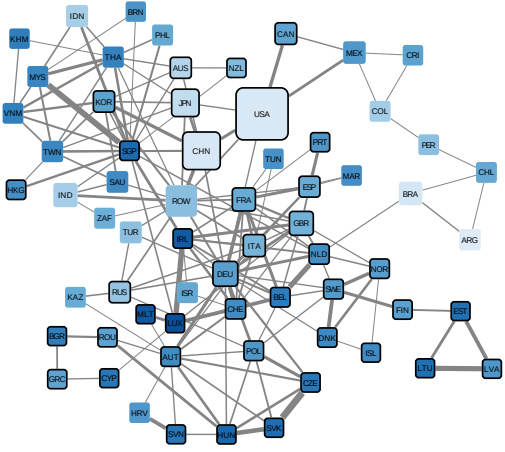
- Price adjustment takes time.
- Labor supply is endogenous.
- Central banks respond to price changes.
- Retaliation and foreign central banks' response.
- Household expectations about the future impact prices.
- Country-sector heterogeneities are important (who is who of the supply chain?).

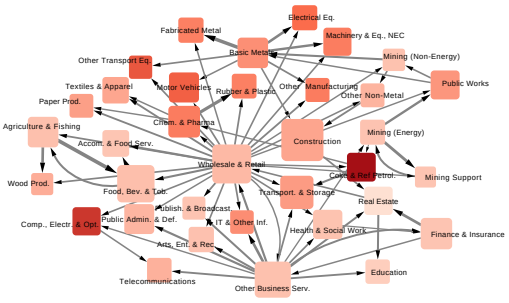
Adapted from Krugman, Obstfeld & Melitz (2022)

What is different compared to SOE?

- World prices are given in the SOE setting. All prices are endogenous with global networks.
- World demand is fixed in SOE, not in global GE.
- Sectoral price rigidities interact with global networks.
- Taylor Rule of each country affects the global prices.
- Exchange rates adjust globally.

Importance of Country-Sector Dimension: Production and Trade Network





Çakmaklı, Demiralp, Kalemli-Özcan, Yeşiltaş & Yıldırım, "The Economic Case for Global Vaccinations: An Epidemiological Model with International Production Networks," NBER & CEPR. Conditionally accepted, *Review of Economic Studies*.

Our Paper

We revisit the classical question from a different lens.

A new GE framework to think about propagation of global trade shocks, when:

- Simultaneous impact on consumer demand and producer marginal cost.
- World is connected but fragmenting; tariffs used for geopolitical reasons.
- Monetary policy responds to tariff-induced inflation and unemployment.

Why relevant? **Can a LARGE country-shock change the existing trade and production networks or the country ends in isolation?**

Building a Global GE Model with Networks

- A new NKOE model that combines full global I-O linkages with N-country open economy features and nominal rigidities

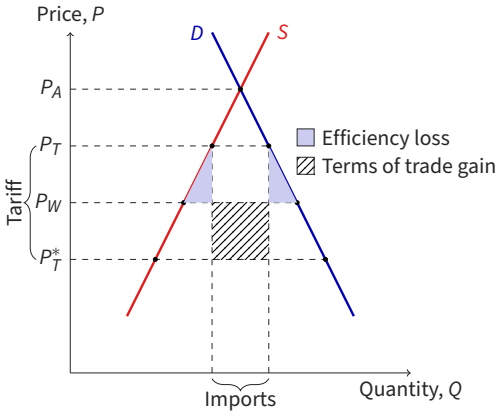
  $\Rightarrow$ Extending **?** to open economy and extending **?** dynamically

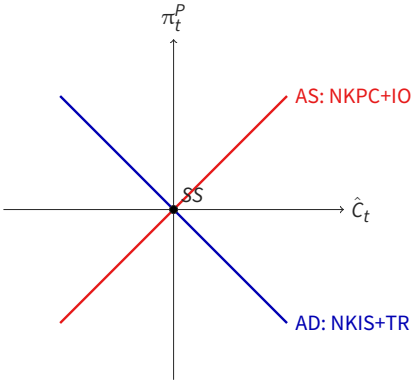
  $\Rightarrow$ Allow us to consider the role of exchange rate and monetary policy dynamics

- Analytics from linearized global GE; quantitative solutions for the non-linear model using granular data from global trade and production network

  $\Rightarrow$ Validate the model on 2017-2018 Trump tariffs
  $\Rightarrow$ Run counterfactuals for future impact of current 2025 tariffs and tariff threats
  $\Rightarrow$ Separate the roles of demand, exchange rate, expectations, policy, stickiness & I-O linkages

Visualizing Our Approach





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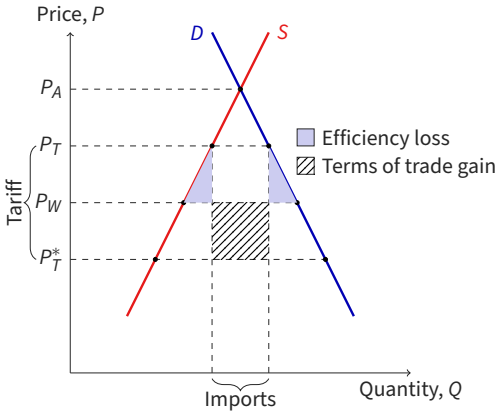

