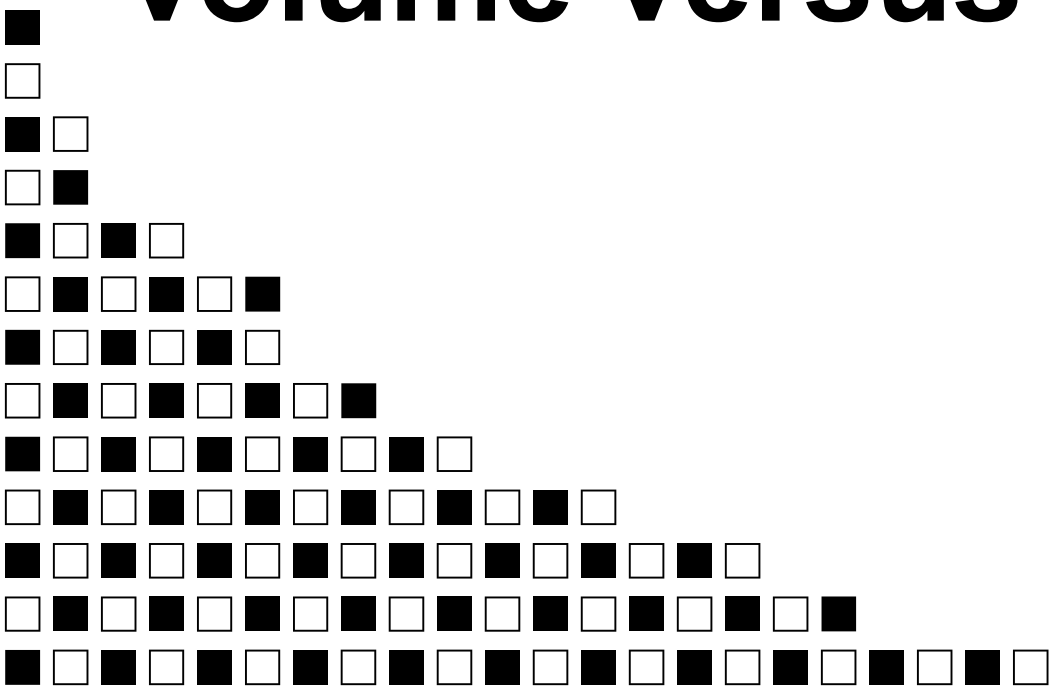
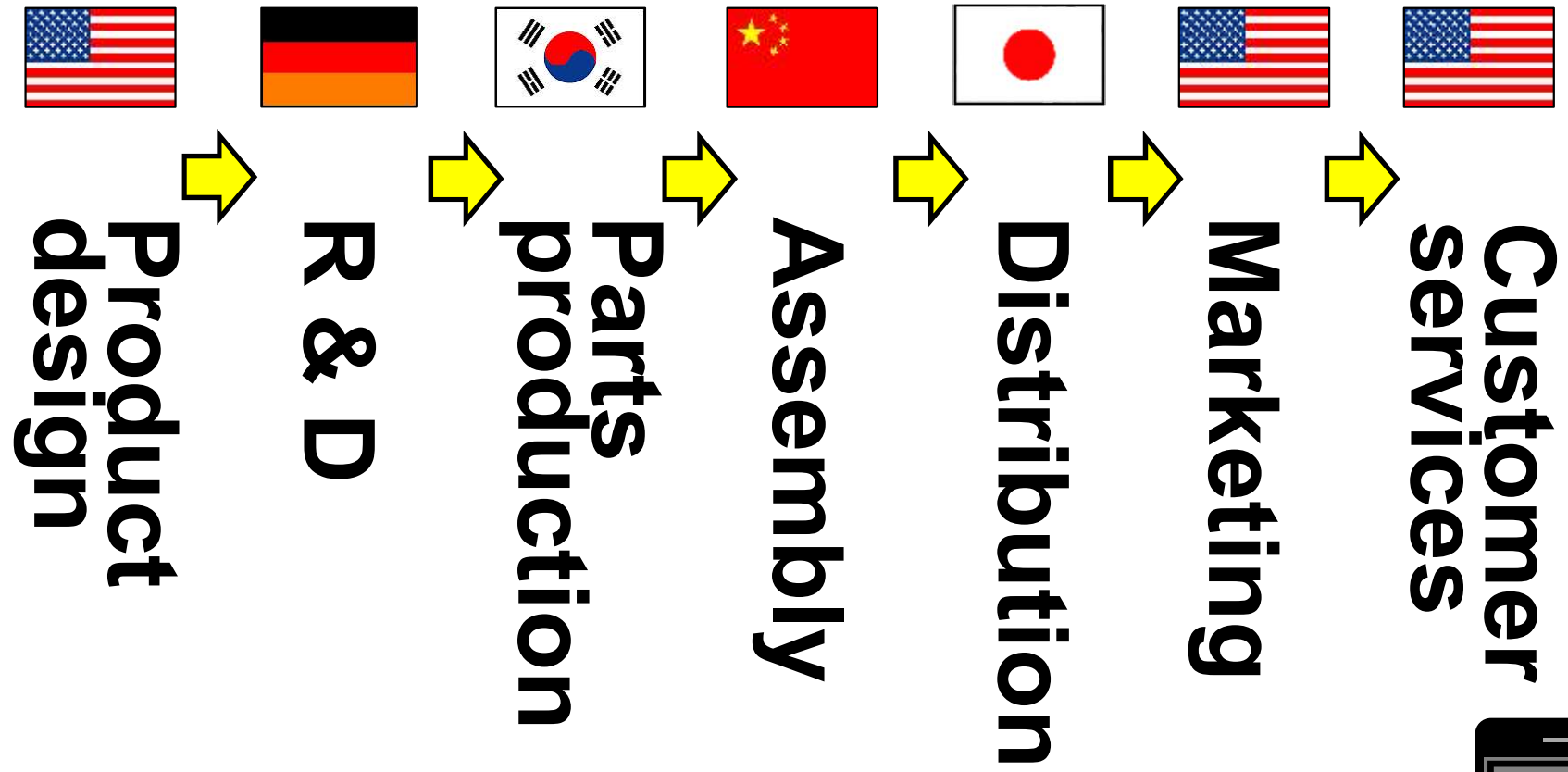
Geographic concentration of global supply chains: volume versus frequency

