The Dynamics of Trade Fragmentation: a Network Approach.

Javier Quintana §

[§] Bank of Spain. Department of Economic Developments.





The views expressed in this presentation are those of the authors and **do not** necessarily represent the views of the Bank of Spain and the Eurosystem.

Trade fragmentation is among the main threats to economic outlook.

Sanctions on Russia as a major driver of the EU economy in the recent period.

Trade decoupling from China could have even grimmer consequences.

What consequences should we expect?

Propagation even if only a small fraction of firms are directly exposed.

) Time as a key factor: much more difficult to subsitute suppliers in the short run.

) Differences by types of goods: (non-durable) intermediate or capital goods.

> In terms of strategic autonomy, are Chinese solar panels the same as Russian gas?

Trade fragmentation is among the main threats to economic outlook.

Sanctions on Russia as a major driver of the EU economy in the recent period.

Trade decoupling from China could have even grimmer consequences.

What consequences should we expect?

Propagation even if only a small fraction of firms are directly exposed.

Time as a key factor: much more difficult to subsitute suppliers in the short run.

Differences by types of goods: (non-durable) intermediate or capital goods.

> In terms of strategic autonomy, are Chinese solar panels the same as Russian gas?

Dynamic Network Approach: multiplier effects and trade rerouting

Trade elasticities increase over time.

- ▷ Easiness to substitute suppliers reduces misallocation.
- ▷ Head and Mayer (2014), Fontagné et al. (2022), Boehm et al. (2023)

Trade disruption affects price of (imported) investment goods.

- ▷ Negative capital contribution piles up over time.
- ▷ Intertemporal substitution: delay investments to periods with higher elasticities
- ▷ Vom Lehn and Winberry (2022), Foerster et al. (2022)

Anticipation response to trade fragmentation.

- ▷ Stock-piling of investment goods from opposite bloc prior to trade fragmentation
- ▷ Khan and Khederlarian (2021)

Consumption: households discount less severe future costs.

Implications: different time profile (Attinasi et al. (2023), Baqaee et al. (2023))

Dynamic multi-sector, multi-country model with intermediate inputs and investment goods networks.

Sectors and households source their intermediate inputs or consumption goods from other sectors and countries.

Sectors also use other sectors' output for their investment bundles.

Scenarios

Simulate scenarios of moderate (*Back to 90s*) or severe (*Cold War*) trade fragmentation.

3 geopolitical blocs: Western, Eastern and Neutral countries.

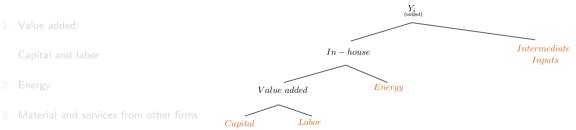
> Introduce iceberg cost to trade between blocs.

Sudden (*Cold turkey*) or anticipated shock.

Model

Dynamic model with production and investment networks.

Firms produce with ((KL)E)MS) structure.

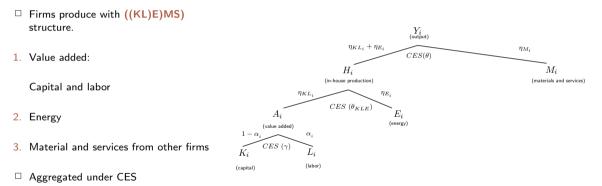


Aggregated under CES

Dynamic model with production and investment networks.

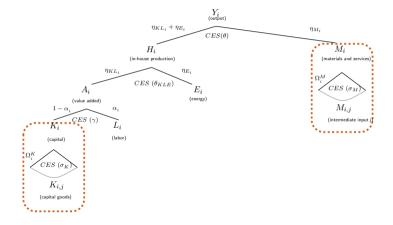
- Firms produce with ((KL)E)MS) structure. Y_{i} 1. Value added: In - houseCapital and labor Inputs 2. Energy Energy Value added Material and services from other firms 3 Labor Capital
- Aggregated under CES

Dynamic model with production and investment networks.



