THE PRICE OF FRAGMENTATION

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Jacob Adamcik provided excellent research assistance.

Facts on Geopolitical Fragmentation—So Far

- Bilateral trade has fallen (US-China), but not global trade.
  - Reallocation via connector countries, like Vietnam.
  - (Gopinath, Gourinchas, Presbitero and Topalova, 2024; Alfaro and Chor, 2023).
- Similar patterns in FDI (Chinese affiliate in Vietnam) and bilateral portfolio flows (via financial centers a.k.a Luxembourg).
  - Geopolitical tensions influence cross-border allocation of investment (Catalán, Fendoglu and Tsuruga, 2023),
  - Together with significant action within sectors (Gopinath, Gourinchas, Presbitero and Topalova, 2024).
- Evidence of increased fragmentation and trade disruptions based on real time shipping and other AI-based data.
  - (Fernandez-Villaverde, Mineyama and Song, 2024; Bai, Fernández-Villaverde, Li and Zanetti, 2024; Fetzer, 2024).

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- Fragmentation seems to be unfolding as: **a reconfiguration of trade and reshoring incentivized by uncertainty, and reallocation of global capital among friendly countries.**
  - (Aiyar, 2024; Leduc and Liu, 2024).

Should Central Banks Care about Fragmentation?

- The LR impact of reconfiguration of trade/capital flows on incomes and prices:
  - Quantitative trade models are used to calculate this impact
- Transition to new steady-state is also important to consider given (SR):
  - Inflationary pressures
  - Unemployment

SR impact of fragmentation could be particularly salient given relative price changes along the global trade and production network—evident during COVID (e.g. di Giovanni, Kalemli-Ozcan, Silva, Yildirim).

Our Contribution

- A global GE-I-O view of aggregate fluctuations via trade and production network
- Start with an initial I-O matrix and apply trade costs to endogeneize the reconfiguration of expenditures and adjustment of trade/capital flows (intensive margin with CES)
- Estimate **inflationary** impact together with **sectoral employment changes** depending on **country-blocs**
- Introduce trade shocks to di Giovanni, Kalemli-Ozcan, Silva, Yildirim open economy macro model:
  - Two-period multicountry model $(n, m = 1, \ldots, \mathcal{N})$
  - Have access to a domestic and a world bond
  - Monetary policy: Taylor rule
  - Downward nominal wage rigidity in home currency
  - Segmented factor markets, domestic and global

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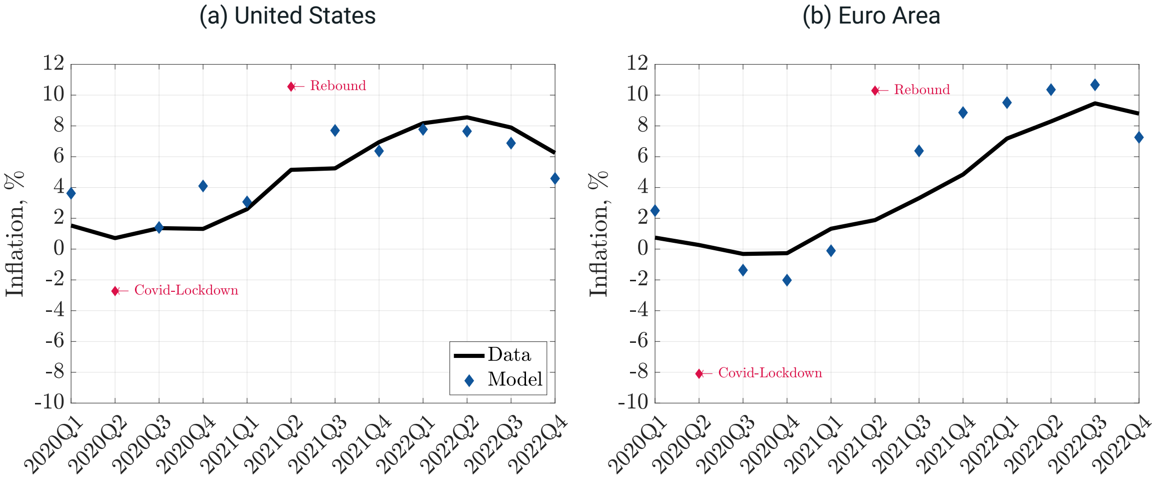
Our work is different from and complementary to:

- Geopolitical-led friendshoring can lead to output losses (Javorcik, Kitzmüller, Schweiger and Yıldırım, 2023)
- LR real income loss (Bonadio, Huo, Kang, Levchenko, Pandalai-Nayar, Toma, and Topalova, 2024)
- Fragmentation results from optimal country responses under coercion (Clayton, Maggiori and Schreger, 2024)
- We focus on a key issue for **central banks:** inflation-unemployment trade-off

Model without trade costs can match pandemic-era inflation



Source: di Giovanni, Kalemli-Özcan, Silva and Yıldırım (2023)

Model

Households in Country "n": Inter-temporal Problem

$$\max_{\{C_{n,0},C_{n,1},F_{n,0},B_{n,0}\}} (1-\beta_n)\frac{C_{n,0}^{1-\sigma}}{1-\sigma} + \beta_n \frac{C_{n,1}^{1-\sigma}}{1-\sigma}$$

s.t.

$$P_{n,0}C_{n,0} + B_{n,0} + \mathcal{E}_{n,0}F_{n,0} \leq \sum_i (W_{ni,0}L_{ni,0} + R_{ni,0}K_{ni,0}) + \mathcal{T}_{n,0},$$

$$P_{n,1}C_{n,1} \leq \mathcal{E}_{n,1}\sum_i (W_{ni,1}L_{ni,1} + R_{ni,1}K_{ni,1}) + (1+i_{n,0})B_{n,0} + \mathcal{E}_{n,1}(1+i_{US,0})F_{n,0} + \mathcal{T}_{n,1},$$

- B_n: domestic bond denominated in local currency units (lcu). Traded domestically.
- F_n: world bond denominated in US dollars. Internationally traded.
- $\mathcal{E}_n$: exchange rate between country n and the US (lcu per dollar)
- i_n: domestic interest rate
- i_{US}: US interest rate

Households in Country “n”: Intertemporal Optimality

- Optimality conditions

$$\frac{(1-\beta_n)}{\beta_n}\frac{C_{n,0}^{-\sigma}}{P_{n,0}} = \frac{C_{n,1}^{-\sigma}(1+i_{n,0})}{P_{n,1}} \qquad \text{(Euler Equation)}$$

$$(1+i_{n,0}) = (1+i_{US,0})\frac{\mathcal{E}_{n,1}}{\mathcal{E}_{n,0}} \qquad \text{(Interest Parity Condition)}$$

- X: steady-state value. 0 present where shocks happen, 1 future.
- $\hat{X}_t = X_t/X$: deviation from steady-state.

