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A Variability Analysis on the Flatfish Production and Revenue using Expectation Hypotheses and GARCH Model†

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Abstract

This work studies the variability of flatfish sales revenue. The theoretical analysis draws functions for equilibrium price and quantity using expectation hypotheses. The functions include unpredictable phenomenon with dummy variable and GARCH. The equilibrium function, using adaptive expectation hypothesis, contains the independent variables of supply and demand, while the equilibrium function, embodying rational expectation hypothesis, includes only the independent variables of supply side, because the demand side disappears by the information extraction process theoretically, if economic subjects build the expectation rational.

The empirical analysis shows: the variability of flatfish production has a spillover effect on the variability of revenue with the adaptive expectation hypothesis. In the case when the model has a rational expectation hypothesis, the variability of flatfish production has a spillover effect on the revenue (the mean equation of GARCH model). This study indicates that there is the variability in flatfish production and sales revenue, and the spillover effect between them. The result can help to build of the rational system for the fishery income stability.

Keywords : Adaptive Expectation Hypotheses, Rational Expectation Hypotheses, Variability Analysis, Spillover-effect, Flatfish production

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Ⅰ. Introduction

1. Rationale and Purpose

Korea-China FTA that reached a settlement by 2014 and possible ratification of TPP(Trans-Pacific partnership)[1] are not a very welcoming news. The subsidies paid to fisherman are expected to be curtailed[2]. If the production cost increases with reducing subsidies, then the demand is likely to diminish with a rise in the price. Tariff lowering resulted from FTA or TPP can increase import of marine products and it reduces income of the fisherman.

On this wise, the globalization shrinks fishery product but it is one of important food with well-being trend. Since 20th century the rice consumption has been reduced, while fish and shellfish consumption has been increased steadily, taking up 40% of animal protein intake by 2016. Thus the economic policy is needed for conservation fishery industry in terms of improving food security and public well-bing.

Major factors threatening the sustainability of fisheries are decreasing income and its uncertainty. Fisheries production belongs to the industry whose correlation between output and input is unstable. The production depends on the natural condition and products can be spoiled during the distribution. Considering these factors, the long term economic subside policy is needed to control the supply and demand of fisheries products. Japanese government has adopted subsides policy for growing of the fishery industry since long before with extra relief funds. Thus our government should help to build private subside funds to maintain for the sustainability of fisheries as entering into more FTAs.

For implementing these economic policies, supply and demand of fisheries products, and its prices are needed to be forecasted and to add to that, the change of fisherman revenues should be investigated. There are many articles which study the supply and demand of fisheries products, while there are little to no study about fisheries income volatility. This paper analyzes the volatility of fisheries products and revenues using a newly-reduced supply and demand function.

Volatility exists in fisheries industry because the prices of baby fishes are rising, and fish diseases and natural disasters disturb propagation of fishes. These factors along with the changes in international condition increase the uncertainty in fisheries production risk, which interferes with sustainable development of fisheries industry. Thus it is necessary to investigate the volatility of fisherman revenues.

The subject of analysis is flatfish, which is one of cultured fishery products with clams and oysters. Flatfish farming, which had started in the 80s, increased steadily between 1995 and 2010, after which began to decrease. Recently the amount started to rise again and b 2016, it had increased 5.4% more than that in the previous year. As fish farming today takes a large percentage of fisheries production with its ratio showing rising tendency, it is considered that fisherman revenues depend largely on fish farming sector. Thus this paper analyzes the production and revenues of flatfish rising.

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1) President of the United States, Donald Trump. announced that USA is going to drop out of TPP, but we cannot rule out the possibility that USA wants to join in TPP when the political and economical condition change.

2) Subsides in TPP-norms; subside for gas bill, which takes up about 45% of expenses of fishing industry, is expected to be curtailed.

The production activity of fisheries industry targets profits like any other production activities. Supplier provide goods and services on the market in order to get profits. This paper defines the volatility as the amount that producer did not expect and it can have either a negative or positive value. And this work will investigate functions, which can be applied to estimating production volatility, and the spillover effects of the production volatility.

This paper will induce functions that represent prices and quantity in equilibriums using expectation hypothesis, and estimate the production and revenues volatility with this functions. After that spillover effects of the production volatility on the revenues volatility will be investigated.

2. Literature review and researching plan

There is no similar articles like this paper, but related articles can be divided into three categories, analysis on the supply and demand of flatfish, analysis using expectation hypothesis and analysis on the volatility with statistical method.

Categories of analysis on the supply and demand of flatfish: Park and Jung(1995) proved the existence of dietary habit on the fisheries demand, through analyzing statistical data about pollack and croaker using demand function with the combination of partial adjustment model. OK, Kim and Go(2007) carried out the time series analysis on flatfish farming with VAR and ARIMA.