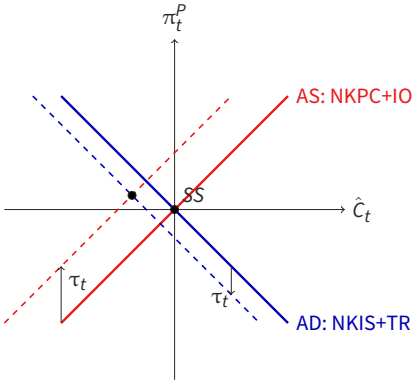

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Summary of Results

- Theroetical results:
  - 5-equation global NK representation that is **analytically** solved
  - Decompose **reallocation** beyond **direct effects** with **demand, ER, expectations, policy, stickiness** & **networks**

- Quantitative results on tariffs:
  - Case 1- 2018:
    - π_t^{US} **0.07pp↑, US RGDP 0.2%** ↓, & **4% USDCNY appreciation**
    - Consistent with **??**
  - Case 2- 2025 Liberation Day Tariffs + No Retaliation:
    - π_t^{US} **0.48pp↑, US RGDP 0.84%** ↓, & **10.02%USD NEER appreciation**
  - Case 3- 2025 Liberation Day Tariffs + Retaliation:
    - π_t^{US} **0.76pp↑, US RGDP 1.58%** ↓, & **4.82%USD NEER appreciation**
  - Case 4- Case 3 Announced Today & Reversed Tomorrow:
    - π_t^{US} **0.62pp↓, US RGDP 0.71%** ↓, & **4.08%USD NEER appreciation**

Model

Model Overview

Model combines

1. New Keynesian model with Rotemberg costs

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2. "Full" open economy $\rightarrow$ N-country DGE
   - Portfolio Adjustment Costs (PAC)
   - Producer Currency Pricing (PCP) and tariffs:

$$P^{C}_{n,mj,t} = \mathcal{E}_{n,m,t} P^{P}_{mj,t} (1 + \tau_{n,mj,t})$$

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1. New Keynesian model with Rotemberg costs
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   - Portfolio Adjustment Costs (PAC)
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3. Production network with full Input-Output (IO) matrix
   - n is consuming country, i is consuming sector, m is producing country, j is producing sector
   - Both consumption goods and intermediate inputs are nested CES
     - German cars+American cars+ Japanese cars $\rightarrow C_t^{cars}$
     - $C_t^{cars} + C_t^{food} \rightarrow C_t$

Household's Problem

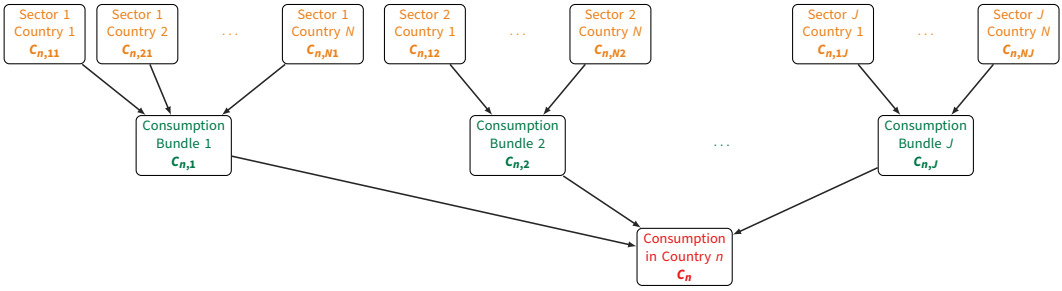
- The household maximizes the present value of lifetime utility:

$$\max_{\{C_{n,t},L_{n,t},B^{US}_{n,t}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_{n,t}^{1-\sigma}}{1-\sigma} - \chi \frac{L_{n,t}^{1+\gamma}}{1+\gamma} \right]$$

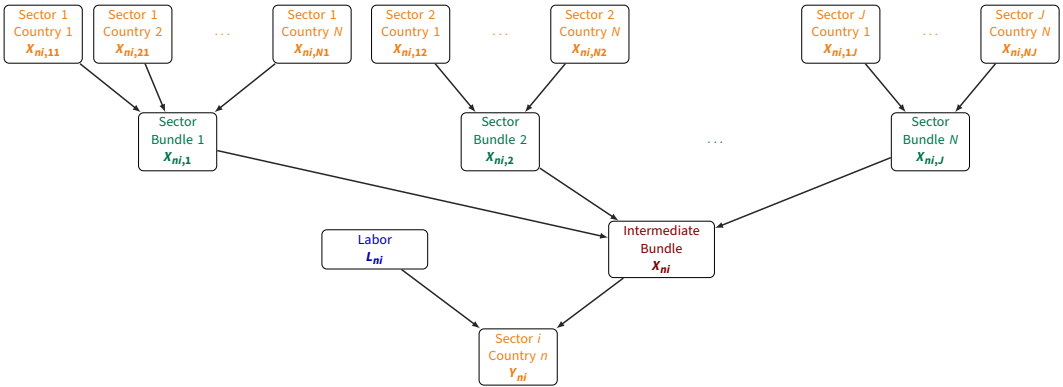
s.t.

