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

- IDRiM Virtual Workshop for Interactive Discussions between Senior and Early-Career Scientists -

Hajime Tanaka, Michael C. Huang, Nagisa Yoshioka

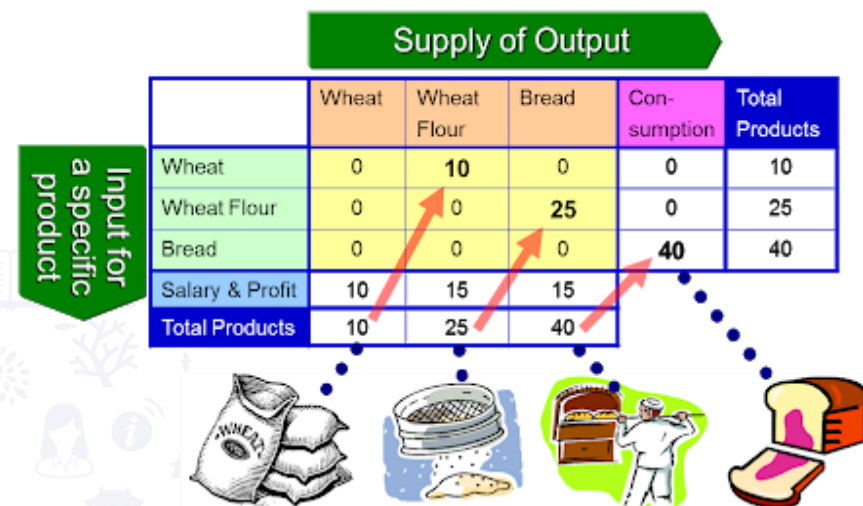**Blue Finance Project, Ocean Policy Research Department**

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1

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, and Future studies.**

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

	Wheat	Wheat Flour	Bread	Con-sumption	Total Products
Wheat	0	10	0	0	10
Wheat Flour	0	0	25	0	25
Bread	0	0	0	40	40
Salary & Profit	10	15	15		
Total Products	10	25	40		

Supply of Output

Input for a specific product

1. Input-output Analysis

2. GIS Analysis

3. CGE modeling

- 42 sectors

- Social accounting matrix

- Economic structure

- 710,059 offices (155 sectors)

- Tsunami Hazard Map

- Damage estimate
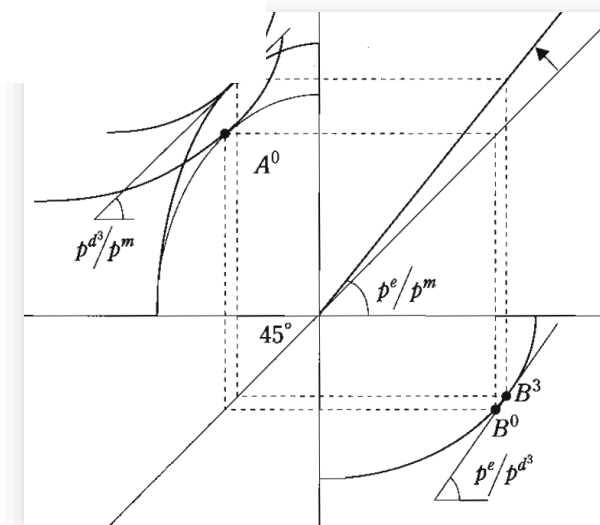
- Aggregate into 19 sectors

