12-2-2019

Three Essays on Fisheries Economics

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This dissertation explores applied fisheries economics, focusing on policy-relevant issues related to the fisheries. It deals primarily with economic growth, food safety, and local branding issues in the target regions of the Philippines and Korea. The results of the study may be significant for the fisheries industries in these countries since both are major maritime nations.

Many developing countries prioritize economic products, and the Philippines is also interested in fisheries production, which can affect the national economy. Climate change has become an important issue in the Philippines as it has a great impact on fish populations. The Philippines highlights these potential impacts and is trying to deal with them. Therefore, the impact of climate change on fisheries in the Philippines will be examined in the dissertation. Korea, which has achieved some degree of economic growth, is interested in qualitative improvement in its fisheries products, focusing on consumer behavior such as food choice as well as quality control to maintain customer satisfaction and loyalty. In this dissertation, the seafood system, which is related to food safety in Korea, will be examined, and local branding as part of the competitiveness development of Korean seafood will be discussed.

The dissertation consists of three essays on fisheries economics, using economic methodologies to examine important issues in communities related to fisheries. The first essay addresses the projected economic impact of climate change on marine capture fisheries in the Philippines and examines the impact in the Philippines using an economic model to elaborate and project the effects on the national economy related to climate change, focusing on marine capture fisheries. The second essay discusses the seafood traceability system in Korea. There has been growing dissatisfaction with the food system as it relates to seafood in Korea, so government organizations are trying to secure food safety through the revitalization of the seafood traceability system. The essay examines the value of seafood traceability in Korea using

contingent valuation. The third essay examines the regional brand value of seafood in Korea. Korean organizations are trying to improve the competitiveness of fishery products by working to make domestic products competitive through the use of local branding. The essay examines the effects of local brand, focusing on geographical indication labels.

Three Essays on Fisheries Economics

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A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

at the

University of Connecticut

2019

APPROVAL PAGE

Doctor of Philosophy Dissertation

Three Essays on Fisheries Economics

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University of Connecticut
2019

ACKNOWLEDGEMENT

I would like to thank Professor Robert Pomeroy whose wisdom and perspective kept me focused and motivated throughout my graduate school career. Thanks to his direction, I was able to overcome many challenges in my studies. His advice profoundly influenced my world view and will continue to guide my life after graduation. I was fortunate to meet him and it was a privilege to work with him.

I also owe thanks to Professor Min Seong Kim and Professor Jungbin Hwang for their guidance of my dissertation as committee members. While very busy, they always made time to assist me and provided me with sincere encouragement. I was able to complete my dissertation due to these exceptional committee members.

I am indebted to the Agricultural and Resource Economics and Marine Science Departments for their help. I especially thank Professor Farhed Shah for sharing his technical expertise. He was kind to me from the start of the program to graduation. I also thank Professor Nathan Fiala and Professor Emma Bojinova with whom I worked. Their friendship made my graduate life more enjoyable. Additionally, I thank Professor Kimberly Rollins, Sandro Steinbach, Professor Richard Dunn and Professor Charles Towe for broadening my knowledge with their instruction and guidance. Similarly, I thank Claire Bazzano and Karen Nye for their help throughout graduate school.

Of course, I owe endless gratitude and thanks to my family. My parents have always supported my aspirations and I hope my dissertation makes them proud. Above all, I thank my wife, Suji, who provided unconditional love and support. I could not have completed my graduate studies without her. I also thank my daughter, Michelle, who is an endless source of joy and happiness in my life.

Thank you to everyone who helped me complete my dissertation and graduate school. Finally, I give thanks to God for blessing my life so abundantly.

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Introduction

1.1 THE IMPORTANCE OF FISHERIES

1.1.1 FOOD SUPPLY

Fisheries provide a good source of high-quality protein and other essential nutrients (Prein &Ahmed, 2000; Irz et al., 2007). In particular, people in developing countries depend heavily on fish for protein intake (Kent, 1997), which acts as one of the strongest ameliorators of poverty. According to the percentage of fish as share of animal protein, countries like the Maldives (83%), Indonesia (65%), and Ghana (57%) consume more than half their protein in fish, and in countries like the Philippines (42%), Thailand (42%), Fiji (42%), and Malawi (36%), fish make a major contribution to animal protein intake (FAO, 2013).

Developed countries, however, consume fish primarily for taste and good health rather than protein. Fish products are easily digested and have a different taste and flavor than meat, making them a favorite among gourmets (De Silva & Anderson, 1994). Some high-quality fish are in high demand even though they are sold at higher prices than meat. For one thing, fish is known as a healthy food, and more people are buying it for good health. In particular, because the iron and long-chain omega fatty acids found in fish are known to benefit the development of the fetus (Daniels et al., 2004; Singh, 2005; Cox & Phelan, 2008), fisheries products are very popular with pregnant women, and omega-3 fish oils are also sold as nutritional supplements.

Likewise, fish play an important role in both developing and developed countries in terms of food supply (FAO, 2018). In addition, if effective management is achieved, it is expected that fisheries can be a stable food resource that can expect continuous production in terms of renewable resources. Fish are expected to make a positive contribution to future food security, especially for developing countries, since fish resources can be an efficient source of food resources since these require low input cost in terms of common properties and open access (Chuenpagdee et al., 2005; Conrad, 2010).

1.1.2 ECONOMIC CONTRIBUTION

Fisheries have a positive impact on a country's economy. In the Marshall Islands, fisheries contributed about 14.1% (valued at 26,300 USD) to the country's gross domestic product (GDP) in 2014 (Pacific Community, 2015). In the United States of America (USA), fisheries contribute less than 1% of GDP, but about 97 billion USD to GDP including commercial fishing, the seafood industry, and recreational fishing in 2015 (NOAA, 2017, Sep. 29).

According to a Food and Agriculture (FAO) report, in 2016, about 59.6 million people were engaged in the primary sector of fisheries including capture fisheries (19.3 million) and aquaculture (40.3 million), and employment has been on the rise for the last 20 years (FAO, 2018). Primary industries account for a relatively large proportion of developing countries compared to developed countries, and fisheries also constitute a major industry responsible for people's livelihood along with agriculture. In 2016, the regions with the most people engaged in fisheries in the world were Asia (85%) and Africa (10%) (FAO, 2018).

Fisheries are also a means of trade for many countries. About 60 million tons of fisheries products were exported, which is equivalent to 142.53 Billion USD (FAO, 2018). In the last 40 years, fisheries exports have increased steadily, especially in developing countries and, in particular, fisheries exports from developing countries grew relatively faster (FAO, 2018). These industries contribute to job and income creation through exports, and have become an important means of growth and development in many developing countries (Bellmann et al., 2016).

1.2 MAIN ISSUES OF FISHERIES

1.2.1 NATURAL AND ENVIRONMENTAL ISSUES

Climate change is one of the major factors influencing fish population changes. Metabolic activity in fish is expected to rise by 10% for each 1 ℃ increase in the temperature of water (Biswas et al., 2005), but climate models indicate that oceanic dissolved oxygen concentration is reducing on the whole, as demonstrated by the expansion of the oxygen minimum zone due to global warming conditions (Matear & Hirst, 2003; Stramma et al., 2008). This implies global warming will eventually drive the ocean into anoxia in certain areas. Theories indicate that change in temperature and chemistry of the world's oceans affect higher functions of fish, such as muscular activity, growth, and reproduction (Pörtner & Knust, 2007; Sumaila et al., 2011).

This phenomenon is especially prominent during a period of global warming since fishes in warmer water are expected to have a smaller maximum body size and smaller size at first maturity (Kolding et al., 2008; Sumaila et al., 2011). Small fishes are less able to cope with environmental fluctuation (Anderson et al., 2008), and these fishes living in warmer environments have higher natural mortality rates (Sumaila et al., 2011). A few studies deal with ecological responses of particular species to climate change focusing on ecological effects including distribution shift. There are threshold temperatures for fish in that the magnitude and duration of high temperature affect thermal stress in fish, leading to the thermal maximum or thermal minimum (Bevelhimer & Bennett, 2000; Beitinger et al., 2000). Studies in the literature show that there are certain conditions thermally more fit for survival for each fish species, but ongoing climate change can be a major challenge to fisheries.

While pollution is a threat to the lives of fish due to human behavior, climate change has affected the environment of fish life regardless of human intervention. Fertilizers coming directly into river or lake waters produce nitrogen and phosphorus, but excessive ingredients cause overpopulation of algae, which leads to low oxygen levels, resulting in conditions inhospitable to fish (Ghosh & Bhat, 1998; Vaccari, 2009). Chemical substances, such as herbicides and pesticides introduced into water, are extremely harmful to fish, resulting in reduced mortality and populations (Cooper, 1993; Rao, 2006). Some of the drugs that humans consume are excreted, but pharmaceuticals that are not removed from the wastewater treatment plant adversely affect fish (Tauxe-Wuersch et al., 2005; Gros et al., 2010).

1.2.2 FAILURES TO MANAGEMENTS

The most common fish problem that people have caused is overexploitation. Fishery resources have traditionally been considered a common property. They are considered to be renewable resources since fish have traditionally reproduced naturally, so in people's perception, they have been resources that can be obtained without restrictions. However, advancements in technology, such as vessel manufacturing technology and fish detection, as well as the development of advanced method fisheries, have made it easier to move around and catch fish (Valdimarsson & James, 2001), while allowing indiscriminate overfishing under conditions of open access, leading to the failure to manage fish populations. As a result, since these conditions of inadequate control have led to the depletion of resources, there has been a sharp decline in the population of fish in some regions.

The regulation of fisheries is one of the spheres of economic policy that needs to consider economic rationality and procedural justice (Turvey, 1964). In fact, monitoring the activity of fishing and maintaining fish stocks has been widely accepted by society (Beddington & Rettig, 1983). However, the allocation of fishing rights is fundamentally a political matter, and the process of regulation depends on the provision of laws in relation to fisheries (Royce, 1996; Hatcher et al., 2000). The necessary decisions can give one group an advantage and give others a disadvantage, since benefits are not uniformly distributed (Royce, 1996).

1.2.3 FOOD AND RELEVANT INSTITUTIONAL ISSUES

As exchanges between countries increased, so did the amount of food traded, and as a result, in many countries, concerns have grown about foods that do not meet hygienic requirements or imported from countries that do not have food safety systems. Fisheries products are also among the items of high concern for food safety since seafood is a perishable food that is difficult to store and control and has been the cause of many food-borne illnesses and outbreaks (Huss et al., 2000; Abila, 2003; Schröder, 2008).

Fish have been the vehicle of transmission for some pathogens (Heinitz et al, 2000) and caused some of the incidents of disease, such as staphylococcal intoxication, cholerae, and hepatitis A (Bryan, 1980; Halpern & Izhaki, 2017). Since these epidemics directly affect human health and require social costs to solve the relevant problems, prevention of this process has been a concern of society. In addition, since some infectious diseases also affect fish themselves, fish populations might be influenced by epidemics—in particular, ornamental species need careful attention because these are very vulnerable to infectious diseases (Evans & Lester, 2001; Kent et al., 2009; Tripathi, 2014). As the trade in fisheries among countries has increased, so have concerns in relation to aquatic epidemics (Mumford, 2002; Kimball et al., 2005).

1.3 FISHERIES ECONOMICS

Fisheries economics is a field of economic research, and it has been recognized from the inception of modern fisheries economics in the early 1950s (Munro, 1992). Fisheries products are also among the goods traded in the market, so the discussion of production and consumption in relation to fisheries is also significant for fisheries economics. For producers, the main interests are to increase profits and improve productivity. Productivity of fisheries has made great progress in technology and production has increased significantly (Valdimarsson & James, 2001; Eigaard et al., 2014). The expansion of productivity is not much different from other foods, but the unique feature of fish that distinguishes them from other products is that fish are an open access resource (Chuenpagdee et al., 2005). Traditional fishery economics dealt mainly with the issues of the catch of fish and overexploitation in terms of fishery management and bioeconomics (Gordon, 1954; Morey, 1980; Conrad, 2010). Fisheries are renewable resources with self-regeneration capacity, but require harvest decisions due to changes in fish stock and the possibility of depletion (Conrad & Clark, 1987; Conrad, 2010; Tietenberg & Lewis, 2016). Therefore, overexploitation arose in the process of solving the profit maximization problem in terms of present state and efficiency (Clark, 1973; Conrad, 2010).

The development of aquaculture has the effect of increasing the supply of fisheries products and at the same time lowering production prices and contributes to the decrease in the motivation for fisheries overexploitation (Anderson, 1985; Natale et al., 2013). Over the last three decades, world fish production of aquaculture has expanded by 12 times, at an average annual rate of 8.8% (FAO, 2012). Aquaculture accounted for 18.5% of the total fish production in 1990 (Chuenpagdee et al., 2005), but reached 46.8% in 2016 (FAO, 2018). Aquaculture has been accompanied by issues of management since it requires the consideration of operation for efficient production, such as water storage, soil fertility, and pest management (Lightfoot et al, 1993).

Fisheries economics covers a wide range of subjects about consumption, from classic factors that affect market demand in relation to fisheries such as fisheries' price, consumers' income, and substitution of fisheries (Gates, 1974; Dupont, 1991; Johnston et al., 2000; Roheim et al., 2011; Asche et al., 2015) to consumers' preferences and behavior related to food choices in the fisheries product market (Nielsen, 1999; Olsen, 2003). Also, food safety has become a key issue in the study of market demand due to one characteristic of fisheries—fish spoil comparatively easily so they are hard to manage. With a rise in the interest in food safety, the analysis of consumers' preferences is being performed with policy-relevant issues, such as ecolabelling, traceability, and quarantine, which is related to the quality and cleanliness of seafood (Wessells et al., 1999; Antle, 2001; Moretti, 2003; Broughton & Walker, 2010; Anderson et al,2012). In addition, studies on ornamental fish or recreational fishing as related to consumer enjoyment are also being carried out (Toivonen et al., 2004; Alencastro et al., 2005).

In addition, fisheries economics has expanded its area of study beyond the focus on product to other areas, such as climate change. Climate change is a vast subject as ocean warming is resulting in shifts in the distribution of species and is affecting the productivity of fish stocks and underlying marine ecosystems (Sarmiento et al., 2004; Cheung et al., 2010). It can also affect the economy of the country because economic impacts from climate change depend primarily on the rate and magnitude of change in climate attributes and the effect on fisheries of these changes (Sumaila et al., 2011). In addition, some studies suggest that ocean acidification may have large potential impacts on fisheries resources (Cooley & Doney, 2009; Narita et al., 2012). These changes may lead to not only loss of productivity, but also decrease in the opening of new fishing opportunities because there can be indirect effects, such job reduction, depending on decreases in fishing grounds (Lam et al., 2012).

1.4 THE OVERVIEW OF THREE ESSAYS

The dissertation encompasses applied fisheries economics, focusing on policy-relevant issues related to the fisheries. It mainly deals with economic growth, food safety, and local branding issues, and the target regions of studies are Philippines and Korea. The result of the study may mean a lot to other countries regarding fisheries, since both countries are among major maritime nations.

Many developing countries prioritize economic products, and the Philippines is also interested in fisheries production that can affect the national economy. As climate change has great effect on fisheries population, climate change has been considered important in the Philippines. Philippines highlights the potential impacts of climate and tries to deal with the effects of climate change. So, impact of climate change on fisheries related to Philippines will be examined in the dissertation. Korea, which achieved some degree of economic growth, is interested in qualitative improvement of fisheries product focusing on consumer behavior, like food choice and quality control, to maintain customer satisfaction and loyalty. In this dissertation, seafood system, which is related to food safety in Korea will be examined, and local branding as part of competitiveness development of Korean seafood will be discussed.

The dissertation consists of three essays on fisheries economics incorporating economic methodologies with important issues in communities related to fisheries. In section 2, the essay covers projected economic impact of climate change on marine capture fisheries in the Philippines. The impact of climate change on fisheries has a great ripple effect and it can lead to economic shock on the nation's economy. This essay examines the impact in the Philippines using economic models to elaborate and project the national economy related with climate change, focusing on marine capture fisheries.

In section 3, the essay covers evaluation of seafood traceability systems in Korea; the regional brand value of seafood in Korea. Despite high consumption for seafood, there has been growing dissatisfaction toward the food system related to seafood in Korea. Accordingly, the Korean government tried to secure food safety by revitalization of a seafood traceability system. This study examines the value of seafood traceability in Korea using a contingent valuation method.

In section 4, the essay covers the regional brand value of seafood in Korea. Recently, the Korean government tried to improve competitiveness of fishery product as the outlook of fisheries seems dark. As part of that effort, they try to make domestic products competitive by building up brand power. This paper examines the effect of geographical indication labels on the purchase of farming fishery products in Korea.

Last, in section 5, the dissertation includes a summary and implication of the three essays. In this section, the future perspectives for fisheries system development will be discussed, based on an economic point of view.

