

# Tariffs and Retaliation: A Macroeconomic Analysis

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# Introduction

- ▶ The new world of trade policy - large unilateral tariffs imposed by US on all trade partners
- ▶ Large debate about their macro impact on inflation, output, trade balance etc..
- ▶ This paper explores impact of tariff shocks in small quantitative model of a global economy
- ▶ Allow for variety of assumptions about trade linkages, economic policy, financial market structure, nominal rigidities, etc?
- ▶ Are there a general predictions across all specifications?
  - ▶ Look at both unilateral tariffs and retaliation
- ▶ Using a small scale NK model, calibrating to US versus ROW

# Description of basic model

- ▶ Two country - US (Foreign) and ROW (Home)
- ▶ A New Keynesian framework with sticky prices (PCP in baseline)
- ▶ Trade in intermediate inputs, investment and capital accumulation, incomplete financial markets
- ▶ Monetary policy targets CPI inflation rate
- ▶ Many extensions and alternative calibrations

# Quick preview of results

- ▶ Details matter, especially for short run impacts of tariffs
  - ▶ Start at a of 3 percent, then raise tariff by 10 percent across the board
  - ▶ In baseline case, US output falls by 1.5 percent and converges to lower steady state level, trade balance deteriorates on impact
  - ▶ US welfare increases with a unilateral tariff, but US loses more in a trade war
- ▶ But departing from baseline can change results significantly
- ▶ Key features of response:
  - (a) Asymmetries in size - US would lose from a global trade war
  - (b) Type of nominal rigidities and monetary policy stance play a large role in short run effects
  - (c) Intermediate imported inputs & trade elasticities play large roles in negative impacts
  - (d) Financial market structure has big affect on short run and long run response.

# Literature review

- ▶ **Open economy macro literature** Corsetti and Pesenti (2001), Benigno and Benigno (2003), Galì and Monacelli (2005), Faia and Monacelli (2008), de Paoli (2009), Costinot et al. (2014), Bhattarai and Egorov (2016), Groll and Monacelli (2020), Fujiwara and Wang (2017), Egorov and Mukhin (2023).
- ▶ **Optimal Tariffs and Retaliation** Bagwell and Staiger (2016), Caliendo and Parro (2021), Johnson (1953), Kennan and Riezman (1988), Syropoulos (2002), Gros (1987), Opp (2010), Felbermayr et al. (2013)
- ▶ **Quantitative assessment of trade wars** Perroni and Whalley (2000), Ossa (2011), Broda et al. (2008) Ossa (2014), Lashkaripour (2021), Fajgelbaum and Khandelwal (2022)
- ▶ **Recent papers on trade policy and monetary policy** Barattieri et al. (2021), Erceg et al. (2023), Furceri et al. (2018), Lindé and Pescatori (2019), Bergin and Corsetti (2020a), Jeanne (2021), Bergin and Corsetti (2020b), Caballero et al. (2015), Lechthaler (2017), ?, Bianchi Coulibaly (2025), Auclert et al. (2025), Guerrieri et al. (2025), Idnatenko et al. (2025), Monacelli (2025), Alessandria et al. (2025), Costinot and Werning (2025)

# Roadmap

1. Basic model
2. Special case with analytical solution
3. Impact of US tariff shock
4. Retaliation
5. Extensions
  - (i) Role of monetary policy
  - (ii) Role of traded goods pricing
  - (iii) Role of intermediate goods and elasticities
  - (iv) Role of financial markets

# Basic Model

- ▶ Home and Foreign, supposed to represent the rest of the world (ROW) and US
- ▶ Households supply labor and consume goods from both countries, as well as saving in bonds and physical capital which is rented to firms
- ▶ Home has share  $n$  of these, with Foreign share  $1 - n$ .
- ▶ Firms use a combination of labor, capital and intermediate goods
- ▶ Capital mobility with bond trade - trade only in one period nominal bond

# Households

- ▶ Home household maximizes its welfare index:

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left( \frac{C_{t+s}^{1-\sigma}}{1-\sigma} - \frac{H_{t+s}^{1+\psi}}{1+\psi} \right),$$

- ▶ With budget constraint:

$$\begin{aligned} S_t F_t + B_t + P_{ht} (C_{ht} + I_{ht}) + (1 + \tau_t) S_t P_{ft}^* (C_{ft} + I_{ft}) + P_t \Lambda_t^f \\ = S_t F_{t-1} R_{t-1}^* + B_{t-1} R_{t-1} + R_t^k K_{t-1} + W_t H_t + \Pi_t + TR_t \end{aligned}$$

- ▶ Three types of assets - home and foreign currency short term bonds, and capital
- ▶ Adjustment costs of investment in capital:

$$K_t = (1 - \delta) K_{t-1} + I_t \left( 1 - \varphi (I_t / I_{t-1} - 1)^2 / 2 \right)$$

- ▶ Foreign good consumption subject to a tariff  $\tau_t$
- ▶ Tariff revenue rebated to households lump-sum

# Consumption, price index

- ▶ Home consumption:

$$C_t = \left( \gamma^{1/\lambda} C_{ht}^{1-1/\lambda} + (1-\gamma)^{1/\lambda} C_{ft}^{1-1/\lambda} \right)^{\frac{1}{1-1/\lambda}},$$

where  $\gamma = n + x(1-n)$ , and  $x$  denotes Home bias.