- **Impact assessment**

- **Capital Vulnerability Index**

*2011 IO table (released in 2018)   ***2020 data**

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%
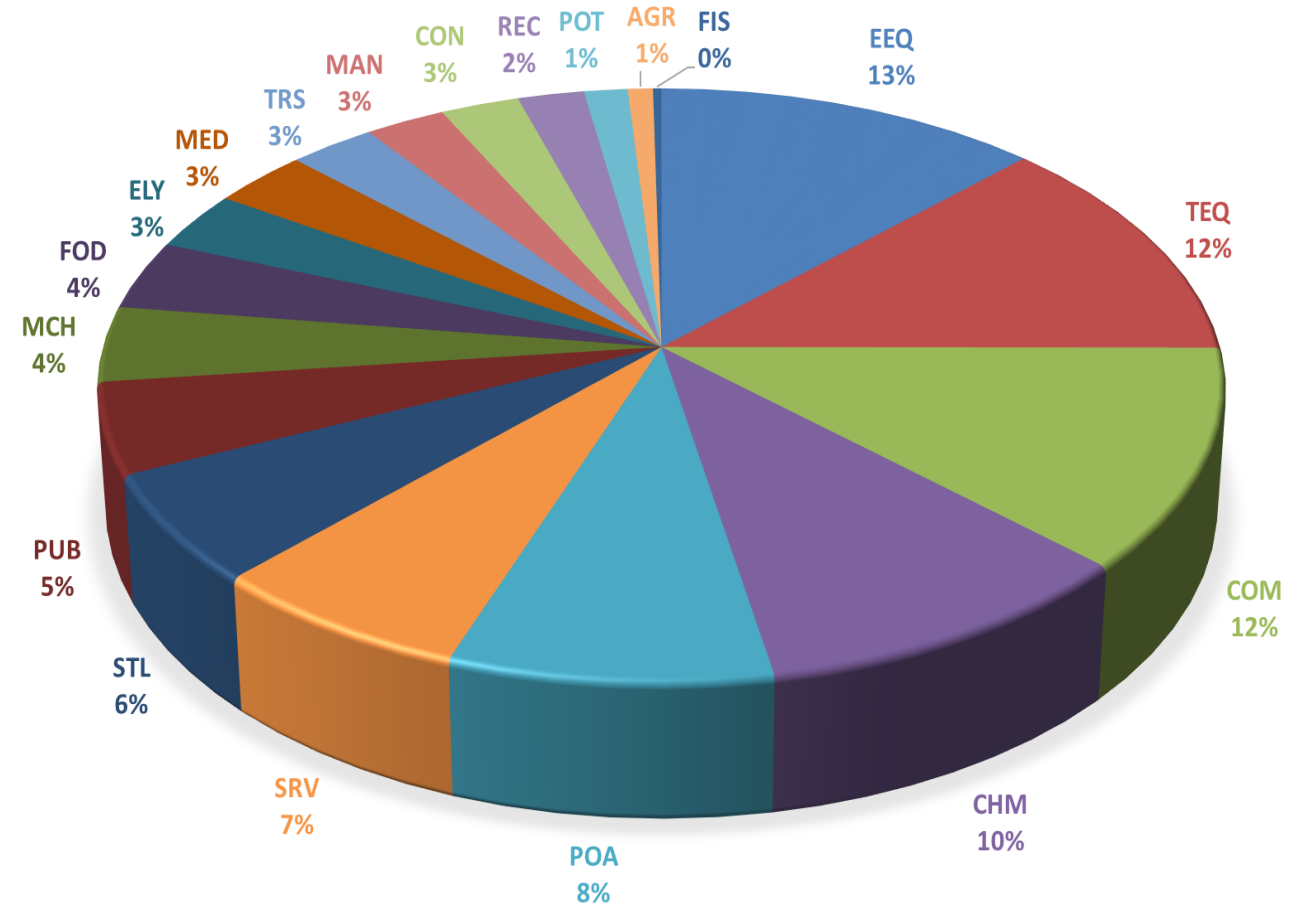
Capital and Labor dependency ratio (IO table)

