Enhanced Disaggregation of the Fishery Sector for Policy Simulation in CGE Models

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I. Introduction

The production activities of economy involve primary production factors such as labor, land, and capital, in addition to intermediate inputs, and resulting into total outputs. The production activities in the fisheries sector have also been analyzed from this perspective. However, when examined in detail, it would be necessary to define and break down the production factor in the fisheries sector, both in terms of its definition and its input components. The difference in production factors between the fisheries sector and the general economy is that, instead of using land, the fisheries sector acquires resources from the sea. In the MAGNET model, the inclusion of fisheries stock as production factors reflects the reality of the fisheries sector's production structure.

However, the fisheries sector is transitioning from capture fisheries to aquaculture, and it is expected that maintaining capture fisheries will become increasingly difficult in Asian countries (FAO, 2024). To analyze the economic effects in the fisheries sector, it is essential to consider this shift from capture fisheries to aquaculture. Additionally, the interdependence between the fisheries and other sectors is gradually deepening. Changes in the production of fish would influence the variation in processed fish, and concurrently, there would be changes in the production of related sectors using fish and processed fish as intermediate. In South Korea's fisheries sector, the production quantity of fish would impact inter-industry relationships within the various sectors. In the most recent Input-Output Table of the Bank of Korea (2019), when examining processed seafood products, it is observed that among the total intermediate input materials, the highest proportion is attributed to fisheries products (27.4%) and processed seafood products (21.6%). In other words, the fisheries sector exhibits mutual interdependence among internal industries, reflecting in the production structure and contributing to the formation of total output.

This study reviewed the methods for creating a database to establish a model that distinguishes between aquaculture and capture fisheries. Unlike capture fisheries, aquaculture focuses on specific fishery species, necessitating detailed categorization of products (FAO, 2024). If fishery resources are split by production method (aquaculture or capture fisheries) and species, the economic relationships between the fisheries and other sectors could be analyzed more accurately. To build fishery species database, we systematically reviewed previous CGE models in terms of development research for an economic impact analysis in fisheries sector. This could be done by presenting step-by-step methodology for building a fishery product-based database.

The proportion of the top 3 species in total aquaculture production (2022).

Inland Aquaculture	Marine Aquaculture	Crustaceans	Molluscs	Algae
30.8	50.1	80.6	64.5	73.5

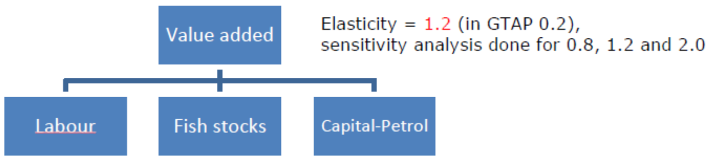
Source: FAO(2024).

II. Literature review

The MAGNET model, which is designed based on the GTAP model, is developed for conducting policy experiments within the EU. While MAGNET is built upon the LEITAP model, which has been widely used for policy analysis, it enhances the flexibility and provides additional options for analysis by incorporating a more extensive setting of regions and industries. Noteworthy in the MAGNET fisheries model is the separation of production factors into labor, capital, crude oil, and “fish stock”.

The fisheries sector is further categorized into capture fisheries, aquaculture, and processed fish, and the production factors encompass labor, capital, and fish stock, which allows simulation reflecting the ripple effects within fisheries sector. Recently, MAGNET has analyzed the economic repercussions of the Brexit on the fisheries sector in the United Kingdom (Bartelings and Kristkova, 2018). For instance, in the case of increased demand for seafood, additional supply would require the utilization of labor, capital, and fishery stock. If there is a shortage of fishery stocks, the additional supply could be achieved by using additional labor and capital inputs in the fishery sector. For instance, shocks in the demand for seafood could contribute to prices and quantity changes in labor and capital, potentially influencing the overall fishery related economy.

Production structure in the fisheries sector



Source: Bartellings and Kristkova(2018).

Bartellings et al. (2020) analyzed the impact of aquaculture subsidies in the EU based on MAGNET by separating aquaculture and fish processing. In the fisheries module of MAGNET, they split the GTAP fisheries sector (frs) into six sub-sectors, comprising one capture fishery and five aquaculture sub-sectors, for detailed analysis. Particularly noteworthy in this study is the examination of the influence of aquaculture subsidies on seafood production (in terms of quantity and price). They also analyzed the impact of increased seafood demand and the effect of changes in seafood demand on aquaculture subsidies.

Unlike previous research, this study constructs a database that includes more detailed items for aquaculture, fisheries, and the seafood sectors. Aquaculture and fisheries have the same number of species, while the seafood includes more categorized items.

