Tsunami Disaster Impact and Vulnerability Index Assessment: An Approach of GIS and CGE model for Mie Prefecture, Japan

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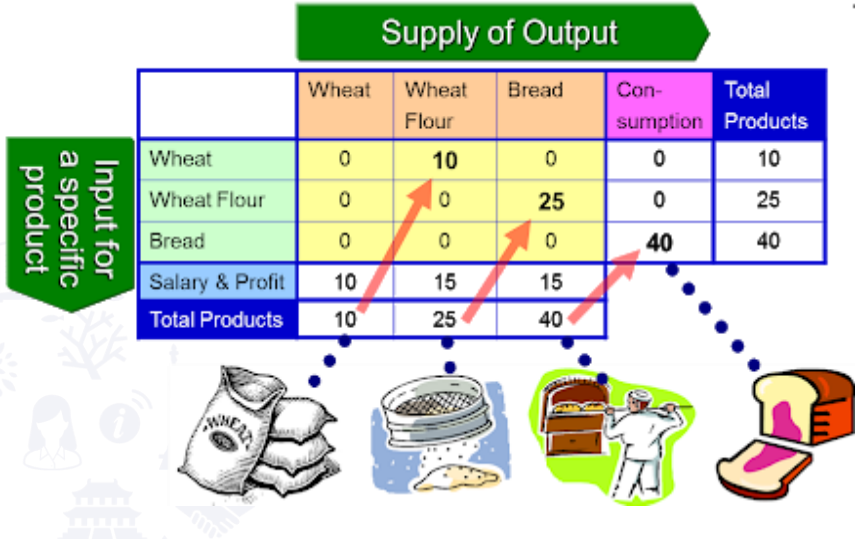
Introduction

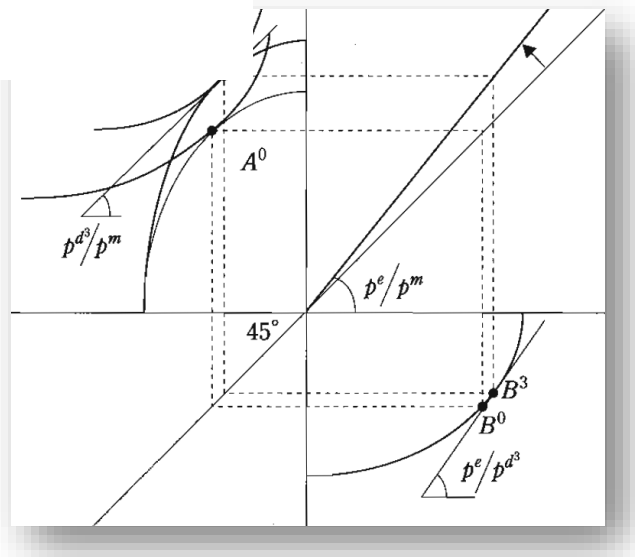
- Research aims
- Methodology(Input-Output Table, GIS , CGE)
- Economic structure of Mie prefecture (Capital dependency ratio)
- Tsunami damage to office (Lost capital ratio)
- Simulation results (Tsunami Impact, Capital Vulnerability Index)
- Discussion and Policy recommendations, Research limitation etc.

Research aims

- To interpret the prefectural economic structure and interdependence to understand the disaster impact on regional industries with **scientific methodologies**
- Provide **holistic and plausible policy recommendations** for disaster risk reduction and for economic resilience
- Provide ***Capital vulnerability index*** for sectors to better understand the vulnerability