- ▶ Price index (Tariff directly enters CPI):

$$P_t = \left( \gamma P_{ht}^{1-\lambda} + (1-\gamma) ((1+\tau_t) S_t P_{ft}^*)^{1-\lambda} \right)^{\frac{1}{1-\lambda}},$$

# Firms

- ▶ The production function for firm  $i$  in the Home country is:

$$Y_t(i) = A_t \left( K_{t-1}(i)^\alpha H_t(i)^{1-\alpha} \right)^{1-\eta} X_t(i)^\eta, \quad (1)$$

- ▶ Intermediate good inputs are composed of Home and Foreign goods

$$X_t(i) = \left( \gamma_x^{\frac{1}{\lambda}} X_{ht}(i)^{\frac{\lambda-1}{\lambda}} + (1 - \gamma_x)^{\frac{1}{\lambda}} X_{ft}(i)^{\frac{\lambda-1}{\lambda}} \right)^{\frac{\lambda}{\lambda-1}},$$

- ▶ where  $X_{jt}(i)$  is the Home firm's use of inputs from country  $j = \{h, f\}$ ,
- ▶ The profits of Home firm  $i$  are then:

$$\Pi_t(i) = ((1 + s)P_{ht}(i) - MC_t) Y_t(i),$$

- ▶ where  $MC_t$  denotes the firm's nominal marginal cost

# Profit Maximization

- ▶ The firm then chooses its price to maximize the present value of expected profits, net of price adjustment costs:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \omega_{t+j} \left( \Pi_{t+j}(i) - \frac{\phi}{2} \left( \frac{P_{ht+j}(i)}{P_{ht+j-1}(i)} - 1 \right)^2 P_{ht+j}(i) Y_{t+j}(i) \right), \quad (2)$$

- ▶ Parameter  $\phi$  captures the presence of a price adjustment cost for the firm.
- ▶ Implies Phillips curve:

$$\theta + \phi \epsilon^{-1} \left( \pi_{ht} (\pi_{ht} - 1) - \mathbb{E}_t \left\{ \omega_{t+1} \pi_{ht+1} (\pi_{ht+1} - 1) \frac{Y_{t+1}}{Y_t} \right\} \right) = \mathcal{MC}_t, \quad (3)$$

- ▶ where  $\theta = \frac{(1+s)(\epsilon-1)}{\epsilon}$ , and  $\mathcal{MC}_t = MC_t/P_{ht}$  is the PPI-based real marginal cost.

# Monetary policy rules target CPI

- ▶ Allowing for interest rate smoothing

$$\log(R_t\beta) = \rho_r \log(R_{t-1}\beta) + (1 - \rho_r)\mu \log(\tilde{\pi}_t),$$

$$\log(R_t^*\beta) = \rho_r \log(R_{t-1}^*\beta) + (1 - \rho_r)\mu \log(\tilde{\pi}_t^*),$$

- ▶ We look at various alternatives to this later (PPI targeting, Output gap inclusion)

# A Special Case of the Model – Small Open Economy

- ▶ Preferences

$$U = \log C - \chi \frac{H^{1+\psi}}{1+\psi}$$

- ▶ World demand for its export good

$$C_{h,f}^* = \Lambda \left( \frac{P_{h,t}}{S_t} \right)^{-\zeta} \quad (4)$$

- ▶ One-period price setting in advance, no investment or capital accumulation.
- ▶ At time  $t = 0$ : a permanent, unanticipated tariff shock.
- ▶ Prices fully adjust after one period

# Response to tariff after adjustment (long run)

- ▶ Tariff reduces gross output  $Y$  and GDP ( $H_t$ )

$$\hat{Y}_t = -\frac{((2\zeta - 1)(3 + \psi) + 2\lambda)}{2(1 + \psi)(2\zeta + \lambda)}d\tau \quad \hat{H}_t = -\frac{1}{1 + \psi}d\tau$$

- ▶ Fall in GDP depends on labor supply elasticity  $\psi^{-1}$
- ▶ Output response depends negatively (positively) on  $\zeta$  ( $\lambda$ )
- ▶ Terms of trade appreciation larger (smaller) with  $\lambda$  ( $\zeta$ )

$$\hat{S}_t = -\frac{(\lambda(1 + \psi) + \psi + 3)}{((1 + \psi)(2\zeta + \lambda))}d\tau$$

