Macroeconomic Effects of Tariffs in a Multi-Country Agent-Based Model

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Overview

What We Do

- We build a **multi-country agent-based model** for global trade. To show the mechanisms, we simulate the US–Canada trade war and Trump's "Liberation Day".
- Two points motivate this study:
  - Trump's "Liberation Day" marked the **largest tariff increase** since World War II.
  - Direct effects of trade shocks are better known (e.g. changes in import prices and trade volumes). **Indirect effects are still unclear** (e.g. GDP and inflation determination over time, by components and propagation across countries and sectors).

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Economic forecasting with an agent-based model

Sebastian Poledna [a,b,c,g], Michael Gregor Miess [k,e,a,b,h], Cars Hommes [d,i,j,c,*], Katrin Rabitsch [f]

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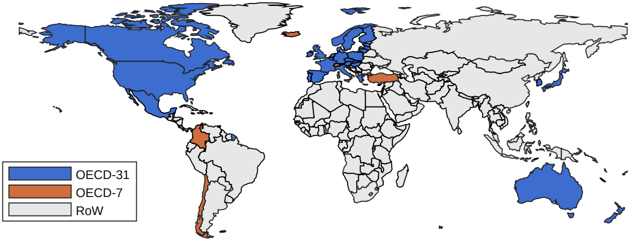
Extension of Poledna et al. (2023)'s model:

- Multi-country setup (31 OECD countries)
- Calibration of sector-country trade shares (OECD ICIOs) like Dawid et al. (2018)'s home-bias; Inclusion of sector-country tariffs shocks
- Firm-level price formation includes demand-pull inflation as in Delli Gatti et al. (2011); Hommes et al. (2022); Dawid et al. (2024) and tariffs-driven inflation expectations (adaptive learning)



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$$pr_{i,t} = \frac{\exp\left(-\gamma \log\left((1+\tau_{i,t})P_{i,t}\right) + \log\left(s_i\right)\right)}{\sum_{j \in I_{cs,gs}} \exp\left(-\gamma \log\left((1+\tau_{j,t})P_{j,t}\right) + \log\left(s_j\right)\right)}$$

where s_i and $\tau_{i,t}$ are sector-country preferences and tariffs for the supplier i

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$$P_{i,t} = P_{i,t-1} \cdot \underbrace{(1 + \pi^{d}_{i,t})}_{\text{Demand-pull}} \cdot \underbrace{(1 + \pi^{c}_{i,t})}_{\text{Cost-push}} \cdot \underbrace{(1 + \pi^{e}_{i,t})}_{\text{Expectations}}$$

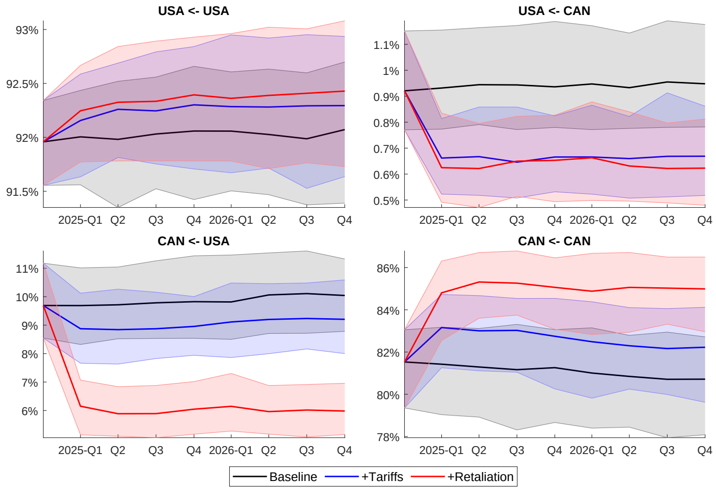
US-Canada Trade War

Scenarios

- We consider three scenarios to highlight the macroeconomic effects of tariffs within our agent-based framework:
  - **Baseline:**
    The model runs without any trade policy interventions or shocks.
  - **Unilateral Tariffs:**
    USA imposes a permanent 25% tariff on all imported goods from CAN.
  - **Retaliation:**
    On top of "Unilateral Tariffs" scenario, CAN responds by imposing reciprocal 25% tariffs on all imported goods from the USA.