2

Projected Economic Impact of Climate Change on Fisheries in the Philippines

2.1 INTRODUCTION

The Philippines, a maritime nation that is a complex of peninsulas and islands, comprises 7,641 islands and has the territorial sea that covers 679,800 km^2 and Exclusive Economic Zone (EEZ) of 2,263,816 km^2. Most parts of the Philippines are coastal areas, and about 70 percent of Filipinos are estimated to live in coastal areas (Palomares & Pauly, 2014). Fisheries have a great significance in terms of food security and economy in the Philippine (Santos et al., 2011). There is a need to secure the food supply to keep feeding people as poverty has remained continuously high and the population has grown in the Philippines. Fisheries are a strategically important factor because it has a positive nutritional effect as a source of necessary protein and essential nutrients (Prein & Ahmed, 2000; Irz et al., 2007). Total fish consumption has been rising steadily with increases in production (Cuvin-Aralar et al., 2016).

The fisheries in the Philippines makes a significant contribution to the national economy in terms of income and employment. Total fish production was estimated at 4.65 million metric tons, and the fisheries sector contributed almost 4.33 billion dollars to the country's economy in 2015 (BFAR, 2016). The fisheries sector employed an estimated 1.6 million people national wide, contributing 1.5% to the gross domestic product (GDP) in 2015 (BFAR, 2016; PSA, 2017a).

According to an FAO report, the Philippines places eighth globally in fish production, as of 2014, and is a key economic sector for the country (BFAR, 2016).

Climate change has been considered particularly important for fishing nations (Kelleher et al., 2009, Barange et al., 2014), but discussion of climate change and impact on fisheries is also a key issue for the Philippines (Santos et al., 2011; Geronimo 2018). These changes may cause not only loss of productivity, but also economic shock on the nation's economy. Since climate change is expected to have different consequences, impacts can be related to vulnerability in countries heavily dependent on fishery, in view of the important contribution of these sectors to employment, supply, income and nutrition (Vannuccini, 2018). The Philippines is actually vulnerable to the impacts of climate change on fisheries and it can lead to economic shock on the nation's economy. Among fishing nations, Philippines is one of the most vulnerable countries to climate change (Badjeck, 2010; FAO, 2016). The Philippines is third in the ranking of vulnerability to climate change risks among 67 developed, emerging and frontier market countries, and is particularly very sensitive to extreme weather events in terms of people affected and economic costs (Paun et al., 2018).

In spite of the importance of economic analysis with regards to the impact of climate change on fisheries, few studies have examined impacts on fisheries, and things are not much different in Philippine. These studies also have been limited to direct effect of change in catch without attempts to carry out economic effect on society as a whole due to change in production. Since fisheries is intimately related to various economic sectors, such as transportation, storage, processing, it is necessary to elaborate a systematic model to understand the economic impact of climate change on fisheries throughout an economy.

In this paper, a computational general equilibrium model is developed to examine how climate change may affect the marine capture fishing sector in the Philippines and consequently how the economy may react to the change. The paper will contribute to the current discussion of climate impacts in the ocean of the Philippines, adding dimensions to macroeconomic interpretations of impact on fisheries focusing on marine capture fish[1] which can be relatively more affected by climate change.

2.2 CLIMATE CHANGE AND THE OCEAN IN THE PHILIPPINES

Climate change is an important thread in the tapestry of earth's history along with the evolution of life and the physical transformations of this planet (Ruddiman, 2001). The study of climate in fisheries also matters for a practical reason: climate is a primary determinant of fish population (Lehodey et al., 2006). Changes in climate condition and shifts in the distribution of species are closely related to the productivity of fish stocks (Perry et al., 2005; Munday et al.,2008; Nilsson et al, 2009; Pankhurst & Munday, 2011; Pratchett et al., 2014). Climate change causes the change of oceanic currents and consequently affects the environment for fish: areas that have favorable conditions increase resulting in expansion in species' range and the growth in population; areas where favorable conditions exist may move, causing a population's numbers to decline in certain areas and increase in others, effectively shifting the population's range; and favorable conditions for a species may disappear, leading to a population crash and possible extinction (Roessig et al., 2004; Ganachaud et al., 2011; Stock et al., 2011; Dunne et al., 2012; Dunne et al., 2013).

[1] Capture fisheries includes not only marine capture fisheries but also inland capture fisheries. This paper focuses on marine capture fisheries which is dominant in capture fisheries – according to fisheries situation report (PSA, 2014), it shows 95% of capture fisheries.

Increase in temperature on the Philippines seas has been reported by several studies (Peñaflor et al. 2009; Pörtner et al., 2014; Khalil et al. 2016; Hoegh-Guldberg et al., 2017; Geronimo, 2018). Sea surface temperature in the sea near the Philippines shows upward trend with the warming rate of 0.2°C per decade over the period 1985-2017, based on 0.05° resolution satellite-based sea surface temperature data (Peñaflor et al. 2009; Khalil et al. 2016). The warming trend is not spatially identical for the Philippines and the warming rate varies by region. The warming rate in the West Philippine Sea bordering the west-central part of the Province of Ilocos Norte shows a faster rate while the rate in the sea surrounding Palawan Island and the sea between Catanduanes Island and Samar Island shows slower compared to other sea areas in the Philippines (Khalil et al. 2016). The forecasting model of warming with a scenario of greenhouse gas (GHG) concentration mitigation under the phase 5 of Coupled Model Intercomparison Project (CMIP), which is collaboration between climate modeling groups for the purpose of advance in knowledge of climate change, indicates that sea surface temperature in the Philippine will increase around 0.36°C up to 2100, noting that the majority of this warming will happen over the next 30 years (Khalil et al. 2016).

The use of linear regression from CMIP5 provides projected changes in SST around the Philippines including the Coral Triangle in the next 90 years. Increase in SST ranges from 0.42°C to 0.76°C for near-term, and 0.58°C to 2.95°C for a long-term, depending on level of GHG concentrations and mitigation (Hoegh-Guldberg et al., 2017). Climate model simulations driven with historical changes in anthropogenic and natural drivers, historical changes in natural drivers without anthropogenic drivers, scenario of RCP4.5 and the RCP8.5 from the average of Hadley Centre Interpolated sea surface temperature 1.1 data from 1986 to 2006, also presents increase in SST around Philippines including coral triangle, comparing historical and unforced natural temperature trends with scenarios of RCP2.6 and RCP8.5 which are related to (GHG) concentration (Hoegh-Guldberg et al., 2017; Pörtner et al., 2014).

2.3 ECONOMIC REVIEW ON IMPACTS OF CLIMATE CHANGE ON FISHERIES

Many empirical studies in oceanography, physiology and ecology began to deal with the relationship between fisheries and climate due to the growing need for extension of the discussion about continued climate change (Brander, 2007; Barange & Perry, 2009), but few studies cover the economic impact on fisheries. Several studies have argued that climate change affects the amount of catch in business terms. Cheung et al. (2010) present maximum exploitable catch of a species under climate change using a dynamic bioclimate envelope model. They demonstrate climate change considerably affects the distribution of catch potential leading to potential fisheries productivity. Their estimation shows that catch potentials will fall in many coastal regions, particularly in the tropics and the southern margin of semi-enclosed seas, since species are expected to move away from the regions due to rising temperature in the ocean. Lam et al. (2016) demonstrate the impacts of climate change on global fisheries revenues. They argue climate change will have a negative impact on the maximum revenue potential of most fishing countries. It was found that coastal Low-Income Food Deficit Countries (LIFDC) are heavily dependent on fish catches as a way of meeting their nutritional needs but almost every coastal LIFDC is in danger of decrease in the maximum revenue potential. Merino et al. (2011) examine the synergistic effect of climate variability and production of fish with estimation of maximum sustainable yield. They put emphasis on global management measures to achieve optimized global supply of marine products, suggesting interaction between global markets and regional climate may be acting as a factor causing sequential overexploitations and resource depletion.

Few studies have analyzed the economic impacts of climate change on fisheries dealing with the national economy. Arnason (2007) estimated the impact of global warming on fish stocks in Iceland and Greenland using Monte Carlo simulations. The result shows positive impact on GDP in Iceland and Greenland. Ibarra et al. (2013) examined economic impacts of climate change in Mexican coastal fisheries in terms of shrimp and sardine fisheries. They found climate change causes a decrease in shrimp production and a high degree of variability and uncertainty of sardine fisheries stocks.

This paper will make several contributions to this literature. First, this study analyzes the impact of climate change in fisheries from the perspective of the economic modelling. It estimates the impact of climate change adding dimensions to macroeconomic interpretations of impact on marine capture fisheries. Few studies deal with the economic impact of climate change on fisheries, but even these studies focus on changes of catch in terms of productivity with simplistic calculations. Thus, the evidence for projection is limited. This study covers the potential causes of economic impact other than production associated with climate change. This paper also presents an economic impact which includes notable indicators with estimation using major national economic variables, so it can be useful in establishing economic mechanism related to fisheries.

Second, the study examines the economic impact of climate change on fisheries for a specific country rather than at a global level. Climate change impacts will differ from region to region and country to country. Some regions will get warmer well above the average, in contrast, others may not get warmer or may even get colder (Arnason, 2006). In addition, the economy of each country has different characteristics. This study carries out modelling specific to the Philippines so that the results obtained will prove helpful in decision-making related to adaptation options.

2.4 METHODS

2.4.1 CONSTRUCTION OF MODEL

In this paper, the model estimates the impacts of climate change constructing future scenarios including one baseline scenario and two climate scenarios for the Philippines. The baseline scenario depicts how the economy of the Philippines might be expected to change if the condition related to climate were not changed. Climate scenarios are based on the Representative Concentration Pathways (RCP) which describes trajectories of greenhouse gas concentration, provided by the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC, 2013). One of climate scenarios assumes RCP 2.6 which is a scenario of strong mitigation (Scenario A) and the other one assumes RCP 8.5 which is a scenario of comparatively high greenhouse gas emissions (Scenario B).

The model employs the method of the projected change in maximum revenue potential (MRP) which is explained by Lam et al. (2016). MRP in the study implies the potential change in revenue, which can be expected under climate change scenarios, resulted from the change in the amount of fish catches due to climate change. The combined outputs of coupled atmospheric-ocean physical and biogeochemical Earth System Models (ESM) with Dynamic Bioclimate Envelope Models (DBEM) and outputs from three ESMs that are available for the Coupled Models Intercomparison Project Phase 5 (CMIP5): the Geophysical Fluid Dynamics Laboratory Earth System Model 2 M (GFDLESM2M,) the Institute Pierre Simon Laplace (IPSL) (IPSL-CM5-MR) and Max Planck Institute for Meteorology Earth System Model (MPI-ESM MR) (Method) were used , employing the model described in Sarmiento et al. (2004), and Cheung et al. (2010). In the model, projected revenue is calculated by the product of ex-vessel price and maximum catch potential. The model assumes that real ex-vessel price is constant for the study period with the fact that the real ex-vessel prices have remained relatively stable since 1970. Maximum catch potential is derived from the product of projected fishing mortality required to achieve the maximum sustainable yield and projected biomass. Since projected fishing mortality is required to achieve the maximum sustainable yield approximates natural mortality rate of the stock, change in revenue is determined by change in biomass. So, in this paper the trend of production is subject to the trend of MRS, assuming production is proportional to biomass *ceteris paribus*.

The climate change involves large changes that are well outside of historical experiences. This suggests the need to use simulation techniques of some kind. The simulation is based on the computable general equilibrium (CGE) model which is a system of equations that describes an economy as a whole and the interactions among its parts. The CGE model is primarily used to simulate and assess the structural adjustments, undertaken by economic systems, as a consequence of shocks, like changes in technology, preferences or economic policy (Berrittella et al., 2006). In the context of the study, climate change works as the shock which affects the economy since increases or decreases in catch is directly connected to supply level and production in the fishing industry and fisheries sector.

CGE has the advantage of analyzing direct and indirect impacts on the nation's economy and estimating how an economy might react to changes because it provides a before and after comparison of an economy when a shock, such as a tax, causes it to reallocate its productive resources in more or less efficient ways (Burfisher, 2017). Static models can tell a powerful story about the ultimate winners and losers from economic shocks, but it cannot represent the object interactions over time, so dynamic CGE model is considered an appropriate model since climate change is not just a one-off shock.

Dynamic CGE has the advantage of reflecting adjustment process in a recursive dynamic framework. The earliest forms of dynamic CGE were carried out by Hudson and Jorgenson (1974) and Adelman and Robinson (1978). Dynamic CGE has become common in forward-looking expectation since Ballard et al. (1985) performed dynamic CGE model for the analysis on tax policy. Recently, the model is often used to figure out the economic effect related to environment such as pollution abatement (Dellink et al., 2004; Dessus & Bussolo, 1998), environment tax (Wendner, 2001; Kumbaroğlu, 2003; Siriwardana et al., 2011), and climate change (Robinson et al., 2012; Eboli et al., 2010). In this paper, the iterative method is used and the updated dataset provided by the simulation of the current period is used for the simulation of the next period, so that each solution is solved in a recursive year-on-year framework (Figure 2.1). Through the analysis, it can derive intuitive economic indicators such as change in GDP, income and balance of trade, according to climate change.

Supply

The model covers economic features that reflect the characteristics of the Philippines and the structure follows the approach of Dervis et al. (1982), Robinson (1989), Shoven and Whalley (1992), Ginsburgh and Keyzer (1997), and Lofgren et al. (2002) based on neoclassical perspective. On the side of supply, the model is established under the assumption of profit maximization. Production involves information of input-output based on factors of production and has flexibility for substitution between the labor and capital. The model assumes a Cobb-Douglas production function for the technology in the production process, so the function is homogeneous of degree one and it has constant returns to scale. The formula for production function can be represented as follows:

$$QA_a = ad_a \cdot \prod_f QF_{fa}^{\alpha va_{fa}} \tag{2.1}$$

where ad_a is production function efficiency, αva_{fa} is value-added share for factor f in activity a, QA_a is production activity level, and QF_{fa} is quantity demanded of factor f by production activity a.

In the model, domestic and export commodity have a constant elasticity of transformation (CET). In other word, the distribution of theses commodities is modeled in the form of CET function, so output transformation can be represented by the function of the quantity of exports and the quantity of domestic output as follows:

$$QX_c = at_c \cdot (\alpha tr_c^t \cdot EX_c^{\rho_c^t} + (1 - \alpha tr_c^t) \cdot QD_c^{\rho_c^t})^{1/\rho_c^t} \tag{2.2}$$

where at_c is shift for output transformation, αtr_c^t is share for output transformation, ρ_c^t is exponent for output transformation, QX_c is the quantity of domestic output, QD_c is the quantity of domestic output sold domestically, and EX_c is the quantity of exports.

Market is represented by perfect competition. Consequently, incidental assumptions are required to develop the model. If price of an input changes then the quantity of the output sold alters, and that affects demand for the input (Hoffmann, 2003). The model assumes the impact of input price is insignificant and firms do not make economic profit, not measuring elasticity of demand which reflects the market power that firms have.

Demand

On the side of demand, the model consists of household, government and the foreign sector reflecting the consumption of domestic good and imported good. Households are classified depending on region. They are divided into two groups: urban and rural household. The government of the model has similar expenditure to the household and gets money through taxation and consumes commodity quantities paying market prices and transfers to households according to the expenditure function. Foreign sector in the model also purchases domestically produced commodity.

The demand side can be represented by the combination of domestic commodity use as follows:

$$\boldsymbol{QD_c = \sum_a IC_{ca} + \sum_h QH_{ch} + gdo_c + QI_c} \tag{2.3}$$

where QD_c is domestic sales of domestic output, IC_{ca} is intermediate use of commodity c by activity a, QH_{ch} is quantity of consumption of commodity c by household h, gdo_c is government demand for commodity, and QI_c is investment demand.

Armington assumption is used for determination of the combination of domestically produced commodity and imported commodity reflecting responses of trade to price changes. Composite supply takes the form of Armington function as follows:

$$\boldsymbol{QQ_c = aq_c \cdot (\alpha co_c^q \cdot IM_c^{-\rho_c^q} + (1 - \alpha co_c^q) \cdot QD_c^{-\rho_c^q})^{-1/\rho_c^q}} \tag{2.4}$$

where QQ_c is quantity supplied to domestic commodity demanders, aq_c is shift parameter for composite supply, αco_c^q is share parameter for composite supply, ρ_c^q is exponent ($-1 < \rho < \infty$) for composite supply, and IM_c is quantity of imports, and QD_c is domestic use of domestic output. Due to the equilibrium of demand and supply (i.e., $QD_c = QQ_c$), the demand side is connected with Armington assumption.