- ▶ Aggregate consumption may rise (with high  $\lambda$ ) or fall, (with high  $\zeta$ )

$$\hat{C}_t = -\frac{(2\zeta - \lambda(1 + \psi) - 3)}{(1 + \psi)(2\zeta + \lambda)}d\tau$$

- ▶ But welfare increases starting from a zero tariff

## Response in short run

- ▶  $P_{h0}$  is fixed, so CPI stabilization  $\implies$  exchange rate appreciates by the size of the tariff shock

$$\hat{S}_0 = -d\tau < \hat{S}_t$$

- ▶ Exchange rate appreciation exactly offsets the tariff and so eliminates expenditure switching - GDP falls more in the short run

$$\hat{Y}_0 = \hat{Y}_t - \frac{((2\zeta - 1)(1 + \psi) - 2)}{3(1 + \psi)} d\tau < \hat{Y}_t$$

- ▶ Trade balance deteriorates: No expenditure switching away from imports, while export demand falls

$$dTB = -\frac{2(\zeta - 1)((2\zeta + \lambda)(1 + \psi) + \psi - 1) + \Gamma}{6(1 + \psi)(2\zeta + \lambda)} d\tau < 0$$

where  $\Gamma > 0$ .

## But with LCP we get the opposite results!

- ▶ With LCP,  $P_{h0}$  and  $P_{f0}$  fixed in dollars, but the tariff falls on top of fixed foreign price
- ▶ Tariff increases aggregate demand - expenditure switching from imports towards domestic goods.
- ▶ Exchange rate appreciation has no effect on foreign export demand or home import demand
- ▶ GDP rises in the short run

$$\hat{Y}_0 = \frac{2\zeta(\lambda - 1) + \lambda(1 + \lambda) + 4}{6(2\zeta + \lambda)} d\tau > 0$$

- ▶ Trade balance improves (exports unchanged while imports fall)

$$dTB = \frac{(\lambda + 2)(\lambda + 2\zeta - 4)}{12(2\zeta + \lambda)} > 0$$

# The Main model: Calibration

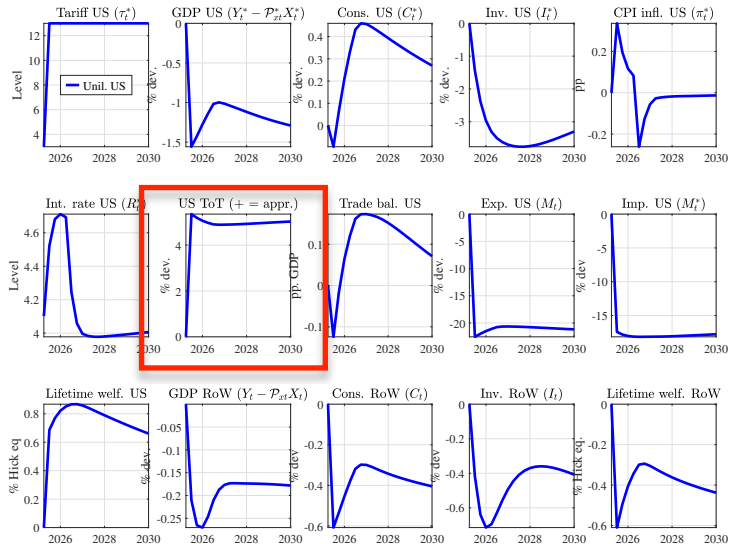
- ▶ Quarterly frequency. Home = ROW Foreign = US.
- ▶ US is calibrated using the relative population of the US,  $1 - n = 0.083$
- ▶ Trade openness of 0.25 in the US
- ▶ ROW has much lower trade openness with the US under 3 percent
- ▶ Trade elasticity is  $\lambda = 5$
- ▶ Rotemberg parameter is  $\phi = 100$ , with PCP pricing in baseline
- ▶ Share of intermediate goods in production to be  $\alpha = 0.4$ .
- ▶ Capital share in value added  $\alpha = 0.36$ , depreciation rate  $\delta = 0.25$ , investment adjustment cost  $\varphi = 2.57$
- ▶ US relative GDP  $A^*/A = 1.987$ .
- ▶ The persistence of the monetary policy rules is  $\rho_r = 0.8$  and the response to annual CPI inflation is  $\mu_\pi = 1.5$ , in line with empirical estimates.

# Main Model: Baseline results with exogenous tariffs

- ▶ Take an unanticipated, permanent rise in US tariffs on Foreign goods by 10 percent against all trading partners. Non-linear perfect foresight solution.
- ▶ Tariff leads to large rise in the cost of imported consumption goods and intermediate inputs
- ▶ Effects depend on many assumptions including trade elasticity, traded goods pricing, share of imported intermediate goods, labor supply elasticity, monetary policy response.