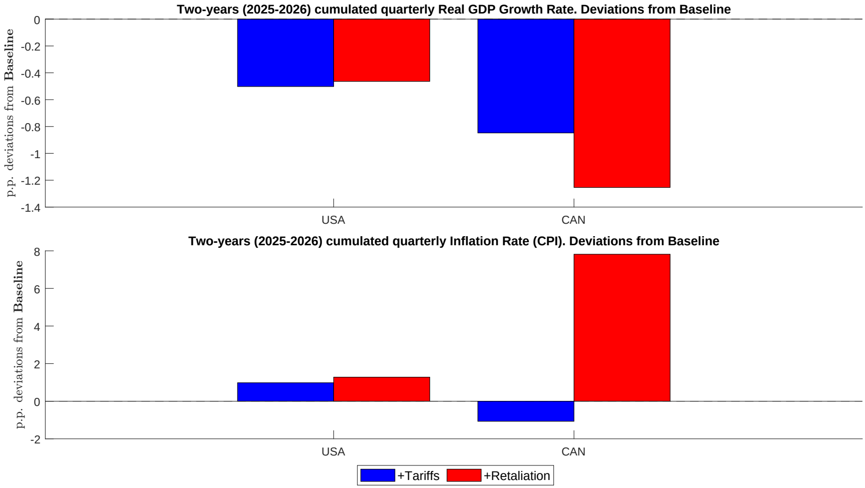
Scenario	USA $\rightarrow$ CAN	CAN $\rightarrow$ USA
Baseline	0%	0%
Unilateral Tariffs	25%	0%
Retaliation	25%	25%

Bilateral Trade Shares



(1) **Imports re-directed domestically** (Import prices ↑) (2) **Exports less competitive** (Inflation kicks ↑)

Cumulated Real GDP Growth and Inflation (CPI)



(3) **Output ↓ in both countries**

(5) **Stagflationary pressures in the tariff-applying country**

(7) **Relative danger is different** (CAN gets hurt more)

(4) **Inflation → heterogeneous effects**

(6) **Deflationary pressures in the targeted country**

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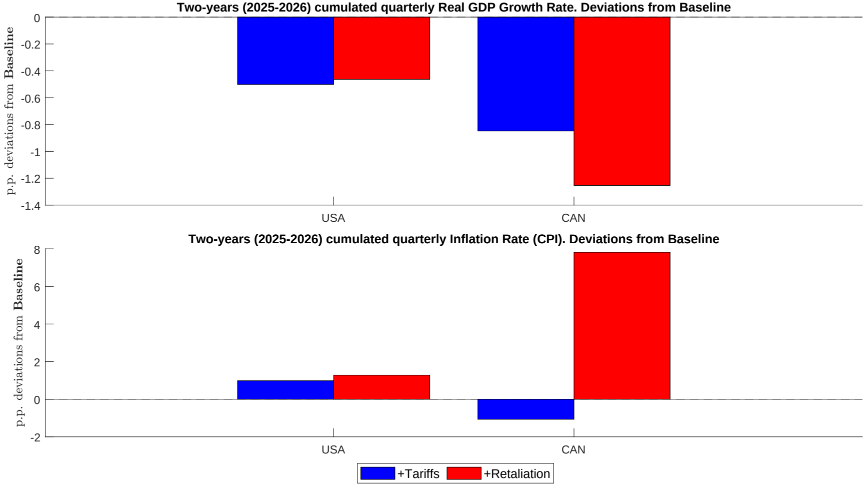