Government

Government also plays a role as a economic agent in general equilibrium. Government consumes commodities while it obtains revenue by collecting tax and transfer. Government revenue and expenditure are represented as follows:

$$\boldsymbol{YG = \sum_h tdh_h \cdot YH_h + CR \cdot tr_{g,r} + \sum_c tco_c \cdot \left(PD_c \cdot QD_c + (PM_c \cdot IM_c)_{|c \in CM}\right)}$$

$$\boldsymbol{+ \sum_c tim_c \cdot CR \cdot pm_c \cdot IM_c + \sum_c tix_c \cdot CR \cdot pe_c \cdot EX_c} \qquad (2.5)$$

where YG *is* government revenue, tdh_h is the income tax rate of household, $tr_{g,r}$ is transfer from government to rest of world, tco_c is the rate of consumption tax, tim_c is the tariff rate on import, pm_c is import price, tix_c is the rate of tax on exports, pe_c is price of exports, CR is the exchange rate, PD_c *is the* price of domestic output, QD_c is the quantity of domestic output sold domestically, PM_c is the price of imports in domestic currency, IM_c is the quantity of imports, and EX_c is quantity of exports.

$$\boldsymbol{GX = \sum_h tr_{h,g} + \sum_c gdo_c \cdot PC_c} \qquad (2.6)$$

where GX *is* government expenditure $tr_{h,g}$ is transfer from household to government, gdo_c is government demand for commodity, and PC_c is price of composite commodity c.

Market Clearing

In the CGE model, some constraints are considered for the equilibrium. One of important constraints is the market clearing, so the model assumes market clearing in the factor market and the commodity market. The condition of the factor market clearing can be represented by the equality of supply and demand of factor as follows:

$$\boldsymbol{FS_f = \sum_a QF_{fa}} \qquad (2.7)$$

where FS_f is supply of factor f and QF_{fa} is quantity demanded of factor f by activity a.

The condition of the commodity market clearing comes from relationship between equation (2.3) and (2.4), and it can be represented as follows:

$$\boldsymbol{QQ_c = \sum_a IC_{ca} + \sum_h QH_{ch} + gdo_c + QI_c} \tag{2.8}$$

where QQ_c is quantity supplied to domestic commodity demanders, IC_{ca} is intermediate use of commodity c by activity a, QH_{ch} is quantity of consumption of commodity c by household h, gdo_c is government demand for commodity, and QI_c is investment demand.

2.4.2. DATA

In the study, the one country, multi-sector and recursive CGE model is constructed. For the analysis, information of the value of all transactions in an economy is required. Thus, it is necessary to utilize a social accounting matrix (SAM) which indicates a logical framework of rows and columns providing a visual display of the transactions as a circular flow of national income and spending in an economy (Burfisher, 2017). In this study, the model uses SAM by modification of the 2013 Social Accounting Matrix from the compilation of the Agricultural Model for Policy Evaluation which is constructed by Briones (2016). It provides a set of transactions between fisheries, industry and service sub-sectors in the Philippines. The SAM includes the primary sector, the manufacturing and industry sector, the service sector, and the public sector. The primary sector encompasses the capture fisheries and aquaculture fisheries and other primary sector such as the agriculture. Parameters are drawn from SAM with econometric analysis, and the effect of marine capture fisheries is calculated by interpolation because values of capture fisheries sector are aggregated in the SAM. The modelling[2] is based on standard hypotheses of CGE and the model is solved in Generalized Algebraic Modeling System (GAMS).

2.5 RESULTS

2.5.1 CLIMATE CHANGE AND FISHERIES

Linearly calculated trends based on the projected change in MRP are put into the production in the capture fisheries sector data assuming functions in the models are the same. To calculate change in production of fisheries, it is necessary to determine the latitude of the Philippine in the Pacific Ocean. The Philippines extends 1,150 miles from north to south and has a comparatively wide range of latitude with reference to Manila (about 14.5°). Initial general equilibrium is constructed from production of capture fisheries in initial data, and the new states are applied by reflecting changes in production repeatedly.

As the capture sector is a subsector of primary industry and products in the capture sector are not an intermediate product which are value added, the effects of marine capture are estimated by calculation of the share of marine capture in the total effects of capture, with the assumption that the marine capture sector and other capture sectors such as freshwater capture do not affect each other's sector.

2.5.2 PHILIPPINES ECONOMY

In this paper, GDP is calculated by sum of the value of final demands and net exports as follows:

[2] The model includes 27 equations to form the system. Most parameters, variables and equations and the code for the model are developed based on Lofgren (2003) and Lofgren et al. (2002) following the neoclassical structure which is well-developed by Dervis et al. (1982).

$$\boldsymbol{GDP} = \sum_h \sum_c \boldsymbol{PC_c\, QH_{c,h}} + \sum_a \sum_c \sum_h \boldsymbol{CA_{ac} QHA_{ach}} + \sum_c \boldsymbol{PC_c QG_c} + \sum_c \boldsymbol{PC_c\, QI_c}$$

$$+ \sum_c \boldsymbol{PC_c qst_c} + \sum_h \sum_c \boldsymbol{PC_c\, QH_{c,h}} + \sum_c \boldsymbol{PM_c\, IM_c} + \sum_c \boldsymbol{PE_c\, EX_c} \qquad (2.9)$$

where PC_c is composite commodity price, QH_{ch} is quantity of commodity consumption by household, CA_{ac} is marginal cost of commodity from activity, QHA_{ach} is quantity of household consumption of commodity from activity for household, QG_c is government consumption demand for commodity, QI_c is quantity of investment demand, PM_c is price of imports in domestic currency, IM_c is quantity of imports, PE_c is price of exports in domestic currency, EX_c is quantity of exports, and qst_c is quantity of stock change.

In the simulations, results show more negative change in economic variables where more extreme changes in climate occur. Since three scenarios are applied in this study, the model focuses on the results on differences in GDP. The result of simulation is shown in Figure 2.2. *Ceteris paribus* except change in production of fisheries resulted from climate change, baseline scenario is normalized in the analysis. Index score of 100 is set based on GDP of baseline specifying 100 as a reference point. So, the score of 100 means the level of GDP in baseline for each year, and scores less than 100 indicate the levels in scenarios are underperforming the comparison in the year. As it shows, higher radiative forcing value causes lower level of GDP compared to baseline scenario assuming no changes in the status quo.

As a result of simulation, GDP is expected to decrease by 0.16% with scenario A and 0.37% with scenario B up to 2060. This state came from direct effect, i.e., reduction in catch in exclusive economic zone and seas in the Philippines leading to dwindling supplies, and indirect effect i.e., effects that came about as other product and factor markets in the Philippines respond to the change in productivity.

For the examination of distributional aspects between urban and rural area, households are grouped by residence. Looking at consumption patterns, the nation's service sector seems most active, and that is especially predominant in urban areas. It is shown that rural households spend more on the primary sector and manufacturing and industry sector compared to urban households. On the other hand, urban households appear to spend more on the service sector. To review the fisheries sector, urban households and rural households are on nearly the same share of household consumption spending on fishery commodities. The share of household expenditure allocated to fisheries indicates about 1.4% (Table 2.1). Urban households spend more on aquaculture products (0.83%) compared to rural households (0.80%), while rural households relatively spend more on marine capture products (0.67%) compared to urban household (0.54%), but there is no significant difference between patterns on the whole.

Table 2.2 presents the household income related with the fisheries sector normalized to 100 for the baseline scenario. *Ceteris paribus*, the result implies that the more global warming, the greater loss of income that will occur. That is to say, climate change has an effect of income reduction. The rate of decrease in income of rural household is 0.163 and 0.372, for scenario A and B respectively; while for the rate of decrease in income of urban household, is 0.160 and 0.360, for scenario A and B respectively.

2.5.3 MARINE CAPTURE FISHERIES SECTOR

Marine capture fisheries in the simulation represents fisheries excluding inland capture and aquaculture. This follows a classification of the fisheries subsector used in the fisheries situation report issued by the Philippine statistics authority (PSA, 2014). According to the volume of fisheries production data in the Philippines (1980-2010), capture fisheries have made up a high percentage (82%) of the total fisheries production for three decades, and the percentage of marine capture fisheries is 89% and that of inland fisheries is 11% among capture fisheries. The percentage of capture fisheries is decreasing recently, because aquaculture is growing. In 2013, capture fisheries accounts for 59% of the total fisheries production in terms of the value of production at constant prices, but based on capture fisheries, marine capture fisheries became more dominant showing 95% of total capture fisheries (PSA, 2014).

Climate change is one of the underlying causes of decrease in production in the marine capture fisheries sector, and the impact of climate change on marine capture fisheries sector is substantial since production is a big part of the economy. In the Philippines, marine capture is currently dominated by roundscad, big-eyed scad, anchovy, Indian oil sardines, Indian mackerel, threadfin bream and tuna species (PSA, 2017a). Production of anchovy is greatly affected by climate change compared to big-eyed scad, Indian mackerel and threadfin bream. Sardine is relatively less vulnerable compared to anchovy but weak upwelling conditions can affect its population. With warmer water and less oxygen available, tuna species in the Philippines (frigate tuna, eastern little tuna, yellowfin tuna, skipjack, bigeye tuna), making 28% of the catch (PSA, 2017a), are expected to decrease due to the shortage of microscopic plants and animals which are an integral part of the tuna food webs (Vousden, 2018).

The marine capture fisheries sector is affected directly by decrease in production while other sectors of the Philippines economy are influenced by only indirect effect. Thus, looking over the marine capture sector, the economic impact of climate change is significant in terms of the ratio. As a result of the simulation, the contribution of marine capture to GDP is expected to decrease by 9.41% with scenario A and 17.95% with scenario B up to 2060 (Figure 2.3).

The decrease in contribution of marine capture to GDP leads to the decrease in income of fishermen. Fishermen in the Philippines, one of the poorest groups in the nine basic sectors, belong to households with income below the official poverty threshold, representing a poverty incidence of 34 percent (PSA, 2017b). Thus, a decrease in contribution of marine capture to GDP has a negative impact on the mitigation of poverty incidence, and that means climate change adds to the social welfare in the Philippines.

Climate change brings negative consequences in terms of rural household income (Figure 2.4). Decreases in productivity leads to income reduction of households engaged in fisheries, dampening profitability of fishing industries. Considering fishermen reside more in rural areas rather than urban areas, it is expected that climate change affects income of rural households more than urban households. Income of rural households is liable to decrease as climate change continues, and it is expected to deepen as climate change becomes extreme.

2.5.4. CAPTURE-AQUACULTURE COMBINED FISHERIES SECTOR

In order to examine the impact of climate change on the production of marine capture fisheries, a simulation about capture-aquaculture combined fisheries is carried out. Capture-aquaculture combined fisheries in this section refers to all kinds of fisheries traded in the Philippine market and Filipino fisheries exported to the world market. As shown by the simulation of the economic sector, GDP of the Philippines is expected to decrease from 0.16% to 0.37% compared to the baseline scenario. In light of the proportion of the fisheries sector (which is about 1.8%) to the national economy, there is a huge amount of influence on the economy. Fisheries GDP is expected to decrease by about 9.27% with scenario A and bout 17.65% with scenario B up to 2060 compared to the baseline (Figure 2.5).

Economic growth is an increase in the production of goods and services due to an improvement in production capacity, and is represented by an increase in GDP. The current Philippines economic data suggests that the fisheries sector will continue to grow due to a rise in demand, an increase in productive capacity, and the development of new technology. Economic growth in fisheries is expected to slow compared to the baseline scenario since climate change brings negative effects. Figure 2.6 shows economic growth in the fishing sector based on capture indicating inflation-adjusted measures in a corresponding year, i.e., the increase in real GDP. As shown in figure 6, the model notes that economic growth in the fisheries slopes upward in all scenarios, but the curves in the scenario A and B show relatively slower economic growth.

Like the marine capture fisheries sector, loss of income affects rural households slightly more than urban households as climate change continues. It implies that climate change can cause urban-rural income disparity. This is because there are more people who work in fisheries in rural areas than urban areas and a decrease in fish catch affects rural household income. Thus, climate change has more negative effect on rural households in terms of fisheries. Figure 7 represents loss in rural household income by scenarios A and B. As shown in the figure, climate change has negative effect of income.

2.6 DISCUSSION

The economy of the Philippines has grown for the last decade, but more than twenty percent of the Philippines population remains poor and the Philippines does not show big dynamism in improvement of economic security, rise in the middle class and even elimination of poverty, compared to other East Asian countries (World Bank, 2016; World Bank, 2018). The problem is that the poor in the Philippines (30.8 percent of the population was economically vulnerable, 18.7 percent was moderately poor, and 6.6 percent of the population was extremely poor) are more vulnerable to negative shocks being exposed to more risks for shortage of resources without ability to cope and capacities necessary to adapt to potential risks (World Bank, 2018). In other words, climate change leads to problems for the collective economy of the Philippines represented by slow economic growth and deterioration of income distribution. In addition, climate change contributes to accelerating the plight of the poor in the Philippines.

The issue related with climate change and fisheries resulting from this study is the slowdown in economic growth in the fisheries sector. The problem is that for poor households in rural regions, a large share of income comes from activities associated with the primary sector (World Bank, 2018). Therefore, it is expected that factors such as climate change will contribute to the plight of the poor in the Philippine due to slow growth of fisheries and the poor's dependency on fisheries sector. The second problem is the fact that negative economic impacts on the fisheries sector may affect fishery resources in Philippines making a vicious cycle since changes in fish abundance and location will cause more completion and conflict for the remaining resources. It would result in a decline in food resources and food security. Decrease in fish products, which are the means of inexpensive and nutritious food supply, causes significant strain on the cost of living of low-Income people in the Philippine due to limited options in terms of food consumption. Thus, poor fisheries productivity caused by climate change is expected to affect the nation's economy but particularly bring hardships to the poor.

2.7 CONCLUSION

This paper examined economic impacts of climate change on fisheries in the Philippines applying the dynamic computable general equilibrium (CGE) model. In the analysis, one baseline scenario and two climate change scenarios based on greenhouse gas concentration were considered. The study focused on GDP and income distribution by sector, which can represent economic conditions in terms of economic growth and distribution.

The climate change impacts on marine capture fisheries in the Philippines is projected to cause a decrease by about 9% of fisheries GDP with the mitigation scenario and about 18% of GDP with the extreme scenario up to 2060, compared to the baseline scenario. This impact results in income reduction by as much as 0.36% for urban households and 0.38% for rural households in the Philippine economy. In addition, urban-rural income disparity increases because loss for rural households is slightly higher than that of urban households.

Climate change will affect the fisheries over a long period of time. Accordingly, it means that the Philippines must prepare itself to get ready for the impact and endeavor to mitigate climate change. To prepare for climate change, the Philippine needs to: i) conduct an assessment of vulnerability to climate change for fisheries at the national level in order to respond to changing economic conditions expected to worsen over time and that the assessment is continuously and periodically carried out; ii) carry out a gap analysis on the capability to cope with the impact of climate change on fisheries for the national economy; the gap analysis enables organizations to take the selective and premeditated actions providing the information about whether a sector or area can potentially be associated with the issue or which community is more vulnerable to climate change; iii) make effective management plans for fisheries to develop adaptation to climate change with the accumulated information in the process - for an effective plan, it is necessary to establish reliable research materials by collecting climate data and fisheries-related information, and these sources should be open to both organizations and the public to help make more informed fisheries management decision; iv) incorporate climate change impacts into national economic development plans and fisheries development plans; and v) incorporate climate adaptation into the fisheries management plan – it should be accompanied by education on climate change that can increase awareness of impacts of climate change and the government advertising campaign against adaptation that can reduce the effect of climate change on fisheries.

Several points are worth noting to contemplate what are the limitations and how they could be extended in future work. The paper assumed perfect competition in the market of the Philippines. In reality, it may be natural to face different types of market structure that do not meet rigorous criteria of perfect competition. It is necessary to incorporate cases of imperfect markets such as price controls, if applicable. It is also necessary to consider the more flexible and complex functional form of analysis, as well as Cobb-Douglas functions, to better reflect the structure of the Philippine economy.

Second, the paper assumed productivity of all sectors except fisheries, which remains constant, i.e., supply of other fields might be altered under the model mechanism, but it does not mean they are directly affected by climate change. The assumption is advantageous for identifying the influence on fisheries, but leaves something to be desired if someone wants to completely examine the state of the economy itself. To improve predictive power of the model and better represent comprehensive economic condition, it is necessary to consider all products being influenced by climate change, such as agricultural products, simultaneously.

Third, the adaption needs to be discussed in depth. This study focuses on assessment of the economic impact by means of the CGE model by reflecting changes in fish catch due to climate change. The model used in this study is reflective of dynamic reaction to change in factors like labor, capital and inputs. However, the adjustment is limited to the changes within the system built to reproduce the economy. Consequently, the adjustments that can progress beyond the current structure is not mechanically reflected in the model as when dealing with non-monetary objectives such as adaptation to climate change. Different adaptabilities could result in change in market structure according to learning effect, change in preference, and new policies. Simulations are performed under the assumption that the current condition persists, but it would be desired to include many situations. It is necessary to reflect various situations with collecting information for any future study.