III. Methodology

Initially, defining fishery products using trade and production data is the first task. Defining processed fishery products accurately is crucial for ensuring consistent comparison and analysis of fishery products on a global scale. Since all kinds of fishery species could not be included in the GTAP database, we aimed to define a limited number of products based on Korea’s economic trade values over the past 5 years.

1. Definition of fishery products

In this study, the total number of fishery products established amounts to 118 excluding salts. Fishery products comprise of 38 as capture fisheries (live or fresh), 38 as aquaculture (live or fresh), 41 as seafood(processed), and 1 as seaweed, and 1 as animal feed. Since salts are categorized in the GTAP data under other mineral resources, we do not consider it as fishery products for model analysis.

The 76 aquaculture and fisheries products are categorized by production methods. Each production value is proportionally aggregated according to the FAO's ASFIS classification system. The aquaculture-fishery production ratios are proportionally allocated and are applied to over the countries. For instance, “Carp” which is not produced by aquaculture in a country, has all production amounts allocated under the definition of "Fishery_carp," while carp in other country produced only by aquaculture have all production amounts allocated under the definition of "Aquaculture_carp". However, since "Fishery_carp" and "Aquaculture_carp" are included in all countries' items, production and export amounts are comparable.

2. Disaggregation for fishery trade

The aquaculture-fishery ratios are applied at the trade disaggregation stage. It is assumed that imported fishery products are imported according to the aquaculture-fishery ratio of the respective trading partner. For Korea, where 92% of Oysters are produced by aquaculture, every country importing Oysters from Korea would allocate 92% of the total import value to the "Aquaculture_oyster" item, while 8% would be allocated to "Fishery_oyster."

To disaggregate the fishery items defined in this manner in the GTAP data, consistent criteria are needed, which are distinguished based on trade and production stages. For the trade stage, we proceeded to disaggregate data based on the defined fishery products. To distinguish fishery products within the GTAP data, we developed a comprehensive country-by-country trade database, aligning with the fishery product definitions from the initial step.

"Taste" is a specially designed program for disaggregating GTAP data and is very useful for such disaggregation at the trade stage. It assigns HS codes to a total of 118 processed fishery items based on the HS 6 classification and disaggregates export and import amounts accordingly. While processed fishery products are disaggregated from "other food [ofd]," agricultural foods included in it are excluded. Additionally, "seaweed” is disaggregated from "crops [crp]," assuming it corresponds to the portion related to the seaweed item of FAO data.

3. Disaggregation for fishery domestic production

For the production stage, we disaggregated data based on the defined fishery products. The total domestic consumption of fishery products in the GTAP data also signifies the production within the fishery sector of each country. We refined the domestic usage within fishery sectors, as outlined in the basic data, into 118 fishery products, utilizing the FAO Global Fishery and Aquaculture Production Statistics as the criteria for disaggregation.

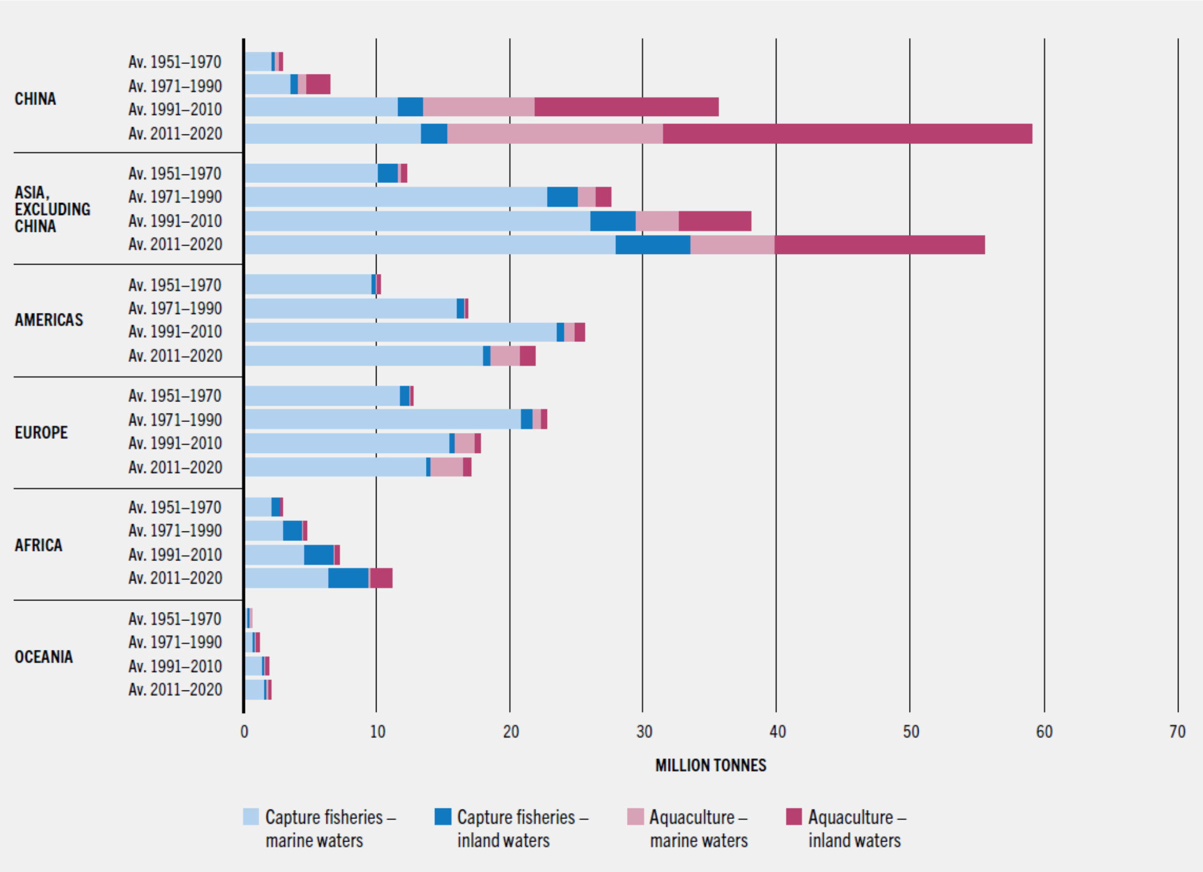
The FAO provides both value and quantity data for aquaculture production, but only quantity data for capture fisheries. Since GTAP data is based on values, data categorized by value is needed. Statistics Korea provides species-specific value data, which has been utilized for this purpose. It is important to check whether other countries also provide value data to ensure accurate data compilation.