Lee(2006) investigated the distribution and consumption system of flatfish, and Park(2008) studied the supply and demand structure of flatfish market with stock-flow model that belongs to system dynamic method. Kim(2014) stu야ed the supply side with panel analysis and demand side with time series analysis. Kim et al.(2015) anticipated the price, the quantity of supply and demand of flatfish through 2917 with OLS including AR(1).

Categories of analysis using expectation hypothesis: Muth(1961) devised the rational expectation hypothesis but Cagan(1956) insisted that the adaptive expectation hypothesis is more realistic than the former (the rational expectation hypothesis). Lucas(1976) built the new classical macroeconomics using the rational expectation hypothesis by Muth. Murik(2013) discussed the relationship between monetary policy and expectation hypothesis, and Lin and Somette(2013) analyzed the bubble phenomenon with expectation hypothesis. Yoon(2016, 2014) explained the causes of failure of Japanese monetary policy using expectation hypothesis.

Categories of analysis on the volatility with statistical method: The Okun had studied the correlation between inflation volatility and inflation level. Friedman(1977) verified that inflation volatility influences the inflation level positively. Krugman(1988) made an opposite conclusion to Friedman’s. Ito & Sato(2006) investigated the effect of exchange rate volatility on the price level.

Articles above give help for this paper indirectly. The works on flatfish discussed the demand side mainly, and the analysis on supply side used ARMA or panel model. Thus these studies are not proper to investigate equilibrium quantities and prices. This study tries to overcome the limitations of these works and will theoretically induce the supply and demand function using expectation hypothesis, and the inquire the sales volume and revenues of flatfish with analysis of supply and demand over a same period.

To form a supply function, we will use the expectation hypothesis while mainly referring to the work of Yoon(2014). The demand and supply function, which are induced by method described above will be estimated with statistical method and be applied to analyze the volatility of equilibrium quantities. Articles included in the 2nd categories hypothesis can help to formulate the supply and demand function, and articles included in the 3rd categories will be used to analyze the volatility.

We define the volatility as the difference between expected and realized values, and estimate volatility of sales volume, which is used to analyze the effects on sales revenues. The 2nd chapter formulates the supply and demand function of flatfish theoretically using the adaptive and rational expectation hypothesis. Exogenous factors can be considered with dummy variable or GARCH model. The 3rd chapter explains variables which are used in the statistical analysis, and presents grounds for proxy variables which are used for the case that we can not find proper variables for the theory statistically. The 4th chapter carries out the empirical analysis with the functions of chapter 2 and statistical variables of chapter 3. We test significance of parameters, estimates volatility, and analyze spillover effects when volatility is present. The 5th chapter summarize the results of the analysis mentioned above.

Ⅱ. Theoretical Model

1. Demand and supply model with expectation hypothesis

According to micro economic theory commodity supply(Q_t^s) depends on its price(P_t), production costs(C_t) and technical level. The technical level can be assumed as constant in a certain term. This classical thinking became more logically by expectation hypothesis[3]. The expectation hypothesis divides commodity supply(Q_t^s) into natural and cyclical components. The former is the production at a normal level(Q_N), just like the supply made by the normal operating rate. The latter depends on the price expectation error: $dQ_t =$ ($P_t = P_t^e$), dQ_t is the cyclical component, changed by the difference between the realized price(P_t) and the anticipated one(P_t^e).

It's based on the assumption that the economic situation has already adjusted on the expected level in the period (t). Suppler estimates the anticipated price(P_t^e) in the period (t-1) with given production costs and planned supply amount with this anticipated price(P_t^e). The planed supply amount comes close to the normal supply level. The supply in the period(t) changes from the normal supply and it depends on price expectation error($P_t - P_t^e$)[4].

According to behavior of suppler mentioned above, supply function consists with a normal production quantity(Q_N) and price expectation error($P_t - P_t^e$). In addition, the change of production cost influences the supply[5].

3) The expectation hypothesis had started with by adaptive expectation hypothesis Cagan(1958) and rational expectation hypothesis by Muth(1961).
4) Lucas(1977) had built New classic model, which involves micro and macro economic thinking. After that most of economist conceded this micro economical causality.
5) It is not considered by macro economical model. This paper includes production cost because we carry out the micro economic analysis.