Methodology





1. Input-output Analysis

- 42 sectors
- Social accounting matrix
- Economic structure

***2011 IO table (released in 2018)**

2. GIS Analysis

- 710,059 offices (155 sectors)
- Tsunami Hazard Map
- Damage estimate

***2020 data**

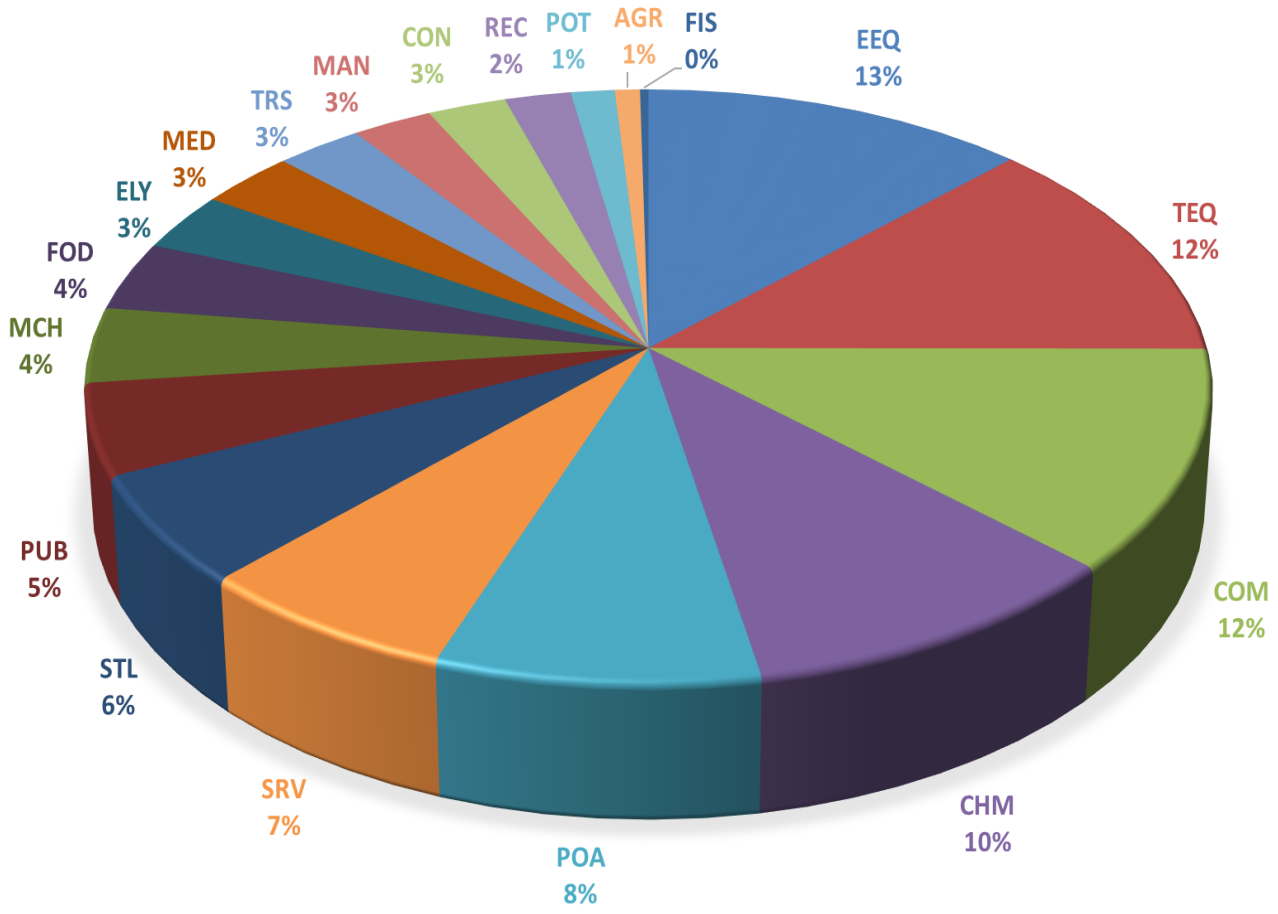
3.CGE modeling

- Aggregate into 19 sectors
- **Impact assessment**
- **Vulnerability Index**

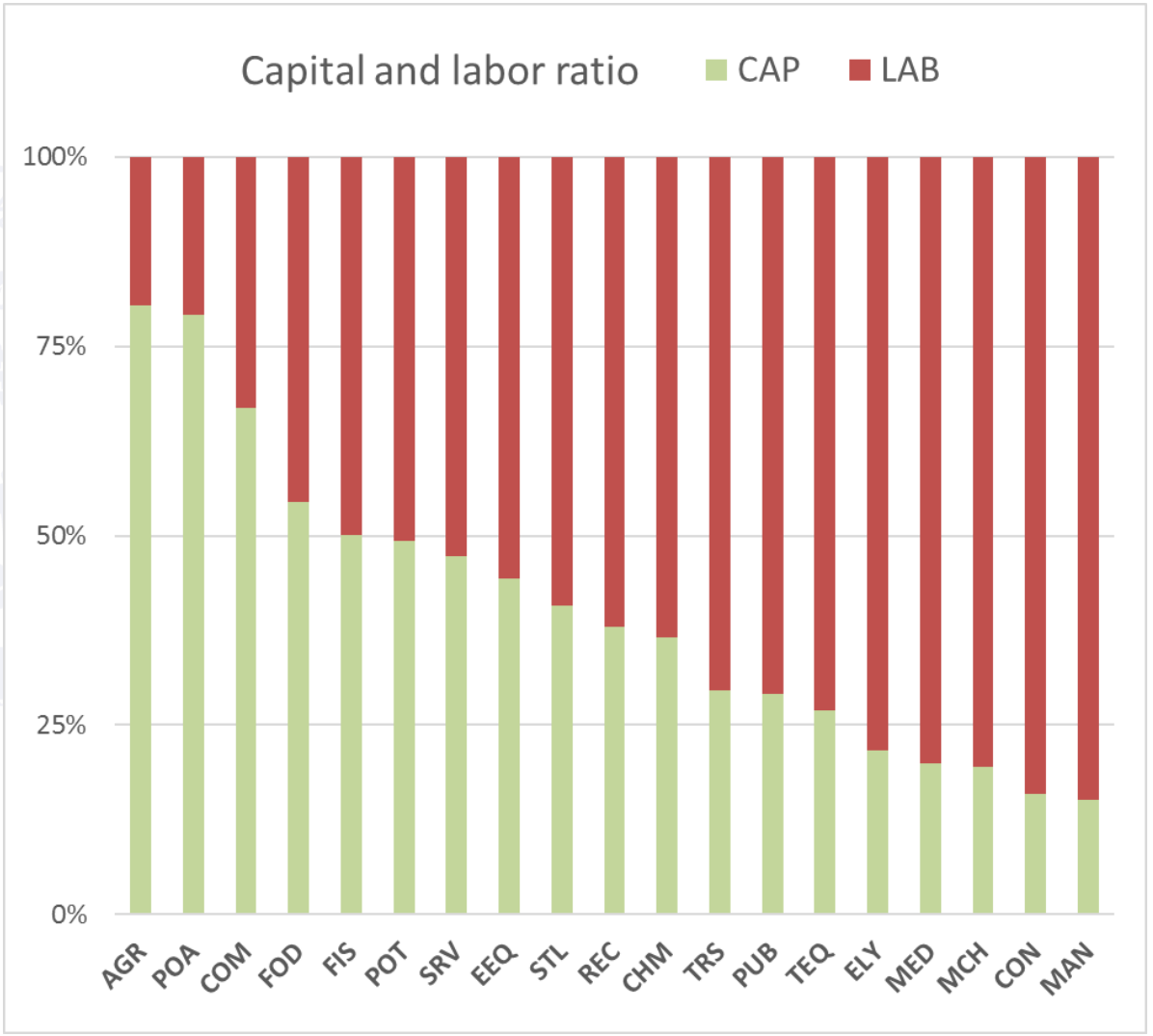
Research case: Mie Prefecture

Mie Prefecture Economic Structure (IO table)

Industry	abbr	%
Electronic equipment	EEQ	13%
Transportation equipment	TEQ	12%
Commerce	COM	12%
Chemical	CHM	10%
Petroleum & mining	POA	8%
Service	SRV	7%
Steel	STL	6%
Public administration	PUB	5%
Machinery	MCH	4%
Food processing	FOD	4%
Electricity & water	ELY	3%
Medical service	MED	3%
Transportation	TRS	3%
Manufacture	MAN	3%
Construction	CON	3%
Recreation	REC	2%
Pottery	POT	1%
Agriculture	AGR	1%
Fishery	FIS	0%