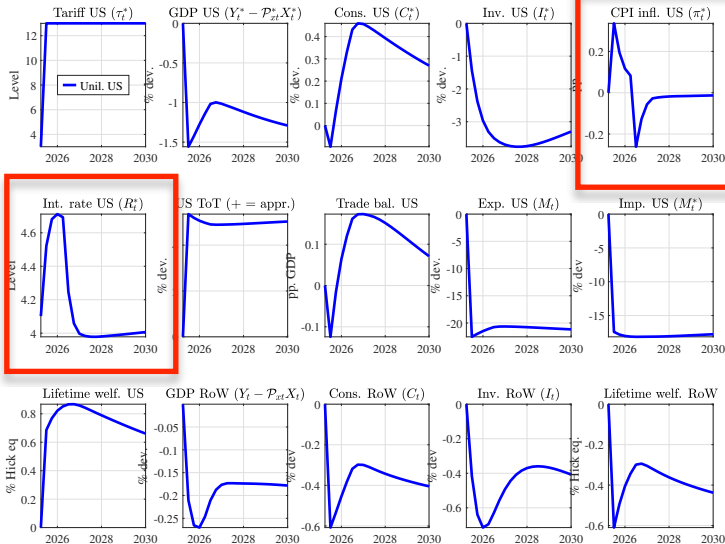
# Terms of trade

- Terms of trade appreciates by 5% - fall in world price of imports



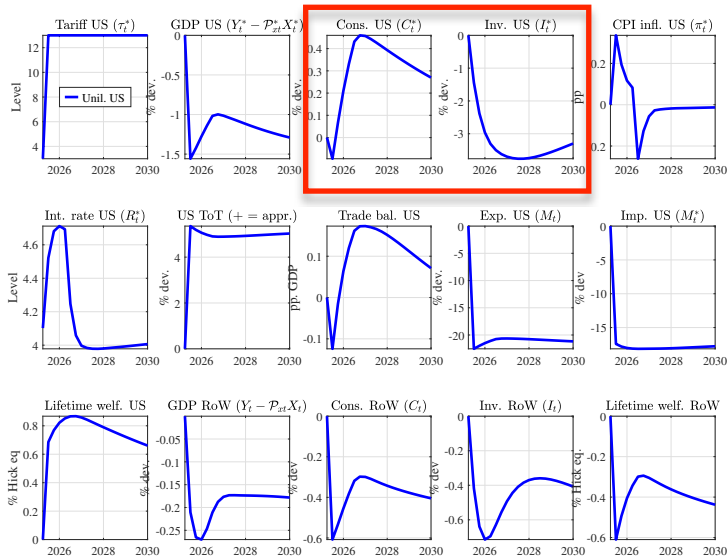
# CPI and interest rate

- Rise in CPI leads to a rise in policy interest rate by 60 bp



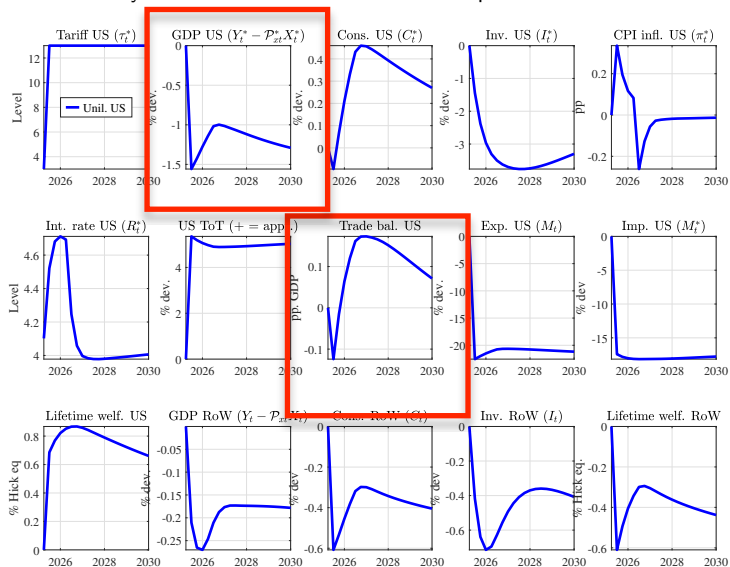
# Domestic Consumption and Investment

- Consumption higher and Investment lower



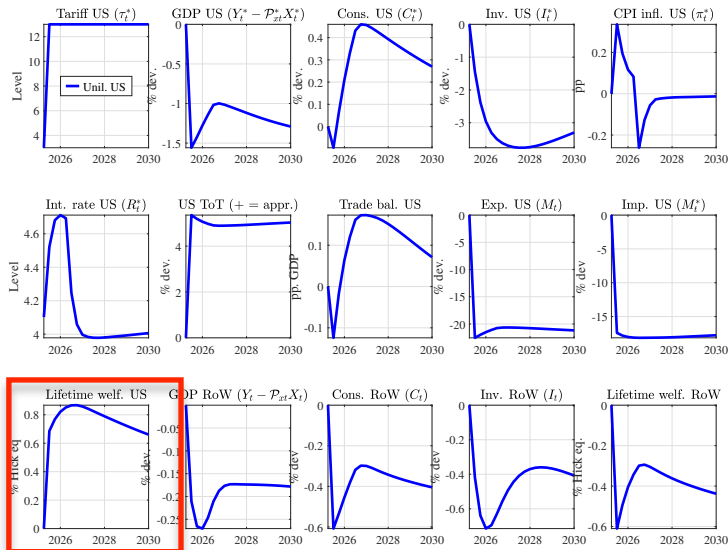
