Extending the GTAP-HS Model to Cover Production Quotas in Disaggregated Fishery Sector

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Abstract

This study investigates the potential of the fisheries sector to address global food shortages and the impact of policy changes on the industry. The study develops a general equilibrium analysis model capable of evaluating the policy effects on fisheries as a food industry and explores the potential applications of this model. The results show that Korea's accession to the CPTPP led to an increase in total fisheries and seafood exports, with notable changes observed in exports to Vietnam, Japan, and New Zealand. The study also found that implementing policies aimed at protecting domestic fishery resources, such as TAC expansion, can effectively reduce actual fishery catches, contributing to sustainable fisheries management. The interplay between TAC expansion and trade liberalization creates a complex interaction of supply and demand factors, influencing fishery product prices and production levels. These findings have implications for policymakers and stakeholders involved in the fisheries industry.

Introduction

The significance of food on a global scale has been steadily increasing due to factors such as rising world population, food security concerns, and the global supply chain crisis. As the value of aquaculture production surpasses that of capture fisheries, fishery products have recently emerged as a potential solution to the global food problem. The fisheries sector contributes a larger share to the GDP of developing countries than to that of developed countries, and many impoverished individuals rely on the sector for their livelihoods. As such, the development of the fisheries sector could offer a solution to food shortages.

Following the establishment of the WTO in 1995 and the proliferation of FTAs since the 2000s, the global product market has experienced liberalization, leading to the development of models centered on the economic effects of the fishery industry. Among these, the Global Trade Analysis Project (GTAP) model utilized the GTAP database, which includes the fisheries sector, thereby enabling the simulation of the impacts of fishery policies. However, comprehensive research on the fisheries sector has been hindered by the lack of a detailed industrial classification for the sector, resulting in available data that does not accurately represent the reality of the sector. Within the GTAP database, the fishery sector is categorized

as "Fishing (FSH)," while processed fishery products are combined with other agricultural and livestock products under "Food products nec (OFD)."

This study aims to develop a general equilibrium analysis model capable of evaluating the policy effects on fisheries as a food industry and to explore the potential applications of this model. To achieve this, we first disaggregate the fishery sector to obtain data for analyzing the impact of tariff rate policies on the sector. Next, we employ a method that imposes high costs on producers when production surpasses a certain threshold by dividing the tax revenue between in-quota and over-quota amounts. Our model takes inspiration from the Tariff Rate Quota (TRQ) model proposed by Bach and Pearson (1996) and Elbehri and Pearson (2005). While these studies apply different tariff rates to traded volumes, our approach modifies this method by implementing additional costs at the production stage.

Methodology

In this study, GTAP-HS model is employed to assess the economic impact on fishery items. Aguiar et al. (2021) proposed an integrated GTAP-HS model that incorporates partial equilibrium analysis and general equilibrium analysis to achieve HS item unit analysis within a general equilibrium framework. The analysis of existing industrial units derives its solution using the general equilibrium method, while the analysis of detailed item units within the industry calculates the change value through the partial equilibrium method.

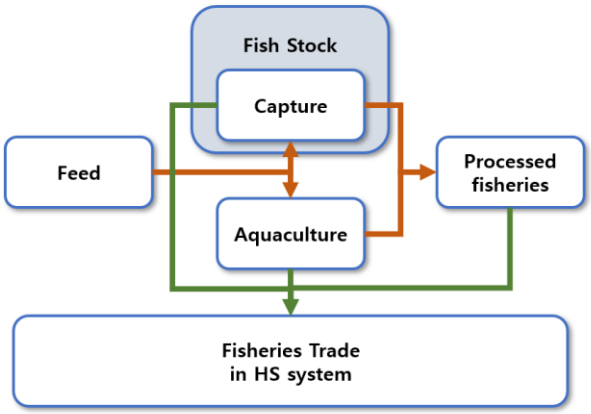
In the standard GTAP model, industry production (qfa) is determined by the supply of domestic goods (qfd) and imported goods (qfm). However, the GTAP-HS model disaggregates the total goods supply (qat) into HS units (qak), further dividing them into domestic goods (qdsk) and imported goods (qmsk). Consequently, not only is the domestic-import elasticity value (ESUBD) required, but also the substitution elasticity value between products (ESUBK).