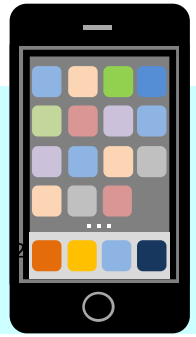


Satoshi Inomata
IDE-JETRO

Global value chain (GVC)



"Designed by Apple in California, Assembled in China."



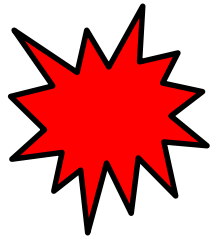
Geographical concentration of key production capacities

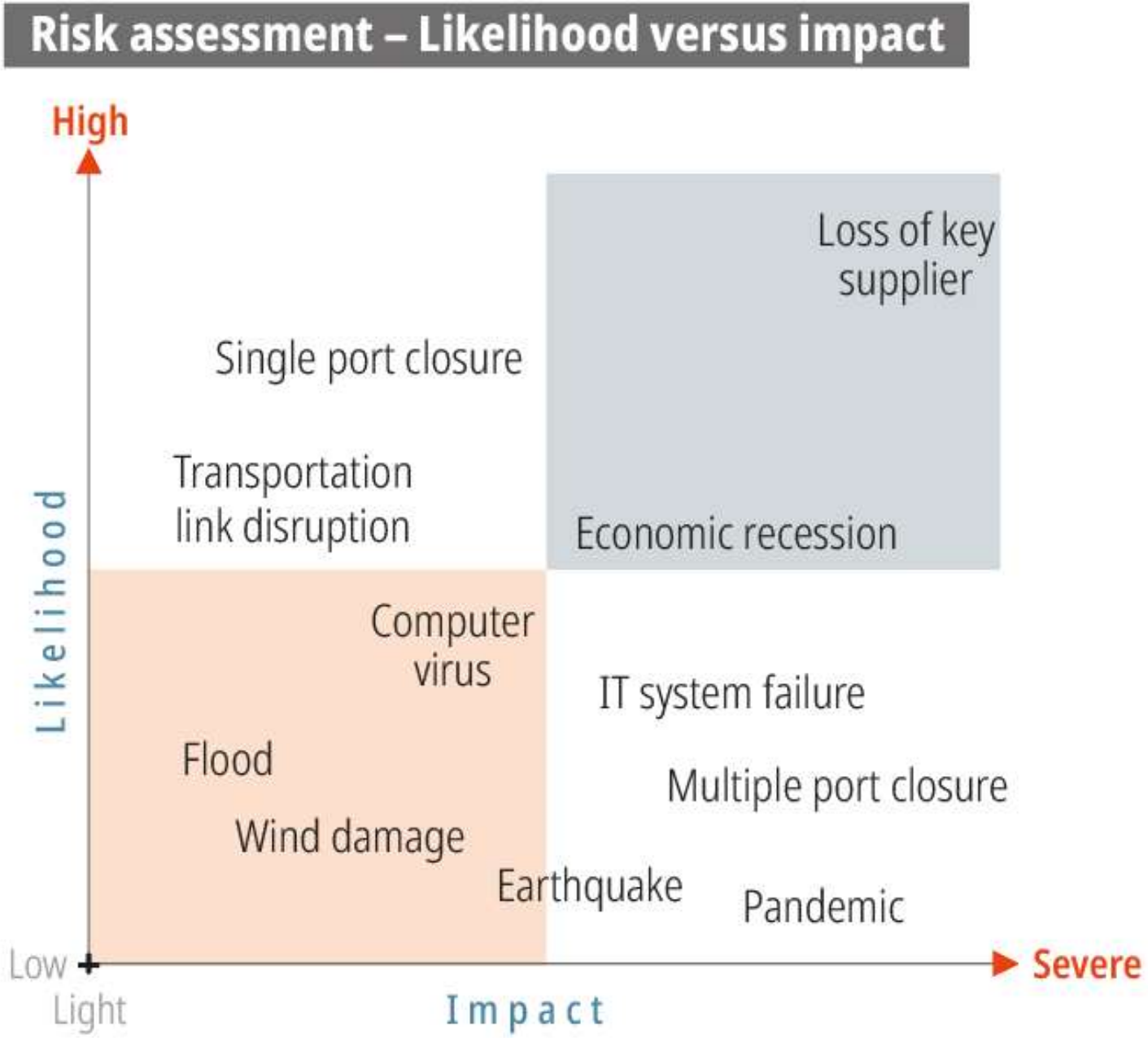
Production hubs ⇨ ⇨ ⇨ “**Choke points**”