Capital and labor ratio ■ CAP ■ LAB
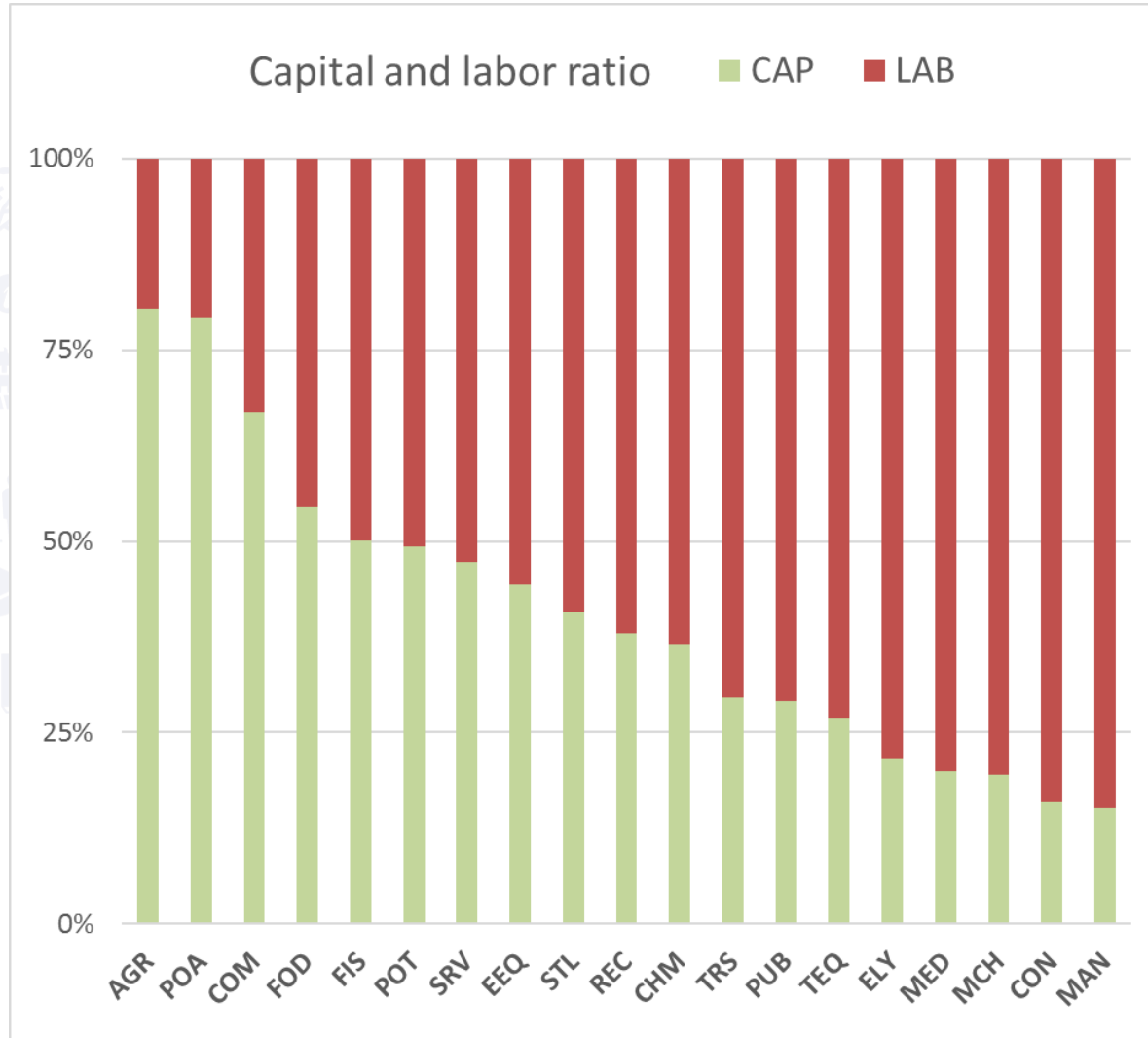
- Labor and Capital Factor endowment (left).

- 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.