Monetary policy and exchange rates

- World expenditure (in US dollars) is *endogenous* and determined by

$$\widehat{E}^{\$}_{W,0} = \sum_n \alpha_n \left(\left[\frac{\beta_n}{(1-\beta_n)} \right] (1 + i_{US,0}) \right)^{-\frac{1}{\sigma}} \left(\frac{P_{n,0}/\mathcal{E}_{n,0}}{P_n/\mathcal{E}_n} \right)^{\frac{\sigma-1}{\sigma}} ; \qquad \alpha_n = \frac{P_n C_n/\mathcal{E}_n}{\sum_m P_m C_m/\mathcal{E}_m}$$

- Bilateral exchange rates depend only on the stance of domestic monetary policies

$$\frac{\mathcal{E}_{n,0}}{\bar{\mathcal{E}}_n} = \frac{(1 + i_{US,0})}{(1 + i_{n,0})}$$

- Domestic monetary policy follows a Taylor rule

$$(1 + i_{n,0}) = \left(\frac{P_{n,0}}{P_n} \right)^{\phi} (1 + i_n)$$

Disaggregated Consumption

- Consumption bundle consists of country-specific sectoral consumption bundles:

$$C_n = \prod_{j=1}^{\mathcal{J}} C_{n,j}^{\Omega^C_{n,j}}, \quad \sum_{j=1}^{\mathcal{J}} \Omega^C_{n,j} = 1$$

- Country-specific sectoral consumption bundles are formed by varieties (Armington aggregator) with sectors-specific Armington elasticities ξ_j^C

$$C_{n,j} = \left[\sum_{m=1}^{\mathcal{C}} (\Omega^{CB}_{n,mj})^{\frac{1}{\xi_j^C}} C_{n,mj}^{\frac{\xi_j^C - 1}{\xi_j^C}} \right]^{\frac{\xi_j^C}{\xi_j^C - 1}}, \quad \sum_{m=1}^{\mathcal{N}} \Omega^{CB}_{n,mj} = 1$$

Disaggregated Production

- Sectors produce by combining the factors (value-added) and intermediate bundle.

$$\min_{\{\mathsf{VA}_{ni}, M_{ni}\}} P_{ni}^{\mathsf{VA}} \mathsf{VA}_{ni} + P_{ni}^{M} Z_{ni}$$

s.t.

$$Y_{ni} = A_{ni} \left[(\Omega^{Y}_{ni,\mathsf{VA}})^{\frac{1}{\theta}} \mathsf{VA}_{ni}^{\frac{\theta-1}{\theta}} + (\Omega^{Y}_{ni,Z})^{\frac{1}{\theta}} Z_{ni}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad \text{with} \quad \Omega^{Y}_{ni,\mathsf{VA}} + \Omega^{Y}_{ni,Z} = 1$$

- Value-added bundle is composed of Labor and Capital:

$$\mathsf{VA}_{ni} = \left[(\Omega^{\mathsf{VA}}_{ni,L})^{\frac{1}{\gamma}} (L_{ni})^{\frac{\gamma-1}{\gamma}} + (\Omega^{\mathsf{VA}}_{ni,K})^{\frac{1}{\gamma}} (\bar{K}_{ni})^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \quad \text{with} \quad \Omega^{\mathsf{VA}}_{ni,L} + \Omega^{\mathsf{VA}}_{ni,K} = 1$$

Intermediate goods' aggregation

- Intermediate bundle consists of country-specific sectoral bundles:

$$Z_{ni} = \left[\sum_{j=1}^{\mathcal{J}} (\Omega^Z_{ni,j})^{\frac{1}{\varepsilon}} X_{ni,j}^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \quad \text{with} \quad \sum_{j=1}^{\mathcal{J}} \Omega^Z_{ni,j} = 1$$

- Country-specific sectoral bundles are formed by varieties (Armington aggregator) with sectors-specific Armington elasticities ξ_j^X:

$$X_{n,j} = \left[\sum_{m=1}^{\mathcal{N}} (\Omega^X_{n,mj})^{\frac{1}{\xi_j^X}} X_{n,mj}^{\frac{\xi_j^X-1}{\xi_j^X}} \right]^{\frac{\xi_j^X}{\xi_j^X-1}} \quad \text{with} \quad \sum_{m=1}^{\mathcal{N}} \Omega^X_{n,mj} = 1$$

Steel (j) comes from country $m = 1 \ldots \mathcal{N}$ into the U.S. $= X_{n,mj}$ as an intermediate input
U.S. (n) creates a steel bundle $= X_{n,j}$ to use in different industries such as U.S. car industry $= Z_{ni}$

Trade Costs

- Producer in country-industry mj charges p_{mj}
- Country n places ad valorem trade cost on mj good equal to $\tau_{n,mj}$
- The price index for the country-specific consumption bundle becomes:

$$p^{C}_{n,j} = \left[\sum_{m=1}^{\mathcal{C}} \Omega^{CB}_{n,mj} (\tau_{n,mj}\, p_{mj})^{1-\xi^{C}_{j}} \right]^{\frac{1}{1-\xi^{C}_{j}}} \quad \text{with} \quad \sum_{m=1}^{\mathcal{N}} \Omega^{CB}_{n,mj} = 1$$

- The price index for the country-specific sectoral bundle becomes:

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Market clearing

- Goods market clearing (as consumption or intermediate goods): for each country n sector i:

$$Y_{ni} = \sum_{m=1}^{\mathcal{N}} (X_{m,ni} + C_{m,ni})$$

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- Segmented labor markets: the labor market in country n, sector i

$$\frac{W_{ni}^{\$}}{E_W^{\$}} \geq \frac{\overline{W}_{ni}}{\mathcal{E}_n E_W^{\$}}, \quad \overline{L}_{ni} \geq L_{ni}, \qquad (\overline{L}_{ni} - L_{ni}) \left(\frac{W_{ni}^{\$}}{E_W^{\$}} - \frac{\overline{W}_{ni}}{\mathcal{E}_n E_W^{\$}} \right) = 0$$

  - Downward wage limit is given in the local currency but the model solves in relative terms (e.g. Schmitt-Grohe-Uribe)
  - Labor cannot go beyond the available labor and one of the constraints should be binding

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$$K_{ni} = \bar{K}_{ni}$$

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- Asset Markets clear: $\sum_n F_{n,t} = 0$

Domestic CPI Inflation w/o Trade Costs ▸ Details

$$\mathrm{d}\log \text{CPI}_n = \underbrace{\mathrm{d}\log E_W^{\$}}_{\text{World Expenditure}} + \underbrace{\mathrm{d}\log \mathcal{E}_n}_{\text{Exchange Rate}} - \underbrace{(\lambda^n)^T \mathrm{d}\log A}_{\text{Productivity Shocks}} - \underbrace{(\Lambda^n)^T \mathrm{d}\log L}_{\text{Factor Changes}} + \underbrace{(\Lambda^n)^T \mathrm{d}\log \Lambda}_{\substack{\text{Local-Global} \\ \text{D-S Imbalance}}}$$

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- *World Expenditure* ($\mathrm{d}\log E_W^{\$}$): US interest rate and countries intertemporal shifters.
- *Exchange Rate* ($\mathrm{d}\log \mathcal{E}_n$): country interest rate relative to the US.
- *Productivity shock* ($(\lambda^n)^T \mathrm{d}\log A$): Productivity changes weighted by the importance of sector in consumption basket of country n.
- *Factor Changes* ($(\Lambda^n)^T \mathrm{d}\log L$): Labor changes weighted by the importance of factor in providing for the consumption basket of country n.
- *Local-Global D-S Imbalance* ($(\Lambda^n)^T \mathrm{d}\log \Lambda$): Changes in global and local factor shares.
  - If world demand increases in factors that also country n demands a lot, then inflationary.