# GDP, Trade Balance

- GDP falls by 1.5% and trade balance falls on impact



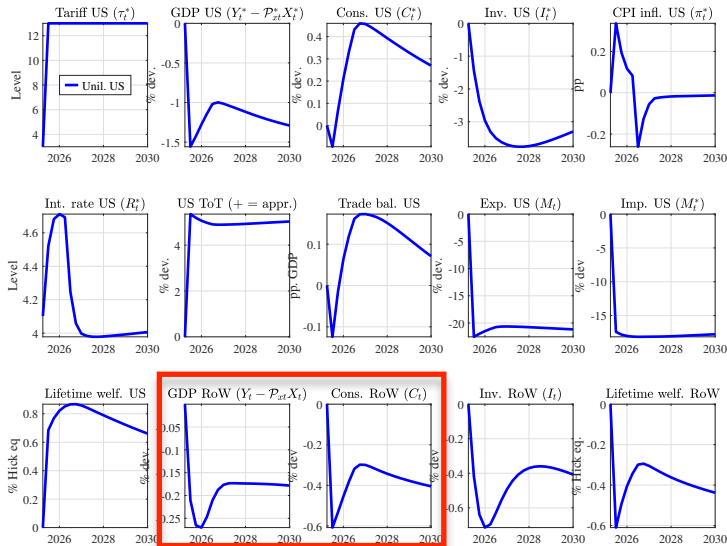
# Welfare gains

- Welfare higher due to lower labor supply and improved terms of trade



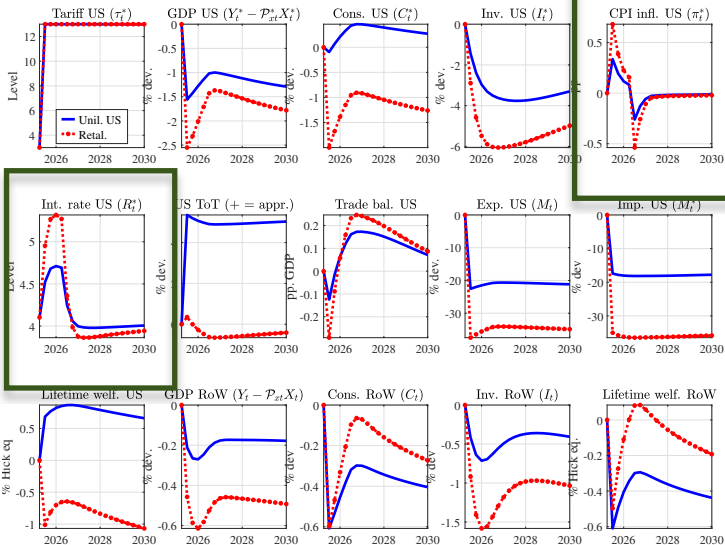
# ROW loses

- ▶ But ROW output and consumption falls much less than US



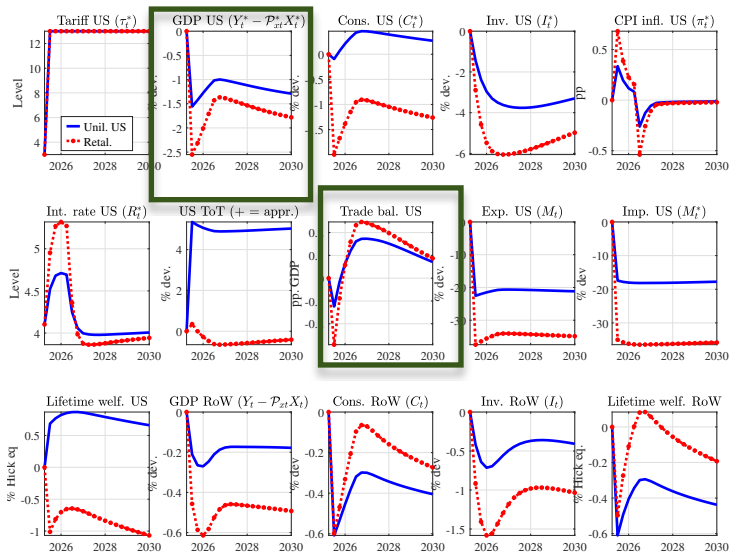
# Retaliation - ROW tariff matches US one for one