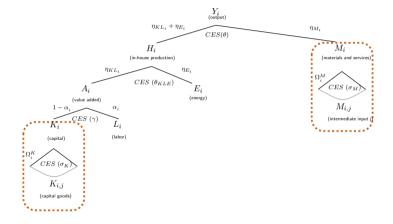
- □ Firms combine output from other sectors to produce:
- 1. Investment bundle, K_i
- 2. Intermediate Inputs bundle, M_i
 - Weight matrices, Ω_i^K and Ω_i^M
 - CES with elasticities, σ^K and σ^M
- □ Firms combine different local varieties of each sector:

Importance of each local variety, $\Lambda_{i,j}^K$ and $\Lambda_{i,j}^M$



- □ Firms combine output from other sectors to produce:
- 1. Investment bundle, K_i
- 2. Intermediate Inputs bundle, M_i
 - Weight matrices, Ω_i^K and Ω_i^M
 - CES with elasticities, σ^K and σ^M
- □ Firms combine different local varieties of each sector:

Importance of each local variety, $\Lambda^K_{i,j}$ and $\Lambda^M_{i,j}$



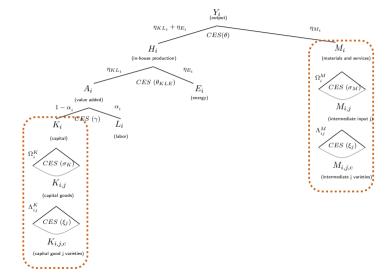
- □ Firms combine output from other sectors to produce:
- 1. Investment bundle, K_i
- 2. Intermediate Inputs bundle, M_i

Weight matrices, Ω_i^K and Ω_i^M

CES with elasticities, σ^K and σ^M

Firms combine different local varieties of each sector:

Importance of each local variety, $\Lambda^K_{i,j}$ and $\Lambda^M_{i,j}$



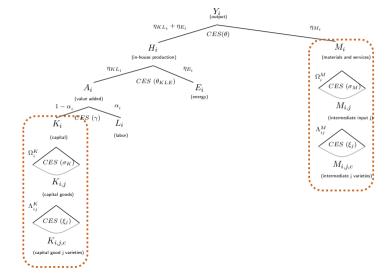
- □ Firms combine output from other sectors to produce:
- 1. Investment bundle, K_i
- 2. Intermediate Inputs bundle, M_i

Weight matrices, Ω_i^K and Ω_i^M

CES with elasticities, σ^K and σ^M

Firms combine different local varieties of each sector:

Importance of each local variety, $\Lambda^K_{i,j}$ and $\Lambda^M_{i,j}$



Each sector accumulates each of the capital goods for the following period. The process of capital accumulation is

$$K_{ijc,t+1} = (1 - \delta_j) \cdot K_{ijc,t} + I_{ijc,t} - \frac{\varsigma}{2} \left(\frac{K_{ijc,t+1}}{K_{ijc,t}} - 1 \right)^2$$
(1)

where δ_i is the rate of depreciation of good j. Firms face convex adjustment cost to change their level of capital.

Production Side: Investment

 $\hfill\square$ Firm i uses different capital goods from other sectors j

$$K_i = \left(\sum_{j=1}^{S} \Omega_{i,j}^K \cdot K_{i,j}^{\frac{\sigma_K - 1}{\sigma_K}}\right)^{\frac{\sigma_K}{\sigma_K - 1}}$$
(1)

where $\Omega_{i,j}^{K}$ represents the importance of the investment good j for firm i.

 $\hfill\square$ Firms also combine different national varieties of each type of capital good

$$K_{ij} = \left(\sum_{h=1}^{C} \lambda_{ijh}^{K} K_{ijh}^{\frac{\xi_{j,t}-1}{\xi_{j,t}}}\right)^{\frac{\xi_{j,t}}{\xi_{j,t}-1}}$$
(2)

where λ_{ijh}^{K} represents the importance of the variety from country h of investment good j for firm i.