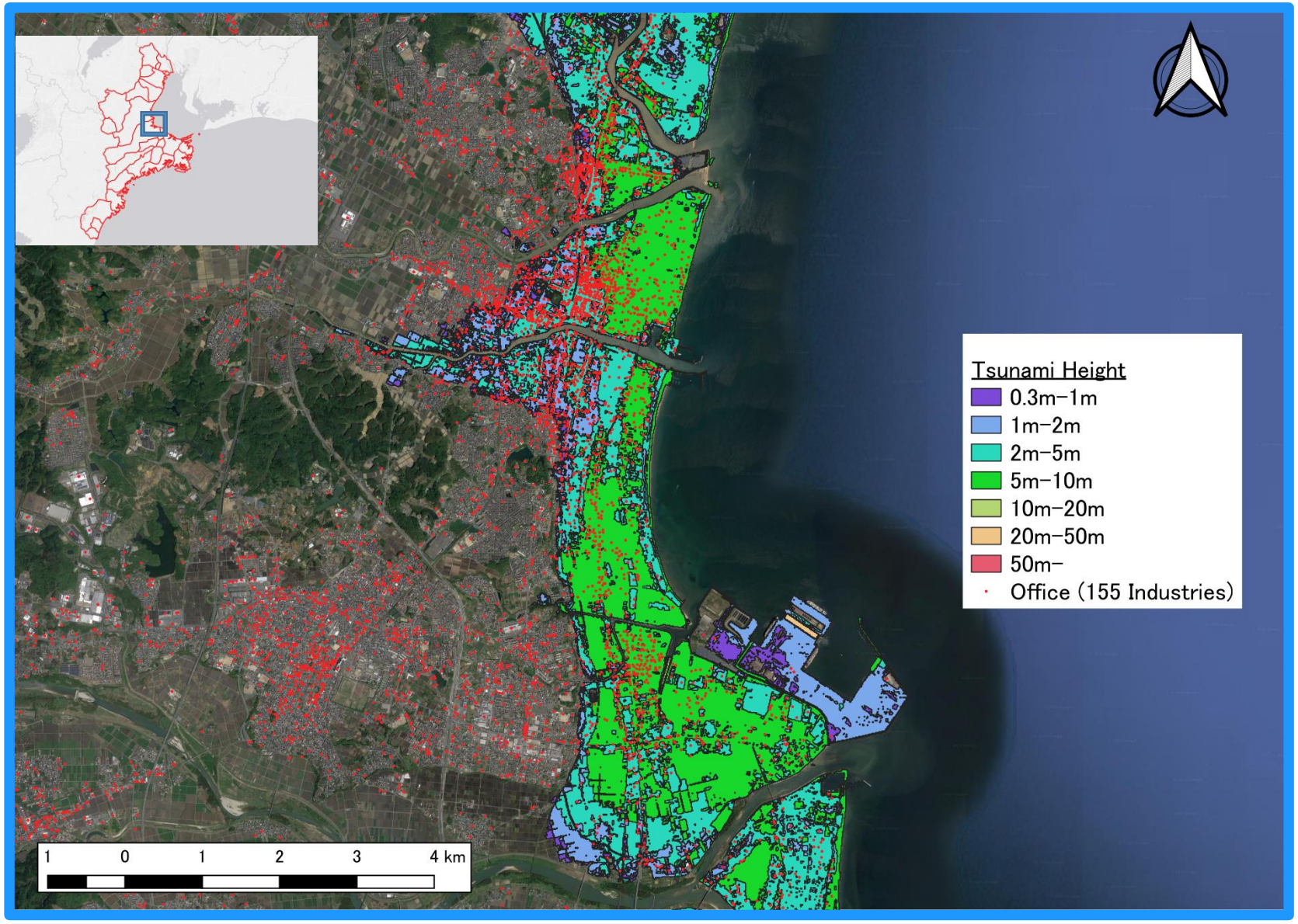


Capital and Labor dependency ratio (IO table)



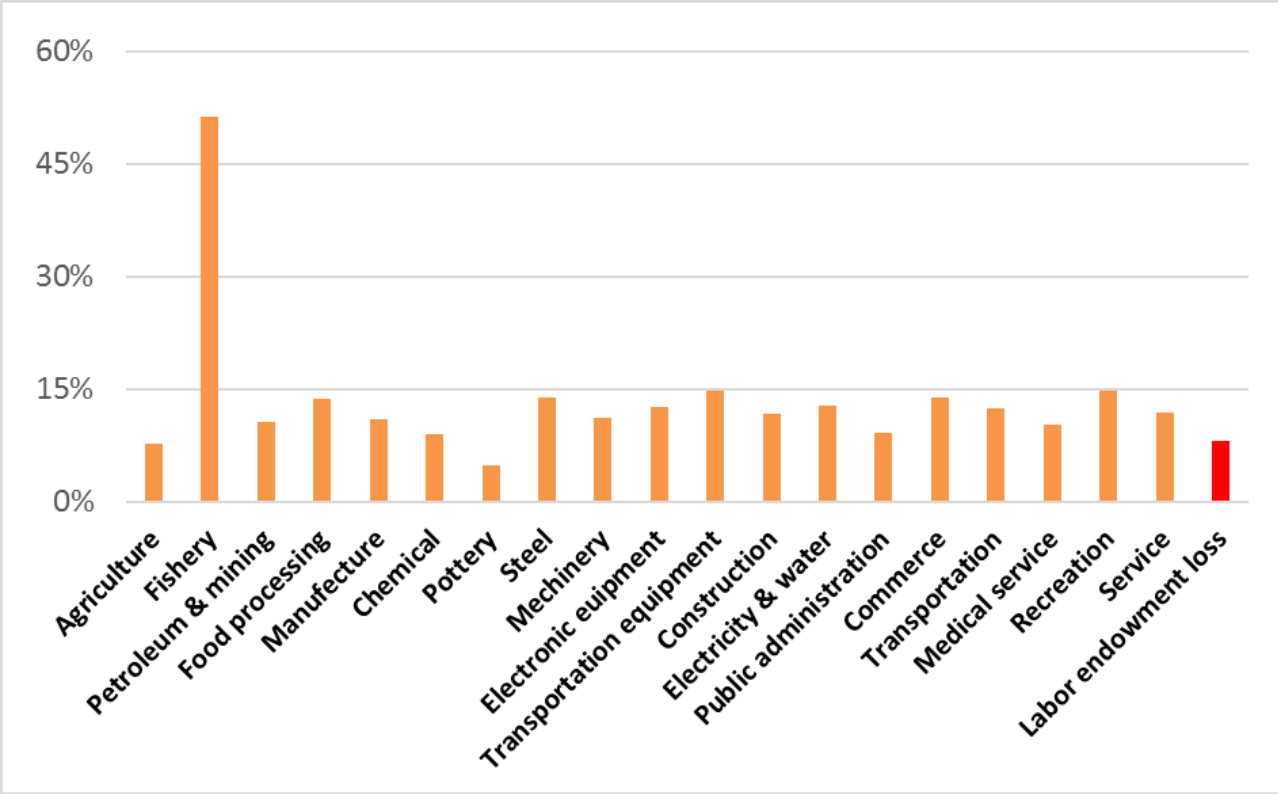
- Labor and Capital Factor endowment (left).
- Capital dependency ratio is high in **AGR**, **POA**, **COM**, **FOD** and **FIS** sectors.
- Higher labor ratio in **REC**, **MED**, **CON**, **MAN**, **TEQ**, indicating the importance of human capital.