$$P_{n,t}C_{n,t} + T_{ni,t} - B_{n,t} - \mathcal{E}^{US}_{n,t}B^{US}_{n,t} + \mathcal{E}^{US}_{n,t}\psi(B^{US}_{n,t}) \leq$$
$$W_{n,t}L_{n,t} + \sum_i \Pi_{ni,t} - (1 + i_{n,t-1})B_{n,t-1} - \mathcal{E}^{US}_{n,t}(1 + i^{US}_{n,t-1})B^{US}_{n,t-1}$$

Intra-temporal Consumption



Production


Sector 1 Country 1 $X_{ni,11}$
Sector 1 Country 2 $X_{ni,21}$
Sector 1 Country N $X_{ni,N1}$
Sector 2 Country 1 $X_{ni,12}$
Sector 2 Country N $X_{ni,N2}$
Sector J Country 1 $X_{ni,1J}$
Sector J Country N $X_{ni,NJ}$
Sector Bundle 1 $X_{ni,1}$
Sector Bundle 2 $X_{ni,2}$
Sector Bundle N $X_{ni,J}$
Labor L_{ni}
Intermediate Bundle X_{ni}
Sector i Country n Y_{ni}

Firm's Problem

- CES Production:

$$Y_{ni,t} = A_{ni,t}\left[\alpha_{ni}^{1/\theta} L_{ni,t}^{\frac{\theta-1}{\theta}} + (1-\alpha_{ni})^{1/\theta}(X_{ni,t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

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- Rotemberg setup:

$$P_{ni,t}^{f} = \arg\max_{P_{ni,t}^{f}} \mathbb{E}_t\left[\sum_{T=t}^{\infty} \mathrm{SDF}_{t,T}\left[Y_{ni,T}^{f}(P_{ni,T}^{f})\left(P_{ni,T}^{f} - MC_{ni,T}\right) - \frac{\delta_{ni}}{2}\left(\frac{P_{ni,T}^{f}}{P_{ni,T-1}^{f}} - 1\right)^2 Y_{ni,T} P_{ni,T}\right]\right]$$

- This yields the New Keynesian Phillips Curve in terms of MC:

$$\left(\Pi_{ni,t} - 1\right)\Pi_{ni,t} = \frac{\theta_r}{\delta_{ni}}\left(\frac{MC_{ni,t}}{P_{ni,t}} - \frac{\theta_r - 1}{\theta_r}\right) + \beta\mathbb{E}_t\left[\left(\Pi_{ni,t+1} - 1\right)\Pi_{ni,t+1}\right]$$

Balance of Payments and NIIP

- Evolution of each country n's net international position:

$$\sum_{m\in\mathcal{N}}\sum_{j\in\mathcal{J}}\left(\frac{P^{C}_{n,mj,t}}{1+\tau_{n,mj,t}}C_{n,mj,t}\right)+\sum_{m\in\mathcal{N}}\sum_{i\in\mathcal{J}}\sum_{j\in\mathcal{J}}\left(\frac{P^{C}_{n,mj,t}}{1+\tau_{n,mj,t}}X_{ni,mj,t}\right)+\mathcal{E}_{n,t}(1+i^{US}_{n,t-1})B^{US}_{n,t-1}$$
$$+\mathcal{E}_{n,t}\psi(B^{US}_{n,t}/P^{US}_{n,t})=\sum_{i\in\mathcal{J}}(P_{ni,t}Y_{ni,t})+\mathcal{E}_{n,t}B^{US}_{n,t}\quad\forall n\in N-1$$

to account for tariffs canceling out we divide $P_{n,mj,t}$ by $1+\tau_{n,mj,t}$.

Definitions, Market Clearing and Policy

Definitions, market clearing conditions and policy:

$$B_t^{US} = \sum_{m}^{N-1} B_{m,t}^{US}$$

$$Y_{ni,t} = \sum_{n \in \mathcal{N}} \left(C_{m,ni,t} \right) + \sum_{m \in \mathcal{N}} \sum_{j \in \mathcal{J}} \left(X_{mj,ni,t} \right)$$

$$L_{n,t} = \sum_{i \in J} L_{ni,t}$$

$$\Pi_{n,t} = \frac{P_{n,t}}{P_{n,t-1}}$$

$$i_{n,t} = (\Pi_{n,t})^{\Phi_\pi}$$

Linearized Model

Analytical Solution

- To provide intuition, we linearize the model:
  - Assuming portfolio adjustment costs are ≈ 0.
  - Adopting **?** preferences with $\sigma = 1$ and $\gamma = 0$.