The Great East Japan Earthquake,

The Thai flood, The Lehman Shock,

Cyber-attacks, Covid-19, Geopolitical tensions …

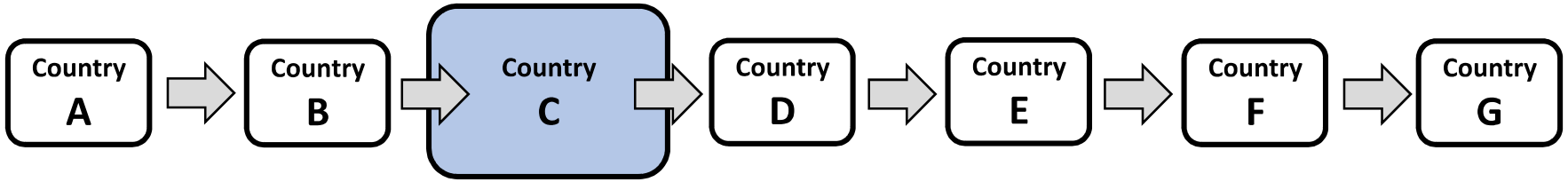




Source https://www.oecd.org/trade/resilient-supply-chains/identify-potential-risks/

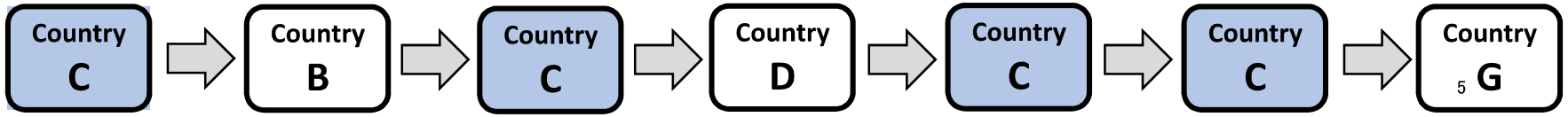
A supply chain is considered highly exposed to a specific country risk,

- if its product contains a significant volume of value-added sourced from the country,

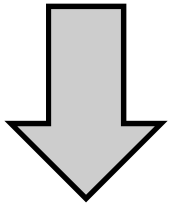


or,

- if the production activities along the supply chain involves frequent engagement with the country's industrial sectors.

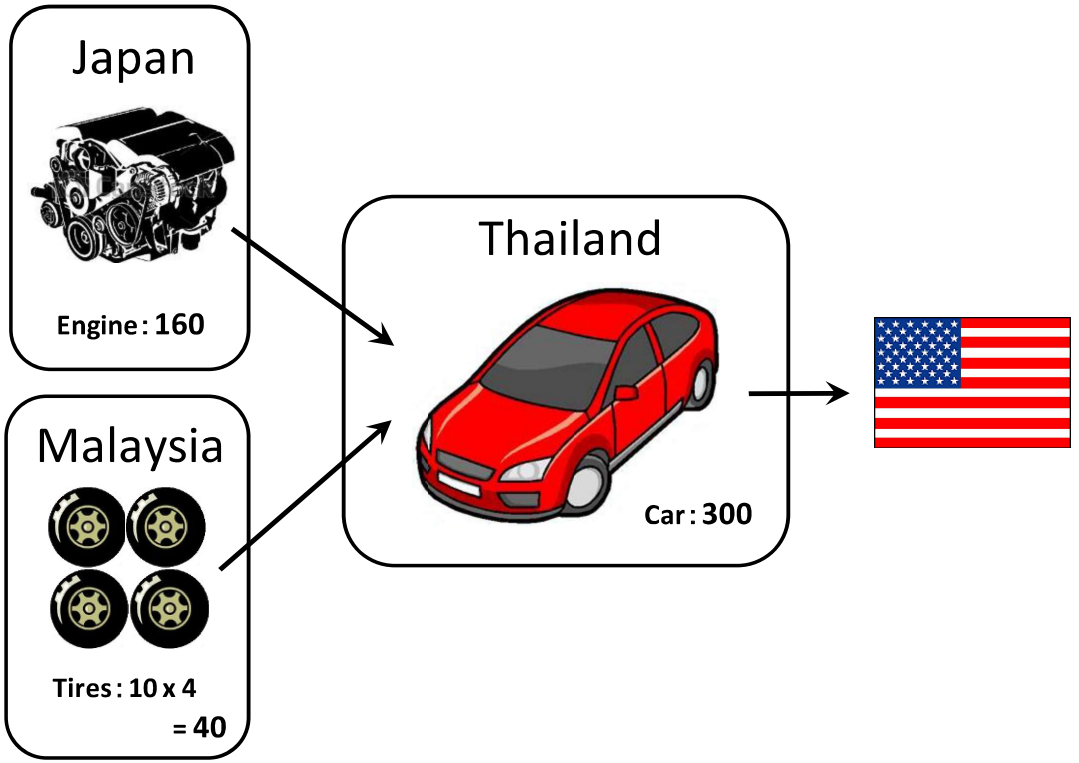


Geographical concentration in volume



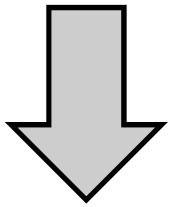
Trade in value-added (TiVA)

International trade as a flow of values rather than of products.