2. Geographical Information of Tsunami and Office



- Combines office location and Tsunami hazard map.
- Hazard map assumes the Nankai Trough Earthquake.
- Tsu city (left) will be covered by Tsunami (0.3-10m)

Tsunami damage estimate

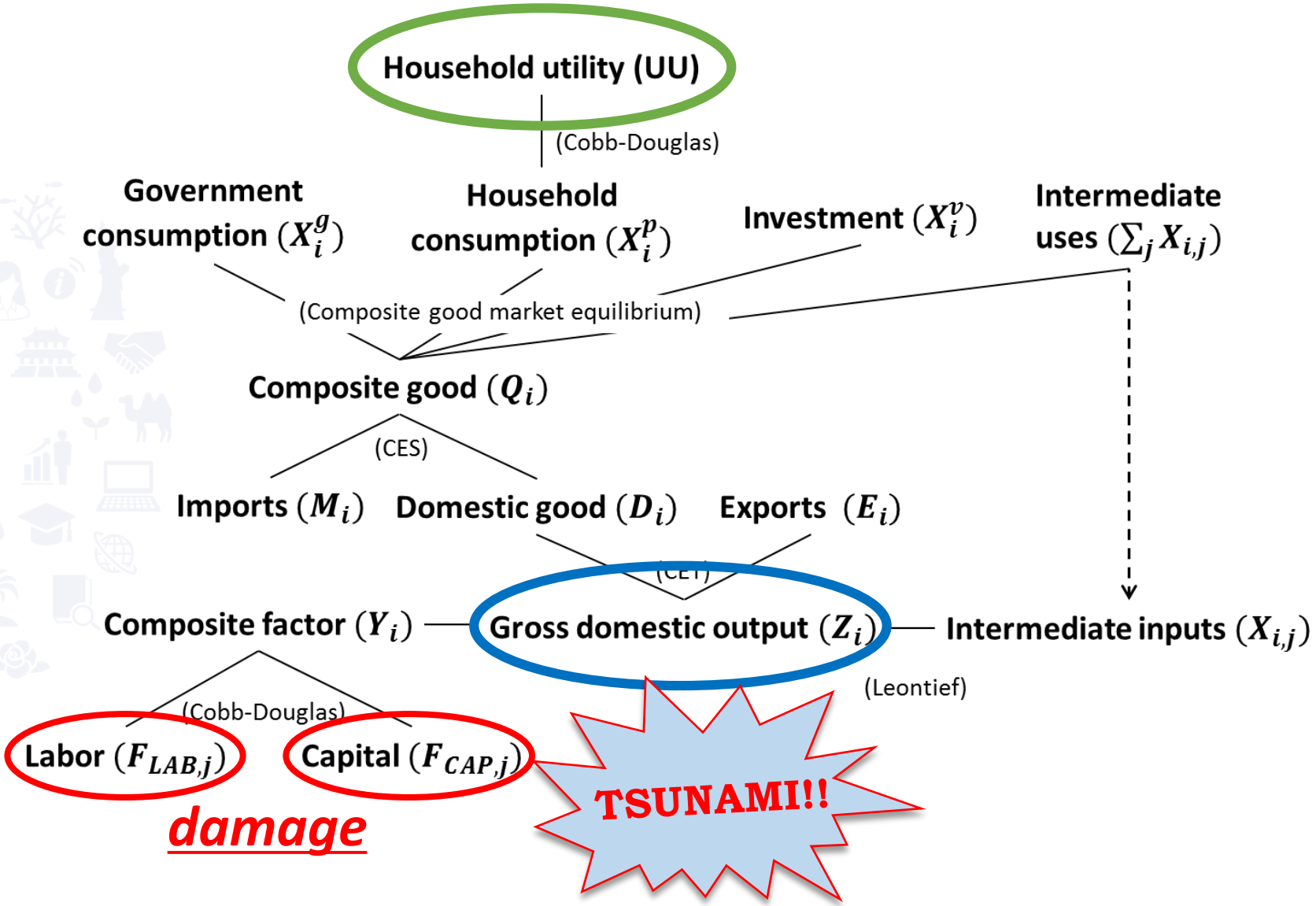


	Flooded height(m)	
Damage Category	Wooden buildings	Non-wooden Buildings
0%	0.0m＜H＜0.3m	0.0m＜H＜2.0m
25%	0.3m≦H＜1.0m	2.0m≦H＜5.0m
50%	1.0m≦H＜2.0m	5.0m≦H＜10.0m
100%	2.0m≦H	10.0m≦H

Note: Based on Shuto (1992). The building ratio was assumed from the city tax record.

- **Lost capital ratio** in each industries (left) was calculated based on our damage criteria (right).
- Most devastated sectors: Fishery(51.4%), Recreation (14.7%), Transportation (14.7%), Steel (13.9%), Commerce (13.9%), Food processing(13.8%),