The aim of this study is to demonstrate the unique features of the GTAP-HS model that enable product-specific analysis, distinguishing it from the existing GTAP model. Fish products are categorized into fresh aquatic products (Fsh) and processed aquatic products, which are further divided into other foods (Ofd) to simulate the GTAP-HS model. Aguiar et al. (2021) presented a GTAP-HS model and examined methods for constructing a detailed HS-based database. Using the GTAP-HS model, this study investigates the practicality of examining the impacts of fishery policies.

Disaggregating products according to HS codes is crucial for analyzing government Free Trade Agreement (FTA) policies, as they are predominantly manifested as tariff reductions for individual HS items. The fishery sector is subdivided into fish capture, aquaculture, and

processed fisheries sub-sectors, with the fish capture and aquaculture sub-sectors further disaggregated using species or families classification based on the HS code (Figure 1).

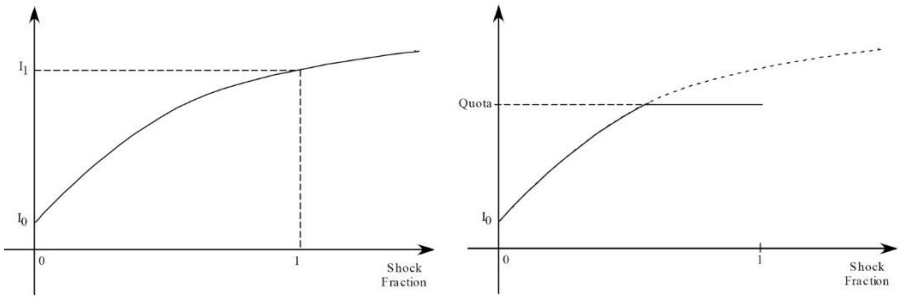
Figure 1. Fisheries products relation in HS system



Source: author

Fish capture, aquaculture, and processed fisheries data were constructed using the FAO FishStatJ database to split the GTAP fishery (FSH) and food products nec (OFD). The status of trade in fishery products by country can be reflected by utilizing UN Comtrade's HS data to create trade data in fisheries. While Bartelings et al. (2020) divided the fishery sector into six specific sectors in the MAGNET model, this study develops a fisheries database utilizing the HS code.

Figure 2. Production restriction system in TAC module of CGE model



Source: Harrison and Pearson (1996, p.170)

Fisheries play a crucial role in global food security, livelihoods, and trade. However, unsustainable fishing practices and over-exploitation of marine resources have threatened the long-term viability of these vital resources. The Total Allowable Catch (TAC) is a crucial tool for sustainable fisheries management, as it sets the maximum annual catch limit for specific fish species to prevent overfishing and maintain a healthy marine ecosystem. Incorporating

TAC into the Computable General Equilibrium (CGE) model is essential for quantitatively analyzing the impacts of sustainable fisheries policies on trade, production, and consumption. In this study, we develop a new GTAP-TAC model by extending the standard GTAP model to incorporate the TAC as a production quota. The GTAP-TAC model captures the relationship between TAC, production, and trade of fishery products by introducing equations that account for the TAC constraint and its implications on the supply and demand of fishery products. To capture the heterogeneity in fishery products, we use a nested production structure that distinguishes between fresh and processed fishery products.

We aim to incorporate the linearization of the Level equation, reflecting the improvements initially suggested by Bach and Pearson (1996), into the model. The linearized equation is as follows. We also have added del_Newton and slack variables and provided additional conditions to enable the module to be activated.

$$\mathrm{qoqratio}(\mathrm{i},\mathrm{r},\mathrm{s}) = \mathrm{qoq}(\mathrm{i},\mathrm{r},\mathrm{s}) - \mathrm{qoqquota}(\mathrm{i},\mathrm{r},s) \quad (1)$$

$$\mathrm{tqoq}(\mathrm{i},\mathrm{r},\mathrm{s}) = \mathrm{psq}(\mathrm{i},\mathrm{r},\mathrm{s}) - \mathrm{pfd}(\mathrm{i},\mathrm{r}) \quad (2)$$

$$\mathrm{VXQD}(\mathrm{i},\mathrm{r},\mathrm{s}) = \mathrm{psq}(\mathrm{i},\mathrm{r},\mathrm{s}) * \mathrm{qfd}(\mathrm{i},\mathrm{r},\mathrm{s}) \quad (3)$$

i and *r* represent items and industries, respectively, and in the analysis of total allowable catch, they are categorized into fisheries, agriculture, manufacturing, and services. *s* represents the country, and in this analysis, it refers to the CPTPP countries. *qoqratio* is a step to check whether the production volume exceeds the quota, and when the production volume exceeds the quota, an excess cost (*tqoq*) needs to be imposed. *VQOD* is a formula that calculates how much production value is produced under the quota.