	Traditional measurement	Value-added measurement
① Japan→Thailand	160	0
②Malaysia→Thailand	40	0
③ Thailand→USA	300	100
④Japan→USA	0	160
⑤Malaysia→USA	0	40
⑥ Total traded values	160+40+300=500	100+160+40=300

Geographical concentration in volume

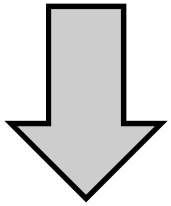


Trade in value-added (TiVA)

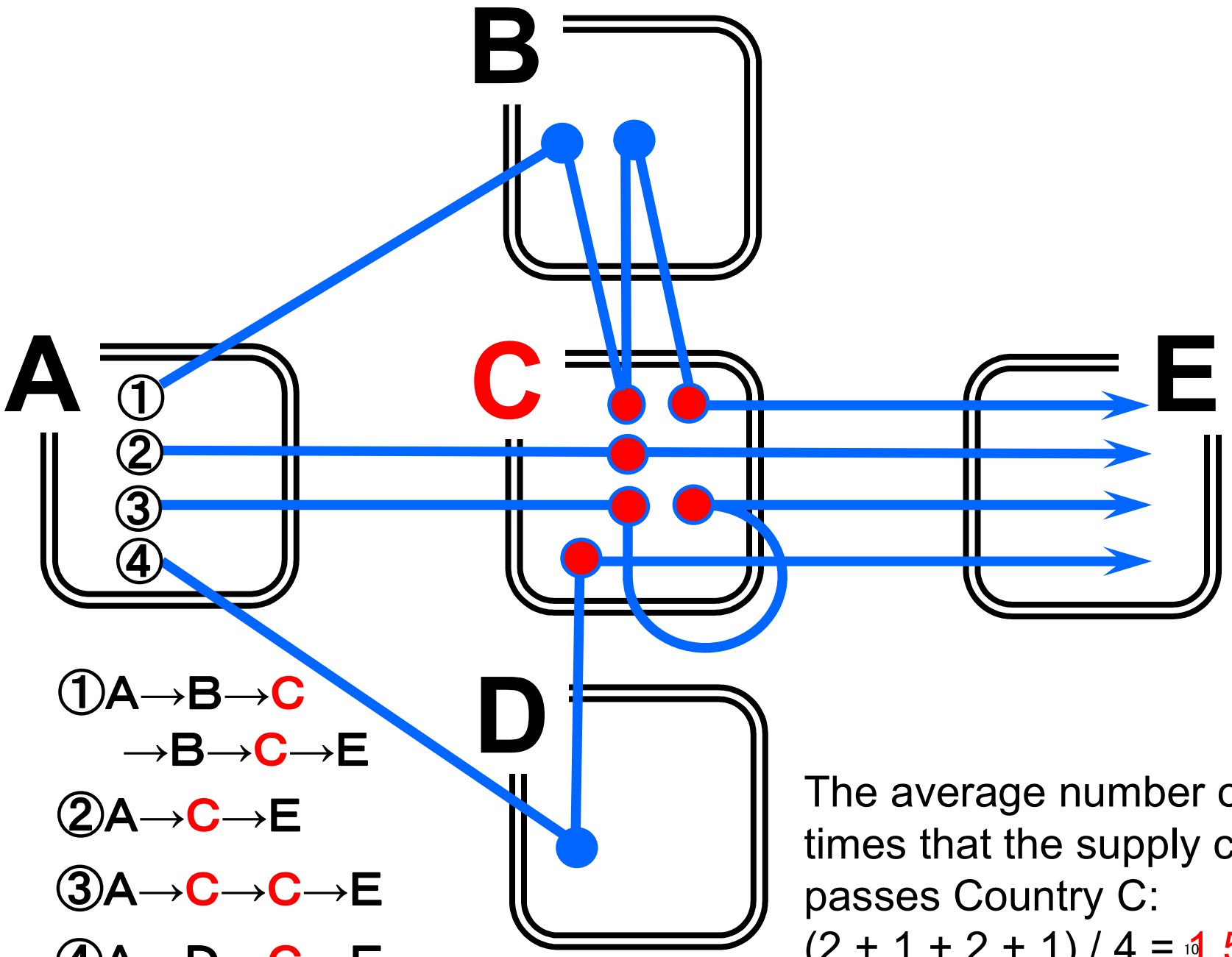
How much value of the products is attributable to the value-added origin of which country

→ supply chain dependence in volume

Geographical concentration in frequency



How frequently a supply chain passes through the industrial sectors of a high-risk country



①A→B→C
→B→C→E

②A→C→E

③A→C→C→E

④A→D→C→E

The average number of times that the supply chain passes Country C:
(2 + 1 + 2 + 1) / 4 = 1.5