- ▶ US Terms of Trade appreciation almost eliminated
- ▶ US CPI rises by much more, leading to a larger rise in policy rate



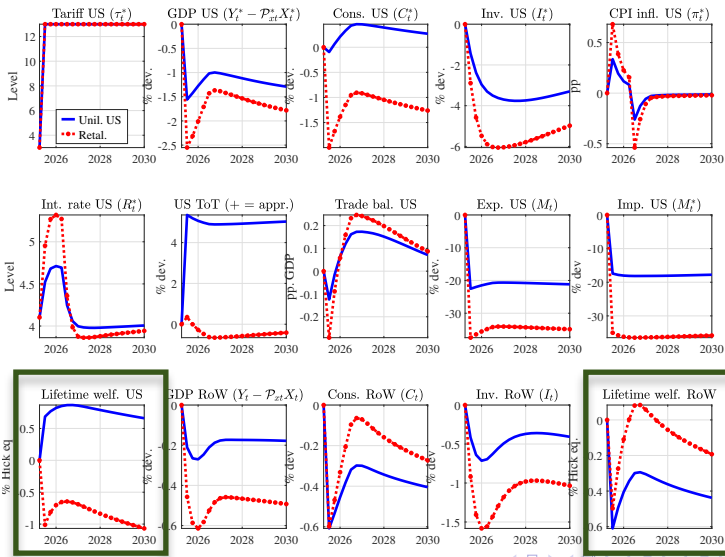
# Retaliation - Output

- ▶ Fall in US output and trade balance deterioration double
- ▶ ROW output falls more, but much less than US



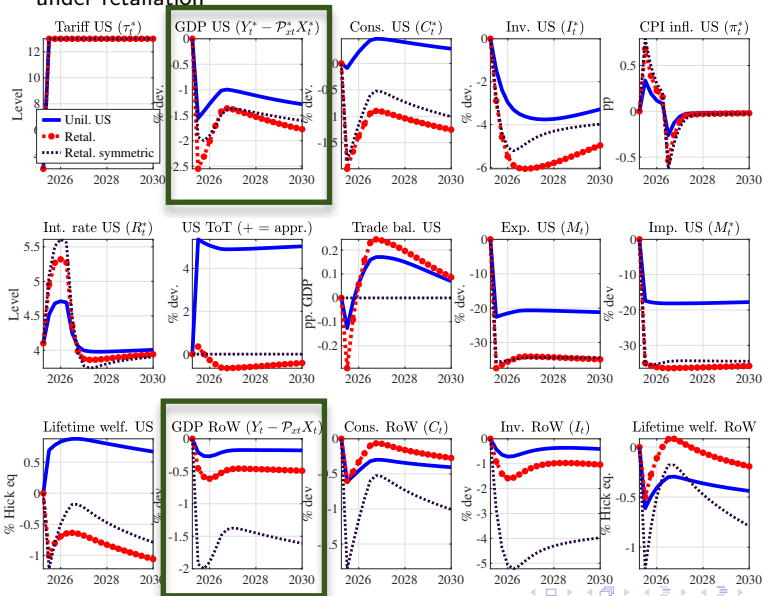
# Retaliation - ROW

- ▶ US welfare loss much greater
- ▶ ROW initially falls more, but converges to lower loss than unilateral



# Why does US do worse in an all-out trade war?

- Asymmetry in size: with equal in size/openness, loss for US would be less under retaliation



# Messages

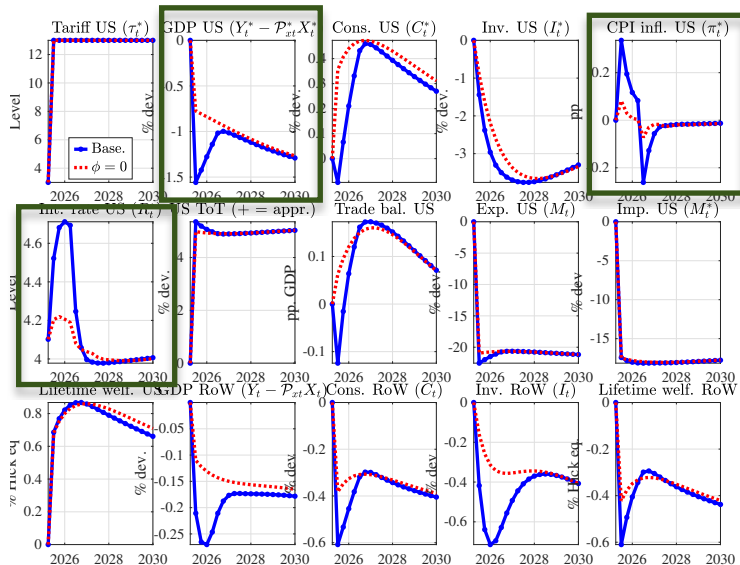
- ▶ Impact effects are large relative to steady state, due to price rigidities
- ▶ Suggests that traditional analysis of costs of protection may be underestimated
- ▶ Without retaliation, even with output loss, US gains
  - ▶ In our model, 10 percent rise in tariffs is (slightly) less than the optimal unilateral tariff
- ▶ With global retaliation everyone loses, but in our calculation US loses much more, since US is a small relative to the world economy