Table 2.1 Share of Household Consumption Spending on Commodity

	Primary Sector		Mfg. and Industry	Service Sector	Public Sector
	Fisheries	Other			
U-HH	0.014	0.056	0.323	0.601	0.006
R-HH	0.015	0.108	0.389	0.482	0.005

Table 2.2 Distribution of Household Income in the Fisheries by Scenario

	Baseline	Scenario A	Scenario B
U-HH	100.000	99.840	99.640
R-HH	100.000	99.837	99.628

Figure 2.1 Conceptual Framework of CGE for Impact of Change on Fisheries.

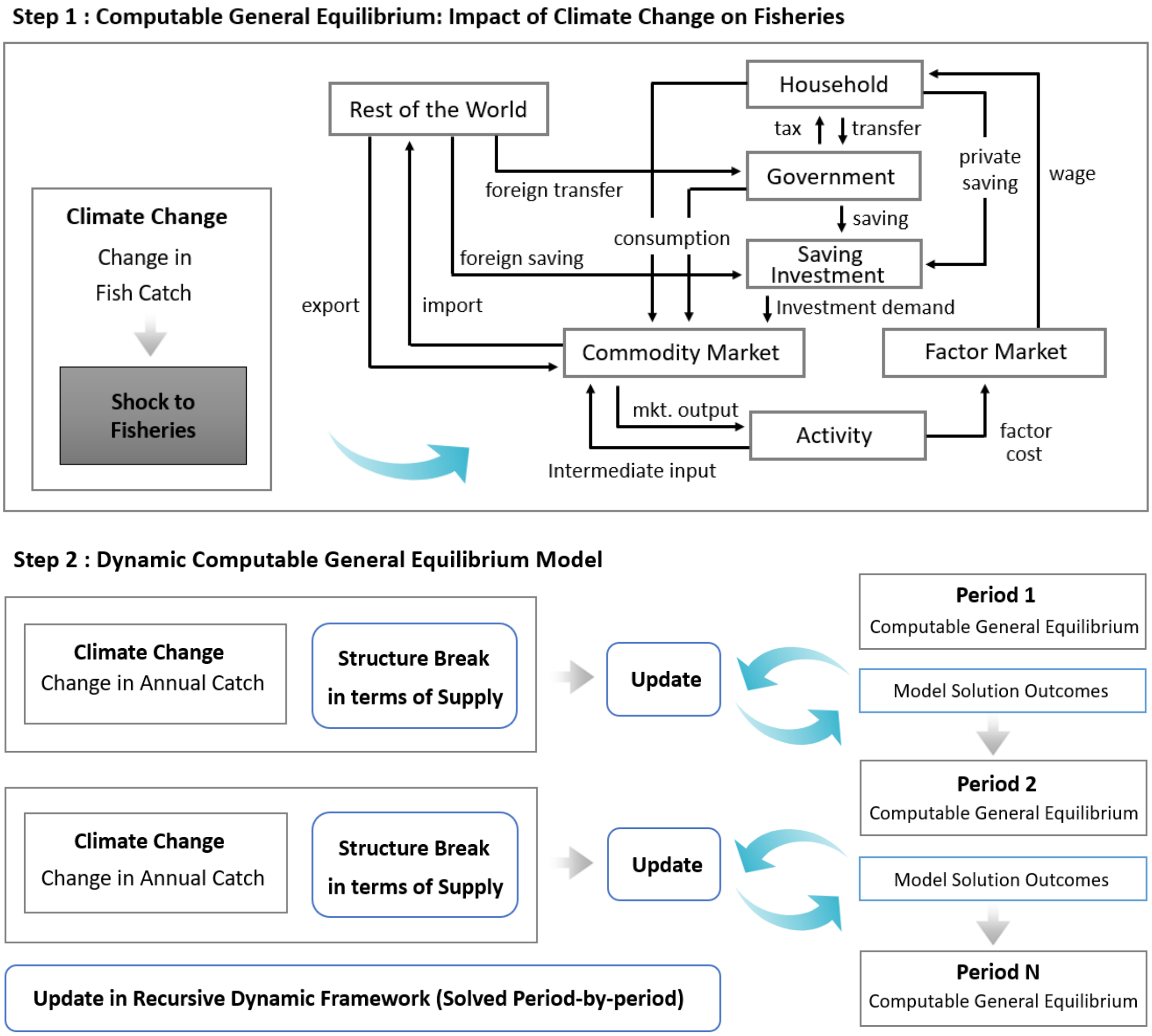
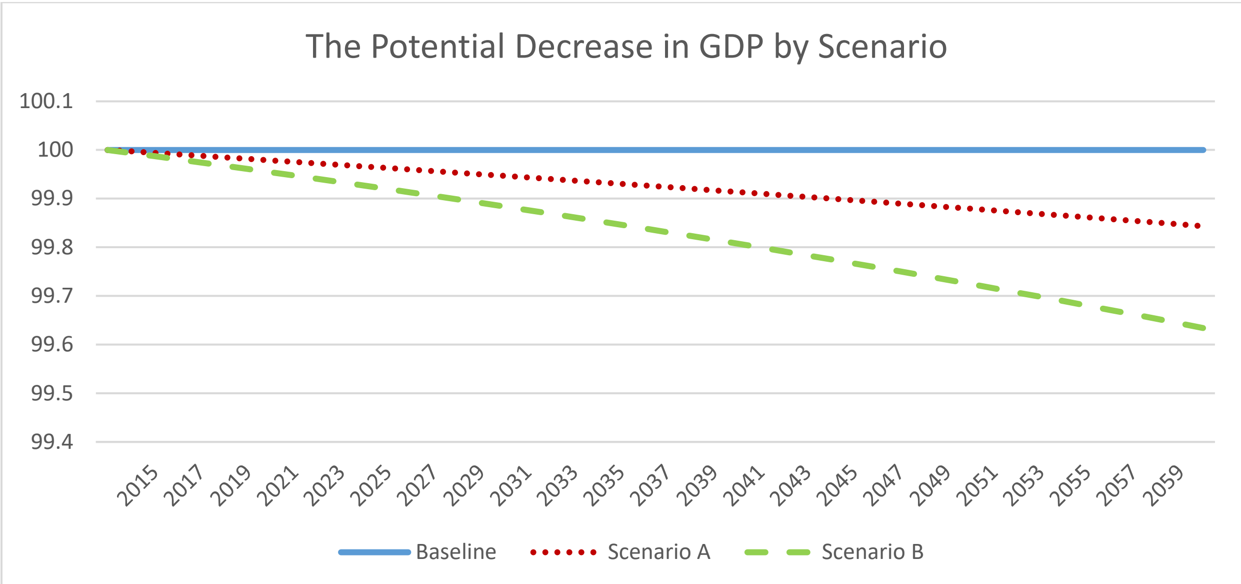
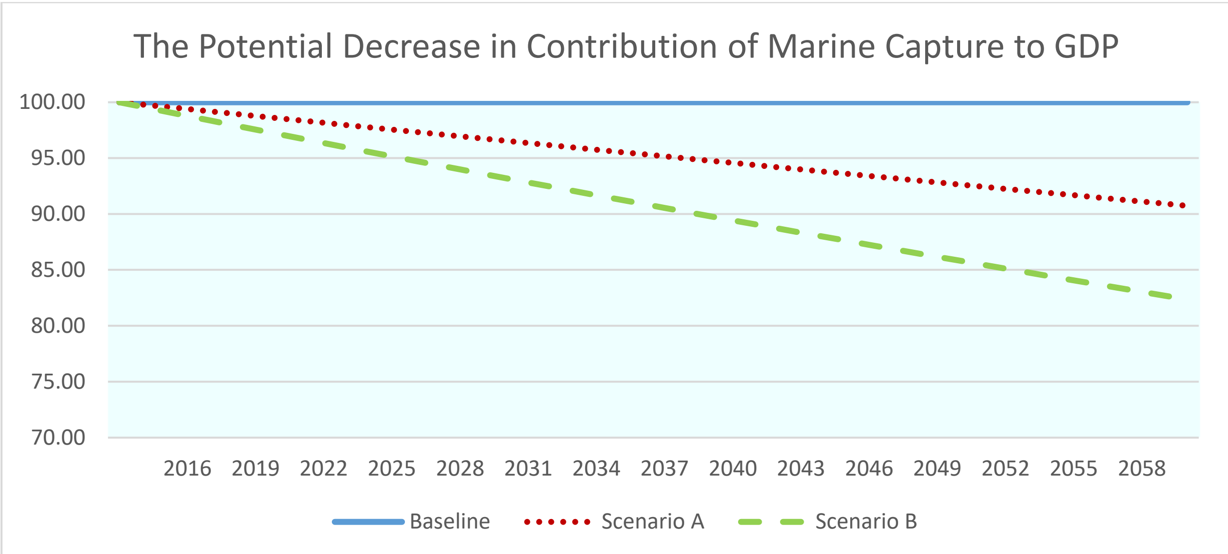


Figure 2.2 Projection of Decrease in GDP by Scenario



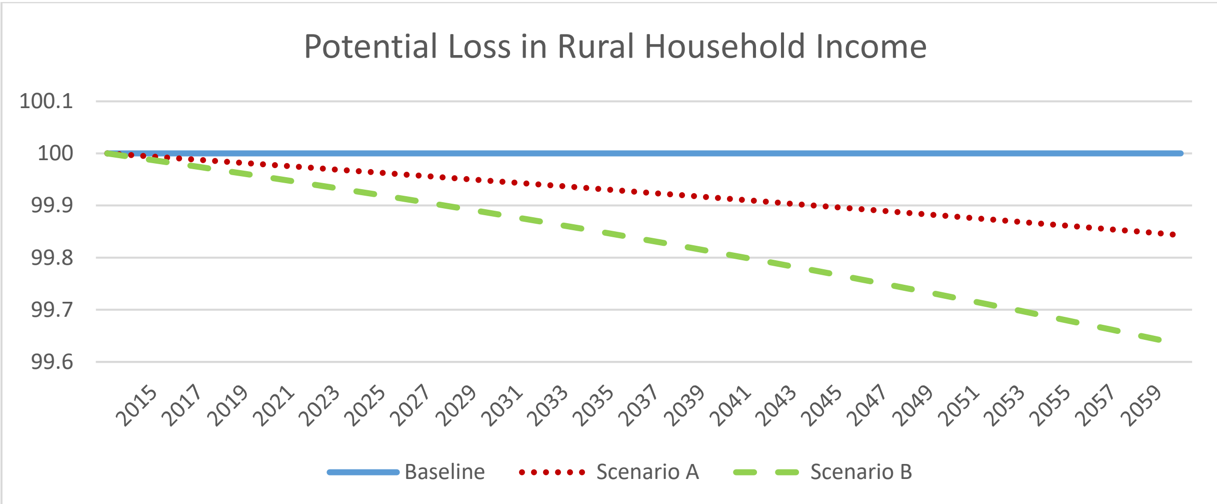
Note: The GDP in base year is normalized to 100.

Figure 2.3 Projection of Decrease in Contribution of Marine Capture to GDP by Scenario



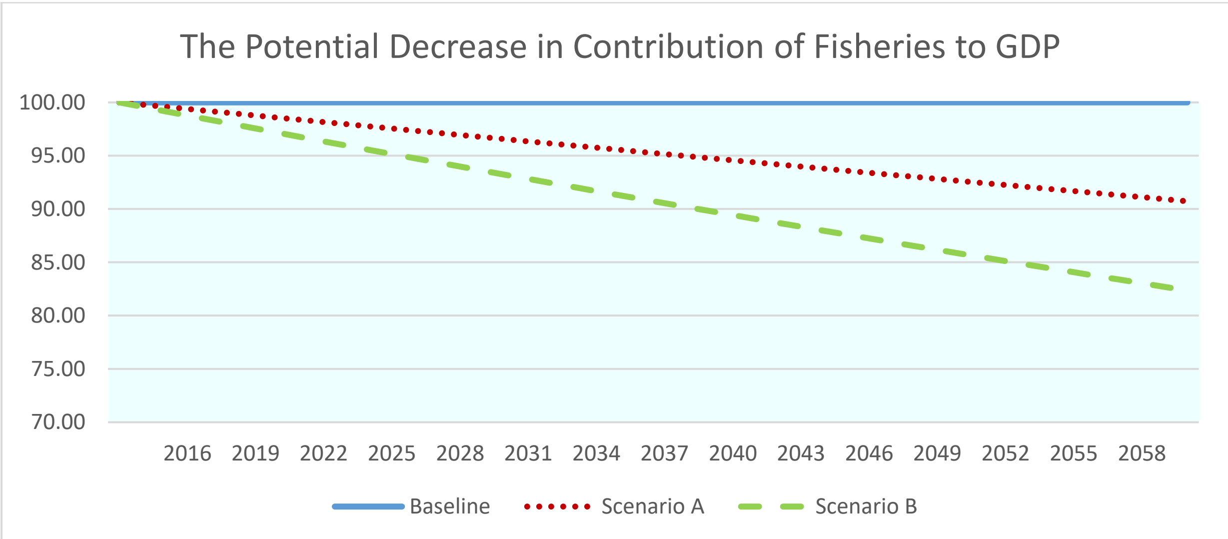
Note: The GDP in base year is normalized to 100.

Figure 2.4 Projection of Loss in Rural Household Income by Scenario.



Note: Income level in base year is normalized to 100.

Figure 2.5 Projection of Decrease in Contribution of Capture-aquaculture combined Fisheries to GDP by Scenario



Note: The GDP in base year is normalized to 100.

Figure 2.6 Projection of Economic Growth in the Fisheries by scenario.

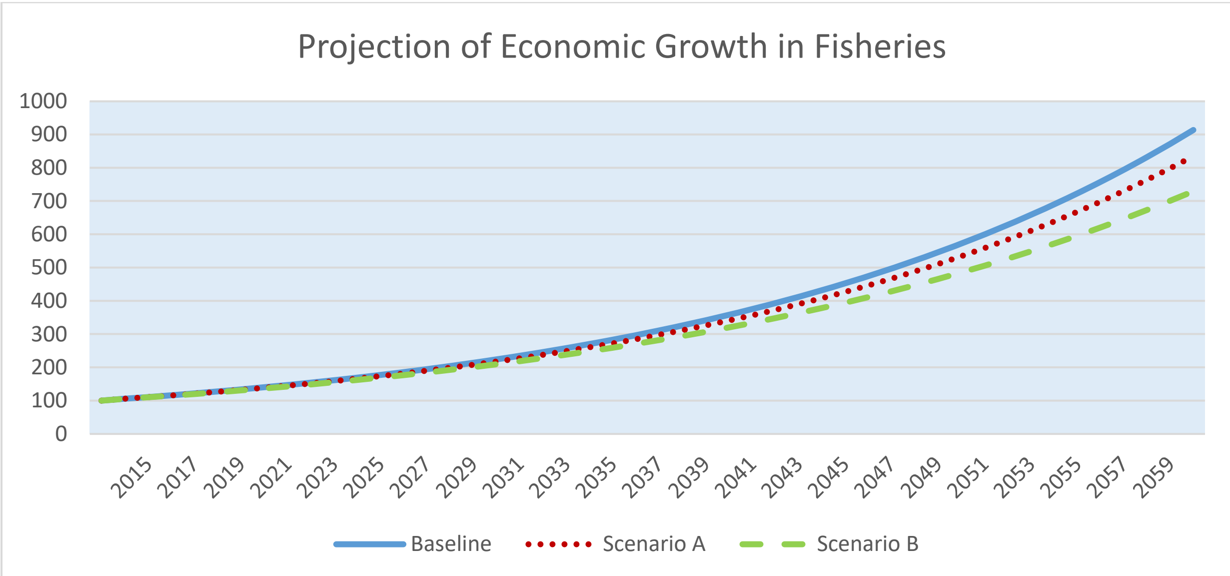
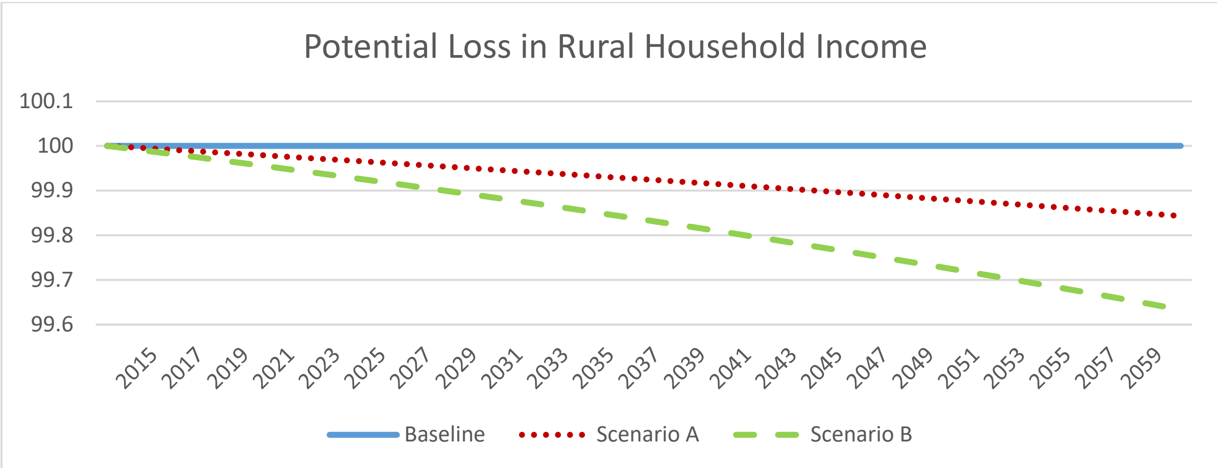


Figure 2.7 Projection of Loss in Rural Household Income by Scenario.