In other words, the production cost in the previous period(C_{t-1}) had been calculated already in the expected price(P_t^e), and thus only the difference of production cost(dC_t) influences the supply amount in present period[6]. And fisheries supply can be affected by natural disasters, for example res tide and El Nino, which can be expressed as error term(ε_t). Accordingly, the supply function has a form as follows:

$$Q_t^s = f(Q_n, P_t - P_t^e, dC_t, \varepsilon_t) \quad (1)$$

$$Q_t^d = f(P_t, Q_{t-1}, O_t, dY_t, NX_t, e_t) \quad (2)$$

Equation (1) shows that the normal supply level(Q_N) and the price expectation error($P_t - P_t^e$) influence supply amount positively [$\partial Q_t / \partial (P_t - P_t^e) > 0$], and the difference of production cost(dC_t) impacts supply amount negatively [$\partial Q_t / \partial (dC_t) < 0$]. Equation (2) indicates a demand function, which shows the inverse correlation between supply and price [$\partial Q_t / \partial P_t < 0$]. Demand amount can be changed with dietary habit[7].

Generally the factor of dietary habit shows positive relationship with demand in previous period(Q_{t-1})[8]. Income influences demand, and income in previous period impacts demand in previous period, which is considered in dietary habit (Q_{t-1}) as an independent variable. Thus we consider only the income change(dY_t) as a factor for demand change[9]. And demand depends on price of substitute goods(O_t) and net export(NX_t). Lastly, demand function for fisheries should be able to consider unexpected factors such as diseases including cholera and vibrio, which occur by fisheries consumption. When we include these in error term (e_t), demand function has a form as equation (2)[10].

1) Adaptive expectation hypothesis

According to adaptive expectation hypothesis by Cagan(1956), economic subjects correct expectation error with their past experience. It means that present expectation error ($P_t - P_t^e$) is an output which the error correction process results. Economic subjects anticipate the future level of variable with error correction process based on the change of variable in the previous period. That is, they correct expectation error with their learning-by doing effect, and it had the form: $(P_t - P_t^e) = \alpha(P_{t-1} - P_{t-1}^e)$. It is changes with differential input method as follows: $(P_t - P_t^e) = (1-\alpha)^i P_{t-1}$. Using this let price and quantity in equilibrium ($Q_t^s = Q_t^d$) calculate from equation (1) and (2) as follows:

$$P_t = f(Q_N, P_{t-1}, dY_t, dC_t, Q_{t-1}, Q_t, NX_t, e_t, \varepsilon_t) \quad (3)$$

$$Q_t = f(Q_N, dP_t, dC_t, e_t) \quad (4)$$

Equation (3) and (4) are outputs of calculation with the simplest form of adaptive expectation($i=1$). The

6) There can be a time lag in the production process, but the paper ignores this fact since it is not so important to this analysis.
7) It is an important factor for fisheries demand, see Park and Jung(1995).
8) Q_{t-1} has the advantage that it increases the value of R^2 and eliminates the auto-correlation. Meanwhile, we have to test multi-collaterality, if price exists as an independent variable. This will be carried out in empirical analysis of this work.
9) If independent variables do not include the previous demand(Q_{t-1}), it can be said that demand depends on the income(Y_t) itself.
10) If we turn equation (2) into price as the dependent variable, it shows an inverse demand function.

equation (3) shows the price in equilibrium ($Q_t^s = Q_t^d$) and indicates that the price has a positive correlation with previous price (P_{t-1}), income change(dY_t), previous demand(Q_{t-1}), prices of substitute goods(Q_t), net export(NX_t) and production cost change(dC_t). Moreover, the price level decreases with increasing normal supply level(Q_N). Equation (4) represents the supply side. Substitution of equation (3) into (4) results in equation (5)[11].

$$Q_t = f(Q_n, P_{t-1}, dY_t, dC_t, Q_{t-1}, O_t, NX_t, \varepsilon_t, e_t) \tag{5}$$

The equation (5) indicates that equilibrium quantity is influenced by normal supply level(Q_n), income change (dY_t), previous demand(Q_{t-1}), prices of substitute goods(O_t) and net export(NX_t) positively, and that equilibrium quantity decreses with increasing production cost change(dC_t), ($\partial Q_t/\partial C_t$)<0. Effects of previous price on the equilibrium quantity($\partial Q_t/\partial P_{t-1}$) depends on the impact of previous price on supply($\partial Q_t^s/\partial P_{t-1}$) and demand ($\partial Q_t^d/\partial P_{t-1}$): To make it simply let ($\partial Q_t^s/\partial P_{t-1}$)$=\alpha$ and ($\partial Q_t^d/\partial P_{t-1}$)$=\beta$.