## Now look at some variants

1. Alternative monetary policies - PPI targeting
2. Alternative pricing - LCP, DCP
3. No intermediate imports
4. Lower US elasticity of substitution  $\lambda$
5. Alternative financial market structure - complete markets

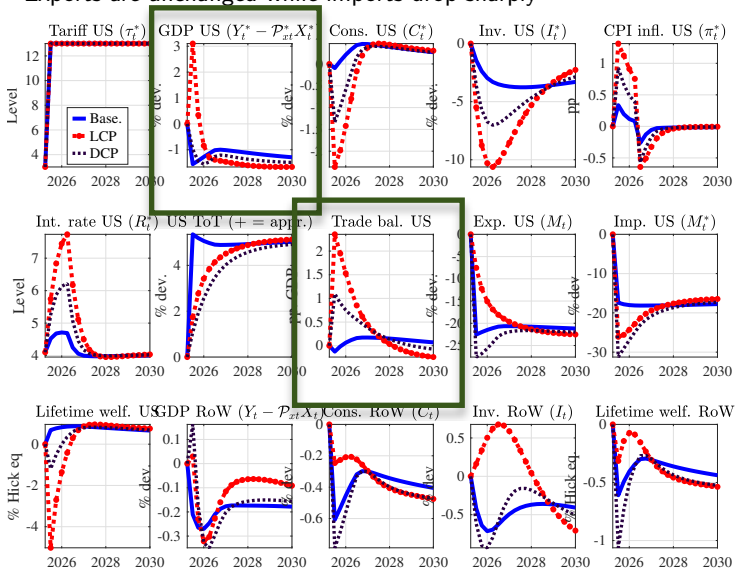
# PPI targeting

- Allows for much higher CPI inflation, avoids interest rate spike



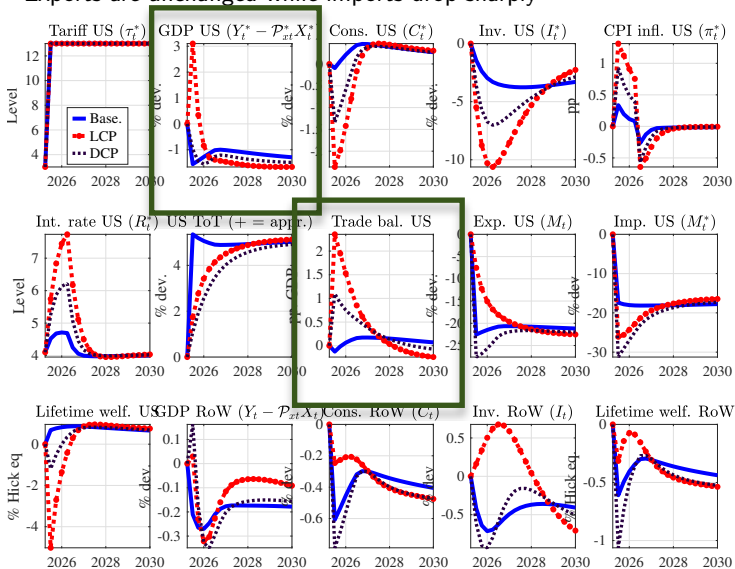
# Alternative currency of pricing

- ▶ With LCP the response of output and trade balance is reversed
- ▶ Exports are unchanged while imports drop sharply