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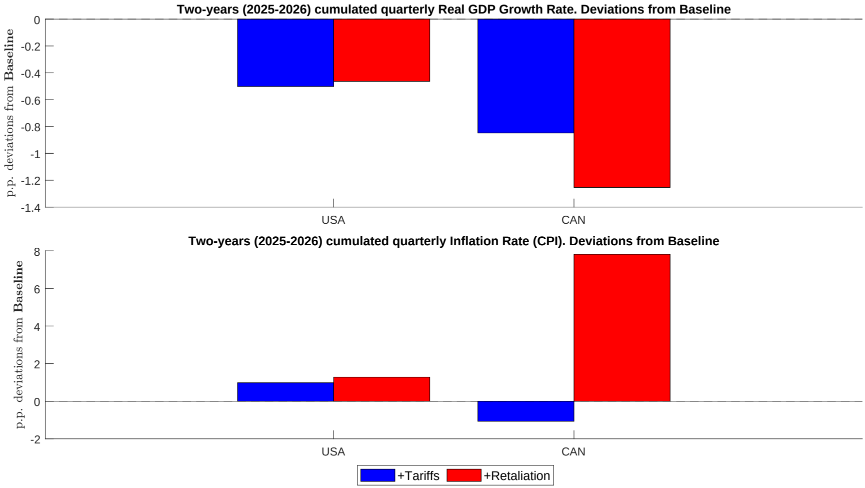

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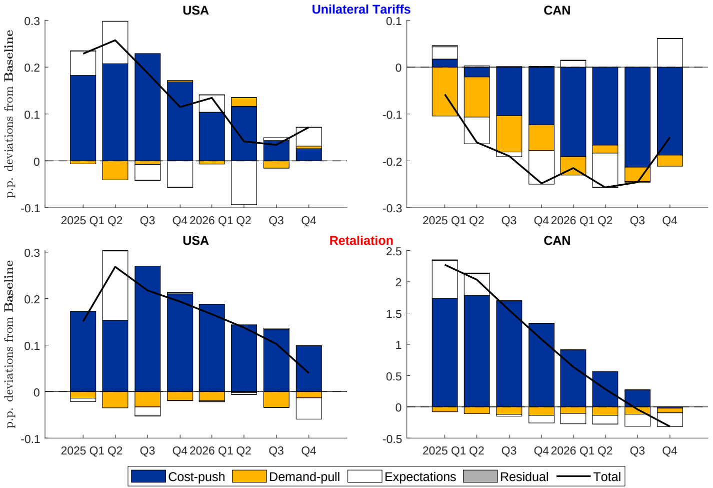
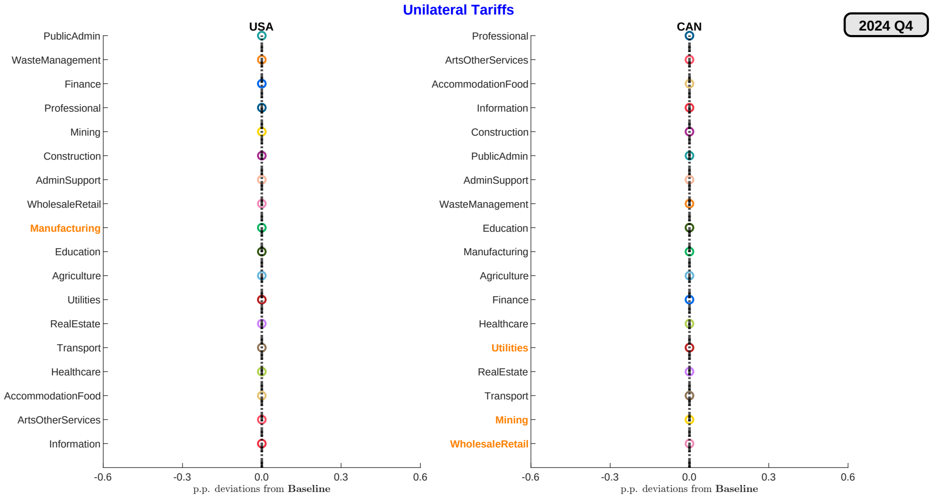
Inflation (PPI) by Components



(8) **Stagflationary pressures are cost-driven** (9) **Deflationary pressures are demand-driven**

Inflation (PPI) by Sector – Unilateral Tariffs



(10) **Stagflationary pressures led by Manufacturing in US** (11) **Deflationary pressures led by Mining in CAN**