Production Side: Investment

 \Box The investment input-output network allows us to express the cost of the capital bundle of firm *i* (that belongs *c*) can be expressed by:

$$P_{i,j}^{I} = \left(\sum_{h=1}^{C} \lambda_{ijh}^{K} \cdot (\tau_{h}^{c} P_{jc})^{1-\xi_{j,t}}\right)^{\frac{1}{1-\xi_{j,t}}} \quad P_{i}^{I} = \left(\sum_{j=1}^{S} \Omega_{i,j}^{K} \cdot P_{ij}^{I\,1-\sigma_{K}}\right)^{\frac{1}{1-\sigma_{K}}}$$

Source of gradual capital adjustment. sudden increase (decrease) in investment demand endogenously increases (decreases) the price of the investment bundle

Nominal Variables

- Trade decoupling increases the relative price of intermediate inputs and capital compared to labor.
- Pin down nominal variables assuming wage rigidities. Two cases:
 - $|1 \rangle$ Nominal rigidities (i.e. $\hat{W}_{i,t} = W_{i,t}$)
 - 2 angle Partial backward adjustment (i.e. $\hat{W}_{i,t} = {}^{1}\!/_{3} \cdot \pi_{i,t} + {}^{1}\!/_{3} \cdot \pi_{i,t-1}$)
- $\hfill\square$ Nominal exchange rates adjust freely for trade balance.

Production parameters and trade information

- Inter Country Input Output (ICIO), OECD, year 2019.
 Complemented with Figaro (Eurostat)
- 44 sectors and 66 countries.
- Calibrate production shares for factors, energy and intermediate inputs. $\triangleright~\alpha_i,~\eta_i,~\Omega^M,~\Lambda^M,~\Omega^E,~\Lambda^E$

Issue: no data availability post Ukraine invasion. • Trade decoupling from Russia has *already* taken place

- $1 \ \rangle$ Simulate trade decoupling between Russia and the West.
- $2\ \rangle$ Use predicted changes in trade flows to recompute IO matrices.

Production parameters and trade information

- Inter Country Input Output (ICIO), OECD, year 2019.
 Complemented with Figaro (Eurostat)
- 44 sectors and 66 countries.
- Calibrate production shares for factors, energy and intermediate inputs. $\triangleright \alpha_i, \eta_i, \Omega^M, \Lambda^M, \Omega^E, \Lambda^E$

Issue: no data availability post Ukraine invasion.

- ▷ Trade decoupling from Russia has *already* taken place.
- 1 \rangle Simulate trade decoupling between Russia and the West.
- $2 \ \rangle$ Use predicted changes in trade flows to recompute IO matrices.

Investment input-output matrix.

- □ Open economy version of Vom Lehn and Winberry (2022) or Foerster et al. (2022)
- $\hfill\square$ Equivalent to standard intermediate inputs IO matrix for investment goods.

Combine two sources:

1 **CIO Database**: trade flows of investment goods from sector-country to country.

- ▷ German vehicle manufacturing sector sells 100\$ as investment goods to Spain
- 2 > **KLEMS Database**: sector-country investment in by type of assets (and depreciation rates).
 - Land transportation sector accounts for 70% investment in transportation equipment in Spain
 - □ Need to create a **bridge file**: from NACE sectors to type of assets.

Trade Elasticities:

□ Fontagné et al. (2022), long-term sector-specific estimates.

Significantly lower elasticities in the short run: $\xi_{i,t=1} = 0.75$

Assume that elasticities grow linearly between up to long-run values over 10 years.

Other production elasticities:

Labor-capital elasticity $\theta_{KL}=0.9$; the elasticity between intermediate inputs and in-house production $\theta=0.5$; Elasticity between intermediate inputs (σ_M), energy sources (σ_E) and capital goods (σ_K) equal to 0.2. Household consumption across sectors $\sigma_C = 0.9$. Value-added and energy, $\theta_{KLE} = 0.4$.