Note: Income level in base year is normalized to 100.

3

Evaluation of Seafood Traceability System in the Korea: Demand-oriented Analysis

3.1 INTRODUCTION

People in Korea, which is surrounded by ocean on three sides, are familiar with seafood, and seafood has traditionally been one of the most widely loved foods in Korea. Seafood has become increasingly popular over time in line with awareness that it is rich in protein and essential nutrition, such as omega 3 fatty acids and calcium, needed for a healthy body. As a result, consumption of seafood in Korea is constantly increasing and Korea has become one of the world's largest seafood consumers (FAO, 2018).

However, despite the high level of consumption of seafood, there has been growing dissatisfaction with the food system in Korea, particularly in relation to food safety, because the system has not been well developed when compared to other major seafood consuming countries (Park & Ryu 1999; Bae & Cho, 2016; Kang, 2015). Quality and safety are two important factors for consumers in terms of perceptions and decision making on choice and purchase of food (Grunert, 2005; Van Rijswijk & Frewer, 2008). The Korean government is attempting to secure these factors by revitalizing the seafood traceability system and are planning a pilot project for a mandatory seafood traceability system from December 2018 to the end of 2021 (MOF, 2018, Oct. 26).

In practice, seafood traceability gives consumers a sense of security in that it helps ensure the quality and lowers the risk of poor food safety. If accidents occur with regard to seafood, the information provided by traceability enables people to discover the cause of the problem, collect the problematic products to limit the damage, and to facilitate an effective contingency plan and clarification of responsibilities (Leal et al., 2015). In addition, it is useful for the management of information in terms of the quality and cleanliness of seafood and enables producers to understand consumers' needs (Yasuda & Bowen, 2006). However, this system is not well-established in terms of producer participation or consumer awareness (Shin, 2018).

From this point view, this paper examines the seafood traceability system from the consumers' perspective in Korea, taking notice of applicability of the system as a part of securing food safety. It is necessary to consider the effects of the preference for seafood and the awareness of seafood safety as part of understanding the system. The relationship between the preference for seafood and the value of a traceability system and the implications of the traceability system in connection with awareness of seafood safety are discussed in this paper.

3.2 SEAFOOD TRACEABILITY

The definition of traceability has become a prominent issue with the International Standardization Organization. Traceability is defined as "the ability to trace the history, application or location of an entity by means of recorded identifications," indicating what should be traced and how the tracing should be undertaken (ISO, 1994; Olsen & Borit, 2013). Accordingly, seafood traceability means traceability aimed at seafood and, according to the Korean Ministry of Oceans and Fisheries, the seafood traceability system is defined as "a system which records and manages the history of seafood from fisheries to our dining table, and discloses the information to help us choose seafood with confidence."(MOF, n.d.)

The start of seafood traceability originated from the need for producers to facilitate the recall of fisheries products, allowing consumers to avoid foodborne illness (Caswell, 1998; Hobbs, 2003), but now the system is also led by government who cares for the safety of the citizen and retailers who want to attain good reputation in relation to food safety (Caswell, 1998; Bailey et al., 2016). A traceability system enables domestic producers to monitoring and maintain good quality of seafood, and provides information by incorporating data from existing reporting systems to better understand regulatory requirements in import and export countries (Borit & Olsen, 2012; USAID, 2017). The system makes exporters abide by the strict policies of international seafood conventions, and takes a role in ensuring all producers follow all relevant regulations (Grote et al., 2006; USAID, 2017; He, 2018). Furthermore, the system contributes to controlling illegal, unreported and unregulated (IUU) fishing and encourages trade in legally caught fish. A traceability system can limit the market for illegal fish and protect producers who are operating legally, preventing the importation and sale of illegally caught fish (Pramod et al., 2014; USAID, 2017). A well-established traceability system can raise the level of food safety even further and contribute to increases in consumer confidence in products in the long run (Van Rijswijk et al., 2008).

A seafood traceability system was introduced in Korea in 2008. It was implemented with 10 seafood items chosen and promoted by the Ministry of Oceans and Fisheries (Shin, 2018). Information about the stages of production, processing and distribution is traceable by an identification number, which is indicated on the product or packaging with appropriate labeling. The National Fishery Product Quality Management Service manages the labeling system, and customers can access information using the internet or a mobile app (Shin, 2018). As of 2019, it applies to 52 kinds of products, including not only general marine products such as trout, flatfish, mackerel, cod, snapper, bass, anchovy and yellow corvina, but also to freshwater products such as loach and catfish. The problem is that the seafood traceability system is under-utilized as consumers of seafood have low awareness of the system and are not interested in utilizing it (MOF, 2015).

According to a survey of the general public conducted by the Ministry of Oceans and Fisheries, 27.3%~39.7% of people know about the seafood traceability system (MOF, 2015). This figure stems from the low rate of participation in the system as the government implemented it on a voluntary instead of a mandatory basis, resulting in it being little more than a name rather than an understanding of its role and purpose.

According to the Ministry of Oceans and Fisheries, approximately ten thousand of a possible sixty thousand businesses, which encompass fish product production, processing, distribution and sales, participated in the seafood traceability system in 2016, with a participation rate of around 16.6%. As of 2016, the items provided in the traceability system include sea mustard (4,478 metric ton), yellow corvina (2,393 metric ton), mackerel (1,653 metric ton), halibut (675 metric ton), cutlassfish (662 metric ton), and squid (576 metric ton). The identification number for traceability is indicated on 10,905 metric tons of products (MOF, 2018a), and represents 22.82% of products targeted. Of the 3.27 million metric tons of products from fisheries in 2016, the percentage of traceable products to the total supply is less than 0.4% (MOF, 2018a).

The Korean government is attempting to gradually enforce the system and expand the range of items, with a growing interest in seafood traceability and improvement in seafood safety, but it is necessary to support this with relevant research (MOF, 2016). However, Korea has a poor record in this regard as the traceability system has not advanced and lacks discussion on the value and promotion of the system, apart from acknowledging the need for the system. Accordingly, examination of the awareness and value of a seafood traceability system can help Korea understand and set the future direction for the system.

3.3 METHOD

This paper applies the contingent valuation (CV) method to measure the value of seafood traceability in Korea, and performs the analysis on change in values. The CV method is an approach used to measure the value of goods when the price is not determined by eliciting willingness to pay (WTP[3]) for the goods in the hypothetical market (Hanemann, 1994; Adamowicz et al., 1998; Mitchell & Carson, 2013). If there is no surrogate market to estimate the value of the nonmarket goods, or the current market is limited to use information about the price, surveys are often the most effective way to derive consumer's preference (Peterson, 2003), and the CV method has the advantage of directly obtaining a monetary measure of value (Ajzen & Driver, 1992; Hoyos & Mariel, 2010). The method began to be considered as an economic valuation tool in the US federal institutions in the 1970s, and has consolidated as a non-market valuation method in academic field from early 90s. (Hoyos & Mariel, 2010).

The method is based on welfare economics and the neoclassical concept of valuation under the utility maximization problem (Hanemann, 1984; Hoyos & Mariel, 2010). The theory starts with difference between the utility with current condition and the utility with new condition

[3] WTP is a term for the maximum price a consumer is willing to pay for a product or service (Varian, 1992). In the context of the study, the concept of WTP is used to evaluate the public system, which is nonmarket goods

(Peterson, 2003). Let V(·) be indirect utility function and the value related with seafood traceability system take the form

$$\boldsymbol{V(S_0, I - C) = V(S_0, I)} \tag{3.1}$$

where S_1 indicates the presence of the seafood traceability system, S_0 indicates the absence of the seafood traceability system, I is income, and C is Hicksian compensating surplus. If a respondent accepts the amount suggested in the discrete-choice question, then it implies the utility of the seafood traceability system is greater than the absence of the system. The deterministic system can be transformed into a stochastic model involving the probability of willingness to pay P_y:

$$\boldsymbol{P_y(\theta) = P[V(S_1, I - \theta) - V(S_0, Y) > u]} \tag{3.2}$$

where P(·) is probability distribution function, θ is the suggested price which is a neutral stimulus and u is the error term. Let ΔV as the difference between V(S_1) and V(S_0) then the probability distribution function and cumulative distribution function take the form

$$\boldsymbol{P_y(\theta) = P\big[\Delta V = V_{S_1} - V_{S_0} > u\big] = F(\Delta V)} \tag{3.3}$$

In this study, the cumulative distribution function of the standard normal distribution is used for the analysis

$$\boldsymbol{F(\Delta V) = [1 + e(-\beta X)]^{-1}]} \tag{3.4}$$

where X is the set of explanatory variables that include preference and recognition, price, and socio-demographic characteristic variable. WTP can be represented by the integral of the cumulative distribution function of ΔV

$$\boldsymbol{WTP = \int F(\Delta V) = -\beta_t{}^{-1}\,[1 + e(-\beta X)]^{-1}} \tag{2.5}$$

where t is the price variable which is the amount suggested in the discrete-choice question.

3.4 SURVEY AND DATA

3.4.1 SURVEY DESIGN

The CV method utilizes survey techniques to ask respondents about the value of nonmarket goods (Ajzen & Driver, 1992). In this study, the survey was designed to provide respondents with general information about the seafood traceability system to enable them to construct a hypothetical market. It described the definition of seafood traceability, and the benefit in terms of consumption-oriented information (transparency throughout channels of distribution and process, efficient determination of the cause of accidents, and rapid recall of items) and production-oriented information (quality control, sanitation management, and understanding customer spending patterns through accumulation of information).

After a brief explanation about the system, several questions asked respondents to state the level of their preference and consumption of seafood, and how they think of the system. Then, for evaluation of the system, the survey constructed a hypothetical market, presenting a scenario: If the government were to establish and maintain the traceability system, people would benefit in terms of food safety from the system. In order for the government to maintain the traceability system, taxpayer money will be required. Each household would have to pay ₩X each year in taxes.

It is also necessary to determinate how to elicit respondents' WTP, considering that it comes from the response to a hypothetical question (Ryan & Donaldson, 2004). While the elicitation method may take the form of an open-ended question or a dichotomous question (Arrow et al., 1993), this study uses the dichotomous method. The respondent is required to respond yes/no to the given amount for the goods in the dichotomous approach. A dichotomous question is easy to respond to because it is based on intuitive judgment and choice, and the method is relatively similar to actual market transactions, so that the respondent can feel familiar with the hypothetical market (Whitehead et al., 1998). The dichotomous choice method is commonly used in contingent valuation, as the open-ended choice method has become debatable due to the possibility of erratic results (Cummings et al. 1995; Donaldson et al., 1997).

This paper utilizes the single bounded and double bounded dichotomous choice methods. For the double bounded method, the statistical efficiency can be improved by asking the respondent to engage in two rounds of bidding: participants respond to an initial price amount[4] and then face a second question involving another price amount, higher or lower depending on the response to the first question (Table 3.1). There are five amounts in the set of tax (2, 7, 10, 13, 18), and the set is based on the result of the pilot test. Each survey suggests the amount of tax randomly assigned among the sets. The respondents were asked about their WTP again, doubling the tax if they gave a "yes" response and reducing the tax by half if they gave a "no" response. Respondents who answered "no" were also asked to indicate the reason they were not willing in order to ascertain if there is purpose for the protest.

[4] Unit is 1,000 KRW. According to the Korea Exchange Bank (Hana Bank), the basic exchange rate is 1200 (i.e., 1 USD is equal to 1200 KRW) as of Sep 27, 2019.

3.4.2 SURVEY DATA

The survey was conducted in Seoul and Busan between March and April 2019. Seoul and Busan, which are the two biggest cities in Korea, were selected as they represent on inland city and a port city, respectively[5]. Survey has various modes such as face-to-face, telephone, and mail, but in this study, the web survey was carried out. Web surveys are advantageous in the use of interactive help and can cover complex audio and video display (Fricker et al., 2005). This mode is comparatively time and cost saving (Kaplowitz et al., 2004) and becoming more popular (Porter & Whitcomb, 2003). The survey was conducted among respondents aged over 20, and the sample was allocated in proportion to each city's population since there is a difference between populations of the two cities. In order to examine socio-demographic characteristics, respondents were asked to indicate both individual and household characteristics when filling out the questionnaire.

A total of 959 respondents were included in the sample after removing protest responses and those missing values (Table 3.2). The sample comprised 719 respondents from Seoul and 240 from Busan, of which 48.5% were men and 51.5% women. The majority of respondents are college graduates (67.1%). Respondents were relatively evenly distributed across age groups: 20s (25.4%), 30s (25.0%), 40s (25.1%), 50s (18.3), and 60s (16.2%). The interval between 4 million Korean won and 5 million Korean won (17.5%) is the highest frequency in terms of household monthly income and the interval between 3 million Korean won and 4 million Korean won (17.2%) was second highest.

The variables can be classified into three groups: recognition and behavior, socio-demographic characteristics, and price variable (Table 3.3). Recognition and behavior of

[5] According to the office of statistics Korea, the population of those two cities accounts for a quarter of the country's total population, as of Feb. 2019.

respondents covers how often respondents purchase seafood, and whether respondents care about the information that the seafood traceability system provides. Variables related to information are constructed according to the functions of the seafood traceability system – consumer function and producer function – which are defined by the Ministry of Oceans and Fisheries. The first variable is the response to the following question: "If the seafood traceability system works, it becomes easier to recall contaminated products when accidents occur due to the information provided by traceability. Do you think it is worth keeping this function of the seafood traceability system?" The second variable is the response to the following question: "If the seafood traceability system works, producers can obtain the pattern of consumption and they can control the quality and sanitary information. Do you think it is worth keeping this function of the seafood traceability system?" Socio-demographic characteristic variables include age, gender, education level, and income variable. The income variable is household monthly income and the unit is 1 million Korean won, which equals 833.33 US dollar. The price variable, which is usually termed the bid in the CV method, is the amount of tax suggested and the unit is 1 thousand Korean won, which equals 0.83 US dollar.

3.5 RESULTS

The analysis of the seafood traceability system was carried out by estimation using two approaches: (1) estimation of the model with no covariates and (2) estimation of the model with covariates. In the first approach, a regression of the dependent variable on the price factor (i.e., tax) without including other covariates was performed. The results are presented in Table 3.4. In this approach, the model is a kind of null model, but it can estimate the respondents' WTP. It is meaningful in that it serves as a benchmark for other models. The results of goodness-of-fit in both the single bounded and double bounded methods demonstrate that the model fits a given data set as each Wald chi-square is statistically significant at the 1% level. Each TAX variable, which the represents price factor, is statistically significant and negative. The negative coefficient values of the variable represent the economic principle that demand for goods is inversely proportional to price.

In the second approach, AGE, GNDR, FREQ, INFO1, INFO2, INC and EDUC are included in the model as explanatory variables, as presented in Table 3.5. The model does not have problem with goodness-of-fit, and the results reveal the single bounded and double bounded methods fit to the data as the Wald chi-square is statistically significant. Coefficients on TAX are statistically significant and negative, as is the case in the no covariates model.

It is considered that preference and recognition factors affect respondents' WTP as the relevant variables are statistically significant. The coefficients on FREQ in both the single bounded and double bounded methods are positive, suggesting that those who buy seafood more frequently appreciate the seafood traceability system. The coefficients on INFO1 and INFO2 are also positive, suggesting that those who identify consumer or producer information, which are functions of the seafood traceability system, as important have higher WTP. It is considered that these factors significantly affect WTP, since the coefficients are relatively higher compared to other variables.

The income coefficients are positive and statistically significant. This means the higher income, the higher the WTP, which is supported by the income effect in economics: the demand for goods is proportional to income. Other demographic variables such as GNDR and EDUC are statistically insignificant, so it is difficult to say that there is a direct correlation between demographic factors and WTP. This implies that individual recognition and preference are intimately related to the seafood traceability system rather than demographic factors.