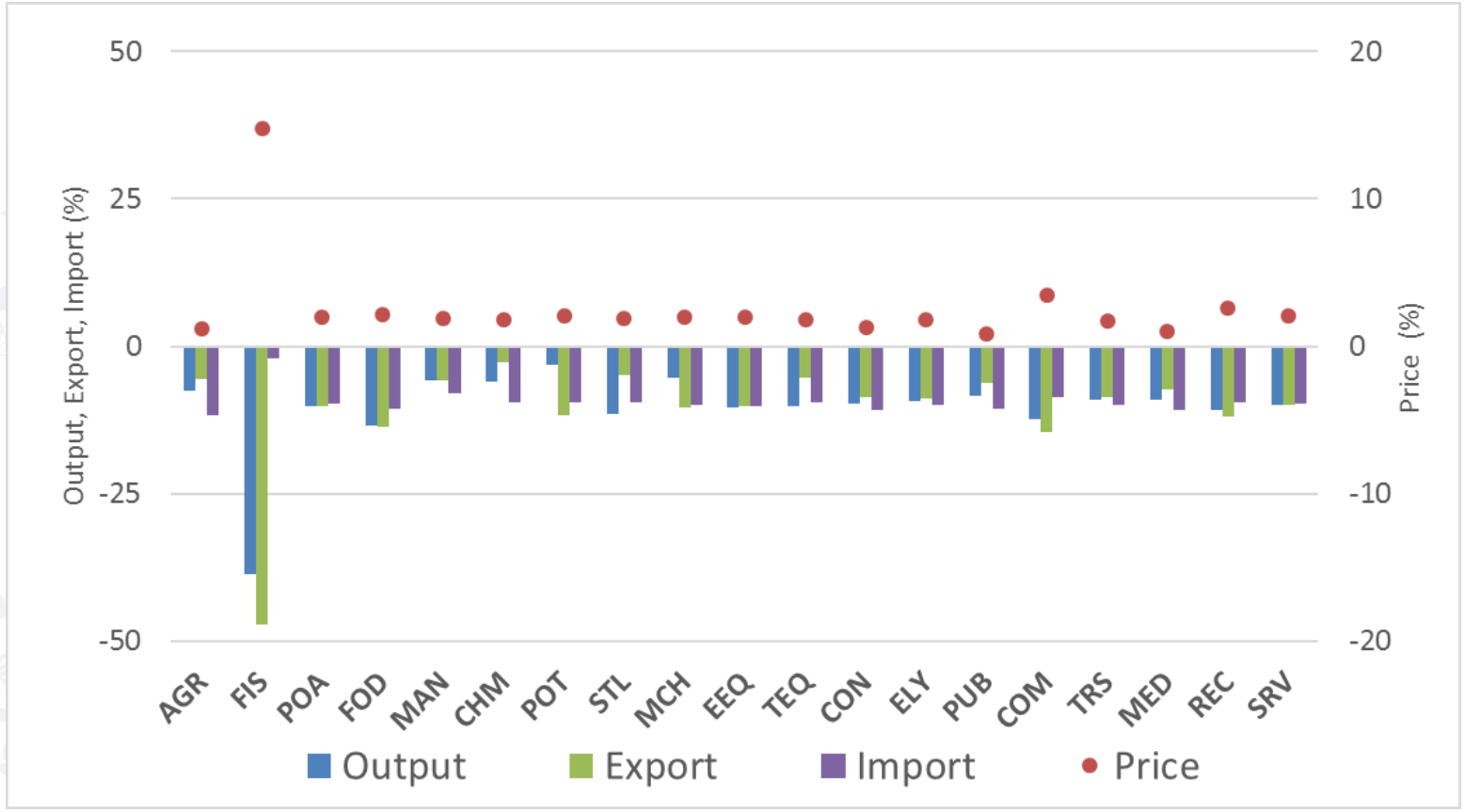
CGE model structure



- Static & single region
- Accommodate with the Mie IO table
- Armington elasticities sourced from GTAP database
- ***Capital*** factor is sectoral specific, ***Labor*** is mobile
- Disaster shock affects production factors, generating new level of output, prices and utility (welfare)

Source: Amended by authors based Huang and Hosoe (2016), (2010); Tanaka and Huang (2020)

Simulation results



Note: Welfare decrease by 494,126.3 million JPY

- Output, external trade decrease in all sectors, severe impact on **FIS**