Atalay (2017) and Baqaee and Farhi (2024)

Trade Disruption

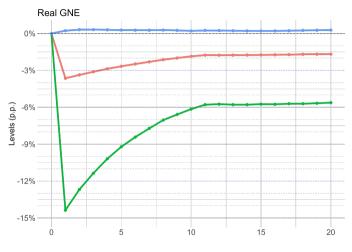
- □ Trade disruption modelled as **increasing** the cost of trade among blocs.
- □ lceberg costs, governments do not collect tariff revenues.
- Applied for all trade between West-East, not with Neutral bloc.
 Intermediate, investment and consumption goods.
- □ This exercise: **150%** iceberg cost.
- > Roughly implies a return to Cold War trade levels

Country Bloc Classification

West	East	Neutral
European Union	China	Rest of the world
United States	Hong Kong	
United Kingdom	Russia	
Canada		
Japan		
South Korea		
Norway		
Switzerland		
Australia		
New Zealand		
Israel		
Taiwan		

▸ Go to Trade Across Blocs

Results



Real GNE 🖝 West 🍝 East 🗢 Neutral

Cold War scenario: Sudden Trade Disruption

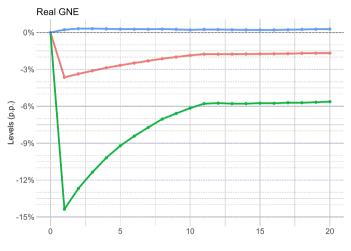
Long-term GNE losses in the West close to 1.6 p.p. GDP

Greater losses in the East.

Small gains for Neutral.

Within the West, Europe is relatively less exposed. Russia

Key: Short-term losses can be significantly higher.



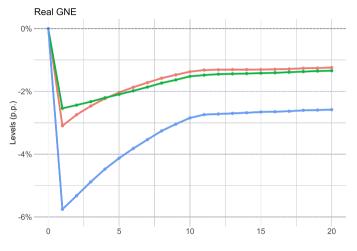
Real GNE 🖝 West 🍝 East 🗢 Neutral

Cold War scenario: Sudden Trade Disruption

- Long-term GNE losses in the West close to 1.6 p.p. GDP
- Greater losses in the East.
- Small gains for Neutral.

Within the West, Europe is relatively less exposed. Russia

Key: Short-term losses can be significantly higher.

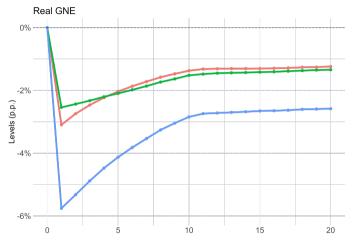


Real GNE - EU - USA - Other West

Cold War scenario: Sudden Trade Disruption

- Long-term GNE losses in the West close to 1.6 p.p. GDP
- Greater losses in the East.
- Small gains for Neutral.
- Within the West, Europe is relatively less exposed. Russia

Key: Short-term losses can be significantly higher.



Real GNE - EU - USA - Other West

Cold War scenario: Sudden Trade Disruption

- Long-term GNE losses in the West close to 1.6 p.p. GDP
- Greater losses in the East.
- Small gains for Neutral.
- Within the West, Europe is relatively less exposed. Russia
- Key: Short-term losses can be significantly higher.

Cold War scenario: Sudden Trade Disruption

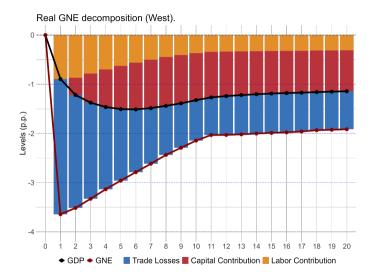
The effects of GVC disruption attenuate over time.

The contribution of lower investment appears gradually.

Non-linearities determine the shape of the effect:

Initial shock and subsequent growth or U-shape.

Inflation

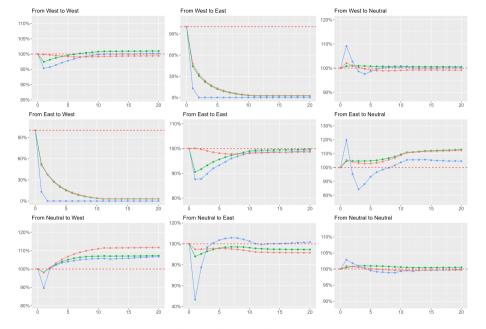


Cold War scenario: Sudden Trade Disruption

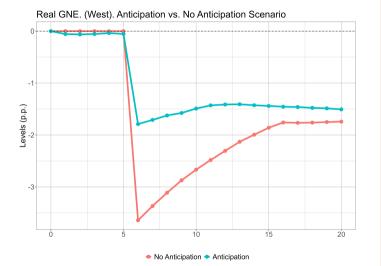
- The effects of GVC disruption attenuate over time.
- The contribution of lower investment appears gradually.
- Non-linearities determine the shape of the effect:

Initial shock and subsequent growth or U-shape.