According to equation (5), ($\partial Q_t/\partial P_{t-1}$) equals to $\alpha\,(\frac{1-(\alpha+\beta)}{\alpha+\beta})$. It means as follows : If ($\alpha+\beta$) is larger than 0, and smaller than 1, ($\partial Q_t/\partial P_{t-1}$) is larger than 0. If, ($\alpha+\beta$) smaller than 0, it comes into ($\partial Q_t/\partial P_{t-1}$) < 0. This means that previous price influences the equilibrium quantity negatively, if the effect of price on demand is greater than that on supply, and that there is no effect, if ($\alpha+\beta$) approach to one.

Multiply of equation (3) and (5) results in equilibrium revenues (R_t)[12].

$$R_t = (QP)_t = f(Q_n, P_{t-1}, dY_t, dC_t, Q_{t-1}, O_t, NX_t, \varepsilon_t, e_t) \tag{6}$$

We can use equation (4) or (5) to calculate equilibrium quantity[13]. The equation (4) presents clear economic causality and the equation (5) involves all independents variables that affect supply and demand. Equation (6) explains equilibrium revenues which depends on the changes in the price and supply level.

2) Rational expectation hypothesis

The adoptive expectation hypothesis above has a logical limitation in that it uses only previous data of one variable it self to form anticipations. This method can not be applied in an information-oriented society. Thus, it is not proper for economic subjects to use a method for expectation formation continuously when they realized that the method includes error. They will use the new information for the anticipation. Muth(1961) had mentioned the logic first and Lucas(1976) systemized it as a rational hypothesis.

The rational expectation hypothesis[14] implies that the anticipated price is formed by informations which a model produces. Using equation (2) and (3), equilibrium price and quantity can be calculated through information abstraction process as follows:

11) The survival time of living flatfish as inventory is 5-7 days. Therefore, supply is equal to demand in monthly data.
12) Net revenue has a same form of (6), because net revenue=total revenues-total cost.
13) Multicollinearity can theoretically exists between P_{t-1} and Q_{t-1} in the equation (3) and (5). It should be tested in the empirical analysis.
14) A weak axiomatic means that economic subjects use the previous data to anticipate independent variables and the information, which a model produces, to anticipate dependent variables, Yoon(2014).

$$P_t = f(Q_n, dY_t, dC_t, Q_{t-1}, O_t, NX_t, e_t, \varepsilon_t) \quad (7)$$
$$Q_t = f(Q_n, dY_t - dY_t^e, dC_t, O_t - O_t^e, NX_t - NX_t^e, e_t, \varepsilon_t) \quad (8)$$

The rational expectation hypothesis is defined as $(P_t - P_t^e) = E(0, V)$. It represents that expectation error $(P_t - P_t^e)$ has a probability distribution of which the average value equals zero and the variance has a value of V.

We can explain reasons for that collectively and individually. The former implies that expectation error of a group can be zero in an information-oriented society. One part of group can overestimate and the other part can underestimate, and so the mean becomes zero if the number of either side is equal. The latter implies that if he anticipates repeated phenomenon, expectation error of one individual can have zero as average value, because there is a psychological law that an individual overestimates at one time and underestimate at the other time.

According to rational expectation hypothesis above-mentioned, the means of independent variables have the value 'zero', and equation (7) and (8) are changed as follows:[15)]

$$P_t = f(Q_n, dY_t, dC_t, Q_{t-1}, O_t, NX_t, \varepsilon_t, e_t, \nu_t) \quad (9)$$
$$Q_t = f(Q_n, dC_t, e_t, \varepsilon_t, \nu_t) \quad (10)$$

Equation (9), which represents the change of equilibrium price, does not include the previous price (P_{t-1}) compared to the equation (3) induced by adoptive expectation hypothesis. Equation (10) means that equilibrium quantity depends on the normal production quantity and the change of production cost, when the supplier plans production according to rational expectation hypothesis. We use the equation (9) and (10) for empirical test in 4th chapter.

Revenue is represented with multiplication (9) by (10) as follows:

$$R_t = (QP)_t = f(Q_n, dY_t, dC_t, Q_{t-1}, O_t, NX_t, \varepsilon_t, e_t, \nu_t) \quad (11)$$

Equation (11) says that revenue(R_t) rises when the change of income (dY_t), net export(NX_t) and price of substitute good(O_t) increase, because these factors influence the demand of observing good positively. The change of production cost(dC_t) is related to production amount negatively but it increases the price[16)]. Impacts that normal production level(Q_n) exerts to sales revenue(R_t), can not be estimated in either case.