Geographical Information of Tsunami and Office

Tsunami Height
- 0.3m–1m
- 1m–2m
- 2m–5m
- 5m–10m
- 10m–20m
- 20m–50m
- 50m–
- Office (155 Industries)
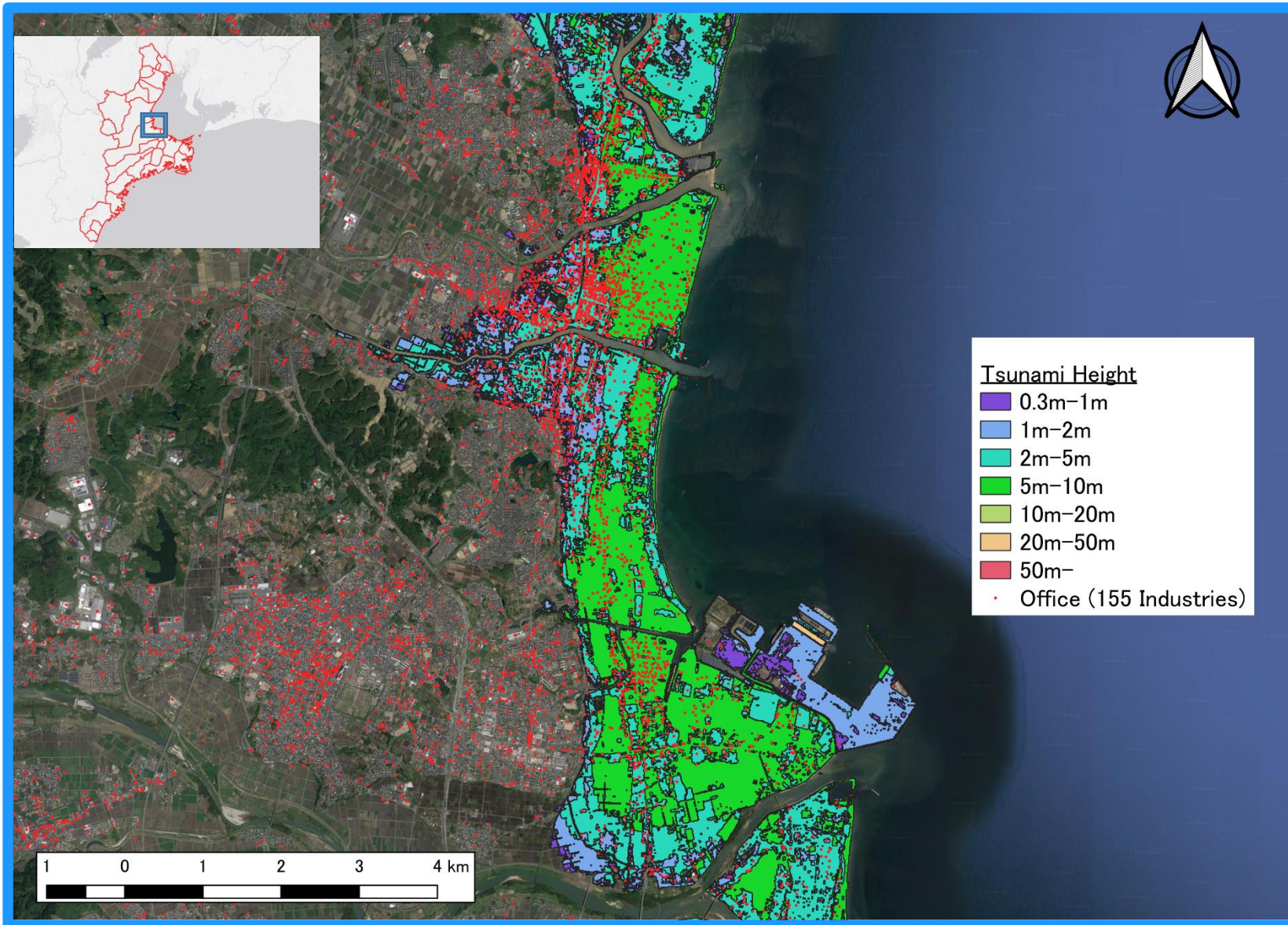
- Combines office location and Tsunami hazard map.

- Hazard map assumes the Nankai Trough Earthquake.

- Tsu city (left) will be covered by Tsunami (0.3-10m)

Tsunami damage estimate
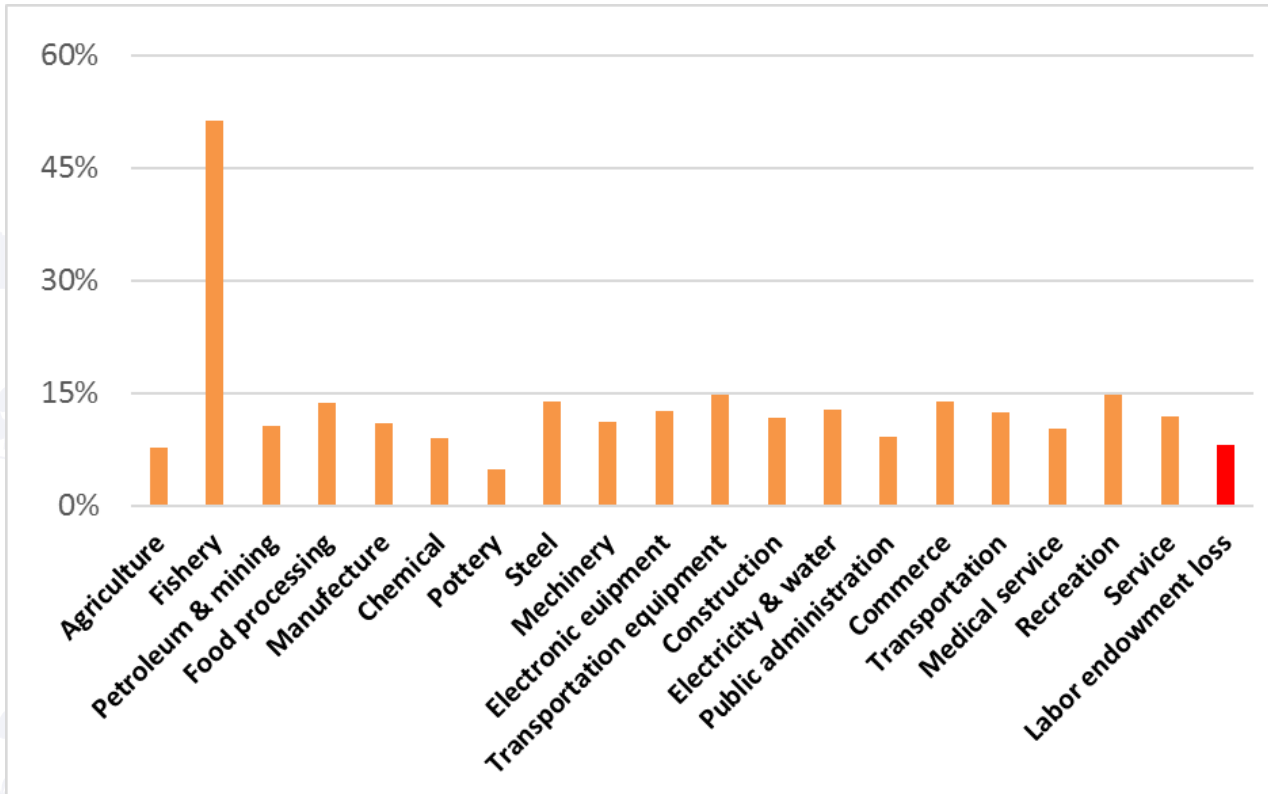
Flooded height(m)