Domestic CPI Inflation with Trade Costs

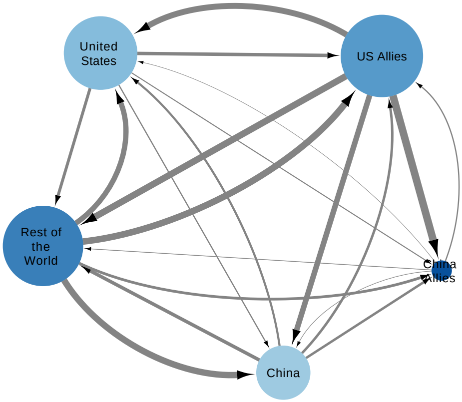
$$\mathrm{d}\log \mathsf{CPI}_n = \mathrm{d}\log E_W^{\$} + \mathrm{d}\log \mathcal{E}_{n,US} - (\lambda^n)^T \mathrm{d}\log A - (\Lambda^n)^T \mathrm{d}\log L + (\Lambda^n)^T \mathrm{d}\log \Lambda$$
$$+ \underbrace{(\lambda^n)^T (\Omega^{SS} \odot \mathrm{d}\log \tau)\, 1_{CN}}_{\text{Trade cost effects}} .$$

- $(\Omega^{SS} \odot \mathrm{d}\log \tau)\, 1_{CN}$ term captures the direct inflationary impact of the trade costs
- Trade costs also impact inflation indirectly through local-global supply-demand imbalances ($\mathrm{d}\log \Lambda$) and factor quantities ($\mathrm{d}\log L$)
- Note that with trade costs ($\tau_{n,mj} \neq 1$), global factor shares are no longer the weighted average of local factor shares:

$$\Lambda \neq \sum_n \frac{E_n/\mathcal{E}_{n,US}}{E^W} \Lambda^n .$$

Quantification

Intermediate Input Linkage between Blocs ‣ Numbers



The node size is proportional to the expenditure of the bloc going from 1.4T USD to 24.5T USD. Node color shows the imported intermediate input share of the bloc (darker blue implies higher imported intermediate shares, ranging from 7.7% to 11.4%). Edge weights reflect the share of the intermediate input from the source country among all imported intermediates going from 1.4% to 56%.

Data and Parameters for Calibration

- 2018 I-O Table from the OECD— Final use, input, value-added, and expenditure shares
- Start with 2018 trade imbalances
- Empirically relevant trade and production elasticities
  - Intertemporal elasticity of substitution: σ^{-1}= 0.5 (Auclert, Malmberg, Martenet and Rognlie, 2021)
  - Between value added and intermediate inputs: $\theta = 0.6$ (Atalay, 2017; Carvalho et. al, 2021)
  - Between labor and capital: $\gamma = 0.6$ (Raval, 2019; Oberfield and Raval, 2021)
  - Among intermediates: $\varepsilon = 0.2$ (Atalay, 2017; Boehm, Flaaen, and Pandalai-Nayar, 2019)
  - Cross-country Armington: $\xi = 0.6$ (Boehm, Levchenko and Pandalai-Nayar, 2023)
- Other parameters
  - Taylor rule: $\phi = 1.5$
  - $\beta_n = 0.4975$ for all n
    - matches 1% interest rate at steady state

Empirically Relevant Trade Costs

BBC

Home News US Election Sport Business Innovation Culture Arts Travel Earth

Biden hits Chinese electric cars and solar cells with higher tariffs

14 May 2024

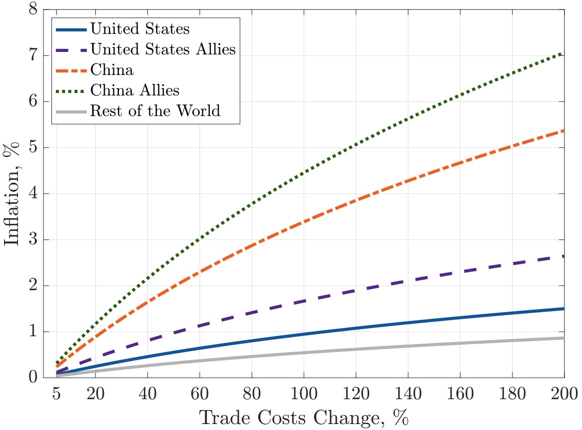
Natalie Sherman
Business reporter, New York

- Electric vehicles - from 25% to 100% in 2024
- Semiconductors - from 25% to 50% by 2025
- Certain steel and aluminium products - from 7.5% to 25% in 2024
- Lithium batteries and critical minerals - from 7.5% to 25% in 2024
- Solar cells - from 25% to 50% in 2024
- Ship to shore cranes - from 0% to 25% in 2024
- Rubber medical and surgical gloves - from 7.5% to 25% in 2026

Solution under Different Scenarios

- Model is solved with the AMPL/Knitro optimizer
  - Normalize all prices, wages, and rents to 1 at steady state
  - Shocks: Deviation of $\tau_{ni,mj}$ from its steady-state value of 1: $(\tau_{ni,mj}\, p_{mj}) \uparrow \rightarrow p_{ni,mj} \uparrow$
  - Calculate relative prices in world expenditure units (numeraire)
  - Convert relative prices to local currency using model's exchange rate and world expenditure changes
- Divide countries into five blocs: US, US allies, China, China allies, and the rest of the world
  - Aggregate flows across countries within blocs—collapse IO matrix to 5 blocs with 16 sectors each
- Consider three scenarios:
  - Scenario (1): 50% increase in $\tau_{ni,mj}$ for inputs flowing from China and China's allies to the US
  - Scenario (2): 50% increase in $\tau_{ni,mj}$ for inputs flowing from US and US allies to China
  - Scenario (3): [Full trade war]: 50% increase in $\tau_{ni,mj}$ for inputs flowing between enemy blocs:

Linearized Direct Effects: $(\lambda^n)^T(\Omega^{SS} \odot \mathrm{d}\log\tau)\,1_{CN}$
Inflation under Full Trade War:



- Assumes constant λ^n and Ω^{SS}.