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- Useful notation: $\underbrace{\Psi}_{\text{Leontief Inverse}} = (\boldsymbol{I} - \underbrace{\Omega}_{\text{IO Matrix}})^{-1} = \sum_{k=0}^{\infty} \Omega^k$

- "Loading" notation $\rightarrow$ exposure of superscript to subscript
  - $\boldsymbol{L}_{\tau}^{C}$ captures how τ_t "loads" onto CPI equation
    $\rightarrow$ tariffs levied on 5% of consumption basket
  - Similarly $\boldsymbol{L}_{\hat{\mathcal{E}}}^{C} \rightarrow$ consumption basket is exposed to a given bilateral exchange rate

5-Equation Global New Keynesian Representation

NKIS+TR:

$$\sigma(\mathbb{E}_t \hat{\boldsymbol{C}}_{t+1} - \hat{\boldsymbol{C}}_t) = \underbrace{\Phi(\hat{\boldsymbol{P}}^C_t - \hat{\boldsymbol{P}}^C_{t-1})}_{\hat{i}_t} - \mathbb{E}_t(\hat{\boldsymbol{P}}^C_{t+1} - \hat{\boldsymbol{P}}^C_t)$$

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UIP+TR:

$$\tilde{\boldsymbol{\Phi}}_1\mathbb{E}_t\tilde{\mathcal{E}}_{t+1} - \tilde{\boldsymbol{\Phi}}_2\tilde{\mathcal{E}}_t = \underbrace{\tilde{\boldsymbol{\Phi}}_3(\hat{\boldsymbol{P}}^C_t - \hat{\boldsymbol{P}}^C_{t-1})}_{\hat{i}_t - \hat{i}^*_t}$$

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CPI:

$$\hat{\boldsymbol{P}}_t^C = \Xi\hat{\boldsymbol{P}}_t^P + \tilde{\boldsymbol{L}}_{\mathcal{E}}^C\tilde{\mathcal{E}}_t + \boldsymbol{L}_{\tau}^C\tilde{\boldsymbol{\tau}}_t$$

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CPI: $$\hat{\boldsymbol{P}}^C_t = \Xi\hat{\boldsymbol{P}}^P_t + \tilde{\boldsymbol{L}}^C_{\mathcal{E}}\tilde{\mathcal{E}}_t + \boldsymbol{L}^C_{\tau}\tilde{\boldsymbol{\tau}}_t$$

NKPC: $$\hat{\boldsymbol{P}}^P_t = \tilde{\Psi}\left[\hat{\boldsymbol{P}}^P_{t-1} + \Lambda\left(\boldsymbol{L}^P_C(\hat{\boldsymbol{P}}^C_t + \sigma\hat{\boldsymbol{C}}_t) + \boldsymbol{L}^P_{\mathcal{E}}\tilde{\mathcal{E}}_t + \boldsymbol{L}^P_{\tau}\hat{\boldsymbol{\tau}}_t\right) + \beta\mathbb{E}_t\hat{\boldsymbol{P}}^P_{t+1}\right]$$

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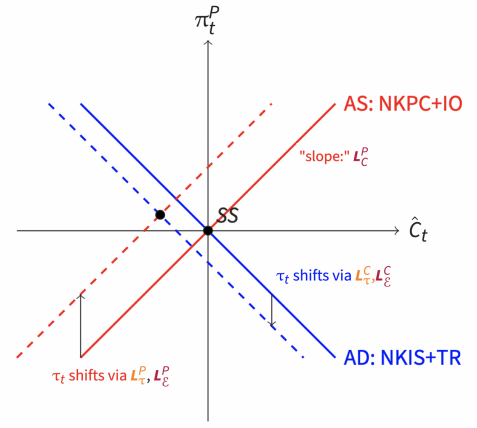
BoP: $\beta\hat{\boldsymbol{V}}_t = \Gamma_1\hat{\boldsymbol{V}}_{t-1} + \Gamma_2\hat{\boldsymbol{C}}_t + \Gamma_3\hat{\boldsymbol{P}}^P_t + \Gamma_4\tilde{\mathcal{E}}_t + \Gamma_5\tilde{\tau}_t$

Visualizing Our Approach



DGE impact of tariffs will depend on direct impact (L_τ^C & L_τ^P) and indirect reallocation via (L_C^P, $L_\mathcal{E}^C$ & $L_\mathcal{E}^P$)

Shock Propagation: The Anatomy of NKOE Leontief Inverse

- Under fixed nominal demand, NKOE Leontief Inverse, $\tilde{\Psi}^{NKOE}$ depends on the eigenvalues and eigenvectors of the matrix (exact solution):

$$\tilde{\Psi} = \left[\boldsymbol{I} \left(1 + \underbrace{\beta}_{\text{Discount F.}} \right) + \underbrace{\Lambda}_{\text{Stickiness}} (\boldsymbol{I} - \boldsymbol{\Omega}) \right]^{-1} .$$

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- Under different Taylor rules, $\tilde{\Psi}_{\phi}^{NKOE}$ depends on:

$$\tilde{\Psi}_{\Phi} = \left[\boldsymbol{I}(1+\beta) + \Lambda \left[\boldsymbol{I} - \Omega + \boldsymbol{L}_C^P \left(\underbrace{\Phi}_{\substack{\text{Central Bank} \\ \text{Sensitivity}}} - \boldsymbol{I} \right) \underbrace{\Xi}_{\substack{\text{Consumption} \\ \text{Shares}}} \right] \right]^{-1}$$

  - Inclusion of Φ and inversion makes some elements negative.