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
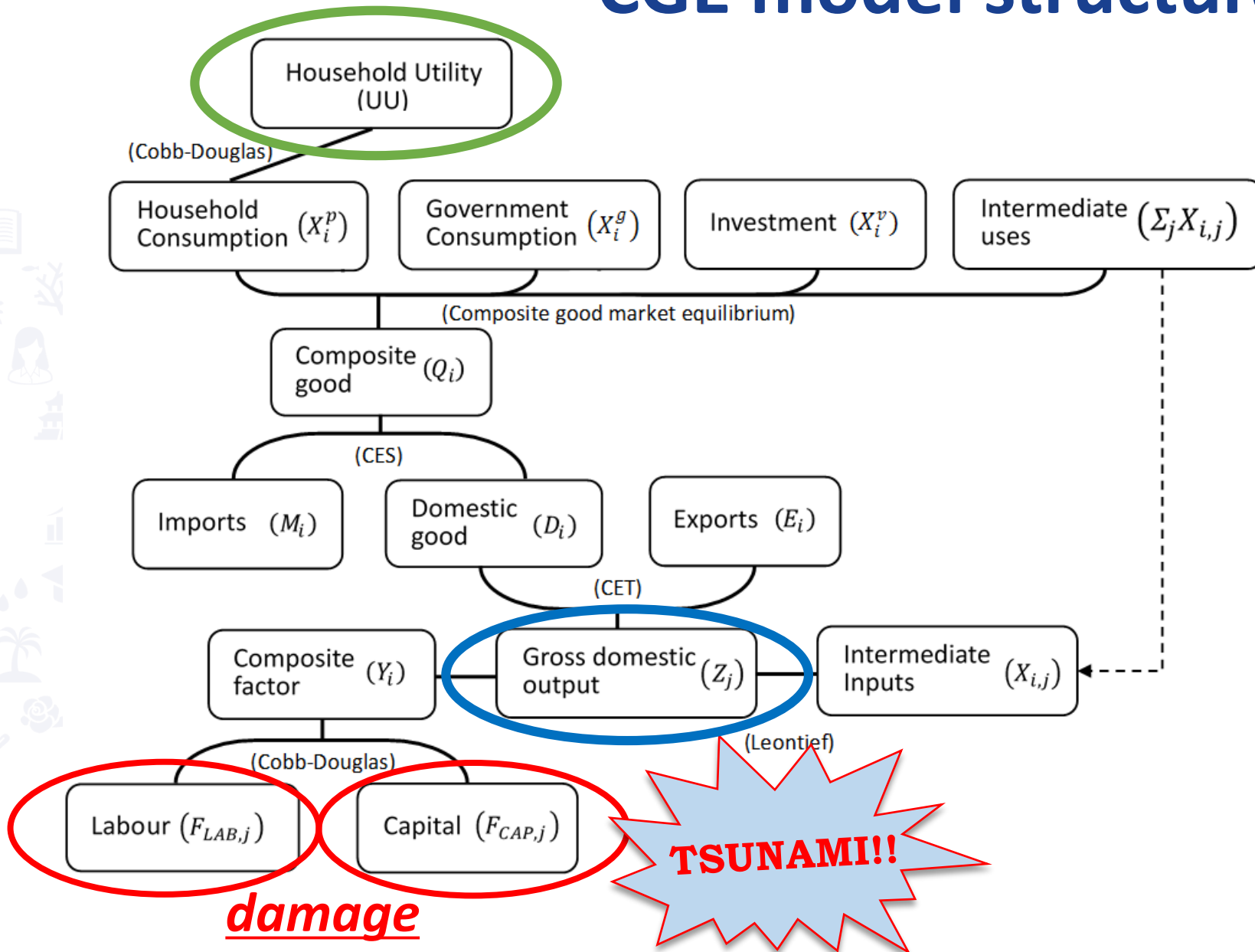
- Static & single region