Inflation with 50% trade shocks in the non-linear model (%)

Scenarios	United States	US Allies	China	China Allies	Rest of the World
US on China	0.594	-0.006	-0.240	-0.026	-0.017
US on China allies	0.033	0.000	0.003	-0.093	0.002
US on China and China allies	0.626	-0.007	-0.241	-0.121	-0.017
China on US	-0.077	0.006	0.398	0.016	0.011
China on US allies	0.014	-0.228	1.508	-0.001	0.030
China on US and US allies	-0.064	-0.222	1.905	0.015	0.042
Retaliation US-China and allies	0.574	-0.226	1.669	-0.104	0.027
Full Trade War	0.613	0.657	1.371	2.237	0.085

Inflation: Full trade war with different trade shocks (%)

Trade costs change	United States	US Allies	China	China Allies	Rest of the World
10%	0.125	0.124	0.271	0.444	0.008
20%	0.249	0.254	0.546	0.893	0.022
30%	0.372	0.387	0.822	1.343	0.040
40%	0.494	0.521	1.097	1.792	0.061
50%	0.613	0.657	1.371	2.237	0.085
60%	0.731	0.793	1.642	2.678	0.110
70%	0.847	0.929	1.911	3.114	0.136
80%	0.961	1.065	2.177	3.545	0.164
90%	1.073	1.200	2.439	3.971	0.193

Aggregate Keynesian Unemployment with 50% trade shocks

Scenarios	United States	US Allies	China	China Allies	Rest of the World
US on China	0.367	0.017	0.472	0.008	0.020
US on China allies	0.025	0.002	0.012	0.215	0.006
US on China and China allies	0.389	0.016	0.471	0.221	0.020
China on US	0.167	0.008	0.274	0.014	0.011
China on US allies	0.031	0.489	1.085	0.086	0.050
China on US and US allies	0.199	0.498	1.351	0.100	0.062
Retaliation US-China and allies	0.592	0.511	1.818	0.320	0.082
Full Trade War	0.646	1.275	2.599	4.115	0.154

Heterogenous ↑ Unemployment: Full Trade War w/50% ▸ bloc slide

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-1.25	-1.33	-2.38	-2.48	-0.11
Mining	-0.99	-7.16	-2.76	-9.65	-0.91
Food products, beverages, and Tobacco	-0.56	-1.05	-2.12	-2.20	-0.07
Textiles, wearing apparel and leather products	-2.60	-2.91	-6.89	-2.89	-0.82
Wood and of products of wood and cork	-0.53	-1.36	-5.31	-7.58	-0.27
Paper and printing	-0.73	-1.82	-3.36	-3.37	-0.20
Coke and refined petroleum products	-0.96	-2.00	-3.31	-13.97	-0.58
Chemical and pharmaceutical	-1.18	-2.74	-3.75	-6.39	-0.36
Rubber and plastic products	-0.40	-1.97	-5.43	-3.19	-0.25
Other non-metallic mineral products	-0.02	-1.39	-3.67	-4.33	-0.18
Basic and fabricated metals	-1.33	-2.82	-4.13	-7.29	-0.41
Machinery and equipment n.e.c.	-1.44	-2.88	-3.58	-4.15	-0.35
Electric and electronical equipment	-1.92	-5.29	-6.03	-3.40	-0.58
Motor vehicles and other transport equipment	-1.47	-2.10	-2.68	-4.13	-0.28
Furniture/repair installation of machinery	-1.54	-1.89	-7.66	-4.33	-0.32
Services	-0.57	-1.07	-1.96	-3.62	-0.11

Color scale: -2, -4, -6, -8, -10, -12

Conclusion

Conclusion and Next Steps

The cost of stabilizing inflationary impact of higher trade costs in a fragmented world is higher unemployment.

- Trade restrictions that are over 50% are highly inflationary.
- At 50% tariff or below, inflation may not go as high in US block, but there is an increase in unemployment (2%-8%) especially in sectors that rely on imported inputs (higher numbers for China bloc), when monetary policy stabilizes inflation.
- Aggregate unemployment ↑ 1.5 (US+) to 4.5 percent (China+) with 90% shock
- Our results are based on a 2-period global GE network model with wage rigidity
  - A big advantage: study spillovers of trade policy to third country output-inflation and so MP reaction; standard open-econ-macro will miss.
  - Can analyze the link between countries' comparative advantage and sector-targeted industrial policies.
- We highlight the importance of both **demand and supply sides of fragmentation**
  - Deviation from standard trade-I-O models with productivity shocks
  - Monetary policy contracts AD due to cost-push inflation as a result of fragmentation
- In progress: Fully dynamic model

Appendix

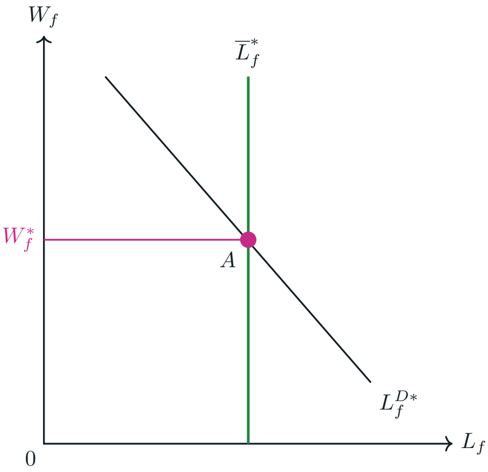
Country and Bloc Table

▸ Inflation ▸ US on China ▸ China on US

Country	Bloc	Country	Bloc
Argentina	Rest of the World	Iceland	US Bloc
Australia	US Bloc	Israel	US Bloc
Austria	US Bloc	Italy	US Bloc
Belgium	US Bloc	Jordan	Rest of the World
Bangladesh	Rest of the World	Japan	Rest of the World
Bulgaria	US Bloc	Kazakhstan	Rest of the World
Belarus	China Bloc	Cambodia	Rest of the World
Brazil	Rest of the World	Korea	US Bloc
Brunei Darussalam	Rest of the World	Lao (People's Dem. Rep.)	China
Canada	US Bloc	Lithuania	US Bloc
Switzerland	US Bloc	Luxembourg	US Bloc
Chile	Rest of the World	Latvia	US Bloc
China (People's Rep.)	China	Morocco	Rest of the World
Côte d'Ivoire	Rest of the World	Mexico	Rest of the World
Cameroon	Rest of the World	Malta	US Bloc
Colombia	Rest of the World	Myanmar	Rest of the World
Costa Rica	Rest of the World	Malaysia	Rest of the World
Cyprus	US Bloc	Nigeria	Rest of the World
Czechia	US Bloc	Netherlands	US Bloc
Germany	US Bloc	Norway	US Bloc
Denmark	US Bloc	New Zealand	US Bloc
Egypt	Rest of the World	Pakistan	Rest of the World
Spain	US Bloc	Peru	Rest of the World
Estonia	US Bloc	Philippines	Rest of the World
Finland	US Bloc	Poland	US Bloc
France	US Bloc	Portugal	US Bloc
United Kingdom	US Bloc	Romania	US Bloc
Greece	US Bloc	Russian Federation	China Bloc
Hong Kong, China	China	Saudi Arabia	Rest of the World
Croatia	US Bloc	Senegal	Rest of the World
Hungary	US Bloc	Singapore	Rest of the World
Indonesia	Rest of the World	Slovakia	US Bloc
India	Rest of the World	Slovenia	US Bloc
Ireland	US Bloc	Sweden	US Bloc

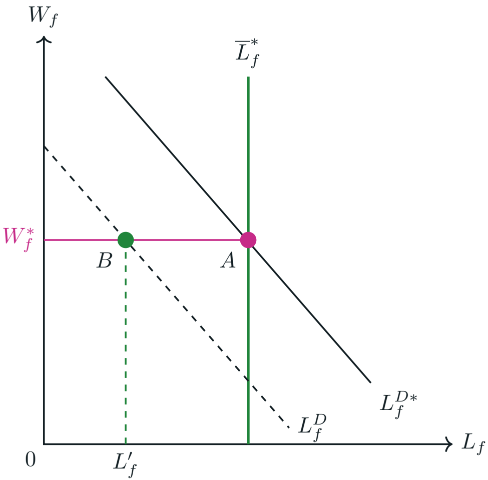
Segmented factor markets: Closed versus open economy

- $\overline{L}_f$: Potential level for factor f.