Impact of Tariffs on Inflation in Global Networks

Proposition 1

Based on analytical solution, the impact of a one-time tariff on CPI inflation is

$$\frac{\partial \pi_t^C}{\partial \tau_t} = \Xi \tilde{\Psi}_{\Phi}^{NKOE} \Lambda \left[L_\tau^P + \left(L_C^P (\mathbf{I} - \Phi) + \beta (L_C^P + L_{\mathcal{E}}^P) \Phi L_{\mathcal{E}}^C \right) L_\tau^C \right] + L_\tau^C \tag{2}$$

where $\tilde{\Psi}_{\Phi}^{NKOE} \rightarrow$ *stickiness- and policy-adjusted NKOE Leontief inverse &* $\Phi \rightarrow$ *Taylor rule coefficients.*

Impact of Tariffs on Inflation in Global Networks

Proposition 1

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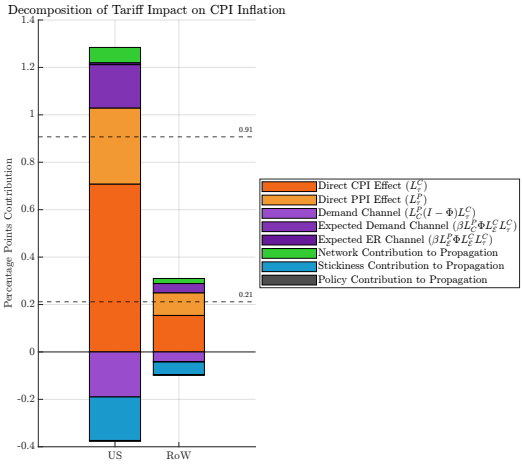
where $\tilde{\Psi}_{\Phi}^{NKOE} \rightarrow$ *stickiness- and policy-adjusted NKOE Leontief inverse &* $\Phi \rightarrow$ *Taylor rule coefficients.*

Rearranging Equation (2) yields the following decomposition:

$$\frac{\partial \pi_t^C}{\partial \tau_t} = \underbrace{L_\tau^C}_{\text{Direct CPI effect}} + \underbrace{\Xi L_\tau^P}_{\text{Direct PPI effect}} + \underbrace{\Xi L_C^P (\mathbf{I} - \Phi) L_\tau^C}_{\text{Demand channel}} + \underbrace{\beta \Xi L_C^P \Phi L_{\mathcal{E}}^C L_\tau^C}_{\text{Expected demand channel}}$$
$$+ \underbrace{\beta \Xi L_{\mathcal{E}}^P \Phi L_{\mathcal{E}}^C L_\tau^C}_{\text{Expected ER channel}} + \underbrace{\Xi (\tilde{\Psi}_{\Phi}^{NKOE} \Lambda - \mathbf{I}) \mathbf{Z}}_{\text{Network Propagation}} \tag{3}$$

Decomposing the Impact on Inflation

- Two-country case: U.S. and RoW
  - 10% reciprocal tariffs
- One-time tariff $\rightarrow$ caveats:
  - Contemporaneous ER impact negligibly small under *EoS* < 1
  - One-time shock impact on π_t larger than permanent shock



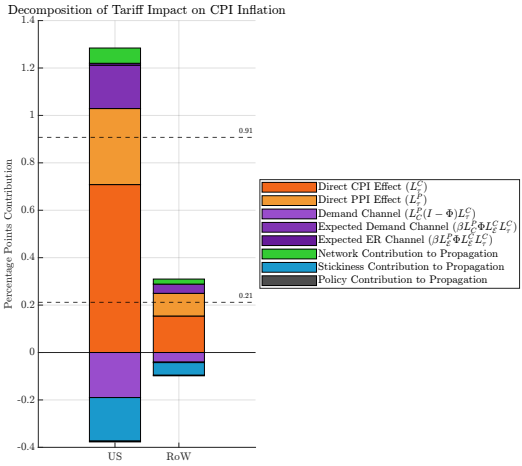
Decomposing the Impact on Inflation

$$\frac{\partial \pi_t^C}{\partial \tau_t} =$$

$$\underbrace{\boldsymbol{L}_\tau^C}_{\text{Direct CPI effect}} + \underbrace{\Xi \boldsymbol{L}_\tau^P}_{\text{Direct PPI effect}}$$

$$+ \underbrace{\Xi \boldsymbol{L}_C^P (\mathbf{I} - \Phi) \boldsymbol{L}_\tau^C}_{\text{Demand channel}} + \underbrace{\beta \Xi \boldsymbol{L}_C^P \Phi \boldsymbol{L}_\mathcal{E}^C \boldsymbol{L}_\tau^C}_{\text{Expected demand channel}}$$

$$+ \underbrace{\beta \Xi \boldsymbol{L}_\mathcal{E}^P \Phi \boldsymbol{L}_\mathcal{E}^C \boldsymbol{L}_\tau^C}_{\text{Expected ER channel}} + \underbrace{\Xi \left(\tilde{\Psi}_\phi^{NKOE} \Lambda - \mathbf{I}\right) \mathbf{Z}}_{\text{Network Propagation}}$$