We analyze the impacts of two scenarios: (1) South Korea joining the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), and (2) expanding the TAC system by 10%. The CPTPP is a mega FTA that South Korea is likely to join in the future, and it includes major fishery trading countries such as Japan. The TAC expansion scenario represents a policy intervention to promote sustainable fisheries management by reducing the total allowable catch by 10%.

Results

The study found that Korea's accession to the CPTPP resulted in an increase in total fisheries and seafood exports, with notable changes observed in exports to Vietnam, Japan, and New Zealand. Exports to other global markets also experienced a slight uptick, which could be attributed to enhanced productivity in the aquatic product export industry without the

occurrence of trade diversion. When tariffs were eliminated solely for fresh aquatic products, exports of all items increased. The removal of tariffs for fresh and processed aquatic products resulted in an increase in the export of certain fresh aquatic products, including tuna and shrimp. The growing demand for processed products has led to an increased demand for fresh fisheries products as raw materials in industries, contributing to the rise in demand for seafood and subsequently, the increase in exports of fresh aquatic products like tuna and shrimp.

Exports of other processed seafood products experienced the most significant growth, followed by fresh pollack, processed tuna, processed octopus, and fresh tuna. The results from the GTAP-TAC model reveal that expanding the TAC for fresh fishery products leads to a decrease in Korea's fishery production and an increase in imports. Consequently, fishery product prices rise due to the TAC expansion. These findings are consistent with the study by Waters and Seung (2010), which discovered that a reduction in Alaska pollock TAC results in a decline in fishery production and an increase in fishery product prices.

Our analysis suggests that the implementation of policies aimed at protecting domestic fishery resources, such as TAC expansion, can effectively reduce actual fishery catches, contributing to sustainable fisheries management. Moreover, Korea's accession to the CPTPP has implications for its fishery trade, as imports increase due to trade liberalization. The interplay between TAC expansion and trade liberalization creates a complex interaction of supply and demand factors, influencing fishery product prices and production levels.

Conclusion

This study aims to analyze the effects of fishery trade policies by advancing existing models in two key aspects. First, given that the Korean fisheries sector is influenced by the interdependence of various products based on production volume, this study disaggregated fisheries products and reflected them in the model. Second, the study considered an equation that imposes excess costs when the production volume exceeds a set quota. The analysis revealed that the results of the fisheries sector analysis differed significantly from previous studies when the products were disaggregated. Moreover, reflecting the characteristics of each product showed that there were significant differences in the export impacts of individual products following the CPTPP accession. The impact analysis of the TAC system demonstrated that while the production volume decreased, the import volume increased, indicating that the sole adoption of the TAC system could have a negative impact on the domestic fisheries industry.

The GTAP-TAC model offers valuable insights for policymakers striving to strike a balance between sustainable fisheries management and trade and economic growth objectives. By

quantifying the impacts of TAC expansion and trade liberalization on fishery production, trade, and prices, the model aids in evidence-based policy decisions. Our findings indicate that while TAC expansion can effectively support sustainable fisheries, the resulting decrease in domestic production may be offset by the increased import volume due to trade liberalization. This underlines the need for complementary policies that bolster domestic fishery production while ensuring sustainable resource management.

Additionally, the GTAP-TAC model's disaggregation of fishery products into fresh and processed categories reveals the varying impacts of TAC expansion and trade liberalization on different segments of the fishery sector. This information enables policymakers to devise targeted interventions to assist the most affected industry segments. In conclusion, the GTAP-TAC model serves as an invaluable tool for quantitatively examining the effects of sustainable fisheries policies and trade agreements on fishery production, trade, and prices. The findings from this study can inform future research and policy measures aimed at fostering sustainable fisheries management while accounting for trade and economic growth implications.