It is noteworthy that the AGE variable is statistically significant in the double bounded method. It is considered that WTP is inversely proportional to age, as AGE is negative. Thus, it can be inferred that young people tend to value food safety when they purchase seafood while those who are older tend to value other features such as price and flavor, since the survey results reveal that the rate of placing a priority on price or flavor is proportional to age.

The results of the WTP by model are presented in Table 3.6. They reveal that estimates are higher in the no covariates analysis and the values from the single bounded model are slightly higher compared to those of the double bounded model. The estimated WTP for the seafood safety system ranges from \$8.58 to \$9.88 and all values are statistically significant at the 1% level. The estimated mean WTP is \$9.17, and the 95% confidence interval indicates \$7.88 at the lower bound and \$10.45 at the upper bound.

According to the Korean Statistical Information Service, there were 1,115,744 households in Seoul and 3,784,490 households in Busan in 2015. Converting the result to annual benefits of Seoul and Busan by the product of the number of households and estimated WTP, it is calculated that approximately \$44.94 million can be generated annually from the seafood traceability system (Table 3.7).

3.6 DISCUSSION

One of the challenges of the seafood traceability system is lack of participation by producers. This is caused by production cost. While it is comparatively easy to label fisheries' products at shipment since only pallet-level traceability is required at this stage, product subdivision is inevitable over the course of the value chain, so item level labeling becomes difficult and costly due to the small size of the fish and too many markets (Shin, 2018). Hence, there is no motivation for businesses to participate in the system because it leads to an increase in production cost.

The seafood traceability system in Korea is, in effect, a voluntary system, but since policy is driving toward a mandatory system, businesses will need to comply with the system at some point. Producers need to develop a way to use the seafood traceability system as means of increasing productivity by understanding trends and patterns of consumption and maintaining product quality, leading to a high degree of adaptability in the new environment, and moving to wider participation in the system. From the standpoint of government, the provision of incentive is considered one of the ways to induce businesses to participate in the system. Since the seafood traceability system generates a certain level of benefits, as the analysis results demonstrate, government spending is acceptable within a similar level to benefit the development of the system.

The other challenge of the seafood traceability system is consumers' lack of recognition. The seafood traceability system in Korea has been developed but many people still do not know that the system is in operation and a considerable number of consumers do not know how to use the system even though they have heard about it. Consequently, it is necessary to raise awareness of the system by focusing efforts on an awareness and education campaign. Estimating the value change based on the analysis outlined in this paper, the utility of the system and benefits that consumers recognize increase as consumers appreciate the awareness and importance of information.

The improvement in the awareness of the importance of information brings about the effect of an increase in the value of the system of between 0.51 US dollar and 1.27 US dollar, as presented in Table 3.8. The rise in the value of the seafood traceability system will make a positive contribution to the vitality of the system in the longer run. Thus, if the Korean government wants to activate the system, promoting information can be one of the top strategic priorities.

3.7 CONCLUSION

The Korean government seafood traceability has not worked well, compared to other major seafood consuming countries. However, the Korean government is planning to convert the system, which has been operated on a voluntary basis, to a mandatory system, taking notice of applicability of the system as a part of securing improved food safety.

This paper examined the value of the seafood traceability system by applying the contingent valuation (CV) method and focusing on awareness of food safety value, represented by recognition of the importance of the information that the seafood traceability system provides. The result of the studyshow that Korean consumers positively assess the functions and benefits of a seafood traceability system and it is estimated that approximately $44.94 million can be generated annually from the system. Hence, seafood traceability can be worthy of maintaining the system, particularly in terms of the consumers.

In practice, seafood traceability gives consumers a sense of security over and lowers the risk of poor food safety by providing information on the source of seafood. Thus, the value of seafood traceability is predominant in the provision of information. With 90% of respondents identifying themselves as seafood lovers, it is plausible that seafood is a staple food item in Korea and the fact that information related to food safety is a matter of consequence to Korean people is persuasive. More than half the respondents indicated they check place-of-origin when they purchase seafood and take it into consideration when deciding to buy or not. This implies that Korean consumers are influenced by information about the product in some way.

However, despite the significance and benefits of the seafood traceability system, it is still not well-known in Korea, and as such, is under-utilized. Paradoxically, people have a positive awareness of provision of information on seafood and think it is necessary to maintain a system like seafood traceability. This implies that there is a gap between necessity and utilization of the seafood traceability system, and the gap can be filled by making the existence and role of the system known. The revitalization of the seafood traceability system is needed, but it should be accompanied by an increase in consumer awareness through promotion about the existence of the system.

To improve the awareness of seafood traceability, the government and private business organizations related to fisheries need to promote the function and benefit of seafood traceability. To do so, mass media advertising campaign about seafood traceability should be combined with education on food safety. It also requires information about its use in increasing convenience of consumers. For example, easy access to related website or development of well-designed mobile app can contribute to consumer-friendly traceability. Finally, the system should be well-organized so that consumers will not feel uncomfortable using the system and also the assessment of awareness of seafood traceability has to be carried out regularly.

Table 3.1 Price Suggested

Scenario	First round	Response	Second round
Taxpayer money being needed to establish and maintain the system	2	Yes	4
		No	1
	7	Yes	14
		No	3.5
	10	Yes	20
		No	5
	13	yes	26
		no	6.5
	18	yes	36
		no	9

Note: Unit is 1,000 KRW (0.83 USD).

Table 3.2 Sample by Age Group and Location

AGE	20s	30s	40s	50s	60s
Sample	244	240	241	175	59
Percent	18.64%	25.42%	23.73%	23.73%	8.47%

Location	Seoul	Busan	Total
Sample	719	240	959
Percent	5.98%	6.67%	6.15%

Table 3.3 Definition of Variables and Data Summary

	Variable	Definition	Mean	Std. Dev.
Recognition and Behavior	FREQ	frequency of seafood purchase Likert scale: 1 (almost never) to 9 (daily)	5.9135	1.6549
	INFO1	1 if information of consumer side is important for respondent, 0 otherwise	0.9729	0.1625
	INFO2	1 if information of producer side is important for respondent, 0 otherwise	0.9552	0.2071
Socio-demographic Characteristic	AGE	age in years of respondent	39.7987	11.6993
	GNDR	gender of respondent (1 if respondent is male, 0 otherwise)	0.4849	0.5000
	EDUC	education level of respondent (1: middle school, 2: high school, 3: undergraduate, 4: graduate school)	2.9771	0.5103
	INC	monthly income of household unit: 1 million KRW (833.33 USD)	5.0730	1.9160
Price (bid)	TAX	the amount suggested respondent in the discrete-choice question. unit: 1,000 KRW (0.83 USD)	9.8916	5.4171

Table 3.4 Results: Model with no covariates

Variable	Single Bounded			Double Bounded		
	Estimate	Std. Err.	z value	Estimate	Std. Err.	z value
Intercept	0.4430***	0.0859	5.16	1.2384***	0.0756	16.37
TAX	-0.0373***	0.0076	-4.92	-0.1274***	0.0051	-25.14
Log Likelihood	-650.9236			-1429.7069		
Wald Chi-Square	24.1804***			58.82***		

Note: *** denotes significance at the 1% significance level.

Table 3.5 Results: Model with covariates

Variable	Single Bounded			Double Bounded		
	Estimate	Std. Err.	z value	Estimate	Std. Err.	z value
Intercept	-1.8527***	0.4659	-3.98	-1.6533***	0.6295	-2.63
TAX	-0.0419***	0.0078	-5.36	-0.1324***	0.0053	-25.17
AGE	-0.0032	0.0036	-0.88	-0.0168***	0.0052	-3.22
GNDR	-0.1169	0.0842	-1.39	-0.0826	0.1200	-0.69
FREQ	0.0894***	0.0266	3.36	0.1239***	0.0384	3.22
INFO1	0.9523***	0.3242	2.94	1.4866***	0.4467	3.33
INFO2	0.7479***	0.2396	3.12	0.7027**	0.3164	2.22
INC	0.0845***	0.0229	3.70	0.1317***	0.0334	3.94
EDUC	-0.0264	0.0846	-0.31	0.0451	0.1211	0.37
Log Likelihood	-619.30813			-1429.7069		
Wald Chi-Square	78.28***			58.82***		

Note: ** and *** denote significance at the 5% and 1% significance level, respectively.

Table 3.6 WTP by Model

Model	WTP	Std Err	z value	95% Confidence Interval	
SB with no covariate	11.8606*** (9.884)	1.1593	10.23	9.5885 (7.990)	14.1327 (11.777)
SB with covariate	11.5197*** (9.600)	1.0396	11.08	9.4822 (7.902)	13.5572 (11.298)
DB with no covariate	10.3548*** (8.629)	0.4840	21.40	9.4062 (7.839)	11.3033 (9.419)
DB with covariate	10.2904*** (8.575)	0.4705	21.87	9.3683 (7.807)	11.2125 (9.344)
Mean	11.0064 (9.172)			9.4613 (7.884)	12.5514 (10.460)

Note: *** denotes significance at the 1% significance level. Unit of calculated WTP is 1,000 KRW (US dollar in parentheses).

Table 3.7 Aggregate WTP by Model

	Seoul	Busan	Total	Lower Bound	Upper Bound
SB	10,869,346	36,867,713	47,737,059	38,937,872	56,536,246
DB	9,597,816	32,554,814	42,152,630	38,333,101	45,971,954
Mean	10,233,581	34,711,263	44,944,844	38,635,487	51,254,100

Note: Unit of aggregate WTP is US dollar.

Table 3.8 Increase in WTP by Awareness of Necessity of Information

	Current	Promotion 1	Increase in Value by P1	Promotion 2	Increase in Value by P2	Total Increase
SB	11.5197	12.1361	0.6164 (0.514)	12.4303	0.9106 (0.759)	1.5270 (1.273)
DB	10.2904	10.6257	0.3353 (0.279)	10.5652	0.2748 (0.229)	0.6101 (0.508)
Mean	10.9051	11.9187	0.2904 (0.242)	10.9006	0.5927 (0.494)	1.0686 (0.891)

Note: Unit of calculated WTP is 1000 KRW (US dollar in parentheses).

Figure 3.1 Map of the Target Areas (Seoul and Busan)

4

The Value of Regional Branding Seafood Focusing on Seaweed in the Korea

4.1 INTRODUCTION

As technology develops and markets grow, supply systems using mass production to sell standardized goods have become the major method for supplying traditional markets (Sabel & Zeitlin, 1985). This method has been used by the Korean fishing industry (Kim, 2008; Joo & Lee, 2010). Fisheries have sought to produce homogeneous goods continuously with a focus on quantity but with little concern for competitiveness or awareness of differentiating the product. This was possible because the corresponding market was developed based on demand, and thus, it was not a problem that deserved attention in Korea, where there has consistently been a high demand for fishery products.

However, as markets and economies have become more open, large stocks of cheaper fishery products have been made available by many producers around the world, and it has become apparent that the existence of demand in Korea does not guarantee the consumption of domestic fishery products. As a result, the Korean government has encouraged suppliers to produce high-quality products and establish brands with an aim of strengthening the competitiveness of Korean fishery products in the market. Goods can be conceived as an aggregation of information cues, and each cue provides consumers with a hint that can be used to evaluate the goods (Bilkey & Nes, 1982). Therefore, brands, which include a name, sign and/or symbol applied for the purpose of differentiating products (Kotler & Gertner, 2002), can be used as a means of providing positive information cues that improve the competitive power of a product. Thus, fishery product branding is one of the effective ways of coping with price competitiveness if the brand coincides with high quality goods.

The Korean government has given attention to the use of regional brands as a part of fishery product branding, using geographical indications in this context (Joo & Lee, 2010). One example of this attempt by the Korean government has been the promotion of the use of geographical sources on products. Well-established brands can provide intuitive information such as the region of product origin, and this can create a synergy between products from the same region as they become accompanied by positive associations.

In this study, hedonic pricing was used to study the value of regional brands in the fishery product market, specifically seaweed, identifying price factors that reflect regional differences. More specifically, this study examined whether regional branding works well for improving competitiveness while investigating whether the indication of geographical source is useful and how much the certification of geographical indication contributes to fishery product branding.

4.2 SEAWEED BRANDING

If there are many similar products in the market, producers will attempt to distinguish the differences of their products from others in order to make them more attractive (Kotler & Keller, 2011). However, this can take a considerable amount of time and money if they must explain their unique differences whenever products are released. Brands can be a solution to this problem and serve as part of a strategy aimed at differentiating products (Farhana, 2012).

There can be many factors in differentiation, but in the case of food the region of origin can be one significant factor for differentiation (Anselmsson et al., 2014). This is because the characteristics of a production area, such as the climate, soil, water quality, and location, can affect a product's characteristics. With this in mind, the Korean government has been trying to build and manage regional brands in relation to fishery products (Joo & Lee, 2010).

One reflection of this effort can be found in the development of protected geographic indication (PGI) designations by the National Fishery Product Quality Management Service for selected fishery product production areas to protect regional brands (NFPQMS, n.d.). An area designated with a PGI can be regarded as the most famous area for the production of particular fishery products, and the designation itself can be considered as a high-value brand.

Among these products, the best managed items in regard to PGI are seaweed products, which Koreans consume in large quantities, and for this study, sea mustard and sea tangle were selected due to the ease of their quantification. Sea mustard is an edible brown seaweed with the binomial name Undaria pinnatifida (Rupérez, 2002; Bang et al., 2011). It mainly inhabits the coasts of Korea and Japan and some regions along the coasts of Australia and New Zealand (Synytsya et al., 2010). In Korea, it is widespread on all coastlines, and annual production of sea mustard was 496,290 metric tons in 2016 (MOF, 2018a). Sea mustard is known for its health benefits as it contains large amounts of calcium, iodine, iron, and magnesium (Taboada et al., 2013), and it is especially popular among new mothers in Korea because it is considered nutritious after childbirth and for nursing (Bang et al., 2011). Recently, the sales of sea mustard, which is good for removing heavy metals from the body (Figueira et al., 2000), have increased as there has been an increase in pollutant-containing dust in Korea. Sea mustard can be enjoyed in a variety of forms, such as in soup, noodles, jam, or tea (Nisizawa et al., 1987; Rupérez, 2002), but Koreans tend to prefer it in soups and salads (Bang et al., 2011; Sanjeewa et al., 2018).

Sea tangle is another edible brown seaweed, and its binomial name is Laminaria japonica (Lee et al., 2004). Sea tangle is mainly consumed in Korea, China, Japan, and other East Asian countries (Otsuka, 1998). In Korea, sea tangle is highly consumed, much like sea mustard, and annual production was 433,246 metric tons in 2016 (MOF, 2018a). Sea tangle has a unique flavor and is mainly used as a condiment to make soups and noodles. Sea tangle contains many inorganic salts, such as iodine, potassium, and calcium, and is known as a diet food since it has the effect of making people who eat it feel full, and it also relieves constipation and smooths the skin through its large alginic acid content (Cho et al., 2006; Kim et al., 2008; Islam et al., 2014; Wang et al., 2014).

Seaweed products are generally manufactured in the form of dried and salted products. There are products that try to differentiate themselves by making seaweed cut for the convenience of consumers or packaging it in fashionable paper boxes as a gift-wrapping. Most seaweed sold to consumers is farmed, but some that live attached to rock are naturally harvested (MOF, 2018b), and natural sea mustard is much more expensive than farmed sea mustard. The most famous production areas for sea mustard and sea tangle are Gijang, Goheung and Wando, which are counties in Korea (Figure 4.1), and only a small number of products produced in these areas are permitted to be labeled with a PGI.

4.3 METHOD

The term "goods" is an aggregation of product characteristics, so that consumption of the goods implies that a consumer prefers the goods as a consequence of measuring relative utilities between characteristics (Lancaster, 1966). A hedonic price, defined as the characteristics related to each good (Rosen, 1974), indicates the value of characteristic and the relative importance of the characteristic. The method of hedonic price was popularized by Griliches (1971) and is useful in measuring the implicit prices of products characteristics.

In the model, the seaweed product (x) can be represented by a set of k characteristics $(x_1, x_2, x_3, \cdots, x_k)$, which is included in the seaweed product, as follows: In the model, the seaweed product (x) can be represented by a set of k characteristics $(x_1, x_2, x_3, \cdots, x_k)$, which is included in the seaweed product, as follows:

$$\mathbf{x} = (\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{x_3}, \cdots, \boldsymbol{x_k}) \tag{4.1}$$

Therefore, seaweed product is associated with value of the x, and the function of the price can be formulated as follows:

$$\boldsymbol{P}(\mathbf{x}) = \boldsymbol{f}(\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{x_3}, \cdots, \boldsymbol{x_k}) \tag{4.2}$$

where P is the price of the seaweed product and $x_1, x_2, x_3, \cdots, x_k$ are the characteristics including geographical indication.