- 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 on Hosoe et al., (2010); Tanaka and Huang (2020)

10

Simulation results
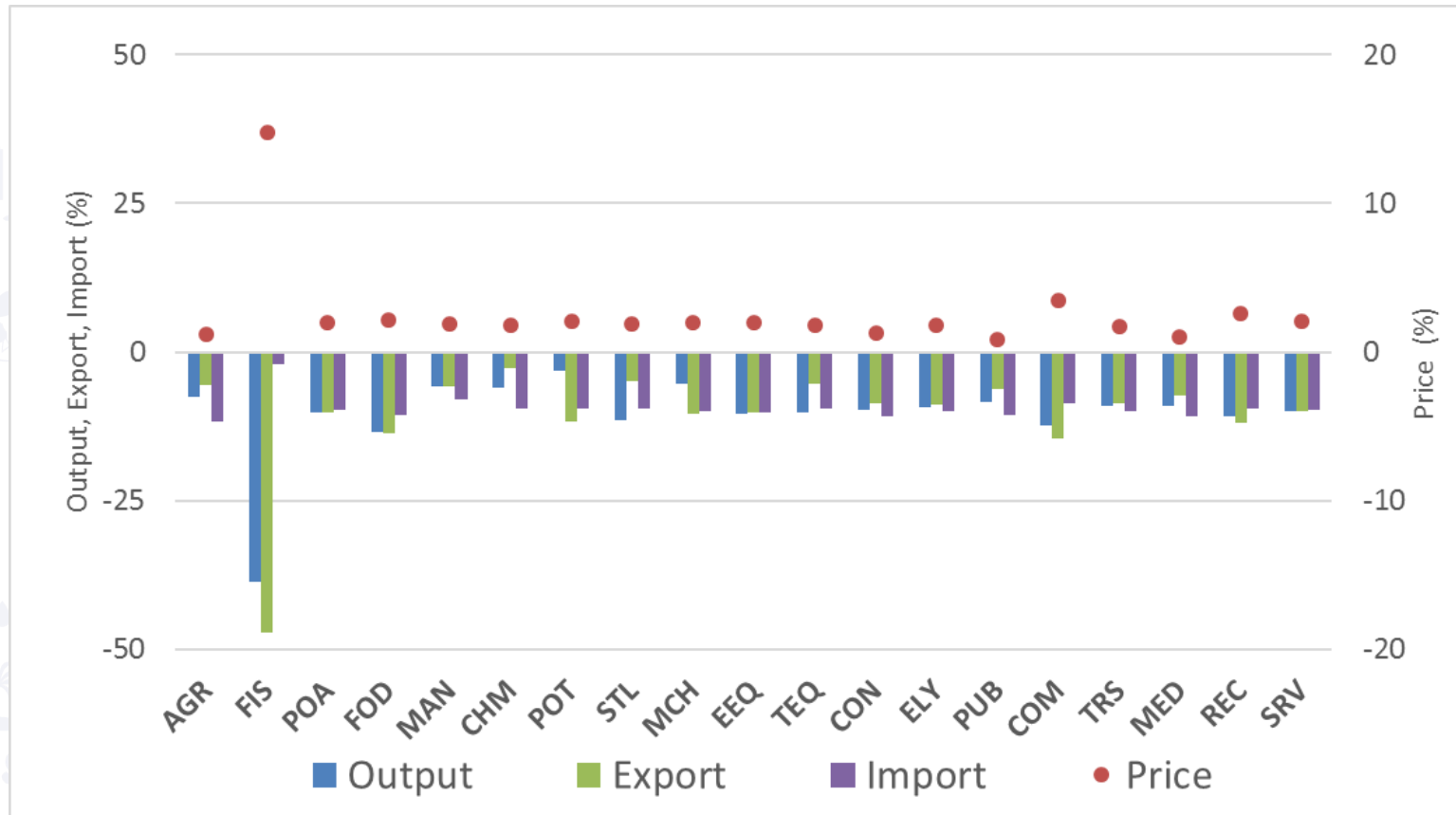
Note: Welfare decrease by 494,126.3 million JPY