Network concentration indicator

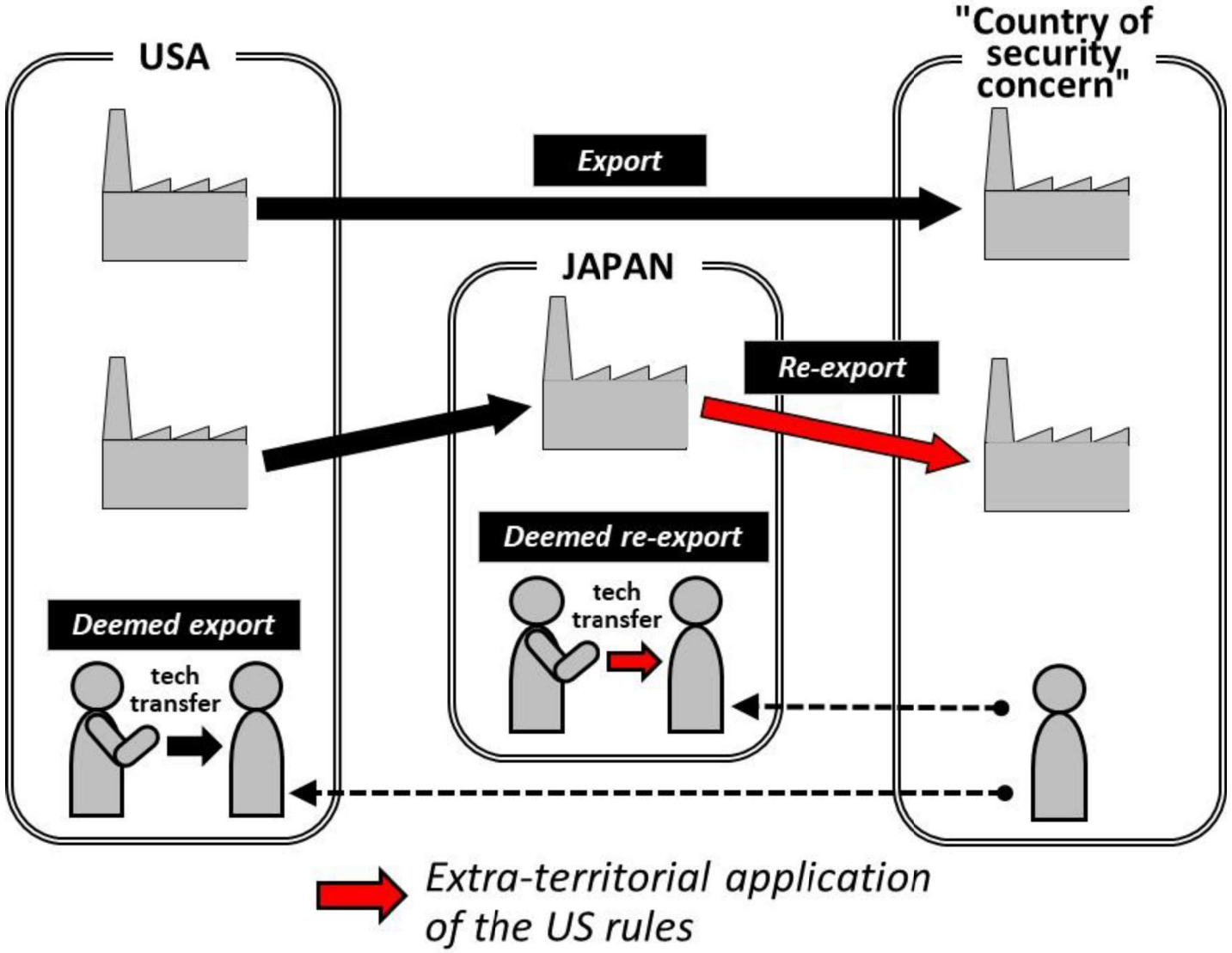
Pass-through Frequency (PTF):

The average number of times that a target supplier emerges along production paths;

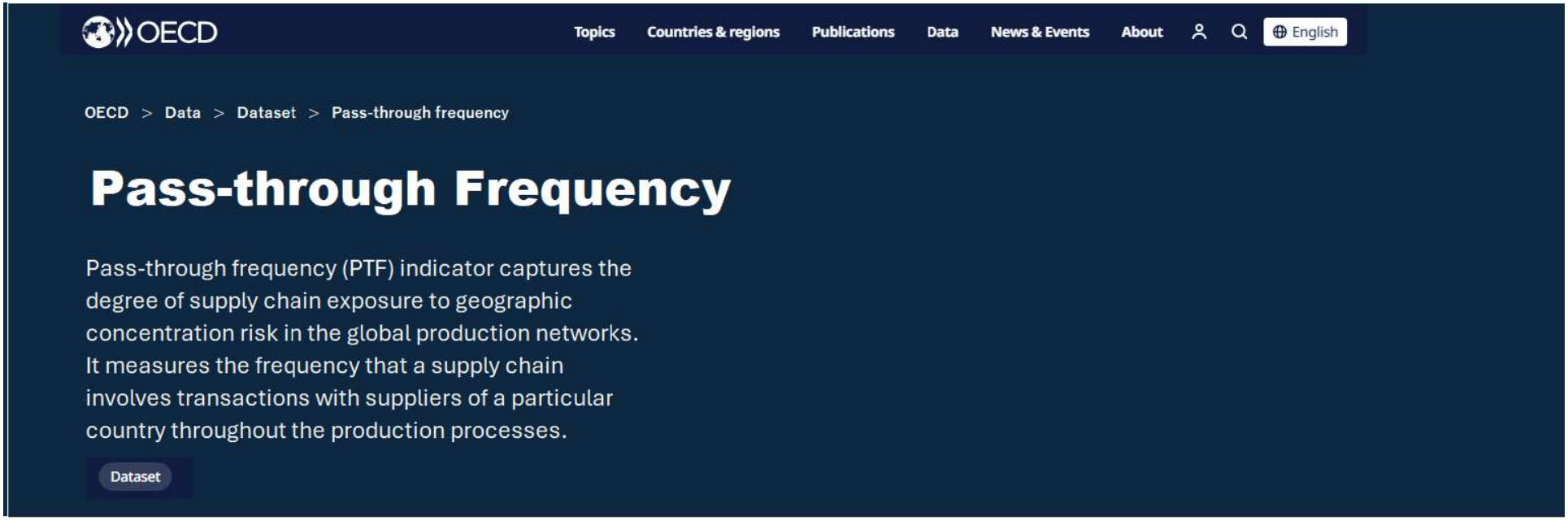
In our context …

→ The *frequency* that a supply chain passes through the industrial sectors of a high-risk country.