The marginal cost of a characteristic provides information on hedonic price of an additional unit of characteristic (McConnell & Strand, 2000), and it is determined by the partial derivative of the price with respect to a variable:

$$\partial P(x)/\partial x_j = \partial f(x_1, x_2, x_3, \cdots, x_k)/\ x \qquad j = 1, 2, \cdots, k \tag{4.3}$$

The hedonic price function can be applied to several form such as linear, semi-log, double-log, and quadratic function. To examine values of characteristics of seaweed, the linear and semi-log forms are used in the model, since variables are constrained to be nonzero for logarithmic transformation, and quadratic forms are week in calculation of unbiased estimates when variables are omitted (Cropper et al., 1988).

Assuming the relationship between the price of seaweed product and the characteristics is linear, the price equation is determined as

$$P_i = \beta_1 x_{1i} + \ \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + \varepsilon_i\ , \qquad i = 1, 2, \ldots, n \tag{4.4}$$

where P_i is a price, x_{1i} , x_{2i} , $\cdots$, x_{ki} are characteristics and ε_i is an error term, for seaweed product i. On the other hand, if it is assumed that the relationship between the price and the characteristics of seaweed product is semi-log, then the price equation can be written

$$logP_i = \beta_1 x_{1i} + \ \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + \varepsilon_i\ , \qquad i = 1, 2, \ldots, n \tag{4.5}$$

The estimate of β_j is interpreted as the approximate percentage change in price, since the logarithmic price scale is used as the response variable and the coefficient of a dummy variable is the percentage effect of variable on the response variable in this model (Kennedy, 1981; Taylor, 2003).

It is also necessary to consider firm level characteristics since they can affect the value of products. Suppose that price equation has unobserved firm level characteristics:

$$\varepsilon_i = \gamma z_i + u_i\ , \qquad i = 1, 2, \ldots, n \tag{4.6}$$

where z is firm level characteristics, and u_i is the structure error. When the correlation between z and PGI is non zero (i.e., $z = \delta_0 + \delta_1 PGI + r;\ x$ is uncorrelated with z and structural error term

r), it is necessary to consider the asymptotic bias with $plim\hat{\theta}_k = \theta_K + \gamma\delta_1$. Assuming firm level characteristics and PGI are positively correlated (i.e., $\delta_1 > 0$), it results in plim $\hat{\theta}_k > \theta_K$, and it is possible that PGI is overestimated. [6] In this paper, information about the sales, the number of employers and the age of company is used as proxy to mitigate potential bias.

4.4 DATA AND VARIABLE

The data for the price of sea mustard and sea tangle for the first half of 2019 was used in the model. There was difficulty in obtaining the data as it requires the collection of individual producer price information. There are very many small firms producing seaweed products, with free entry and exit. The prices often vary from seaweed product to another based on how the seaweed material is manufactured or stored and depending on the characteristics of different processed seaweed. The data for this analysis was obtained from a retail e-commerce site in Korea, which encompasses general information and price of products. The information in relation to price was considered as a general set of prices with the assumption that sale prices on the internet converge into the lowest price. The one of major retail e-commerce sites [7] that are most preferred by Korean customers as of 2017 was selected for the collection of price information, and the lowest price was selected for overlapping goods. The goods were restricted to single products because it was difficult to assess the price of each product in a bundle. For example, product bundles made up of both sea mustard

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[6] If PGI has substantial variation in proportion to the covariance between PGI and firm level characteristic, the bias can be mitigated (Wooldridge, 2002).

[7] The e-commerce site is Gmarket, which, is leading e-commerce marketplace in Korea (Yoo et al.,2015). It was founded in 2000 and has been a subsidiary of eBay since 2009. http://global.gmarket.co.kr/Home/Main

and sea tangle were not included in data set. The information about company was collected from their own website and job recruitment sites [8].

The variables were classified into three groups: geographical, characteristic, and price variables (Table 4.1). Geographical variables cover whether a PGI label is indicated on the product and whether the product is distinguished as a regional brand. The variables related to the regional brand are categorical variables and cover three levels: i) a product has geographical indication and is protected by labelling; ii) a product is from a well-known area for a product, but does not have labelling; iii) a product is not from a well-known area. The well-known areas include Goheung, Gijang, and Wando, which have been selected as PGI regions for sea mustard and sea tangle. The characteristic variables encompass whether a product is salted, comes with luxury paper case, is precut, or is natural or farmed. The price variable is the unit price of the product, which is the price divided by gram.

The descriptive statistics for the data used in the model are shown in Table 4.2. The number of products in the data set was 102 and 75 for sea mustard and sea tangle, respectively. The proportion of PGI labelled products was a little greater for the sea tangle, but both were similar in that only a few products were labelled with a PGI. Notable is the NAT variable. In the case of sea mustard, there is wild sea mustard, which is called "rock sea mustard." This refers to natural sea mustard that grows attached to rock, and the sea mustard that is collected from rock is considered precious and expensive. In the case of sea tangle, there is no such concept as "rock sea tangle,"

[8] The job recruitment sites are SaraminHR(https://www.saramin.co.kr) and JobKorea(https://www.jobkorea.co.kr)

and there are few products indicating that it is natural as compared to sea mustard, and in general, consumers tend not to care whether it is farmed or not.

Information of companies that produce seaweed products, such as sales, the number of employers, and the age of the company, is used as proxy for firm level characteristics. Variables in relation to the company are useful proxies for factors that determine the price of the product, and they are likely to be correlated with the geographical variables. For company to obtain the certification of geographical indication, it requires such an ability of a company, so, it is considered that the company information can serve in the regression, explaining the variation in a geographical variable.

Sea mustard is generally considered to be a more high-end product than sea tangle. Accordingly, both the unit and log prices of sea mustard were higher than those of sea tangle. There are also more sea mustard products that are made for gifts, and so there was a difference in the number of products providing paper cases between sea mustard and sea tangle.

4.5 RESULTS

4.5.1 SEA MUSTARD ANALYSIS

The estimation of the sea mustard was performed with two approaches: the linear regression without transformation and the regression using logarithmic transformation. Each approach was carried out by estimation of two models. In the first approach, a regression of the unit price of the sea mustard was performed with a regression model (Table 4.3). Model 1 is a simple regression of the value on product characteristics, and Model 2 includes company information and region controls as well as product characteristics.

It is considered that the PGI variable affects the value of sea mustard as it is statistically significant. The coefficient for PGI is positive, suggesting that PGI labeling is highly relevant predictor for the formation of product value. This implies that a geographical indication that is provided by a reliable organization might make a positive impact on boosting consumer confidence and creating a good image. It is worth noting to watch that the coefficient for PGI has decreased from about 35 to about 24 when company information is added with region control. It is considered that this result comes from partial correlation between firm and regional level characteristics and PGI. Overestimation is mitigated in Model 2 since it includes level characteristics such as climate condition and consumers' preference for certain origin, and firm level characteristic such as experience, cost, and operational efficiency.

The CUT variable was not statistically significant in model 1, but it was statistically significant and positive in model 2, so it is considered that a precut product is preferable. The coefficient for SALT was negative, while the coefficient for NAT was positive. This means that sea mustard that is preserved by salting is perceived as a cheaper as compared to dried sea mustard, and this makes a negative impact on the value of a product. On the other hand, sea mustard gathered from nature, such as from stone, is perceived as a higher quality seaweed than ordinary sea mustard, and this had a positive effect on the value of a product. CASE demonstrated a positive value coefficient in the model, suggesting that the provision of luxury paper cases adds new value to a product.

In the second approach, a logarithmic transformation of the sea mustard price was performed with regression models using the identical explanatory variables as used in the first approach (Table 4.4). The CUT variable was not statistically significant in Model 1, but was statistically significant in Model 2. All characteristic variables were in Model 2 statistically significant, which was the same result as in the first approach. However, there were slight differences in significance levels and t values.

In the log scale, the coefficient for the explanatory variable was the difference in the expected means of the log prices of a PGI product and unlabeled product. So, the exponentiated coefficient for PGI can be represented as the ratio of the expected mean of the PGI products over the expected mean of the unlabeled products when the other variables are held at the mean value. For the PGI variable, it is expected to cause a 43.19% increase in the unit price of a sea mustard product. In the same way, a salted product is expected to cause a decrease of 53.65% to the value of the sea mustard, the provision of luxury case is expected to cause an increase of 54.65% to the value of the sea mustard, and a natural product can expect an increase of 98.58% to the value of the sea mustard.

4.5.2 SEA TANGLE ANALYSIS

In order to examine the factors that affect the value of sea tangle in the second stage, two approaches were again carried out. In the first approach, linear regression was performed without transformation, and the unit price of the sea tangle was used as a response variable (Table 4.5). Model 1 includes product characteristics, and Model 2 adds company information and region controls.

As a result of the estimation, it is believed that geographical factors affect the value of sea tangle as PGI was a statically significant variable. PGI was a positive variable, and this implies that an organization that certifies its geographical indication gains a positive effect on the value of its sea tangle, which was the same as with sea mustard. The coefficient for PGI has fallen but the effect was not that large like sea mustard, even though company information is added with region control. Two cases can be considered for the reason: region controls or company information used in this model might not be a reasonable proxy for unobserved firm and regional level characteristics; or PGI of sea tangle actually has a high value compared to sea mustard.

The coefficient for SALT was negative and the coefficient for NAT was positive. Both were statistically significant, which was also the case with sea mustard. In the case of sea mustard, the CASE variable had a relative importance, but in the case of sea tangle, it was shown that whether a product provides a luxury case or not makes no significant impact on its value. Hence, it is difficult to say whether a luxury case comes with sea tangle affects the value of the product or not.

In contrast, the results of sea tangle analysis showed that the CUT variable is significant in Model 1, which is unlike sea mustard - the CUT variable was not statistically significant in Model 2, but since it was statistically significant in both models of log price cases, it can be expected that CUT becomes statistically significant if the number of observations increases. Sea tangle is thick and hard to cut as compared to sea mustard, so there is difficulty in cutting and preparing it for cooking because it is large. However, when cooking, only a small amount of sea tangle is used at one time, so there is great preference for a precut product.

In the second approach, a regression of the log price of sea tangle was performed based on product characteristics (Table 4.6). As with first approach, the value of the sea tangle was determined by the PGI, SALT, CUT and NAT variables, but there were slight differences in significance levels and t values. For the PGI variable, it is expected to cause a 45.06% increase in the unit price of a sea tangle product. In the same way, a salted product is expected to cause a decrease of 75.41% to the value of the sea tangle, a precut product is expected to cause an increase of 34.99% to the value of the sea tangle, and a natural product can expect an increase of 100.17% to the value of the sea tangle.

4.5.3 SEA MUSTARD-SEA TANGLE COMBINED ANLYSIS

An integrated model of seaweed deals with sea mustard and sea tangle combined information. As a result of analysis of the first approach, it is suggested that PGI labeling contributes to the formation of product value as PGI was positive and statistically significant in moth Model 1 and Model 2 (Table 4.7). It is considered that overestimation is mitigated in Model 2 since the coefficient for PGI has decreased from about 31 to about 24 when company information is added with region control, suggesting that Model 2 is relatively more reliable to better capture the influence of PGI In Model 2.

All characteristic variables were statistically significant except CUT. Both CASE and NAT were positive and statistically significant. The provision of luxury case is such an addition of service and goods, and it is regarded as a creation of new values to the product. In the case of NAT, it is considered that natural products are recognized as more valuable compared to cultivated seaweed, regardless of kind of seaweed.

SALT is negative and statistically significant. It means that the salted sea mustard is perceived as low quality product in the case of both sea mustard and sea tangle, and it can be generalized that the value of seaweed is related to the preservation method when expanded to the whole seaweed group.

The integrated model was again carried out with logarithmically transforming of seaweed price (Table 4.8). The PGI variable and all seaweed chracteristic variables including SALT, CASE, CUT and NAT variables were statistically significant, and there was a slight difference in significance level and t value compared to the first approach.

For the PGI variable, the value of seaweed is expected be approximately 43.19% higher for the products which obtained certification of geographical indication than ordinary products. In the same way, a salted product is expected to cause a decrease of 53.65% to the value of the seaweed, the provision of luxury case is expected to cause an increase of 54.65% to the value of the seaweed, a precut product is expected to cause an increase of 36.21% to the value of the seaweed, and a natural product can expect an increase of 98.58% to the value of the seaweed.

4.6 DISCUSSION

It is clear that local values exist in the product as shown in the research results, but the result shows that the absolute value of the product that increases due to the local certification mark is greater. This means that there is a possibility that government-certified public confidence is greater than the confidence that information about the product's location gives, or, the increase in effectiveness of product brand may be far greater than if it simply provided local information because government certification and product regional information have synergies. In other words, the influence of the certification is very high, and information about the areas given by the product may be insufficient to form the local brand alone without certification.

The government's brand protection activities, i.e., the provision of certification marks, obviously play an important role, but in a proper sense, to develop regional brands, the overall branding of local products is necessary, not of one product. For the branding of region, not the branding of the just some minority products, above all, the reliability and image that the region can give, with respect to the production of products, will be important.

For example, when oranges produced in Florida have a high value, consumers think of the Florida itself, rather than thinking of a Florida company that produces oranges, as a reason of its value. Because the fact, that it was produced in Florida itself, has high expectations of the quality of the product, regardless of which company it was produced. In the case of products that have a reputation as local specialty products in the world, brand values are already well formed, maintaining brand value even without the government's certification mark.

For a product to have such a high level of local brand value, consideration of the local image will have to precede. In the case of Goheung, Wando, and Gijang, these names may be familiar to those who live here or frequently purchase seaweeds, but in the case of those who live far away or do not buy products often, the local names may be unfamiliar. In order for fisheries products to have a high-profile and popular image like Florida's oranges, it is necessary to improve the awareness of fisheries product regions.

In Korea, many coastal areas are known as tourist attractions and famous landmarks, but in comparison, there are relatively few areas which are famous to consumers for their fisheries products. To solve this problem, it is necessary to make the region widely known and familiar with the geographical names in order to brand the product in the region.

For example, the organization can establish a destination branding through the hosting of the regional food festivals, then this can improve the association between regions and products. It is also necessary to attract visitors through the promotion of ongoing experience-oriented cultural activities, such like Cheongyang which is famous for peppers, and Bosung which is famous for green tea [9], to use them as opportunities for product promotion and local promotion. If product quality and local awareness are combined, this could be a good chance to increase synergies effect of regional brand. If product quality and local awareness are combined, this could make synergy effects to solidify regional brand.

4.7 CONCLUSION

This paper examines the value of local brands with the characteristics of seaweed family, using the hedonic technique to find out the potential as a brand of aquatic products. As shown in the results, the PGI actually has been shown to have a certain effect on forming the value of a product and it is regarded that PGI works in relation to preference of consumers, as PGI showed positive values in the model of both sea mustard and sea tangle.

Models have shown that products, which are produced in a particular region, contribute to the value of the product through the nature of origin. As the research results show, the current sea mustard and sea tangle include local values in their characteristics, in other words, seaweed and sea tangle products which are produced in Goheung, Gijang and Wando contain local brand values. Thus, in order to raise the brand value of seaweeds such as sea mustard and sea tangle, it can be considered that using the local concept as a brand is of great significance and contributes to the value formation of products.

[9] Cheongyang and Bosung have tried to brand pepper and green tea which are their local products, respectively, and, in these days Cheongyang Peppers and Bosung Green Tea are used as a kind of proper noun in Korea.

In addition, the value of the product represented by the attachment of the PGI is greater than the value improvements produced in a particular region. It implies that it is necessary to further develop the image of the region in order to settle down regional brand, and for PGI products, the role of PGI is necessary until the recognition of the region is increased.

It is noteworthy that there are limitations to this study. The one of limiting factors in this study is the issue of selection bias and omitted variables inconsistency. Since PGI is not randomly assigned to products, selection bias is likely to occur in this study. In this paper, several approaches were considered to minimize selection bias: company information is added in the regression to adjust for PGI which might affect the value of seaweed; and regional control was performed since characteristics of region, such as transportation, climate condition, local financial state and policy, might affect the value of seaweed products. These approaches were also useful to mitigate omitted variables inconsistency as company information is used as proxy, considering firm level characteristics can affect the value of seaweed products.

Despite some biases are mitigated, it is still possible that a part of bias would remain. For the future study, it is necessary to consider more precise firm level characteristics, such like the firm's cost of production and lagged quantities, to capture the factors that might affect the PGI or (indirectly affect) the value of product. It will be also necessary to construct the panel data for the seaweed in order to develop the study. The panel data analysis is expected to capture unobserved firm characteristic and common economic shock and enables us to extract a causal relationship from observational study data between regional factors and the value of products, by using difference-in-difference method and advanced panel analysis.