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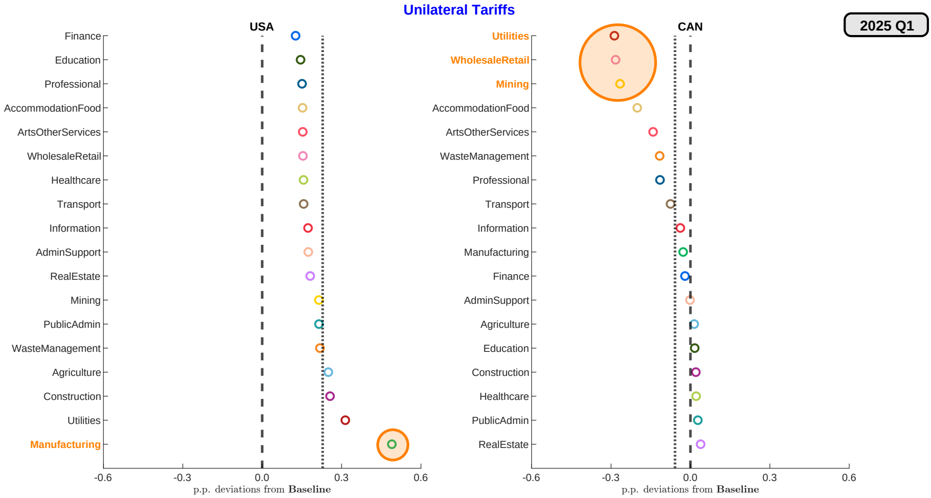

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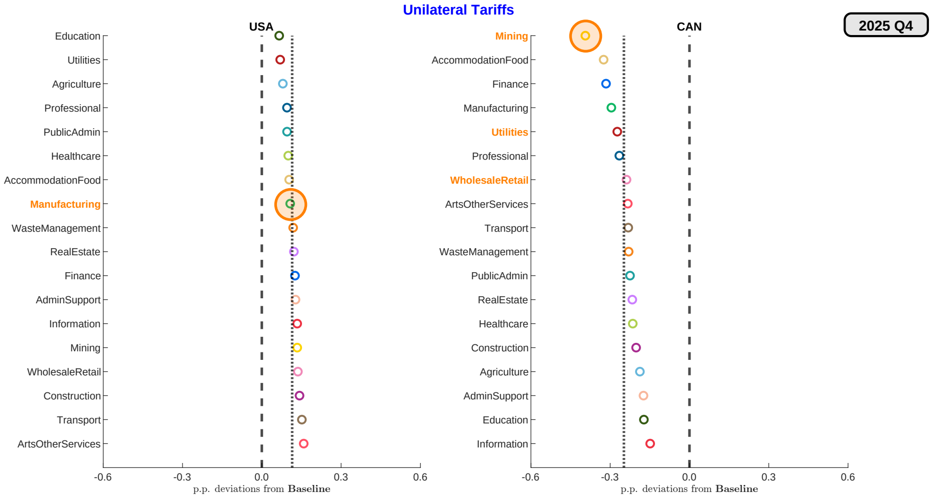

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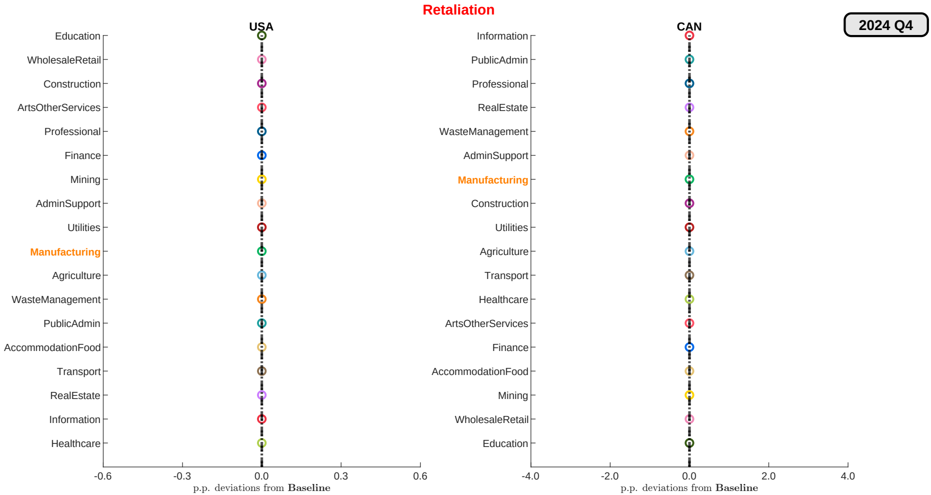
Inflation (PPI) by Sector – Retaliation