Inflation

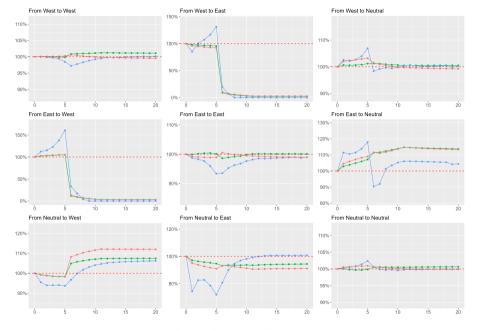


- Consumption - Intermediate inputs - Investment goods

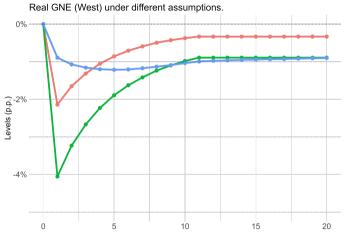


Sudden vs. Anticipated Trade Disruption

- With anticipation, GDP level losses are substantially smaller in the short term
 ▷ Equal in the long term.
- Higher elasticity of substitution and lower costs of new suppliers.
- Stockpiling of investment goods from opposite blocs.
- Small pre-shock losses: *statically* inefficient investments.



- Consumption - Intermediate inputs - Investment goods



No Capital acc. or Invest. IO
 No Capital acc.
 Dynamic model

What is the contribution of capital accumulation and investment matrix?

Two comparisons:

- No capital dynamics (full within period depreciation) and no price of investment bundle.
- 2) No capital dynamics (full within period depreciation) but price of investment bundle.
 - Gradual depreciation reduces the short-term impact.
 - > The price of the investment bundle increases the long-term effects.

Main results:

Moderate long-run effects in Western economics:

- Between 0.8pp and 1.7pp level effect on GNE over 10-year horizon depending on the degree of trade fragmentation (60% or 95% trade reduction between blocs).
- Potentially large **short-run** effects with sudden trade trade stop:
 - > Up to 4pp GDP loss over first 3 years in the Cold War (severe) scenario.
 - > In the short run disruption of intermediate inputs GVC has stronger effect. In the long run the lower stock of capital becomes more relevant.
- Anticipation allows a smoother (from above) transition.
 - > Pre-shock: increases trade of investment goods across blocs.
- More severe effects for **Eastern** bloc: between 3pp and 6pp lower GDP level.
- Small gains for neutral countries: between 0.1pp and 0.5pp higher GNE.
 - $\rangle\rangle$ Gains from trade rerouting but mitigated by lower world GDP.

- Atalay, E. (2017). How important are sectoral shocks? *American Economic Journal: Macroeconomics*, 9(4):254–280.
- Attinasi, M. G., Boeckelmann, L., and Meunier, B. (2023). The economic costs of supply chain decoupling.
- Baqaee, D., Hinz, J., Moll, B., Schularick, M., Teti, F., Wanner, J., and Yang, S. (2023). what if? the effects of a hard decoupling from china on the german economy. *Kiel Policy Brief*.
- Baqaee, D. R. and Farhi, E. (2024). Networks, barriers, and trade. *Econometrica*, 92(2):505–541.
- Boehm, C. E., Levchenko, A. A., and Pandalai-Nayar, N. (2023). The long and short (run) of trade elasticities. *American Economic Review*, 113(4):861–905.
- Foerster, A. T., Hornstein, A., Sarte, P.-D. G., and Watson, M. W. (2022). Aggregate implications of changing sectoral trends. *Journal of Political Economy*, 130(12):3286–3333.
- Fontagné, L., Guimbard, H., and Orefice, G. (2022). Tariff-based product-level trade elasticities. *Journal of International Economics*, 137:103593.