Quantitative Model

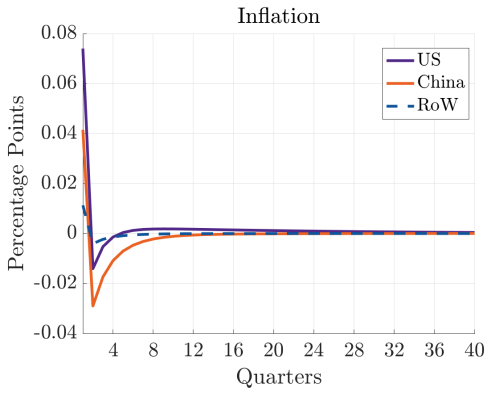
Calibration

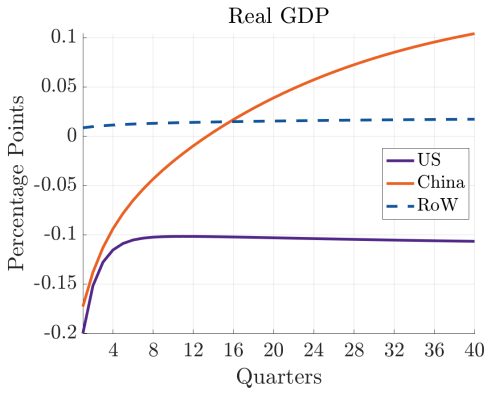
- IRFs computed non-linearly with MIT shocks (perfect foresight)
- Global I–O structure: 2018 OECD ICIO
- Elasticities:
  - CRRA, $\sigma = 2$
  - Labor supply elasticity: $\gamma = 1$
  - EoS for CES Bundles: $\theta = \theta_l^j = 0.6$
  - EoS between intermediates and labor: $\theta_h = 0.2$
- 2018 treated as steady state
  - Permanent capital account wedge Unpleasant SS Arithmetic

Full Calibration Table

Benchmarking: 2018's Trump Tariffs

25% tariffs by U.S. on China in 2018. No retaliation. Near-permanent shock ($\rho^{\tau} = 0.95, \phi_y = 0$).





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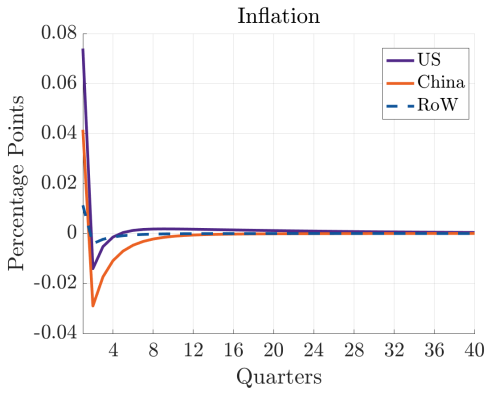

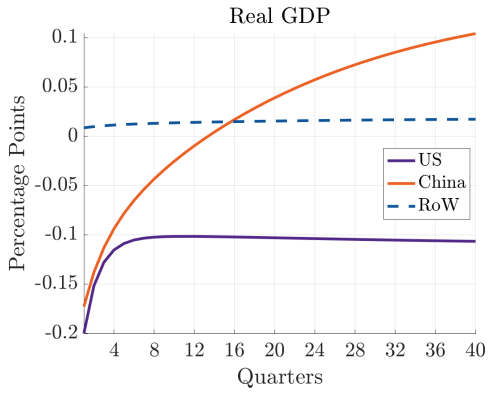

? estimate 0.1 to 0.2pp increase in $\pi^{C}_{US,t} \rightarrow$ model predicts 0.07pp

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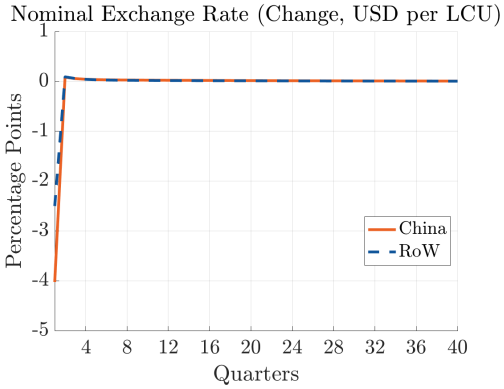