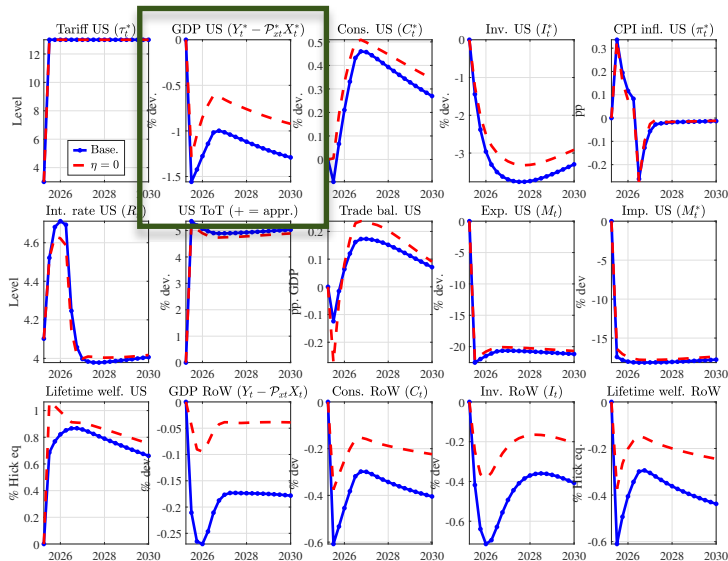
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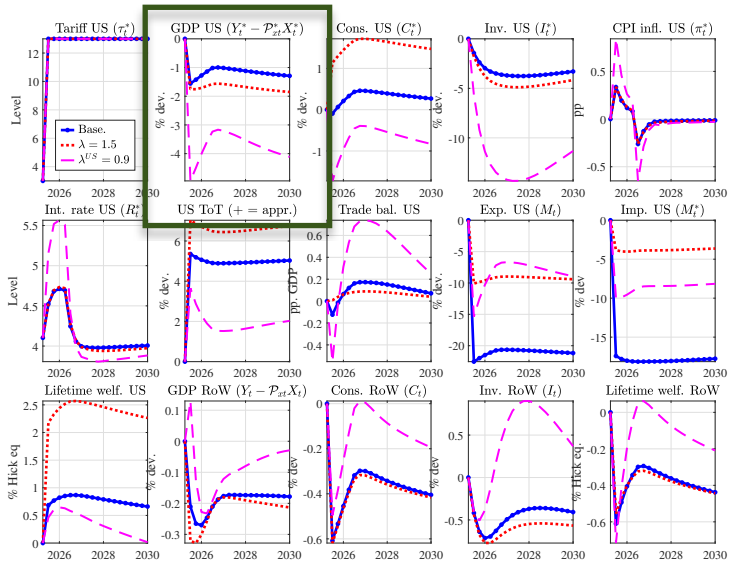
# Intermediate imports

- Both own effects and spillovers from a unilateral tariff are reduced absent supply chains



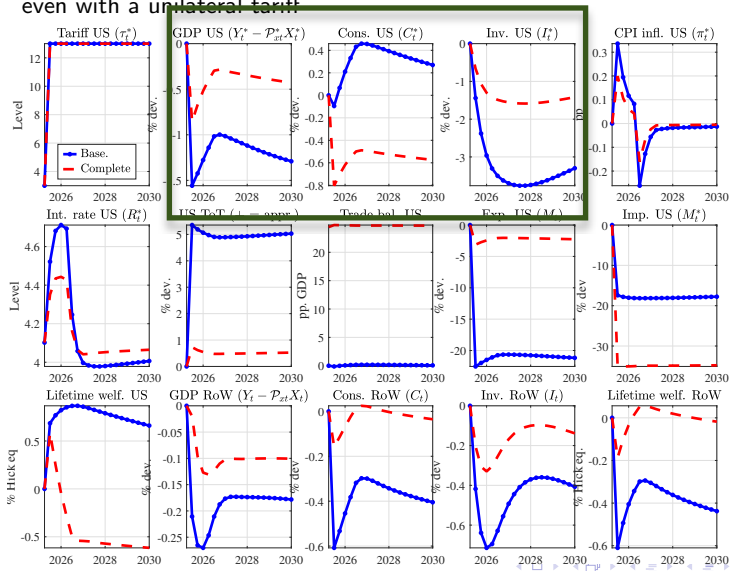
# Elasticity

- Lower elasticity of substitution for US severely reduce the benefits of the unilateral tariff



# Complete Markets

- Financial market structure is a critical determinant of tariff effects
- Complete markets lead the welfare cost to be shared, and US does worse, even with a unilateral tariff



# Other extensions in paper

1. Import adjustment costs
2. Anticipated effects
3. Tariff revenue used to fund fiscal spending

# Conclusions

- ▶ Effects of a tariff shock is complicated - depends on many structural features
- ▶ Analysis captures key dimensions: vertical integration of supply chains, monetary policy responses, international interactions
- ▶ Ignores details of sectoral heterogeneity and sectoral input-output linkages
- ▶ Four factors are key
  - ▶ Asymmetry in size effects of tariff shock
  - ▶ Response of monetary policy and types of nominal rigidities
  - ▶ Importance of intermediate inputs & trade elasticities
  - ▶ Financial market structure
- ▶ Different assumptions with respect to these factors will give different quantitative and qualitative effects

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