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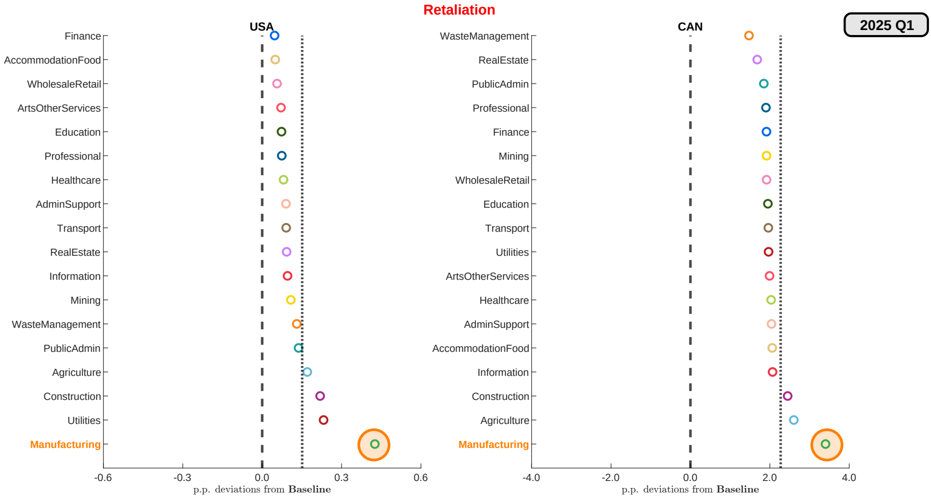

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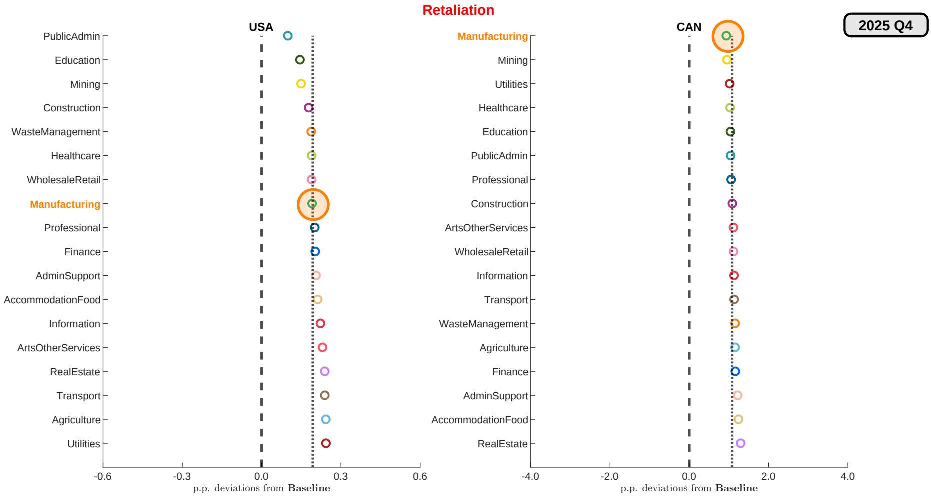

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Trump's "Liberation Day"