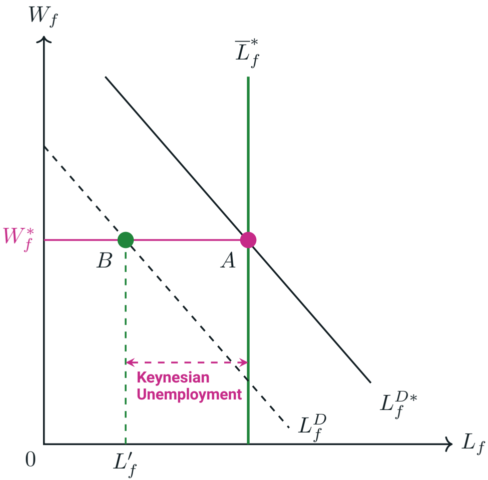
Segmented factor markets: Closed versus open economy

- $\overline{L}_f$: Potential level for factor f.
- L_f: Equilibrium employment level for factor f
  - Demand effects+downward wage rigidity $\Rightarrow$ workers employed might be lower than *potential*



Segmented factor markets: Closed versus open economy

- $\overline{L}_f$: Potential level for factor f.
- L_f: Equilibrium employment level for factor f
  - Demand effects+downward wage rigidity $\Rightarrow$ workers employed might be lower than *potential*
- Difference between $\overline{L}_f$ and L_f: Keynesian unemployment



Segmented factor markets: Closed versus open economy

- $\overline{L}_f$: Potential level for factor f.
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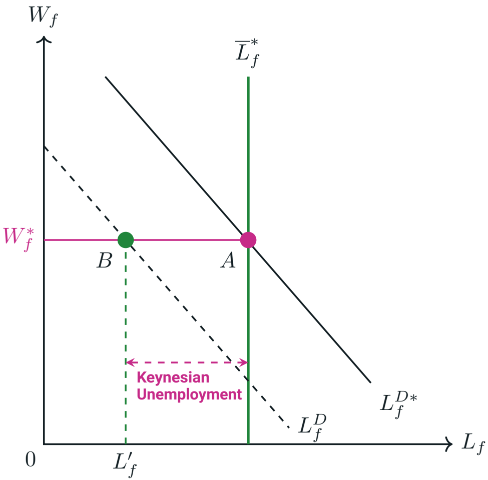
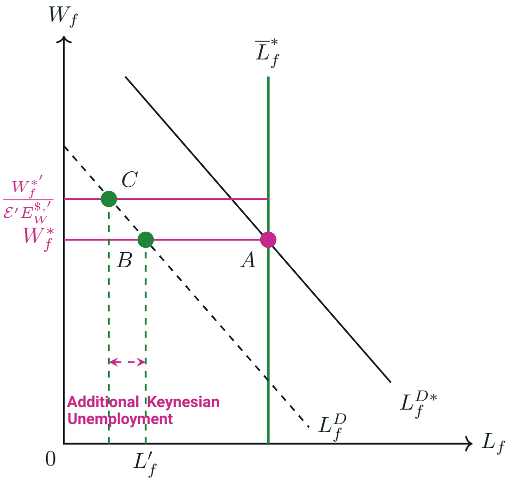
- Point B is where the story ends in closed econ.



Segmented factor markets: Closed versus open economy

- $\overline{L}_f$: Potential level for factor f.
- L_f: Equilibrium employment level for factor f
  - Demand effects+downward wage rigidity $\Rightarrow$ workers employed might be lower than *potential*
- Difference between $\overline{L}_f$ and L_f: Keynesian unemployment
- Point B is where the story ends in closed econ.
- **Open economy has an additional channel**: shifts the relevant lower bound of wages
  - due to changes in exchange rates ($\mathcal{E}$) and world expenditure ($E_W^{\$}$)
  - spillover to factor markets across countries



Fragmentation Shocks in Recent Literature

- Ambrosino, Chan & Tenreyro (2024) find balance of demand and supply depends on scenario
  - Two-sector (tradable and non-tradable) small open economy NK setting with constrained households
  - Key parameters: home bias (0.75),share of tradables (0.2), $\phi_\pi = 2$ and Frisch elasticity of 1
  - 3 scenarios modeling fragmentation as increase in import costs or decline in tradables' TFP:
    1. Gradual Fragmentation: may lead to lower real incomes and CB loosening policy
    2. Front-loaded fragmentation: might lead to SR inflation-output tradeoff
    3. Decline in productivity of tradables: might be neutral for inflation
- Bonadio, Huo, Kang, Levchenko, Pandalai-Nayar, Toma, and Topalova measure fragmentation from 2015-2023
  - Changes in gravity model residuals interpreted as change in bilateral trade costs
  - US bloc, China bloc and unaligned bloc $\rightarrow$ they find cross-bloc trade costs $\uparrow$ and within-bloc trade costs $\downarrow$
  - Rescaled matrix of trade cost changes applied as shocks to multi-sector international trade model $\rightarrow$ median country (within the world & within each bloc), sees 0.4-0.6% higher real income
  - Result driven by overall trade and overall trade costs being stable from 2015-2023

Additional model details

Calculating Inflation ▸ Back

- Industry shares in consumption baskets and industry to industry flows:

$$\Omega^{CS} \equiv \Omega^{C}\Omega^{CB}.$$

$$\Omega^{SS} \equiv \Omega^{Y}\Omega^{Z}\Omega^{X}.$$

- All direct and indirect flows from industry to industry (Leontief Inverse):

$$\Psi = \left[I - \Omega^{SS}\right]^{-1}$$

- Factor shares (for all factors, including labor and capital):

$$\Omega^{F} \equiv \Omega^{Y}\Omega^{\text{VA}}.$$

1. Prices in dollars ($\mathrm{d}\log P^{\$}$):

$$\mathrm{d}\log P^{\$} = -\Psi\,\mathrm{d}\log A + \Psi\,\Omega^{F}\,\mathrm{d}\log W^{\$} + \Psi(\Omega^{SS}\odot\mathrm{d}\log\tau)\,1_{CN}$$

2. Country's n CPI changes

$$\mathrm{d}\log CPI_n = (\Omega^{CS}_n)^T\mathrm{d}\log P^{LC,n} = \mathrm{d}\log\mathcal{E}_n + (\Omega^{CS}_n)^T\mathrm{d}\log P^{\$}$$

3. Relate factor price f to its factor share at the *world level* $\Lambda_f = W^{\$}_f L_f / E^{\$}_W$

$$\mathrm{d}\log W^{\$}_f = \mathrm{d}\log E^{\$}_W + \mathrm{d}\log\Lambda_f - \mathrm{d}\log L_f$$