2. GARCH model

As mentioned above, error terms (e_t, ε_t, ν_t) in equation (9), (10) and (11) includes exogenous factors as cholera, red tide, vibrio septicemia and EL Nino, which affects the demand and supply of fisheries production. These can be divided into two groups: one that occurs during the particular months and the other that occurs randomly. The former can be expressed with dummy variable[17)], We will use GARCH to express

15) From equation $(X_t - X_t^e) = E(0, V)$, V turns to as error term (ν_t).
16) It is related to the net revenue negatively. Equation (11) represents total revenue and its change can not be calculated by change of production cost.
17) Season adjust can help to eliminate these factors, when these appear seasonally. However, these occurs during particular months. Thus, the dummy variable is proper to express these factors and is added to equation (5) or (11) as independent variable.

the latter. GARCH model, devised by Engels(1987), includes the variance equation besides the mean equation. A representative form as GARCH(1,1) is as follows:

Mean equation: $Z_t = X_t{}' + \varepsilon_t$; Variance equation: $G_t = \alpha + \alpha\varepsilon_t^2 + \beta G_{t-1}$

Equations above-mentioned, [(5), (6), (10) and (11)], will be the mean equation in this paper. $G_t(=\alpha_t^2)$ indicates the conditional variance and ε_t^2 is the ARCH term in the variance equation. Yoon(2005) had used GARCH model to test the volatility spillover effect in the macro economic causality[18]. This paper estimates spillover effect of flatfish production volatility on the flatfish sale revenue. Null hypothesis is:

H_0: Volatility of flatfish production has no influence on flatfish sale revenue.

The anticipated result is that the volatility spillover effect will exist when volatility of flatfish production does not affect the price of flatfish and that the volatility spillover effect is partly offset and will be small when volatility of flatfish production influences the price of flatfish negatively.

Ⅲ. Variables Explanation

This paper applies monthly data from January 2006 to December 2015. Variable, used for the empirical analysis in 4th chapter, are as follows:

1. Trade quantity and price

Trade quantity(Q_t) and price(P_t), which are involved as dependent variables of the equation in chapter 2, represent the level in equilibrium. Trade quantity and price, which exist in real market, may not always shows level in equilibrium, but depend on supply and demand. The market price approaches to the level in equilibrium, if demander and supplier act stably[19].

Thus we use production quantity and sale revenue of flatfish in KOSIS KOSIS[20]: for Q_t and R_t in equilibrium. As KOSIS does not announce statistical data about flatfish price(P_t), we calculate it with R_t divided by Q_t. But this value changes in the same direction with the price level. To eliminate this tendency and to change into real value, we divide the revenue and the price by GDP-deflator of KOSIS and use it for the empirical analysis in 4th chapter[21].

2. Normal production level

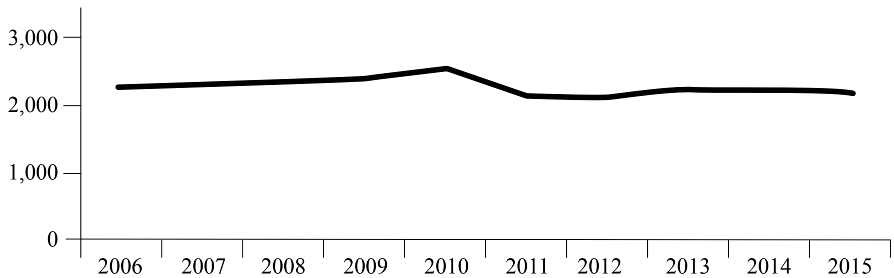
New Classical economists assume that the normal level of production(Q_N) in equation (3) is constant. Meanwhile we consider it a changing variable, because this paper uses 10 years monthly data from January

18) Yoon(2005) had studied the share prices volatility induced by money stock.
19) It signifies that supply and demand functions are stable.
20) http://kosis.kr/statisticsList. Production quantity, announced by kosis.co.kr, means sales and demand quantity because survival time of living flatfish as inventory are 5-7 days. Therefore, supply equals to demand in monthly data.
21) When we use nominal values, the tendency of income and cost changing within the same direction is not eliminated. Thus, the statistical test can not find an accurate economic causality.

2006 until December 2015. Thus, we should find a proxy variable, which impacts supply in long term, and use it instead of the normal production level, because there is no data for the normal production level. This paper selected fish farming area as the proxy variable[22].

The level of normal production generally depends on capital stock. The area of fish farming represents capital stock in fisheries industry, and thus it can be used as a proxy variable for the normal production level. Flatfish farming achieved success by 2010 and with the form of land based seawater and cage-aquaculture. The land based seawater takes over 90% and KOSIS annually announces data of its area with 『Fish farming trends survey』. Fig. 1 shows that the area held 2,289,000m^2 by 2006 and increased to 2,527,000m^2 by 2010, and after that decreased to 2,184,000m^2 by 2015.