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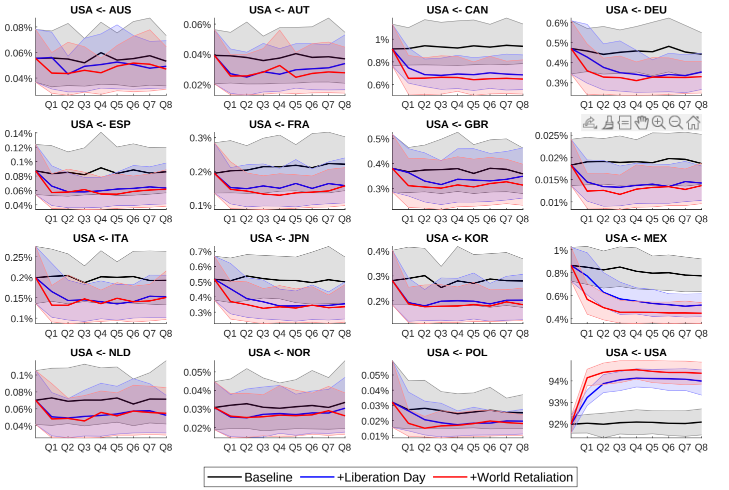
- We consider three scenarios to highlight the macroeconomic effects of tariffs within our agent-based framework:
  - **Baseline:**
    The model runs without any trade policy interventions or shocks.
  - **Liberation Day:**
    The USA imposes permanent tariffs on all imported goods, with partner-specific rates following the *"Trump's tariff table"*.
  - **World Retaliation:**
    On top of "Liberation Day" scenario, all the countries in the World respond with reciprocal tariffs on all imported goods from the USA.

Scenario	**USA → Foreign Countries**	**Foreign Countries → USA**
Baseline	0%	0%
Liberation Day	Varies by partner	0%
World Retaliation	Varies by partner	Varies by partner

US Imports over Total Spending



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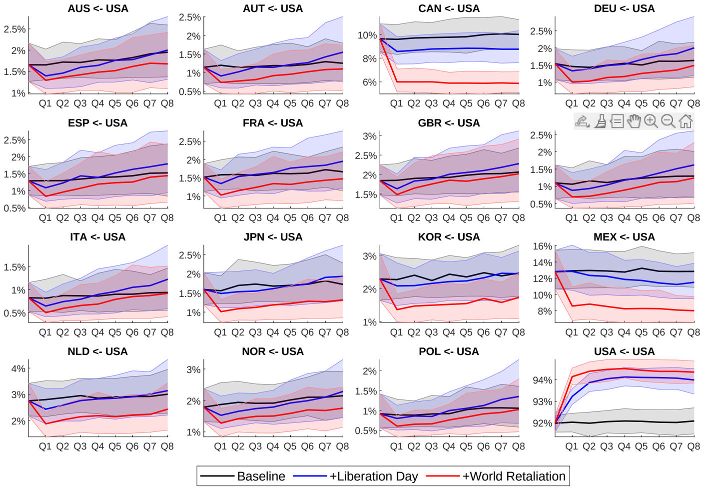