Structure of the Input-Output matrix

$\Omega =$

	C	Y	Z	VA	X	CB	L	K	Ric	Fut
C	0	0	0	0	0	Ω^C	0	0	0	0
Y	0	0	Ω^Y_Z	Ω^Y_{VA}	0	0	0	0	0	0
Z	0	0	0	0	Ω^Z	0	0	0	0	0
VA	0	0	0	0	0	0	Ω^{VA}_L	Ω^{VA}_K	0	0
X	0	Ω^X	0	0	0	0	0	0	0	0
CB	0	Ω^{CB}	0	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0
Ric	$1-\beta$	0	0	0	0	0	0	0	0	β
Fut	0	0	0	0	0	0	0	0	0	0

Index	Description	Size	Elasticity
C	Current Consumption	$\mathcal{N}$	1
Y	Goods / Varieties	$\mathcal{N} \times \mathcal{J}$	θ
Z	Intermediate Bundle	$\mathcal{N} \times \mathcal{J}$	ε
VA	Value-Added	$\mathcal{N} \times \mathcal{J}$	γ
X	Country-Sector Bundles	$\mathcal{N} \times \mathcal{J}$	ξ_i
CB	Consumption Bundles	$\mathcal{N} \times \mathcal{J}$	ξ'_i
L	Sector Specific Labor	$\mathcal{N} \times \mathcal{J}$	
C	Sector Specific Capital	$\mathcal{N} \times \mathcal{J}$	
Ric	Ricardian Consumer	$\mathcal{N}$	1
Fut	Future Consumption	$\mathcal{N}$	

Structure of the Input-Output matrix

$\Omega =$

	C	Y	Z	VA	X	CB	L	K	Ric	Fut
C	0	0	0	0	0	Ω^C	0	0	0	0
Y	0	0	Ω^Y_Z	Ω^Y_{VA}	0	0	0	0	0	0
Z	0	0	0	0	Ω^Z	0	0	0	0	0
VA	0	0	0	0	0	0	Ω^{VA}_L	Ω^{VA}_K	0	0
X	0	Ω^X	0	0	0	0	0	0	0	0
CB	0	Ω^{CB}	0	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0
Ric	$1-\beta$	0	0	0	0	0	0	0	0	β
Fut	0	0	0	0	0	0	0	0	0	0

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C	Sector Specific Capital	$\mathcal{N} \times \mathcal{J}$	
Ric	Ricardian Consumer	$\mathcal{N}$	1
Fut	Future Consumption	$\mathcal{N}$	

- Rows: Price equations

$$\theta_i \neq 1 \quad \Rightarrow \quad P_i^{1-\theta_i} = \sum_j \Omega_{ij} P_j^{1-\theta_i}$$

$$\theta_i = 1 \quad \Rightarrow \quad \log(P_i) = \sum_j \Omega_{ij} \log(P_j)$$

Structure of the Input-Output matrix

$$
\Omega = \begin{array}{c|cccccccccc}
 & C & Y & Z & \text{VA} & X & CB & L & K & \text{Ric} & \text{Fut} \\
\hline
C & 0 & 0 & 0 & 0 & 0 & \Omega^C & 0 & 0 & 0 & 0 \\
Y & 0 & 0 & \Omega^Y_Z & \Omega^Y_{\text{VA}} & 0 & 0 & 0 & 0 & 0 & 0 \\
Z & 0 & 0 & 0 & 0 & \Omega^Z & 0 & 0 & 0 & 0 & 0 \\
\text{VA} & 0 & 0 & 0 & 0 & 0 & 0 & \Omega^{\text{VA}}_L & \Omega^{\text{VA}}_K & 0 & 0 \\
X & 0 & \Omega^X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
CB & 0 & \Omega^{CB} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
L & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
K & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\text{Ric} & 1-\beta & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \beta \\
\text{Fut} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}
$$

Index	Description	Size	Elasticity
C	Current Consumption	$\mathcal{N}$	1
Y	Goods / Varieties	$\mathcal{N} \times \mathcal{J}$	θ
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$$\theta_i \neq 1 \quad \Rightarrow \quad P_i^{1-\theta_i} = \sum_j \Omega_{ij} P_j^{1-\theta_i}$$

$$\theta_i = 1 \quad \Rightarrow \quad \log(P_i) = \sum_j \Omega_{ij} \log(P_j)$$

- Columns: Output (Domar weights)

$$\frac{P_i Y_i}{\text{GDP}_W} \equiv \lambda_i = \sum_j \Omega_{ji} \left(\frac{P_i}{P_j}\right)^{1-\theta_j} \lambda_j$$

Model solution method

- Calibrate the model with ICIO 2018 Table from OECD
  - Final use shares
  - Input shares
  - Value added shares
  - Expenditures
  - Allow for initial trade imbalances
- Normalize all prices, wages and rents to 1 at steady state
- From this stable equilibrium (2019 pre-pandemic) introduce shocks
- AMPL / Knitro optimizer
- Calculate the relative changes in common currency
- Convert the common currency price changes to local currency by multiplying with the model-consistent exchange rate

Additional charts

Visualizing Inter-Dependence

Country-Country Intermediate Input Flows

▸ Back

All Suppliers

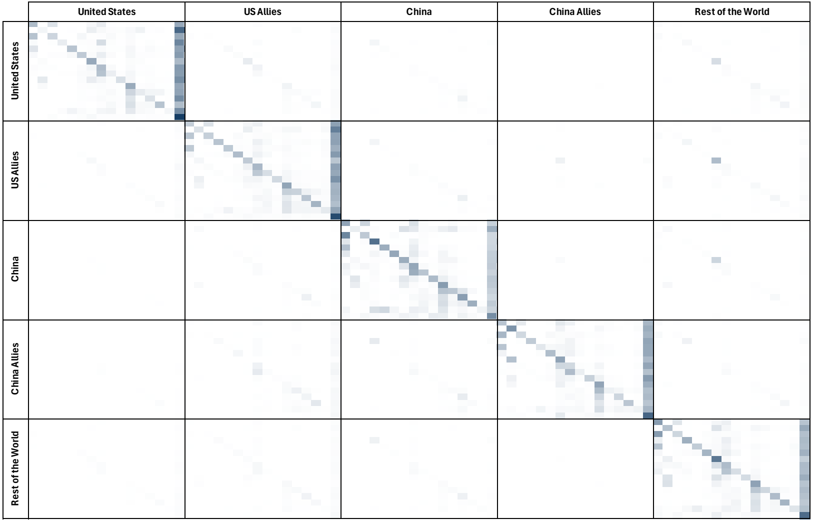
	United States	US Allies	China	China Allies	Rest of the World
United States	91.4%	3.8%	1.3%	0.1%	3.4%
US Allies	2.5%	90.1%	1.8%	0.8%	4.9%
China	0.6%	3.2%	92.3%	0.2%	3.7%
China Allies	0.8%	6.4%	2.0%	88.6%	2.2%
Rest of the World	2.2%	5.1%	2.7%	0.4%	89.5%

International Suppliers

	United States	US Allies	China	China Allies	Rest of the World
United States		44.3%	15.0%	1.4%	39.3%
US Allies	25.0%		17.8%	8.3%	48.9%
China	8.0%	41.3%		3.2%	47.5%
China Allies	6.7%	56.4%	17.3%		19.6%
Rest of the World	21.4%	49.0%	25.3%	4.2%	