4. Sets and parameters

The sets and parameters were prepared using Aguiar, Corong, and Mensbrugghe (2021). Files were created according to the definition of fishery products, and a program was used to generate the sets and parameters. To ensure that the parameters for all types of fishery products were not uniform, elasticity values were calculated. Lim (2021) derived the Armington elasticity values for each fishery product using the Error Correction Model, as follows (Lim, 2021). Finally, ‘sets’, ‘parameters’, and ‘basedata’ were generated and applied to the GTAP-HS model.

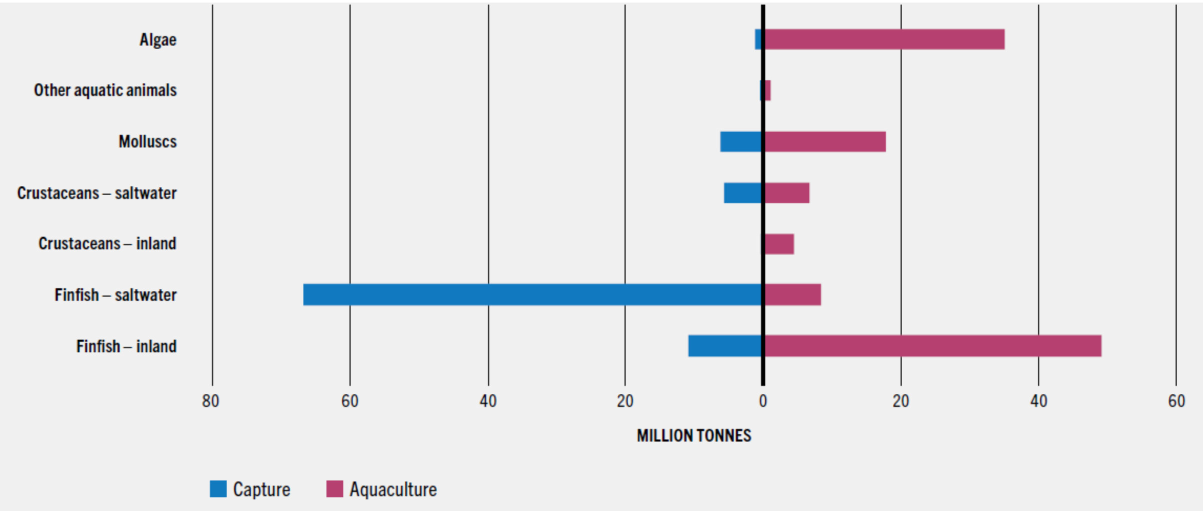
we integrated the disaggregated trade and production data into the existing GTAP database, thereby constructing a comprehensive general equilibrium database.