While these data are published yearly, we need to carry out empirical analysis with monthly data[23]. Thus we turned the yearly data to monthly data using monthly difference and its 12-month moving average(AM_t) will be used as proxy variable for normal production level(Q_N).



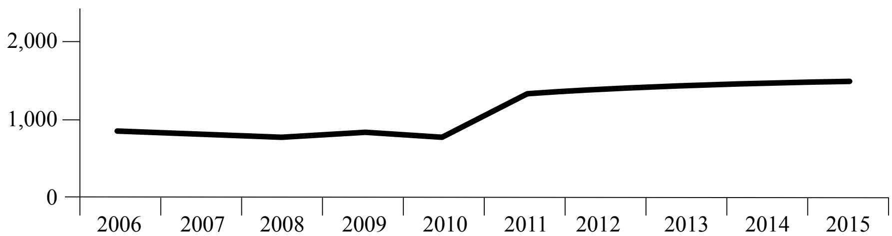
Source : KOSIS, 『Fish farming trends survey』each year(unit: 1,000m^2)

Fig. 1. Fish farming area.

3. Production cost and net export

1) Production cost

We use data of 『Required cost of fishery fund』 by Ministry of Oceans and Fisheries[24] and Korea



Source : 『Marin fisheries statistics annual report』, each year(unit: won)

Fig. 2. Total cost for Fish Forming.

22) The moving average of production in previous period can be a proxy variable for normal production. The empirical result with this is similar to that with fish farming area. We will show an analysis with moving average of production as a proxy variable for normal production in another paper.
23) All variables except fish farming area and production cost are announced monthly.
24) See, 『Marin fisheries statistics annual report』 by Ministry of Oceans and Fisheries.

National Statistical office as production cost. Cost categories consist of seeding cost, financial cost, loan and depreciation cost. This paper uses the total cost for Fish Forming shown in Fig. 2.

It was 849,150 won per unit by 2006 and decreased to 782,742 won by 2010, and upturned to 849,150 won by 2011 again with slight increase since.

These data are published yearly, and we turned it to monthly data using monthly difference method and producer price index for this paper[25]. The calculation is as follows: $dC_i = \Delta C * W$ and $W = dPI_i / \Delta PI$, where dC_i is the monthly change of production cost, ΔC is the annual change. W represents the weight value which is resulted by the monthly change of producer price index(dPI_i) divided with the annual change(ΔPI). To find its real value, we divided it with producer price index again.

2) Net export

Flatfish is exported to Japan, and Korea Maritime Institute provides export data monthly, but there is no data for import. 『Marin fisheries statistics annual report』 by Ministry of Oceans and Fisheries shows no data except 9,005kg by 2006, 4,206kg by 2007, 104kg by 2008, 548kg by 2015[26]. These have the percentage of 0.24%, 0.12%, 0.003% and 0.018% compared to the amount of export. Since these are small in percentage, we will use the monthly export as a proxy variable for net export.

Export depends on the difference of price in trading two countries, income and dietary habit of the importing countries, etc. Some of these variables have not been announced and mistakes can occur in the statistical estimation[27]. In addition to that the target of this paper is not the analysis on flatfish export. Thus we use the expert amount itself by Korea Maritime Institute, as net export.

4. Income, price of substitute goods and dummy variable

We use monthly industry production index by KOSIS as the proxy variable for income, because income has only quarterly data[28]. The price of substitute goods can be the price of other fisheries or meat. This paper uses price of tripletail, pig and cow. The price of tripletail was divided with GDP-Deflator by KOSIS to get the real value. KOSIS provides prices of pig and cow with index form and this paper uses the data as it is.

Dummy variable is applied to represent special exogenous changes of the demand and supply appeared in certain months. The special exogenous changes can be eliminated by season adjustment, when these occur seasonally, but in the reality these appear in the particular months. Thus using dummy variable is desirable in this case. This paper uses dummy variable to discriminate the period from June until September to other months.

25) In this case, producer price index is more proper than other price index such as consumer price index because it considers production cost.

26) It seems to be zero during 2009-2014.

27) Correlation coefficient between flatfish export and its export price, using monthly data between 2000 and 2015 by KOTRA, is 0.081, and it means there is no correlations by two variables.

28) Macro economic analysis uses industry production index as proxy variable for income generally.

Ⅳ. Empirical Analysis

1. Method of Analysis

Functions which are induced theoretically in chapter 2 has a nonlinear form. To change it into a linear form, we use variables with natural logarithm. Analysis period is from January 2006 until December 2015. This paper uses equations which are induced theoretically in chapter 2 and variables which are explained in chapter 3, and the statistical test procedure is as follows: First, we test existence of the unit root, because this paper applies time series data. It is a general step since Nelson & Plosser(1982) insisted that a problem of spurious regression can occur when time series data has the unit root.