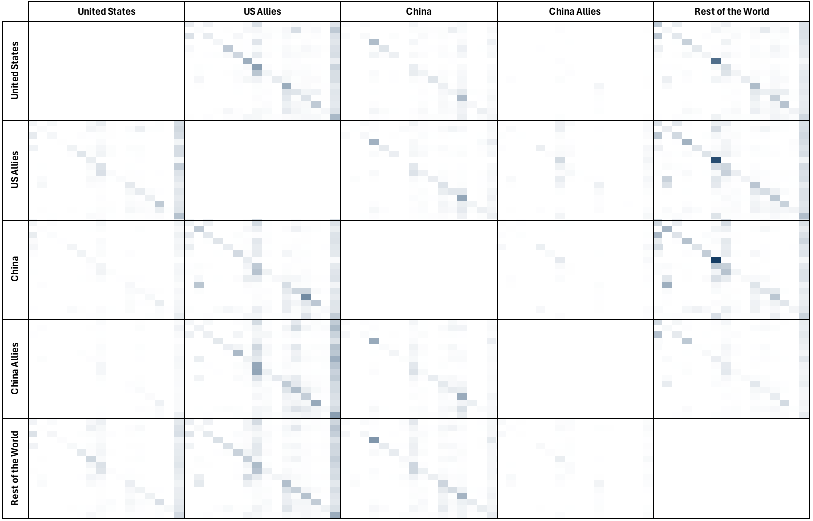
Visualizing Inter-Dependence

Full ICIO

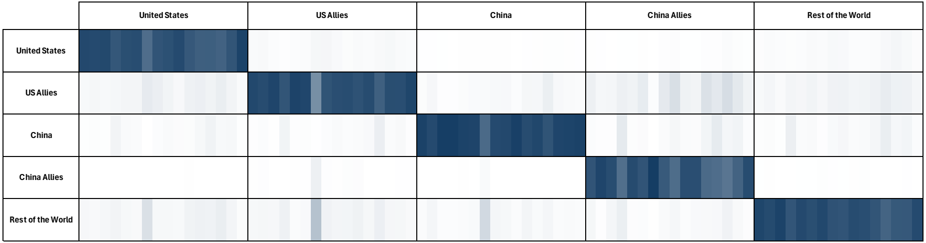


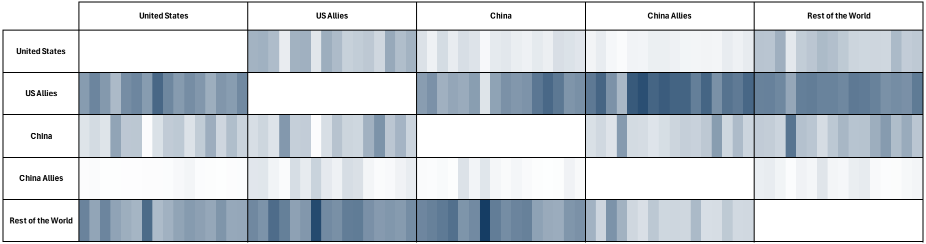
Visualizing Inter-Dependence

Trade Within Blocs Omitted



Visualizing Inter-Dependence





Additional results on blocs

Aggregate Keynesian Unemployment: Full trade war with varying shock size

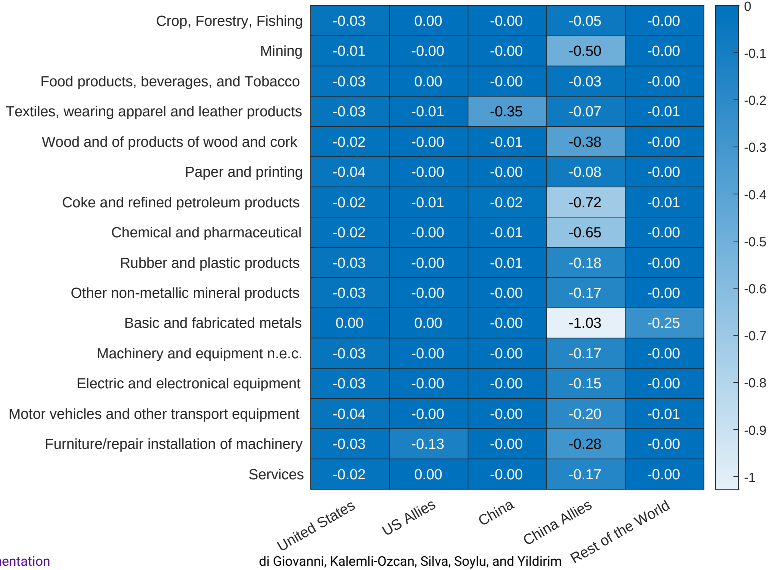
Trade costs change	United States	US Allies	China	China Allies	Rest of the World
10%	0.148	0.302	0.622	0.988	0.032
20%	0.285	0.576	1.183	1.878	0.064
30%	0.412	0.827	1.694	2.687	0.095
40%	0.532	1.059	2.164	3.429	0.124
50%	0.646	1.275	2.599	4.115	0.154
60%	0.754	1.478	3.004	4.753	0.182
70%	0.857	1.669	3.383	5.348	0.210
80%	0.955	1.850	3.741	5.907	0.237
90%	1.050	2.022	4.078	6.434	0.264

Employment: US on China

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-0.46	-0.01	-0.37	-0.01	-0.01
Mining	-0.37	-0.27	-0.75	-0.07	-0.22
Food products, beverages, and Tobacco	-0.36	-0.01	-0.25	0.00	-0.00
Textiles, wearing apparel and leather products	-2.14	-0.11	-2.27	0.00	-0.37
Wood and of products of wood and cork	0.00	-0.01	-1.80	-0.27	-0.06
Paper and printing	-0.25	-0.02	-0.80	-0.06	-0.03
Coke and refined petroleum products	-0.50	-0.07	-0.47	-0.08	-0.11
Chemical and pharmaceutical	-0.37	-0.07	-0.99	-0.05	-0.09
Rubber and plastic products	0.00	-0.05	-1.60	-0.02	-0.03
Other non-metallic mineral products	0.00	-0.02	-0.67	-0.01	-0.01
Basic and fabricated metals	-0.40	-0.09	-0.92	-0.05	-0.08
Machinery and equipment n.e.c.	-0.64	-0.05	-0.77	-0.00	-0.04
Electric and electronical equipment	-0.93	-0.25	-1.93	-0.01	-0.15
Motor vehicles and other transport equipment	-0.57	-0.03	-0.43	-0.00	-0.01
Furniture/repair installation of machinery	-1.20	-0.06	-3.04	0.00	-0.10
Services	-0.34	-0.01	-0.23	-0.00	-0.01