Figure 1. Regional Contribution to World Capture Fisheries and Aquaculture Production



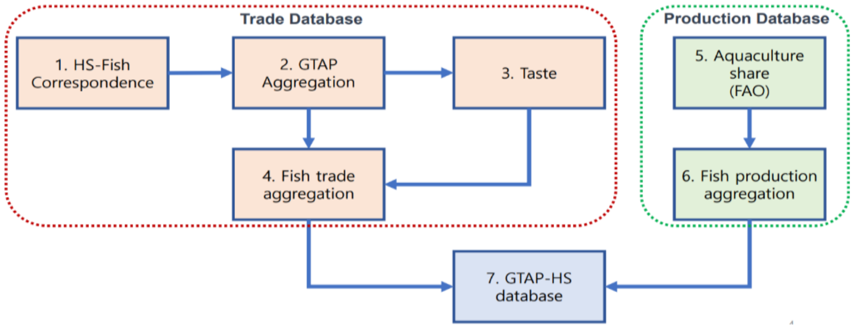
Unit: Live weight equivalent. Source: FAO(2024).

Figure 2. Share of Aquaculture in Total Fisheries and Aquaculture Production by Major Species Group, 2020



Unit: Live weight equivalent. Source: FAO(2024).

Figure 3. Data building process



Source: Author.

Table 1. Price and Armington Elasticity for Fisheries Imports

Products	OLS		PAM		ECM		ECM2	
	Price	Armington	Price	Armington	Price	Armington	Price	Armington
1	−2.013***	2.661***	−0.968***	1.255***	−1.227***	1.384***	−1.043***	1.146***
2	−2.655***	3.221***	−2.583***	3.046***	−3.271***	3.067***	−3.680***	3.196***
3	−0.867***	1.341***	−0.332**	1.050***	0.382	0.915***	0.383	0.704***
4	−0.541***	0.522***	−0.519***	0.498***	−1.476***	0.606***	−1.826***	0.852***
5	−0.763**	1.091***	−0.339	0.625*	−0.318	0.606*	−1.097*	1.145**
6	−1.504***	1.262***	−0.778***	0.840***	−1.022***	0.951***	−0.898***	0.846***
7	−0.280***	0.684***	−0.174***	0.407***	−0.200	0.691***	−0.378**	0.697***
8	−0.907***	0.559***	−0.772***	0.560***	−0.931***	0.715***	−0.902***	0.884***
9	−0.246**	2.031***	−0.160	1.138***	−0.809***	1.343***	−0.629*	1.130***
10	−0.841**	2.704***	−1.075***	1.798***	−2.164***	2.067***	−2.023***	1.793***
11	1.776***	0.109	1.366***	−0.030	1.824***	−0.070	1.735***	−0.214
12	0.445**	1.771***	0.203	1.155***	0.157	1.233***	0.051	1.022***
13	−1.136***	0.127	−0.602***	0.162	−0.876***	−0.002	−0.808***	0.056
14	1.494***	0.569	0.166	0.381	−0.265	0.613*	−0.401	0.448
15	−1.123***	1.527***	−0.755***	0.805***	−1.261	0.743***	−1.707*	0.400*
16	−1.145***	1.038***	−1.243***	0.665**	−1.265***	0.697**	−1.193***	1.054***
17	0.339***	0.687***	0.180**	0.545***	−0.132	0.750***	−0.307	0.821***
18	−0.231***	0.697***	−0.182**	0.576***	−0.488**	0.638***	−0.291	0.363*
19	1.053***	0.192	0.409***	0.089	0.696***	0.073	0.568***	0.021
20	−2.179***	1.242***	−1.192***	0.700***	−0.763	0.650*	−0.493	0.323
21	−0.578***	0.474***	−0.423***	0.310***	−1.220***	0.373***	−1.502***	0.309***
22	−2.552***	1.147***	−1.290***	0.686***	−1.868***	0.711***	−1.768***	0.588***
23	−1.491***	2.075***	−0.350***	0.826***	−0.904***	1.346***	−0.814***	1.133***
24	−0.526***	0.513***	−0.979***	0.870***	−1.034***	0.897***	−1.027	1.892
25	−0.284***	0.969***	−0.187***	0.806***	−1.163***	1.423***	−1.171***	1.593***
26	0.001	0.234	−0.264	0.665***	−0.602***	0.783***	−0.997***	0.981***
27	−1.109***	0.956***	−0.762***	0.736***	−0.272	1.035***	0.395	1.190***
28	−1.811***	1.683***	−1.853***	1.732***	−1.879***	1.753***	−1.895***	2.121***
29	−0.236***	1.532***	−0.181***	1.146***	−1.223***	1.181***	−1.420***	1.176***
30	−0.856***	0.855***	−0.364***	0.618***	−1.027***	0.726***	−1.047***	0.663***

Source: Lim(2021).