- Price is rather steady except for **FIS**, indicating its scarcity and non-substituted
- Drastic price changes resulted in welfare decrease, implying 664,882 JPY losses for each household

Vulnerability Index (IV)

$$Vulnerability\ Index\ (VI) = \frac{Disaster\ impact}{Capital\ damage}$$

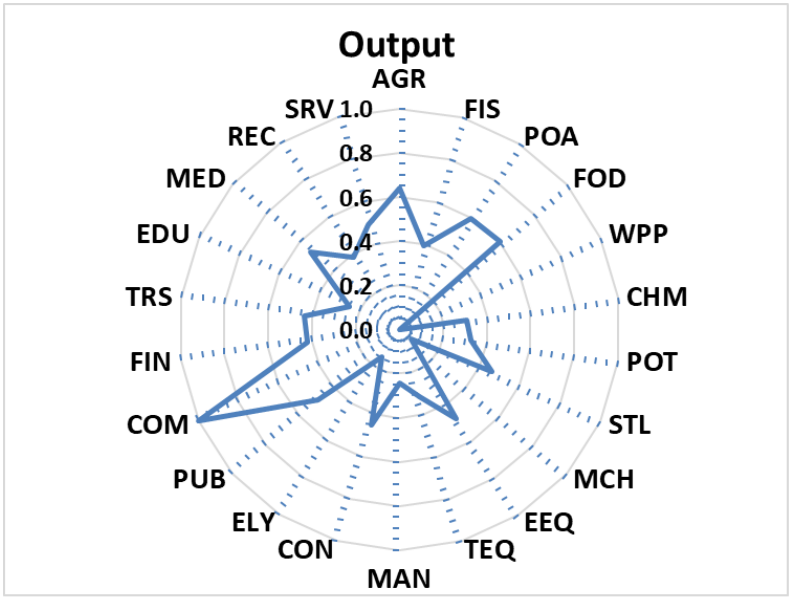
where disaster impact: change of output, price, and external trade

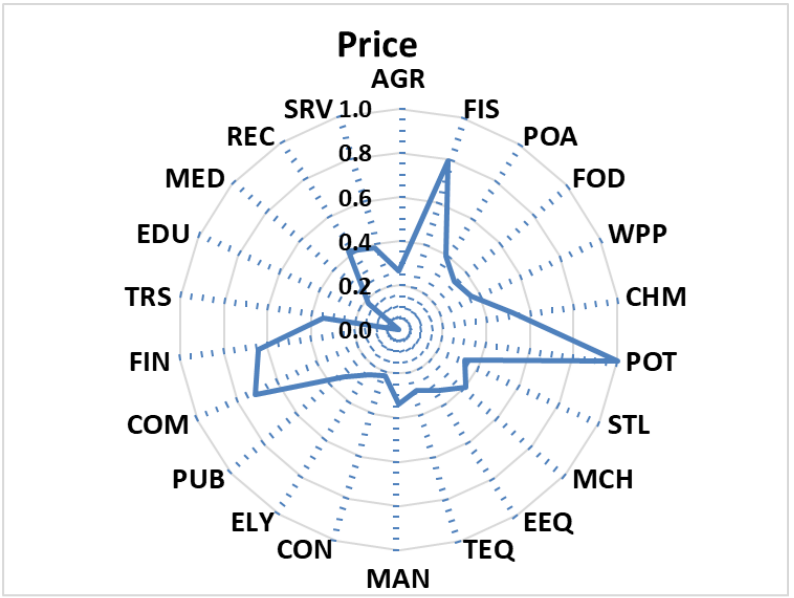
$$\widetilde{VI}_i = \frac{VI_i - VI_i^{Min}}{VI_i^{Max} - VI_i^{Min}}$$