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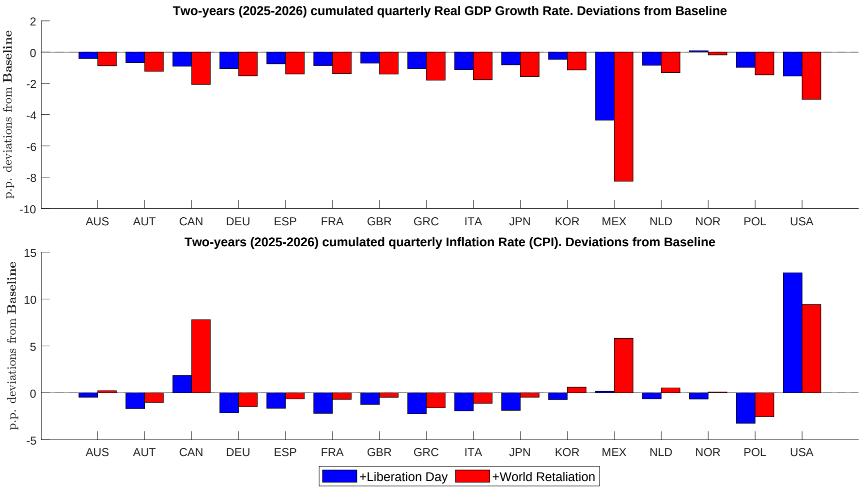
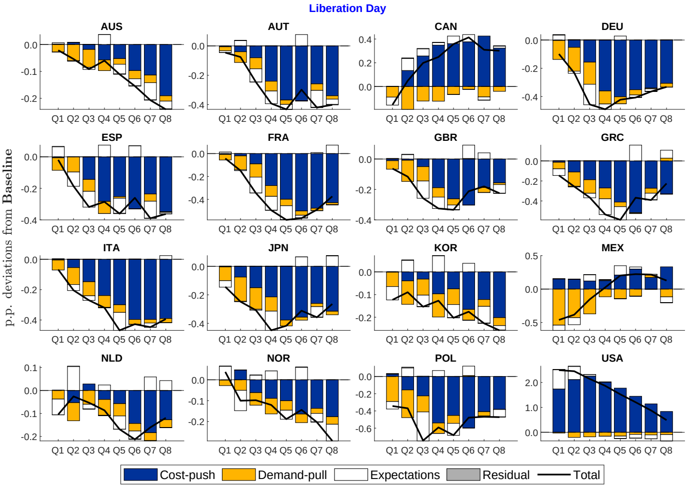


(3) **Output ↓ globally** (4) **Inflation → heterogeneous effects** (5) **Relative damage is different**

Inflation (PPI) by Components - Liberation Day



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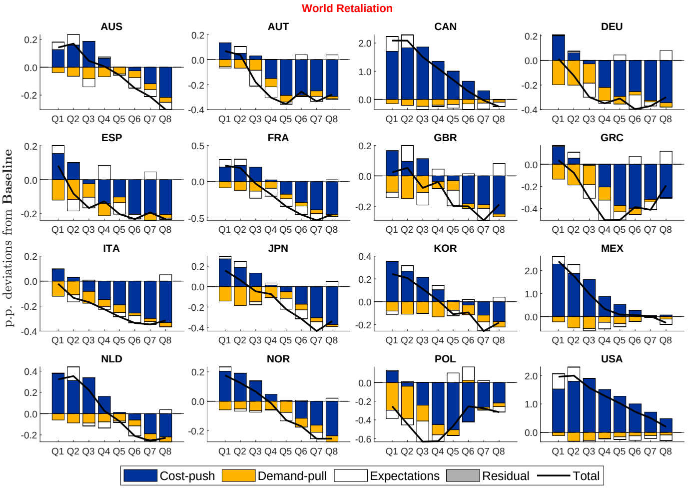
Inflation (PPI) by Components - World Retaliation



(8) **Combination of Stagflationary and Deflationary pressures**

Conclusions

Preliminary Takeaways

- Our ABM is in line with trade theory (Ricardo (1817); Krugman (1980); Fajgelbaum et al. (2020)):
  - **Tariff shocks reduce output and trade globally.**
  - **Stagflationary pressures for the tariff-imposing country.**
  - **Deflationary pressures in the targeted country.**
- Sectoral PPI inflation by-component disaggregation:
  - **Stagflationary pressures are mainly cost-driven.**
  - **Deflationary pressures are mainly demand-driven.**
- Sectoral PPI inflation by-sector disaggregation:
  - **Reveals the sectoral source of inflation pressure.**
  - **Shows how the shock propagates across sectors and countries.**
- Shortcomings and Next Steps:
  - **Calibration limited to OECD-31.**
  - **Exchange rate dynamics are missing.** Delli Gatti et al. (2024)? $\rightarrow$ *next paper*

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Thank you all!