Second, we estimate equation (10) with TSLS and confirm heteroscedasticity with White-test. Thirdly we estimate equation (10) with GARCH model again and calculate the volatility(GARCH). Fourth we examine whether, the calculated volatility(GARCH) impacts the sale revenue in equation (11) with Granger causality test.

Table 1 shows results of unit root test. Max lag is 6, which is confirmed by *HQ* of *VAR* · *L*. means the natural logarithm, *D* represents the first difference. Table 1 represents the results of Augmented Dickey-Fuller (unit root) Test on quantity(Q), price(P), Fish farming area(AM), income(Y), price of substitute good(O_i)[29) , net export(NX). Null Hypotheses: X has a unit root.

The test above implies that unit root exists in price(LP), Fish farming area(LMA), tripletail price(LO_1) with 10% significant level but it does not seem to generate spurious regression[30).

Table 1. Augmented Dickey-Fuller Test

	LQ	*LP*	*LAM*	*DLY*	*DLC*	*LNX*
t-stat.	−5.810	−2.517	−2.477	−10.30	−2.705	−6.196
prob.	0.000	0.114	0.112	0.000	0.076	0.000
	LO_1	LO_2	LO_3			
t-stat.	−2.516	−3.815	−2.927			
prob.	0.113	0.034	0.045			

* Test critical values 1%=(−3.487), 5%=(−2.886), 10%=(−2.580)

2. Estimation of equilibrium quantity

Table 2, 3 indicates the estimation result of equation (3). Fish farming area(LAM) used by estimation was lagged with one 12months. We choose time lag with 12 months because the raising term of flatfish is 12months. Table 2 shows the estimation of mean equation and Table 3 indicates one of variance equation

29) LO_1 is price of tripletail, LO_2 indicates price index of pig, and LO_3 is price index of cow.

30) Except ARIMA and VAR, spurious regression can occur when independent and dependent variable have unit root at once, and it can not occur when one of the independent variables has unit root. The probabilities, shown as 11.4% and 11.3% in Table 1, are not much high. In addition, Johansen Cointegration test between *LQ* & *LAM* or *LQ* & *LP* rejects Null Hypothesis at 5% significance level. This means that there exists a cointegration between variables and that we can use level variables. The first difference of tripletail price(DLO_1) does not have a unit root, and the estimation with DLO_1 has a similar result with tripletail price(LO_1). Thus, we write only the estimation result with LO_1 in Table 2.

using GARCH(1,1). (Method 1) of Table 2 is the estimated result of equation (5) to which the adaptive expectation hypothesis is applied. The hypothesis that coefficients on the first difference of income and the prices of substitute goods[32] are zero is not rejected at 10% significance level, while coefficients on other variables are significant at 10% level.

Table 2. Estimation of equilibrium quantity: Mean equation

LQ	C	LAM	LP_{t-1}	LQ_{t-1}	DLY	LO	DLC	LNX	D_2	$AR(1)$
M1	−6.655 (1.52)	1.677 (3.30)	−0.319 (2.65)	0.254 (3.92)	0.125 (0.62)	0.006 (0.12)	−2.899 (2.55)	0.115 (2.78)	0.119 (4.18)	
M2	−4.499 (1.84)	1.567 (4.03)	−0.352 (4.67)	0.235 (2.60)			−2.793 (3.13)	0.110 (3.35)	0.119 (4.90)	
M3	−6.463 (2.45)	1.800 (5.26)					−3.841 (3.61)	0.105 (2.72)	0.182 (6.29)	
M4	−7.156 (8.16)	1.846 (3.89)					−3.427 (2.81)	0.170 (12.1)	0.135 (3.86)	0.405 (4.51)

( )=z-statistic 10%=1.645, 5%=1.96, 1%=2.58

Table 3. Estimation of equilibrium quantity: Variance equation

LQ	*White-F*	C_g	RES^2_{t-1}	G_{t-1}	R^2	adR^2	DW	$GARCH$
M1					0.536	0.482	1.959	
M2	1.675 (0.061)	0.002 (3.86)	−0.127 (12.62)	0.996 (7.26)	0.536	0.493	2.012	GAM1
M3					0.420	0.379	1.382	
M4	2.186 (0.016)	0.000 (0.85)	−0.112 (1.854)	1.077 (6.23)	0.475	0.432	1.98	GAM2

( )=z-statistic, White-F is F-statistic of White test and ( ) represents its prob.