Why does frequency matter?
A case of the US export control measures



Relative risk positions: the United States vs China (1995, 2018)



About

The pursuit of optimal resource allocation across borders often resulted in the agglomeration and concentration of key production capacities in a specific country. With increasing uncertainty of the global economy, however, these production hubs can quickly become “choke points” for the entire economic system.

Trade in value-added (TiVA) indicators present origins of value added in gross exports/final demand, but what happens in-between? How many countries-industries do intermediate goods and services pass through, and how often, before being used in final production?

Where are the potential exposures to concentration risk along supply chains?

https://www.oecd.org/en/data/datasets/pass-through-frequency.html

OECD Inter-country input-output table: Industrial sector classification (45 sector)

Code	Industry	Code	Industry
01T02	Agriculture, hunting, forestry	35	Electricity, gas, steam and air conditioning supply
03	Fishing and aquaculture	36T39	Water supply; sewerage, waste management and remediation activities
05T06	Mining and quarrying, energy producing products	41T43	Construction
07T08	Mining and quarrying, non-energy producing products	45T47	Wholesale and retail trade; repair of motor vehicles
09	Mining support service activities	49	Land transport and transport via pipelines
10T12	Food products, beverages and tobacco	50	Water transport
13T15	Textiles, textile products, leather and footwear	51	Air transport
16	Wood and products of wood and cork	52	Warehousing and support activities for transportation
17T18	Paper products and printing	53	Postal and courier activities
19	Coke and refined petroleum products	55T56	Accommodation and food service activities
20	Chemical and chemical products	58T60	Publishing, audiovisual and broadcasting activities
21	Pharmaceuticals, medicinal chemical and botanical products	61	Telecommunications
22	Rubber and plastics products	62T63	IT and other information services
23	Other non-metallic mineral products	64T66	Financial and insurance activities
24	Basic metals	68	Real estate activities
25	Fabricated metal products	69T75	Professional, scientific and technical activities
26	Computer, electronic and optical equipment	77T82	Administrative and support services
27	Electrical equipment	84	Public administration and defence; compulsory social security
28	Machinery and equipment, nec	85	Education
29	Motor vehicles, trailers and semi-trailers	86T88	Human health and social work activities
30	Other transport equipment	90T93	Arts, entertainment and recreation
31T33	Manufacturing nec; repair and installation of machinery and equipment	94T96	Other service activities
		97T98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use

Pass-through Frequency (PTF)

$$f_{(t)_{s_1 s_k}} = c_{(t)} \cdot \frac{a_{s_1 s_k}}{[\boldsymbol{L} - \boldsymbol{I}]_{s_1 s_k}}$$

✓ Can be calculated solely from the information in an input-output table, hence
✓ Highly cost-effective, hence
✓ A handy reference of the first resort for relevant policy-making.

$$+ \sum_{k=3}^{\infty} \sum_{s_2,\ldots,s_{k-1}} \left(c_{(t)} \cdot \frac{a_{s_1 s_2}\, a_{s_2 s_3}\, a_{s_3 s_4} \ldots a_{s_{k-1} s_k}}{[\boldsymbol{L} - \boldsymbol{I}]_{s_1 s_k}} \right)$$

$$\Leftrightarrow \quad f_{(t)_{ij}} = \frac{\left[\boldsymbol{L}\, \boldsymbol{J}_{(t)} \boldsymbol{L} - \boldsymbol{J}_{(t)}\right]_{ij}}{[\boldsymbol{L} - \boldsymbol{I}]_{ij}}$$

$\boldsymbol{J}_{(t)}$: a matrix with 1 for $(t, t)^{\text{th}}$ element and zeros elsewhere.

High-risk country
Japan (natural hazards): 2018

Rank	Final product producer (j)	Value-added source (i)	TiVA_ij (million USD)	PTF index Japan
1	USA_29	AUS_07T08	376.64	3.61
2	USA_41T43	AUS_07T08	313.93	2.21
3	IDN_41T43	AUS_07T08	354.73	2.05
4	CHN_28	CHL_07T08	339.32	1.53
5	CHN_26	AUS_07T08	1043.47	1.25
6	KOR_29	AUS_07T08	308.36	1.23
7	CHN_41T43	CHL_07T08	1145.40	1.20
8	CHN_29	BRA_07T08	320.90	1.15
9	KOR_41T43	AUS_07T08	646.14	1.08
10	CHN_45T47	AUS_07T08	351.01	1.00
11	CHN_29	PER_07T08	304.68	0.95
12	CHN_41T43	CAN_07T08	669.78	0.92
13	CHN_28	BRA_07T08	452.20	0.90
14	CHN_28	PER_07T08	423.39	0.75
15	CHN_41T43	IDN_07T08	685.33	0.75
16	CHN_29	AUS_07T08	1503.30	0.74
17	CHN_29	ZAF_07T08	318.65	0.72
18	CHN_30	AUS_07T08	414.51	0.66
19	CHN_41T43	USA_07T08	534.23	0.64
20	CHN_41T43	BRA_07T08	1745.11	0.61