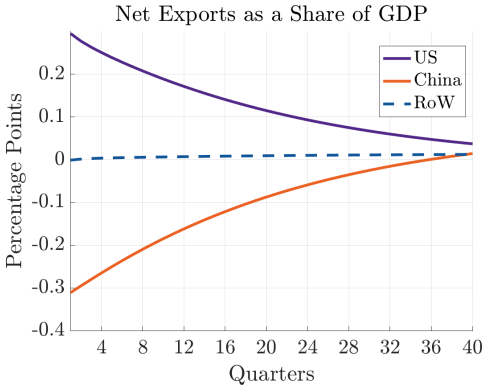

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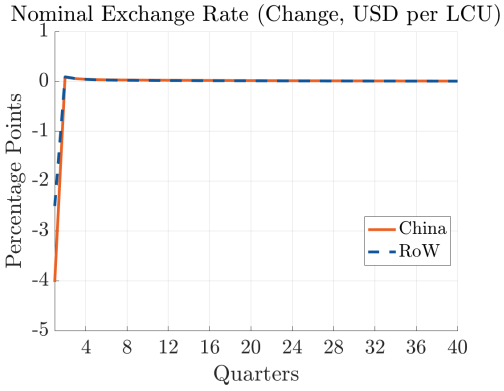
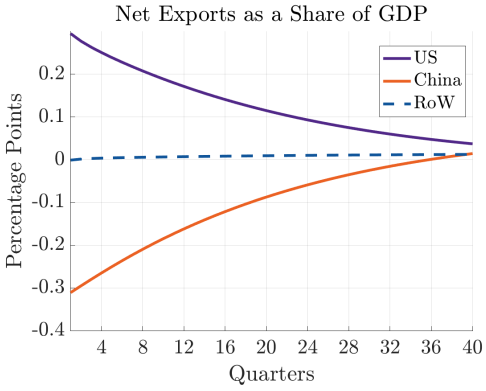


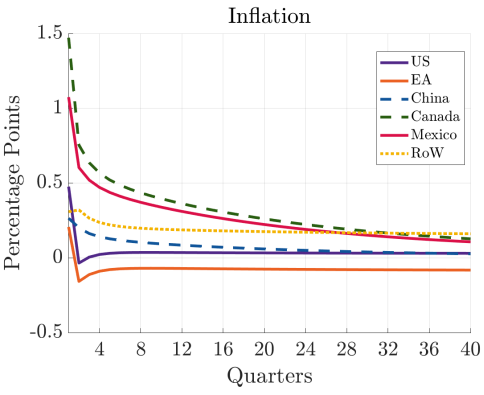


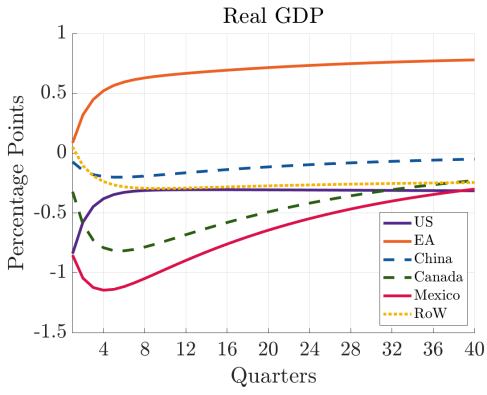
USD appreciated by ~6% from June 2018-December 2018- model predicts ~4%

2025 Liberation Day

Case 2: 2025 Tariffs

US tariffs on EA (20%), China (34%), Canada (25%), Mexico (25%), and RoW (10%) & no retaliation. ($\rho^{\tau} = 0.95$, $\phi_y = 0.1$).





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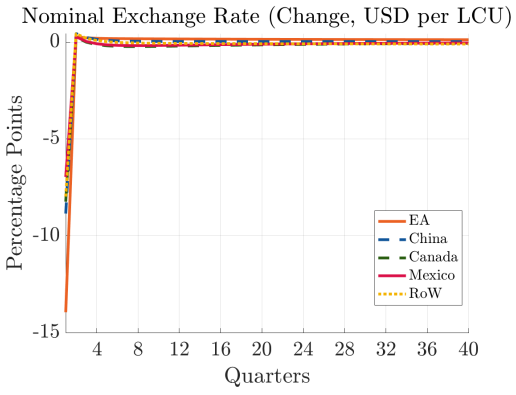
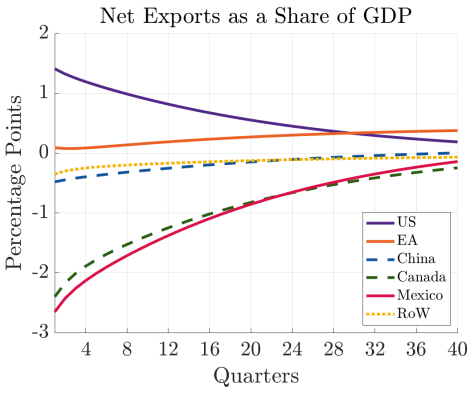
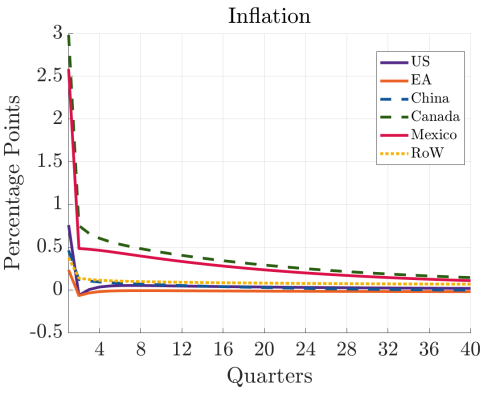
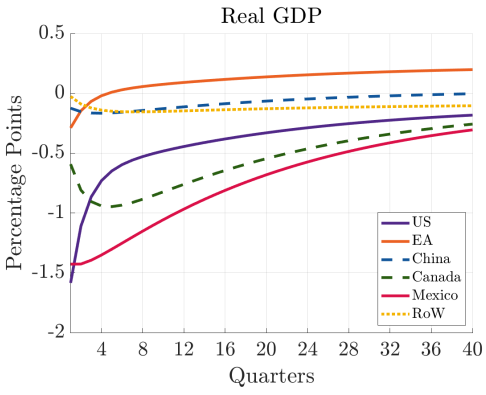