Current seaweed products on the market have some local brand value, so that the government's strategy to brand region products in relation to fisheries can be seen as a feasible and applicable strategy. This requires efforts to expand the awareness of regions and products, to maintain the quality of fisheries products, and to continuously manage the brand. If the establishment of a fisheries brand is established in a stable manner, Korean fishery products could be an alternative to the competitiveness of imported fishery products in the long run.

Table 4.1 Definition of Variable

	Variable	Definition
Geographical Information Variable	PGI	Protected geographical indication (1 if product has PGI label, 0 if not)
	REGION	Region indicator (categorical variable)
Characteristic Variable	SALT	1 if it is salted, 0 if not
	CASE	1 if it has a luxury case, 0 if not
	CUT	1 if it is precut, 0 otherwise
	NAT	1 if it is harvested from rock (or natural places), 0 if not
Firm Level Variable	LSALE	Log transformation of sales of the company (unit of sales is 100 million KRW)
	EMPLOYER	The number of employers
	YEAR	Company's age (1 if age $<$ 10, 2 if 10 $\leq$ age $<$20, 3 if 20 $\leq$ age $<$30, 4 if 30 $\leq$ age $<$ 40, 5 if 40 $\leq$ age $<$50, 6 if age $\geq$ 50)
Price Variable	PRICE	Unit price of a product
	LPRICE	Log transformation of unit price

Table 4.2 Data Summary

Variable	Sea Mustard					Sea Tangle				
	N	Mean	Std. Dev.	Min	Max	N	Mean	Std. Dev.	Min	Max
PGI	117	0.060	0.238	0	1	76	0.066	0.250	0	1
SALT	117	0.077	0.268	0	1	76	0.079	0.271	0	1
CASE	117	0.256	0.439	0	1	76	0.026	0.161	0	1
CUT	117	0.145	0.354	0	1	76	0.237	0.428	0	1
NAT	117	0.179	0.385	0	1	76	0.079	0.271	0	1
LSALES	76	4.136	1.926	1	11.590	49	3.678	1.317	1.253	9.951
EMPLOYER	85	331.765	1676.592	1	13450	55	64.727	397.499	1	2956
YEAR	97	2.082	1.115	1	6	69	1.841	1.232	1	6
PRICE	117	57.049	48.613	4	381.05	76	26.557	15.879	2.45	84.5
LPRICE	117	3.773	0.758	1.386	5.943	76	3.086	0.680	0.896	4.437

Table 4.3 Regression Results for Sea Mustard (no transformation)

	Model 1			Model 2		
Variable	Estimate	Std. Err.	t	Estimate	Std. Err.	t
PGI	35.327**	13.717	2.58	23.777*	13.982	1.70
SALT	-28.056***	5.515	-5.09	-16.455*	8.514	-1.93
CASE	28.590***	8.253	3.46	26.194***	6.919	3.79
CUT	-2.563	5.983	-0.43	10.474**	4.779	2.19
NAT	41.058***	10.097	4.07	38.958***	12.606	3.09
LSALES				0.526	2.085	0.25
EMPLOYER				-0.002	0.002	-1.12
YEAR				2.386	3.114	0.77
1.Region				13.286***	3.389	3.92
2.Region				5.688	6.636	0.86
3.Region				35.971***	5.58	6.45
4.Region				11.664***	3.639	3.21
5.Region				16.149**	7.887	2.05
6.Region				6.127	4.833	1.27
7.Region				45.276***	11.674	3.88
8.Region				33.288**	13.049	2.55
9.Region				5.323	19.25	0.28
10.Region				5.936	7.346	0.81
Intercept	6.011	10.989	0.55	8.778	16.154	0.54
MSE	612.909			468.723		
R-squared	0.522			0.703		
N	75			75		

Note: *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.

Table 4.4 Regression Results for Sea Mustard (logarithmic price scale)

	Model 1			Model 2		
Variable	Estimate	Std. Err.	t	Estimate	Std. Err.	t
PGI	0.625***	0.195	3.21	0.359*	0.181	1.99
SALT	-1.046***	0.258	-4.05	-0.769**	0.306	-2.51
CASE	0.484***	0.123	3.94	0.436***	0.097	4.48
CUT	-0.004	0.123	-0.03	0.309***	0.098	3.14
NAT	0.731***	0.125	5.86	0.686***	0.152	4.51
LSALES				0.282	0.264	1.07
EMPLOYER				0.194	0.228	0.85
YEAR				0.037	0.037	0.98
1.Region				0.399***	0.128	3.12
2.Region				0.183	0.217	0.84
3.Region				0.858***	0.153	5.6
4.Region				0.366***	0.121	3.01
5.Region				0.521	0.332	1.57
6.Region				0.250*	0.144	1.74
7.Region				0.935***	0.21	4.45
8.Region				0.859***	0.246	3.5
9.Region				0.282	0.264	1.07
10.Region				0.194	0.228	0.85
Intercept	3.552***	0.087	40.6	2.790***	0.202	13.82
MSE	0.230			0.156		
R-squared	0.567			0.761		
N	75			75		

Note: *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.

Table 4.5 Regression Results for Sea Tangle (no transformation)

	Model 1			Model 2		
Variable	Estimate	Std. Err.	t	Estimate	Std. Err.	t
PGI	21.640**	8.656	2.5	21.235***	7.633	2.78
SALT	-17.309***	2.565	-6.75	-14.347***	3.483	-4.12
CASE	-0.562	1.972	-0.28	3.925	5.875	0.67
CUT	9.443**	3.771	2.5	6.720	5.152	1.30
NAT	23.518***	6.69	3.52	22.213***	7.147	3.11
LSALES				-0.975	2.851	-0.34
EMPLOYER				0.074	0.076	0.97
YEAR				1.992	2.271	0.88
1.Region				3.860	3.486	1.11
2.Region				-0.910	5.138	-0.18
3.Region				10.718**	4.705	2.28
4.Region				5.211	4.225	1.23
5.Region				-213.723	211.934	-1.01
Intercept	22.243***	2.144	10.38	15.899*	9.337	1.70
MSE	121.396			115.799		
R-squared	0.635			0.717		
N	49			49		

Note: *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.

Table 4.6 Regression Results for Sea Tangle (logarithmic price scale)

	Model 1			Model 2		
Variable	Estimate	Std. Err.	t	Estimate	Std. Err.	t
PGI	0.468***	0.172	2.72	0.372*	0.207	1.80
SALT	-1.563***	0.264	-5.92	-1.403***	0.315	-4.45
CASE	-0.013	0.149	-0.09	-0.116	0.279	-0.42
CUT	0.380***	0.13	2.93	0.300*	0.170	1.76
NAT	0.677***	0.191	3.54	0.694***	0.237	2.93
LSALES				-0.087	0.105	-0.83
EMPLOYER				0.004	0.003	1.46
YEAR				0.090	0.095	0.95
1.Region				0.225	0.206	1.10
2.Region				0.188	0.238	0.79
3.Region				0.374	0.245	1.53
4.Region				0.154	0.228	0.68
5.Region				-11.045	7.499	-1.47
Intercept	3.018***	0.093	32.44	2.912***	0.335	8.70
MSE	0.194			0.190		
R-squared	0.700			0.762		
N	49			49		

Note: *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.

Table 4.7 Results for Integrated Seaweed Model (no transformation)

	Model 1			Model 2		
Variable	Estimate	Std. Err.	t	Estimate	Std. Err.	t
PGI	30.876***	10.793	2.86	23.968**	10.596	2.26
SALT	-26.393***	4.692	-5.63	-15.103***	4.907	-3.08
CASE	33.026***	7.839	4.21	32.507***	6.896	4.71
CUT	-0.949	4.263	-0.22	2.686	4.372	0.61
NAT	34.247***	7.844	4.37	27.664***	8.958	3.09
LSALES				0.548	1.423	0.39
EMPLOYER				-0.001	0.001	-0.95
YEAR				1.915	2.223	0.86
1.Region				11.275**	5.192	2.17
2.Region				-0.602	5.514	-0.11
3.Region				26.411***	4.514	5.85
4.Region				10.953***	3.352	3.27
5.Region				13.663***	4.735	2.89
6.Region				5.971*	3.411	1.75
7.Region				55.876***	7.781	7.18
8.Region				44.403***	9.18	4.84
9.Region				12.953	14.736	0.88
10.Region				8.912**	4.333	2.06
11.Region				1.702	9.771	0.17
Intercept	32.577***	2.565	12.7	12.583**	5.905	2.13
MSE	507.33			405.338		
R-squared	0.507			0.653		
N	124			124		

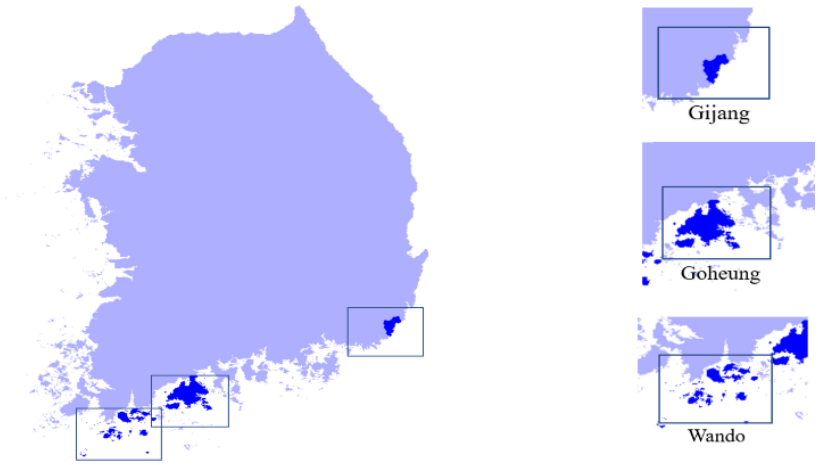
Note: *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.

Table 4.8 Results for Integrated Seaweed Model (logarithmic price scale)

	Model 1			Model 2		
Variable	Estimate	Std. Err.	t	Estimate	Std. Err.	t
PGI	0.631***	0.162	3.9	0.359*	0.181	1.99
SALT	-1.319***	0.254	-5.2	-0.769**	0.306	-2.51
CASE	0.581***	0.135	4.29	0.436***	0.097	4.48
CUT	0.093	0.098	0.95	0.309***	0.098	3.14
NAT	0.736***	0.127	5.79	0.686***	0.152	4.51
LSALES				0.037	0.037	0.98
EMPLOYER				-0.001	0.001	-1.42
YEAR				0.036	0.054	0.66
1.Region				0.399***	0.128	3.12
2.Region				0.183	0.217	0.84
3.Region				0.858***	0.153	5.6
4.Region				0.366***	0.121	3.01
5.Region				0.521	0.332	1.57
6.Region				0.250*	0.144	1.74
7.Region				0.935***	0.210	4.45
8.Region				0.859***	0.246	3.50
9.Region				0.282	0.264	1.07
10.Region				0.194	0.228	0.85
11.Region				0.399***	0.128	3.12
Intercept	3.337***	0.072	46.3	2.790***	0.202	13.82
MSE	0.295			0.156		
R-squared	0.553			0.761		
N	124			124		

Note: *, ** and *** denote significance at the 10%, 5% and 1% significance level, respectively.

Figure 4.1 Map of the PGI areas (Gijang, Goheung and Wando)



5

Conclusion

5.1 SUMMARY

Fisheries economics can be said to be the most likely area to develop among the many areas of applied economics. It has evolved into a comprehensive academic discipline, combining marine science, biology, fisheries management, and environmental issues (Caddy & Cochrane, 2001), and requires a social science approach to resolve regional and institutional concerns. Indeed, there exist various situations, systems, and policies associated with fisheries, and it will be necessary to look at topics from various angles to understand the issues connected with fisheries and to develop the relevant field.

This dissertation attempts to employ that model, using different methods in the different regions it examines. The first essay examining the economic impacts of climate change on fisheries in the Philippines, applies the dynamic CGE model. CGE modeling has proved a remarkably fruitful technique for combining data with economic theory to project the implications for macro, industry, regional, occupational, environmental, and distributional variables of a wide range of policy changes and other shocks to the economy (Dixon & Rimmer, 2010). In the present analysis, one baseline scenario and two climate change scenarios based on greenhouse gas concentrations are considered. The study focuses on GDP and income distribution by sector, which can reflect economic conditions in terms of economic growth and distribution.

The second essay examining the value of the seafood traceability system in Korea applies the CV method, focusing on the awareness of the importance of food safety represented by recognition of the value of the information provided by a seafood traceability system. By using the CV method, which is one of the standard approaches for valuing nonmarket goods and has proved useful when evaluating policies or systems (Hanemann et al., 1991; Alberini& Cooper, 2000), the study shows the need for a traceability system.

The third essay examining the regional brand value in fisheries products uses a hedonic model, identifying price factors that reflect regional differences. The hedonic model is used to estimate the value of factors and examines how each factor affects the price of the product. The study shows that regional branding can be one strategy for marketing fisheries products.

The results of the studies reported in this dissertation support the need for education and the promotion of relative information and systems for the public. To cope with climate change, it is necessary to establish reliable research materials by collecting climate data and fisheries-related information, and these sources should be open to the public to enable appropriate planning. To develop the traceability system and improve the awareness of seafood traceability, governments and private business organizations connected with fisheries need to promote the function and benefit of seafood traceability. Mass media advertising campaigns about seafood traceability should be combined with education on food safety. Information is also required about its use in increasing convenience for consumers. To boost the competitiveness of fisheries products, efforts must be made to expand public the awareness about regions and products, to maintain the quality of fisheries products, and to continuously manage the brand. The essays in this dissertation examine different topics, but they share a common interest in the idea that public awareness of and attention to the relevant issues are necessary.

The topics and methods included in this dissertation are only a fraction of those that fisheries economics can deal with. It would take an enormous amount of space to examine all the research required in different fields of fisheries. Fortunately, many fisheries studies are being conducted using applied economic research by many researchers; and, if this trend continues, the fisheries economics that people will see in the future will be much richer and much more diverse. It is considered that the subjects of climate change, traceability, and regional branding that are covered in this dissertation will contribute to some degree to the study of fisheries economics.

5.2 FUTURE DIRECTIONS

Economics is more closely related to real life than other disciplines, and in the case of applied economics, efforts are made to reflect the results of the practical analysis in economic policy based on the feasibility and predictability of economic theory. Although the field of fisheries economics has been continuously developing since the middle of the twentieth century, there are few cases in which the results of research are applied to actual economic life and economic policy compared with other economic fields.

In the case of agricultural economics, the verification and application of theories are being actively carried out through the construction and application of data since it systematically built its own domain of study, but in many research institutes and schools, there are few cases in which fisheries economics have settled down as academic branches of fisheries and the research results scale up in real life.

The reason that agricultural economics became a comprehensive science in which various fields were applied is that researchers constructed a system of interdisciplinary study by successfully linking agricultural science and economics. However, researchers in fisheries economics are in the process of establishing a system.

In the case of fisheries economics, it is relatively more difficult to find the regularity behind the theory and find the predictability for the future. It is not easy to build a systematic study with the efforts of only a few experts since fisheries economics depends simultaneously on a knowledge of fishery science, which requires specialized knowledge in oceanography, climatology, and biology, and economic knowledge, which must understand social phenomena or economic theory such as individual behavior, history, and institutions. Therefore, a closer academic linkage is needed for the development of fisheries economics.

This can be seen by taking this dissertation as an example. As the first essay in this dissertation demonstrates, the academic linkage, focusing on climatology, tidal current and oceanography, will enable us to reliably predict future climate change and water temperature; and the academic linkage around biology, physiology, and ecology can more accurately predict the survival and migration of fish. Academic links between economics and social science, focusing on social institutions, economic indicators, and human behaviors, can better explain future market changes and economic directions.

As the second essay in this dissertation shows, building a traceability system using barcode and radio-frequency identification technology requires full knowledge of IT, software, and networks. The academic linkage around engineering and distribution management would help the system to develop. In addition, studies on food nutrition and health are required to analyze the impact of the system on people with regard to food safety.

As the third essay in this dissertation demonstrates, knowledge about fishery science is necessary to understand the impact of local climates on fisheries in terms of the production of fisheries products. Additionally, the academic linkage between marketing, which focuses on PR, brand, and sales strategy, and regional planning, which deals with regional information including industry, location, and resident tendency, will help develop the study in terms of the branding and improvement of product sales.

Like the example mentioned above, interdisciplinary study can lead to more professional and advanced research through the convergence of various studies with different information and customized backgrounds, so it is necessary for various experts to form a network and conduct research together. Future studies can produce useful research with more accurate results through close academic linkages. Furthermore, it is hoped that research can ultimately contribute to the establishment of a system in the field of fisheries economics.

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