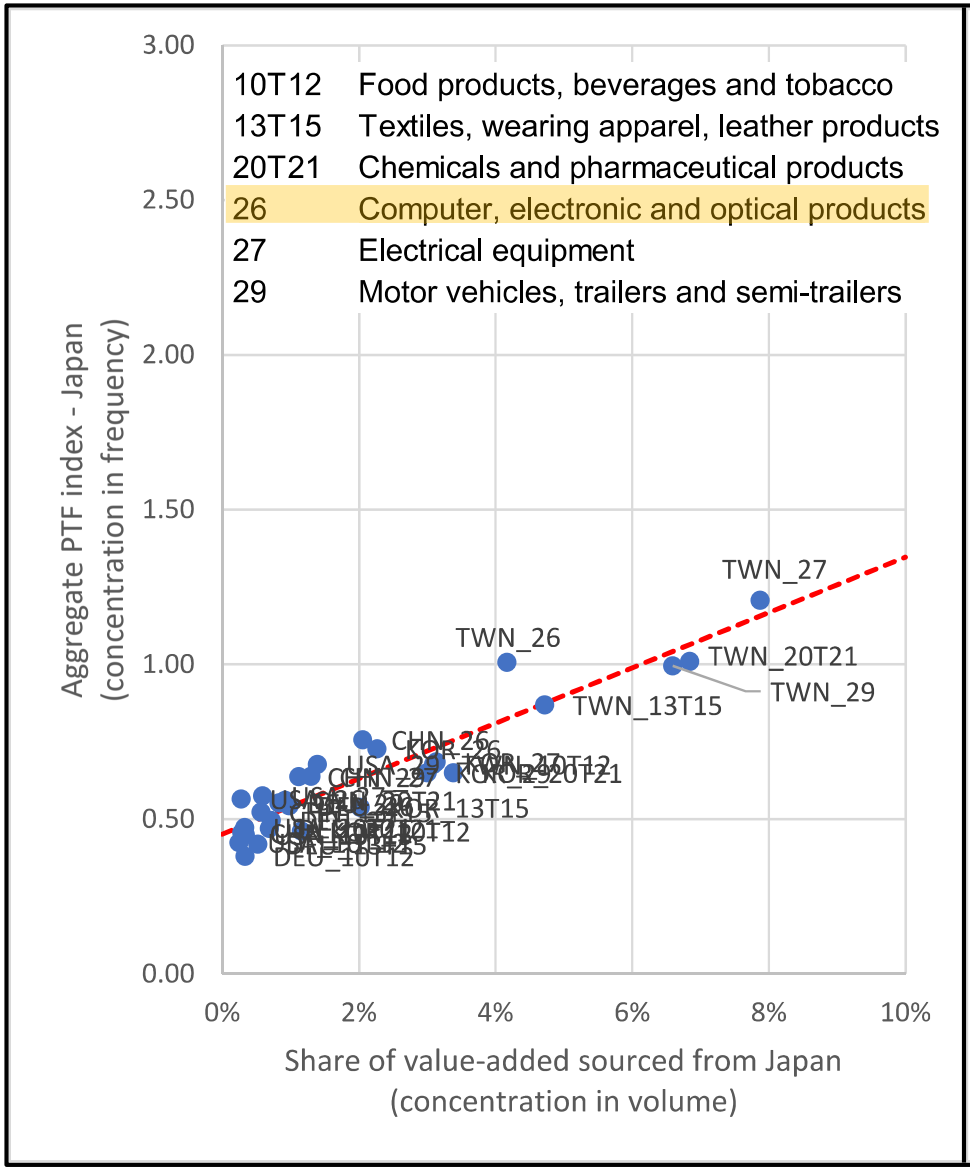
High-risk country
China (geopolitical risks): 2018

Rank	Final product producer (j)	Value-added source (i)	TiVA_ij (million USD)	PTF index China
1	USA_41T43	AUS_07T08	313.93	2.38
2	USA_29	RUS_05T06	327.69	2.30
3	USA_41T43	TWN_26	340.33	2.24
4	USA_41T43	KOR_26	589.33	2.23
5	USA_29	SAU_05T06	651.44	2.14
6	JPN_41T43	SAU_05T06	504.58	2.06
7	USA_41T43	RUS_05T06	597.72	1.92
8	USA_86T88	TWN_26	345.29	1.77
9	USA_29	TWN_26	463.56	1.76
10	USA_86T88	KOR_26	601.41	1.75
11	USA_45T47	TWN_26	316.26	1.69
12	USA_84	TWN_26	672.53	1.67
13	USA_84	KOR_26	1180.61	1.65
14	USA_45T	KOR_26	1.69	1.64
19	USA_26	KOR_26	513.43	1.52
20	JPN_41T43	RUS_05T06	378.59	1.50