Case 3: 2025 Potential All-Out Trade War

US tariffs on EA (20%), China (34%), Canada (25%), Mexico (25%), and RoW (10%) & symmetric retaliation by all partners. ($\rho^{\tau} = 0.95$, $\phi_y = 0.1$).





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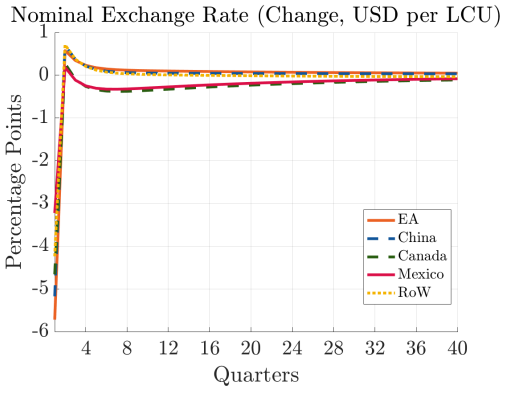
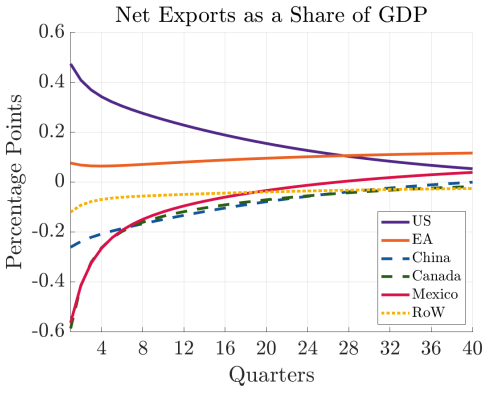
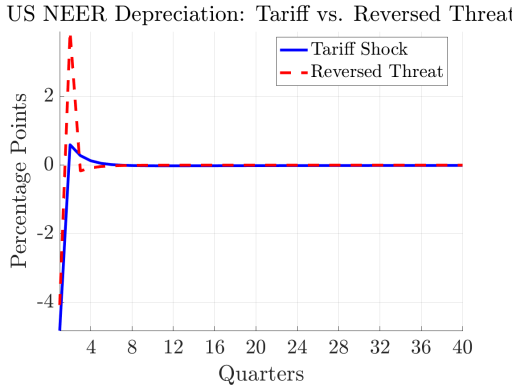
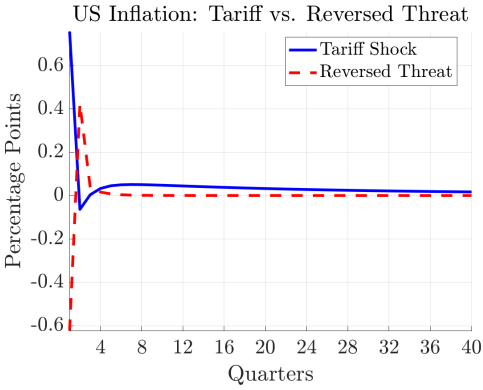




Case 4: Tariff Threats for Geopolitical Reasons

U.S. announces future tariffs, retaliation is anticipated. At = 2 no tariffs implemented.





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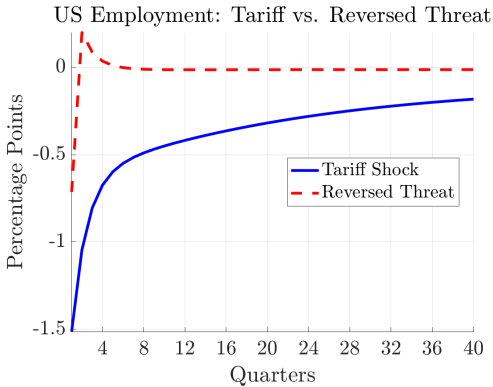

Takeaways

- Tariffs are contractionary
  - Even when EoS>1 and in the long-run
  - Permanent tariff $\rightarrow$ permanent inflationary impulse *relative to initial zero-inflation steady state* a la permanent cost-push shock, impulse distributed over output loss and inflation.
- Tariffs are inflationary
  - Direct inflationary effect on-impact
  - **Tariff-threats:** low demand at the time of announcement lead to deflation
- Do tariffs lead to appreciation?
  - In N-country setting depends on other countries' 1) retaliation and 2) monetary policy.
- Can tariffs improve US trade deficit?
  - Yes, but too little for too much pain
- Can tariffs bring back jobs $\rightarrow$ No