- 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

11

# Capital vulnerability index of tsunami

$$\frac{Tsunami\ Impact*}{Capital\ loss\ ratio \times Capital\ dependency\ ratio}$$

Notes: ***Change of** output, price, export and import*

- It calculates the tsunami damage by lost capital in each industries

- 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
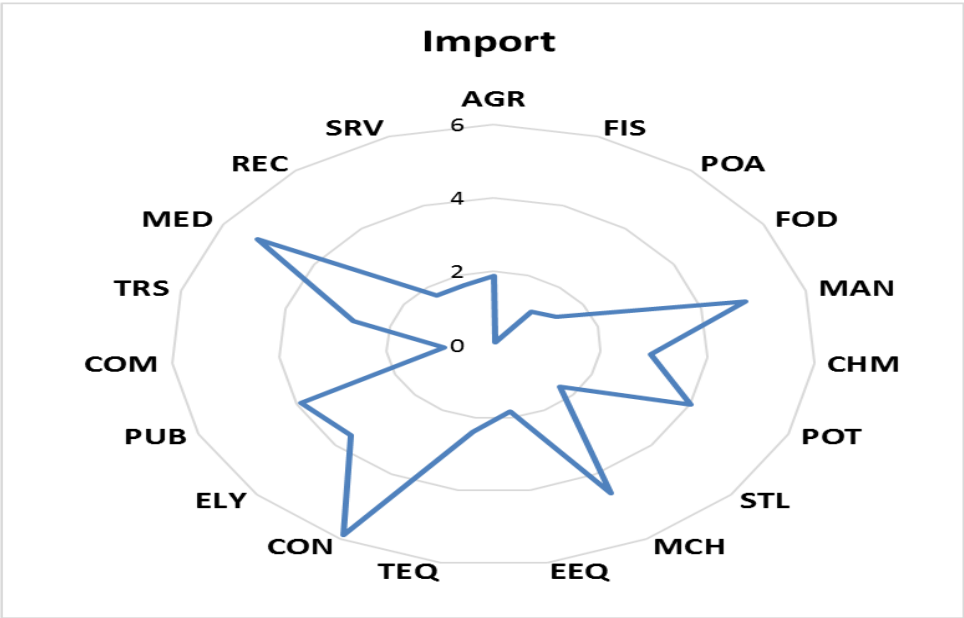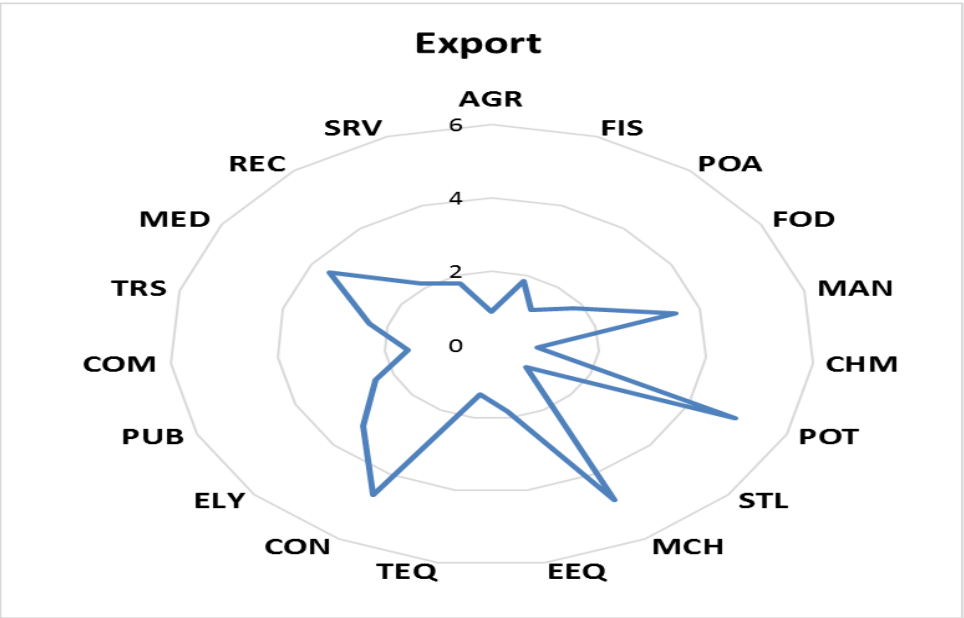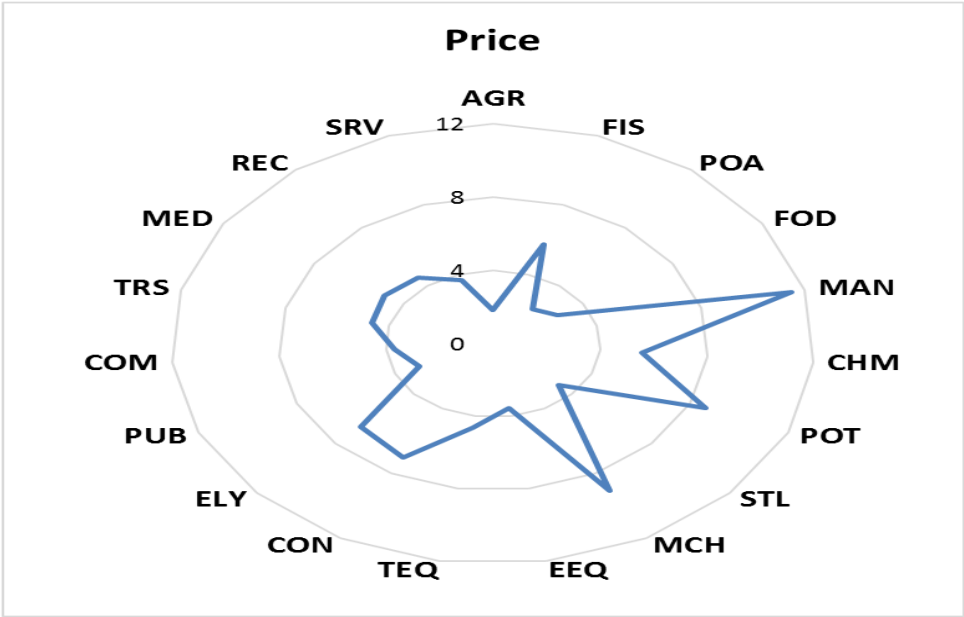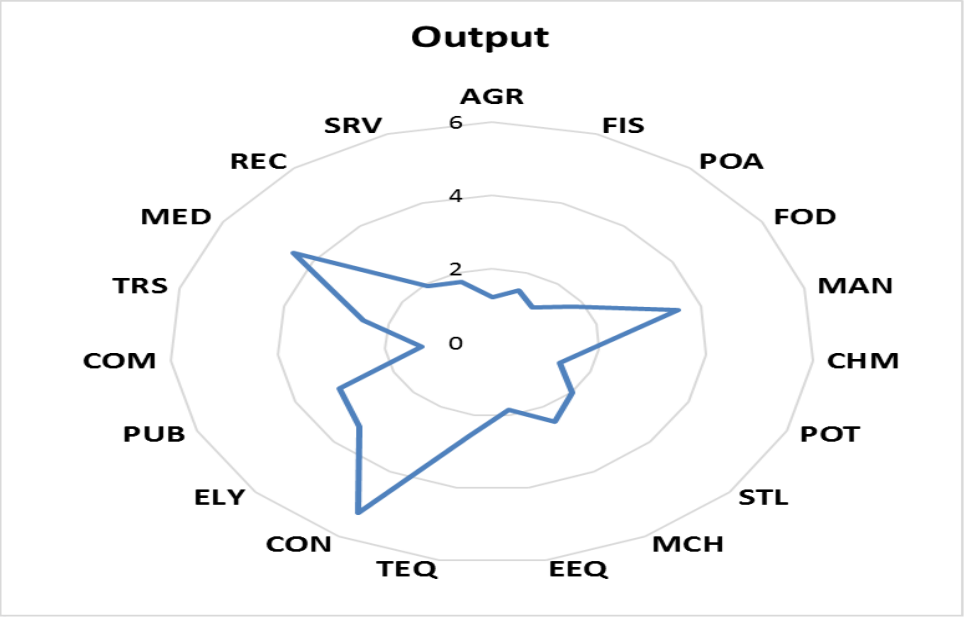
Discussion and policy recommendations

- **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 **Manufacturing (MAN), Construction (CON)** and **Medical service (MED)** 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 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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