- Head, K. and Mayer, T. (2014). Gravity equations: Workhorse, toolkit, and cookbook. In *Handbook of international economics*, volume 4, pages 131–195. Elsevier.
- Khan, S. Y. and Khederlarian, A. (2021). How does trade respond to anticipated tariff changes? evidence from nafta. *Journal of International Economics*, 133:103538.
- Vom Lehn, C. and Winberry, T. (2022). The investment network, sectoral comovement, and the changing us business cycle. *The Quarterly Journal of Economics*, 137(1):387–433.

Households

□ Households' preferences are represented by the function

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\log C_t - \frac{L_t^{1+1/\mu}}{1+1/\mu} \right)$$
(1)

where μ is the Frisch elasticity of labor supply and β the discount factor.

$$C_{i} = \left(\sum_{j=1}^{S} \Omega_{i,j}^{C} C_{c,j}^{\frac{\sigma_{C}-1}{\sigma_{C}}}\right)^{\frac{\sigma_{C}}{\sigma_{C}-1}}$$
(2)

where the (i, j) element of matrix Ω^C represents the importance of goods from sector j on the basket consumption of country's i household.

Trade Across Blocs

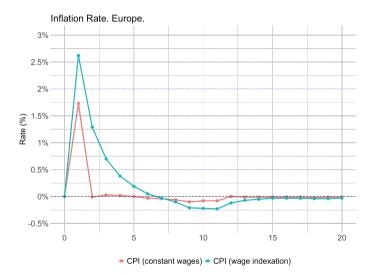
		Total			Final Consumption		
	West	East	Neutral	West	East	Neutral	
From West	-	4.3	9.2	_			
From East	1.6	_	2.7		_		
From Neutral	3.1	2.5	-			_	
		Intermediate Inputs			Investment Goods		
	Inter	mediate	e Inputs	Inve	stment	Goods	
	Inter West	mediate East	e Inputs Neutral	Inve West	stment East	Goods Neutral	
From West			·				
From West From East			·				

Imported shares from origin blocs over total consumption by type of goods and services.

Trade Across Blocs

	Total			_	Final Consumption			
	West	East	Neutral		West	East	Neutral	
From West	_	4.3	9.2		-	3.7	6.7	
From East	1.6	_	2.7		1.3	_	1.6	
From Neutral	3.1	2.5	_		2.1	2.0	-	
	Intermediate Inputs							
	Inter	mediate	e Inputs		Inve	stment	Goods	
	Inter West	mediate East	e Inputs Neutral		Inve West	stment East	Goods Neutral	
From West			·					
From West From East		East	Neutral	-		East	Neutral	

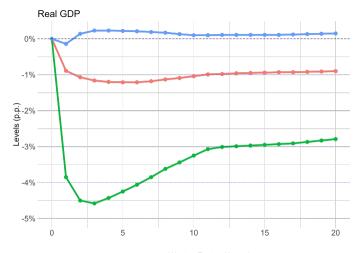
Imported shares from origin blocs over total consumption by type of goods and services.



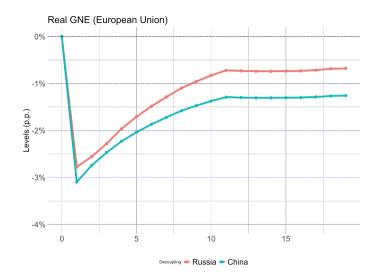
Cold War scenario: Sudden Trade Disruption

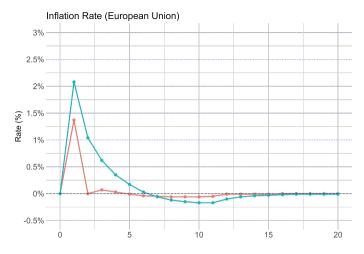
- Trade fragmentation significantly increases the cost of other factors relative to labor.
- Wage indexation can lead to significant second-round effects.

Back



Real GDP 🗢 West 🗢 East 🗢 Neutral





CPI (constant wages) - CPI (wage indexation)

Back