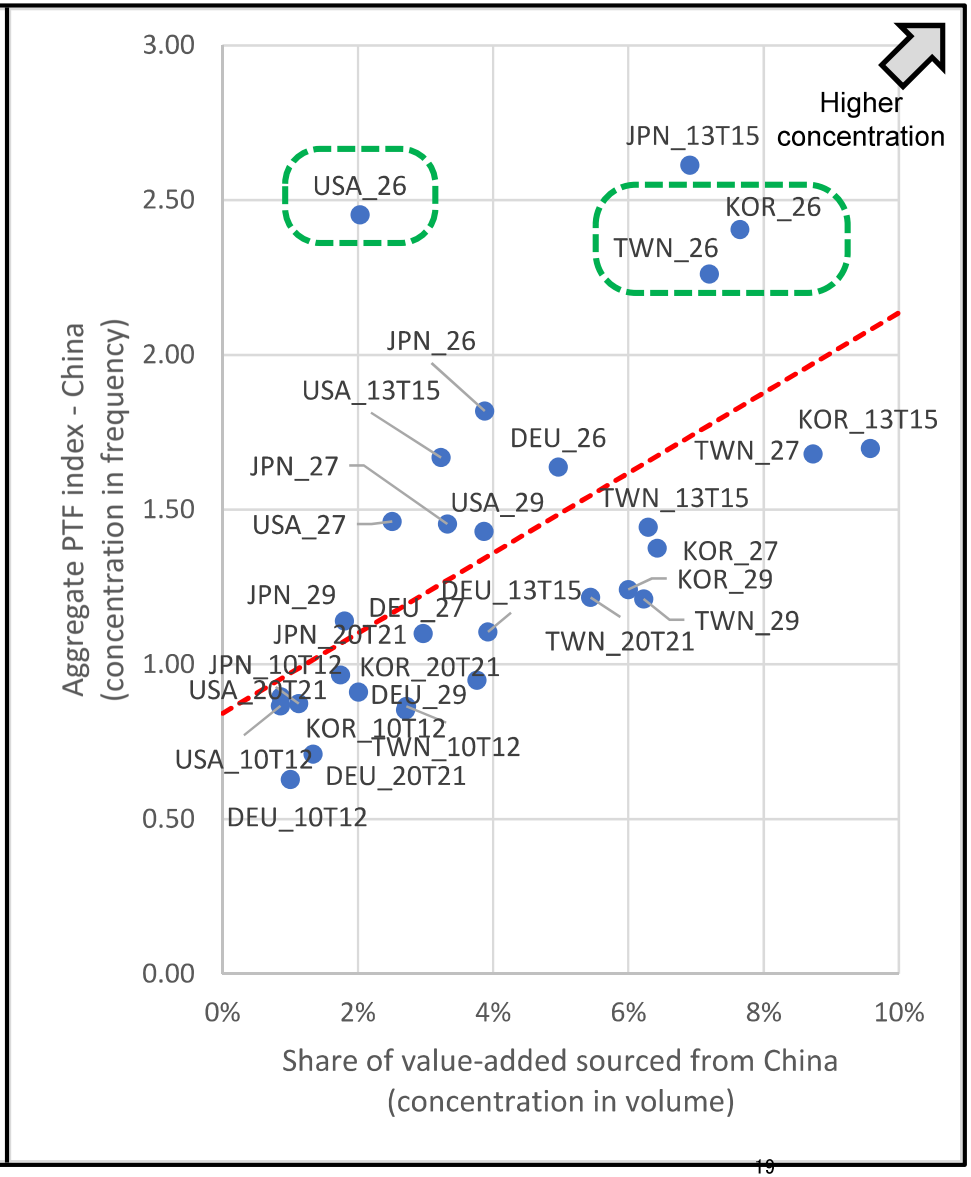
Public admin., defence, social security

Computer/ electronic and optical products

High-risk country
Japan (natural hazards): 2018



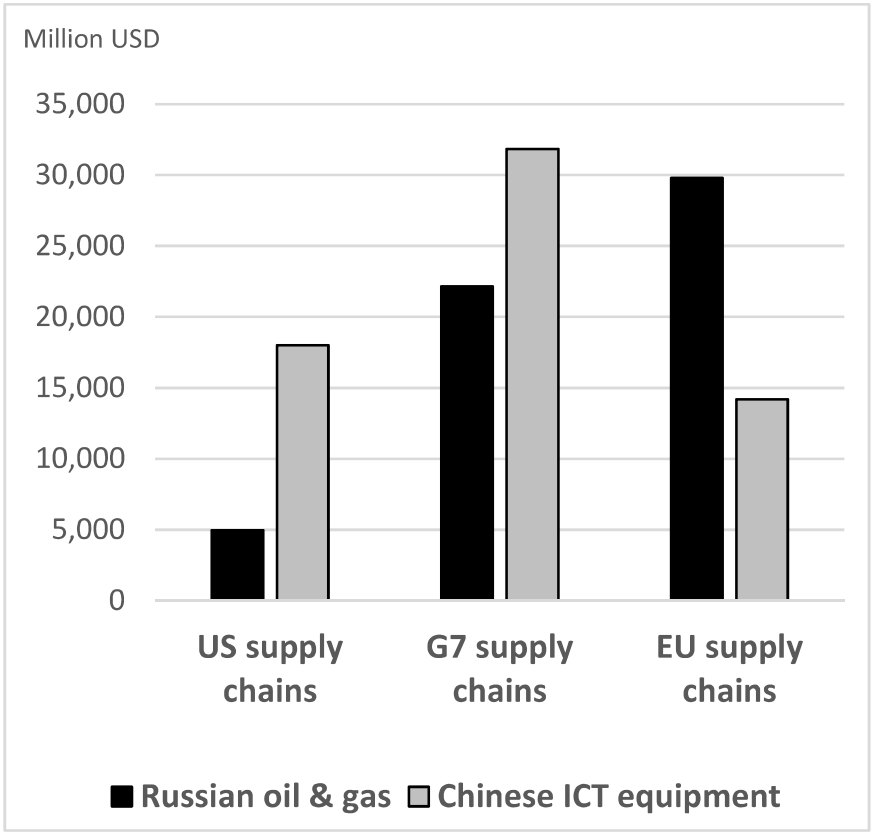
High-risk country
China (geopolitical risks):2018



Source：Inomata and Hanaka (2021)

Concentration risk analysis at the sectoral level (2020)

Volume-based concentration (Share of value-added sources)



Frequency-based concentration (PTF)