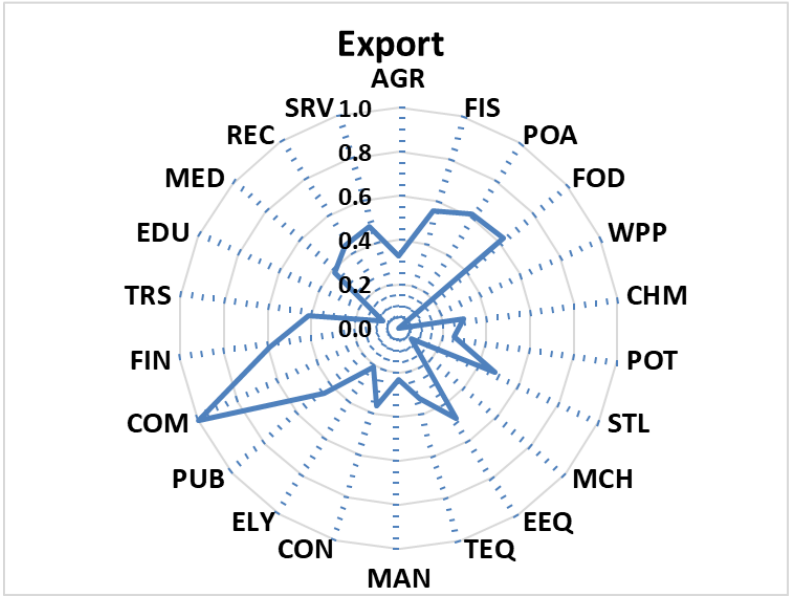
where i: sectoral impact, $VI_i^{Max} - VI_i^{Min}$ is the interval of the index;
the interval could be reversed if VI_i is negative

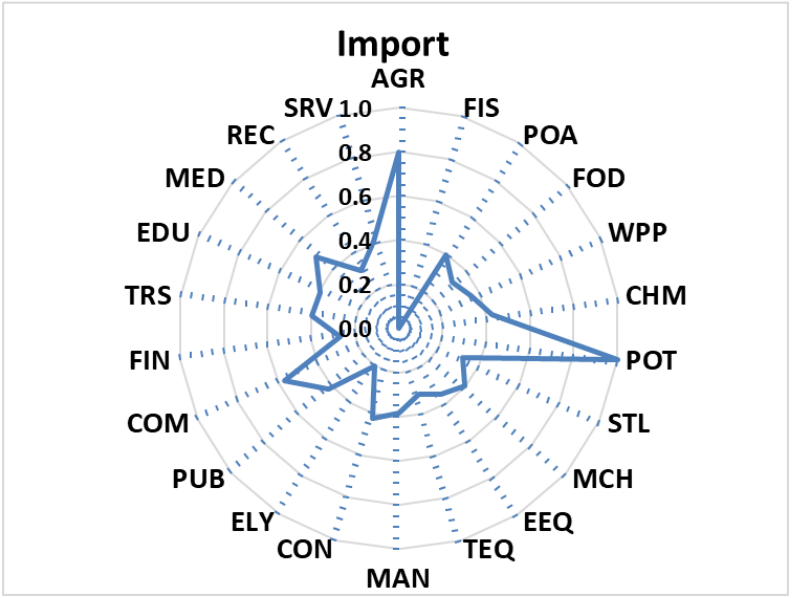
- This index reveals the overlooked vulnerable industries against tsunami
- Help identify the sensitivity of impact caused by the tsunami damage
- Higher index could refer to the drastic change and the vulnerability

Capital vulnerability index of tsunami









Discussion and policy recommendations

- **Fishery (FIS)** sector require ***resilience investment*** for ex-ante disaster risk reduction
- The regional "***vassal and harbor support mechanism***" should be developed to increase the capacity toward disaster
- In terms of capital vulnerability index of output, additionally we see **Commerce (COM), Food (FOD), Petroleum (POA**), and **Agriculture (AGR)** are also vulnerable against Tsunami, which could have been overlooked.
- The Index could help making **ex-ante** disaster preparedness and countermeasures for DRR.

Research limitations

- The assumption of damage category of Tsunami is based on Shuto (1992), but it needs more sophisticated.
- Input-Output Table (42 industries) is too rough to include 155 industries (GIS).
- The interference between other regions in Japan are not in considerations, inter-regional analysis may be necessary.

Next steps

- Dynamic analysis for recovery path and fund requirement estimate
- Compound disasters (eg. Pandemic, energy crisis, etc.)
- Data (IO table, GIS) compilation and filed work for higher accuracy
- Further studies focuses on vulnerable sectors

Thank you for your attention!

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