Color scale: 0, -0.5, -1, -1.5, -2, -2.5, -3

Employment: US on China allies



Employment: US on China and China allies ▸ bloc slide

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-0.49	-0.01	-0.37	-0.06	-0.01
Mining	-0.38	-0.27	-0.75	-0.56	-0.22
Food products, beverages, and Tobacco	-0.38	-0.00	-0.25	-0.03	-0.00
Textiles, wearing apparel and leather products	-2.16	-0.11	-2.27	0.00	-0.37
Wood and of products of wood and cork	-0.00	-0.01	-1.80	-0.65	-0.06
Paper and printing	-0.28	-0.02	-0.80	-0.14	-0.03
Coke and refined petroleum products	-0.52	-0.07	-0.48	-0.79	-0.11
Chemical and pharmaceutical	-0.39	-0.07	-0.99	-0.70	-0.09
Rubber and plastic products	0.00	-0.05	-1.60	-0.19	-0.03
Other non-metallic mineral products	-0.00	-0.02	-0.67	-0.18	-0.01
Basic and fabricated metals	-0.32	-0.09	-0.92	-1.08	-0.08
Machinery and equipment n.e.c.	-0.67	-0.06	-0.77	-0.17	-0.04
Electric and electronical equipment	-0.95	-0.25	-1.93	-0.15	-0.15
Motor vehicles and other transport equipment	-0.60	-0.03	-0.43	-0.19	-0.02
Furniture/repair installation of machinery	-1.23	-0.06	-3.03	-0.27	-0.10
Services	-0.36	-0.01	-0.23	-0.17	-0.01

Color scale: 0, -0.5, -1, -1.5, -2, -2.5, -3

Employment: China on US

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-0.67	-0.01	-0.27	-0.01	-0.01
Mining	-0.36	-0.04	-0.39	-0.03	-0.04
Food products, beverages, and Tobacco	-0.11	-0.00	-0.28	-0.01	-0.01
Textiles, wearing apparel and leather products	-0.24	-0.03	-0.37	-0.05	-0.04
Wood and of products of wood and cork	-0.46	-0.02	-0.23	0.00	-0.02
Paper and printing	-0.34	-0.01	-0.26	-0.00	-0.01
Coke and refined petroleum products	-0.30	-0.04	-0.38	-0.04	-0.04
Chemical and pharmaceutical	-0.56	-0.02	-0.25	-0.02	-0.01
Rubber and plastic products	-0.31	-0.01	-0.32	-0.00	-0.02
Other non-metallic mineral products	-0.24	-0.01	-0.39	-0.01	-0.01
Basic and fabricated metals	-0.76	-0.03	-0.30	-0.04	-0.03
Machinery and equipment n.e.c.	-0.48	-0.02	-0.30	-0.02	-0.03
Electric and electronical equipment	-0.65	-0.00	-0.33	-0.02	-0.03
Motor vehicles and other transport equipment	-0.55	-0.03	-0.35	-0.02	-0.04
Furniture/repair installation of machinery	-0.16	-0.02	-0.33	-0.03	-0.02
Services	-0.13	-0.01	-0.26	-0.01	-0.01

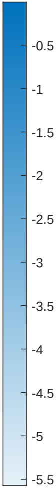
Color scale: 0, -0.1, -0.2, -0.3, -0.4, -0.5, -0.6, -0.7

Employment: China on US allies

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-0.03	-0.49	-1.17	-0.00	-0.02
Mining	-0.14	-5.54	-0.21	-0.41	-0.20
Food products, beverages, and Tobacco	-0.01	-0.33	-1.11	0.00	-0.02
Textiles, wearing apparel and leather products	-0.17	-0.79	-1.45	-0.19	-0.15
Wood and of products of wood and cork	-0.03	-0.66	-1.48	-0.18	-0.07
Paper and printing	-0.04	-0.83	-1.26	-0.07	-0.06
Coke and refined petroleum products	-0.14	-1.31	-1.47	-0.53	-0.31
Chemical and pharmaceutical	-0.08	-1.66	-0.88	-0.22	-0.09
Rubber and plastic products	-0.04	-1.09	-1.32	-0.09	-0.08
Other non-metallic mineral products	-0.01	-0.83	-1.53	-0.07	-0.05
Basic and fabricated metals	-0.16	-1.90	-1.25	-0.29	-0.16
Machinery and equipment n.e.c.	-0.11	-1.47	-1.31	-0.09	-0.12
Electric and electronical equipment	-0.17	-4.07	-0.83	-0.11	-0.17
Motor vehicles and other transport equipment	-0.08	-0.88	-1.35	-0.04	-0.09
Furniture/repair installation of machinery	-0.09	-0.62	-1.27	-0.13	-0.08
Services	-0.02	-0.33	-1.03	-0.06	-0.04

Employment: China on US and US allies ▸ bloc slide

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-0.70	-0.50	-1.43	-0.01	-0.03
Mining	-0.50	-5.57	-0.60	-0.44	-0.24
Food products, beverages, and Tobacco	-0.12	-0.33	-1.38	-0.00	-0.03
Textiles, wearing apparel and leather products	-0.41	-0.82	-1.81	-0.24	-0.19
Wood and of products of wood and cork	-0.49	-0.68	-1.70	-0.17	-0.09
Paper and printing	-0.38	-0.85	-1.51	-0.08	-0.07
Coke and refined petroleum products	-0.44	-1.36	-1.84	-0.56	-0.35
Chemical and pharmaceutical	-0.64	-1.68	-1.12	-0.24	-0.10
Rubber and plastic products	-0.34	-1.11	-1.63	-0.09	-0.10
Other non-metallic mineral products	-0.25	-0.84	-1.90	-0.08	-0.06
Basic and fabricated metals	-0.93	-1.94	-1.54	-0.33	-0.19
Machinery and equipment n.e.c.	-0.59	-1.49	-1.60	-0.11	-0.15
Electric and electronical equipment	-0.82	-4.08	-1.15	-0.13	-0.20
Motor vehicles and other transport equipment	-0.63	-0.90	-1.68	-0.05	-0.13
Furniture/repair installation of machinery	-0.25	-0.64	-1.59	-0.16	-0.11
Services	-0.15	-0.34	-1.27	-0.07	-0.04



Employment: Retaliation US-China and allies

	United States	US Allies	China	China Allies	Rest of the World
Crop, Forestry, Fishing	-1.19	-0.51	-1.80	-0.07	-0.05
Mining	-0.89	-5.79	-1.34	-1.00	-0.46
Food products, beverages, and Tobacco	-0.51	-0.34	-1.62	-0.03	-0.03
Textiles, wearing apparel and leather products	-2.57	-0.93	-4.03	-0.23	-0.56
Wood and of products of wood and cork	-0.48	-0.68	-3.47	-0.82	-0.15
Paper and printing	-0.67	-0.86	-2.29	-0.21	-0.10
Coke and refined petroleum products	-0.96	-1.42	-2.31	-1.35	-0.46
Chemical and pharmaceutical	-1.03	-1.73	-2.09	-0.94	-0.19
Rubber and plastic products	-0.30	-1.14	-3.20	-0.28	-0.13
Other non-metallic mineral products	-0.00	-0.86	-2.57	-0.26	-0.08
Basic and fabricated metals	-1.24	-2.01	-2.44	-1.41	-0.27
Machinery and equipment n.e.c.	-1.26	-1.54	-2.36	-0.28	-0.19
Electric and electronical equipment	-1.78	-4.28	-3.05	-0.29	-0.35
Motor vehicles and other transport equipment	-1.24	-0.93	-2.11	-0.25	-0.15
Furniture/repair installation of machinery	-1.49	-0.69	-4.57	-0.43	-0.21
Services	-0.52	-0.35	-1.50	-0.24	-0.05