Appendix

Appendix I - NACE Rev. 2 Classification

Description	**NACE Rev. 2**
Agriculture, forestry and fishing	A
Mining and quarrying	B
Manufacturing	C
Electricity, gas, steam and air conditioning supply	D
Water supply; sewerage; waste management, and remediation activities	E
Construction	F
Wholesale and retail trade; repair of motor vehicles and motorcycles	G
Transporting and storage	H
Accommodation and food service activities	I
Information and communication	J
Financial and insurance activities	K
Real estate activities	L
Professional, scientific and technical activities	M
Administrative and support service activities	N
Public administration and defence; compulsory social security	O
Education	P
Human health and social work activities	Q
Arts, entertainment and recreation + Other services activities	R + S

Table 1: NACE Rev. 2 codes description.

Appendix II - Input-output (intermediate block)

		DEMANDERS **(cd, gd)**						
		Country 1		...	Country 31		Country RoW	
SUPPLIERS **(cs, gs)**		Industry 1 ...	Industry 18		Industry 1 ...	Industry 18	Industry 1 ...	Industry 18
Country 1	Industry 1 ...							
	Industry 18							
...								
Country 31	Industry 1 ...							
	Industry 18							
Country RoW	Industry 1 ...							
	Industry 18							

Industry-Country level Share

=

Total imports of industry 1-country 31 of goods from industry 18-country 1

Total spending in industry 1-country 31

Appendix III - Search and Matching with Shares and Tariffs

- The probability that a demander from industry *gd* in country *cd* (i.e., a column entry in the input-output table) chooses to buy from a specific firm *i* depends on:
  - the price offered by the firm ($P_{i,t}$)
  - the demander's preference for that supplier's sector-country (s_i)
  - and the bilateral tariff between the demander's country and the supplier's sector-country ($\tau_{i,t}$)
- The choice probability is given by:

$$pr_{i,t} = \frac{\exp\left(-\gamma \log\left((1+\tau_{i,t})P_{i,t}\right) + \log\left(s_i\right)\right)}{\sum_{j \in I_{cs,gs}} \exp\left(-\gamma \log\left((1+\tau_{j,t})P_{j,t}\right) + \log\left(s_j\right)\right)}$$

- If $s_i = \bar{s}$ for all i (identical preferences) and $\tau_{j,t} = 0$, the formula reduces to a standard logit model as in Dawid and Delli Gatti (2018); Poledna et al. (2023).

Appendix IV - Demand-pull Inflation

- If the realized demand of a firm $D_i(t)$ exceeds its output $Y_i(t)$ and its current price $P_i(t)$ is below the sector–country average $\bar{P}_{g,f}(t)$, the firm raises its price proportionally ($\phi > 0$); vice versa, it lowers its price.

$$P_i(t+1) = \begin{cases} P_i(t)\left[1 + \phi \, \dfrac{D_i(t) - Y_i(t)}{Y_i(t)}\right], & {\scriptstyle \substack{D_i(t) > Y_i(t) \\ P_i(t) < \bar{P}_{g,f}(t)}} \vee {\scriptstyle \substack{D_i(t) < Y_i(t) \\ P_i(t) > \bar{P}_{g,f}(t)}}, \\ P_i(t), & \text{otherwise.} \end{cases}$$

Appendix III – PPI Decomposition: Log-approximation

- The Producer Price Index (PPI) deflator at the country level f is computed as a weighted average of firm-level prices:

$$PPI^f(t) = \frac{\sum_{i \in f} P_i(t) \cdot Q_i(t)}{\sum_{j \in f} Q_j(t)}$$

- Firm-level prices are decomposed into three multiplicative components:

$$P_i(t) = p_i^c(t) \cdot p_i^d(t) \cdot p_i^{\varepsilon}(t)$$

with:

  - $p_i^c(t)$: cost-push component (input cost pressures).
  - $p_i^d(t)$: demand-pull component (markups and demand conditions).
  - $p_i^{\varepsilon}(t)$: expectations component.

- Taking logs of $P_i(t)$ and aggregating across firms using weights $w_i = \frac{Q_i(t)}{\sum_{j \in f} Q_j(t)}$ yields the decomposition:

$$\log PPI^f(t) \approx \sum_{i \in f} w_i \left(\log p_i^c(t) + \log p_i^d(t) + \log p_i^{\varepsilon}(t) \right)$$

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