Multi-collinearity can occur between LP_{t-1} and LQ_{t-1} theoretically, but VIF(Variance Inflation Function) and correlation coefficient imply that there is no multi-collinearity between two variables[33]. Estimation, without the first difference of income and price of substitute goods, had a heteroscedasticity[34] and we estimate the equation with GARCH(1,1) again. *M*2(Method 2) shows result of the estimation and *M*1 represents its conditional dispersion (*GARCH*).

*M*3(Method 3) shows the estimated result of equation (10) where the rational expectation hypothesis. Coefficients on all independent variables are significant at 10% level. According to DW(Durbin-Watson value), there is autocorrelation problem. We estimated the equation with again and the result has a heteroscedasticity[35]. We estimated the equation with GARCH(1,1) again. *M*4(Method 4) shows the result of the estimation and *GAM*2 represents its conditional dispersion (*GARCH*).

32) These are tripietail price, or the price index of pig and cow.
33) According to monthly data from 2000 to 2015 by KOTRA, Correlation coefficient between flatfish export and its export price is 0.081 meaning there is no correlations by them.
34) See *White-F* of *M*2 in Table 3. *White-F* means value of White-test.
35) See *White-F* of *M*4 in Table 3. *White-F* means value of White-test.

3. Estimation of equilibrium revenues

We estimate equilibrium revenue with equation (6) for adaptive expectation hypothesis and with equation (11) for the rational expectation hypothesis. Prices of substitute goods are not included in the estimation above, because it does not influence the equilibrium quantity.

*M*1(Method 1) in Table 4, 5 shows estimation result of equation (6). Coefficients on fish farming area(*LAM*), price at previous period(LP_{t-1}), trading quantity at previous period(LQ_{t-1}), and first difference of income(*DLY*) are significant at 10% level, while coefficients of first difference of production cost (*DLC*) and net export(*LNX*) are not significant.

We estimated equation (6) without first difference of production cost (*DLC*) and net export(*LNX*) again, and found a heteroscedasticity[36]. To eliminate this problem, GARCH model is applied, and its result is represented in *M*2. Table 4 indicates mean equation, while Table 5 displays variance equation. represents the conditional dispersion (*GARCH*) of the estimation(*M*2).

*M*3(Method 3) expresses estimation result of equation(11) which adopts rational expectation hypothesis. Coefficients on net export(*LNX*) and first difference of production cost(*DLC*) are not significant at 10% level and the possibility of autocorrelation is high, because (Durbin-Watson) has a low value. Thus, we estimated equation(11), added *AR*(1) and excluded net export(*LNX*) and first difference of production cost(*DLC*) again, and found a heteroscedasticity[37]. To eliminate this problem, GARCH model is applied whose result was *M*4(Method 4). *GAMR*2 represents the conditional dispersion (*GARCH*) of the estimation(*M*4).

Table 4. Estimation of equilibrium revenues: mean equation

LQ	*C*	*LAM*	LP_{t-1}	LQ_{t-1}	*DLY*	*DLC*	*LNX*	D_2	*AR*(1)
M1	8.758 (2.87)	0.555 (1.14)	0.375 (3.08)	0.290 (2.16)	0.960 (3.76)	−0.894 (0.69)	0.020 (0.40)	0.130 (3.47)	
M2	9.328 (5.98)	0.455 (3.64)	0.363 (6.52)	0.339 (4.26)	1.066 (4.66)			0.117 (3.90)	
M3	6.828 (2.15)	1.217 (2.51)		0.139 (1.19)	0.788 (3.47)	−1.688 (1.30)	−0.009 (0.18)	0.163 (4.16)	
M4	9.290 (6.57)	0.952 (5.49)		0.084 (4.17)	0.887 (4.62)			0.140 (3.85)	0.362 (4.20)

( )=z-statistic 10%=1.645, 5%=1.96, 1%=2.58

Table 5. Estimation of equilibrium revenues: variance equation

LQ	*White-F*	C_g	RES^2_{t-1}	G_{t-1}	R^2	adR^2	*DW*	*GARCH*
M1					0.397	0.334	1.644	
M2	1.761 (0.057)	0.000 (0.01)	-0.060 (1.35)	1.061 (5.81)	0.385	0.336	1.694	GAM1
M3					0.305	0.241	1.300	
M4	1.851 (0.037)	0.000 (0.28)	-0.067 (1.26)	1.057 (5.27)	0.398	0.348	1.893	GAM2

( )=z-statistic, White-F is F-statistic of White test and ( ) represents its prob.

36) See *White-F* of *M*2 in Table 5. *White-F* means value of White-test.
37) See *White-F* of *M*4 in Table 5. *White-F* means value of White-test.

4. Analysis of spillover effect

1) Spillover effect on mean equation

To test the effect of the production[38] volatility on sale revenue calculated above, this paper estimated the mean equation added *GARCH*[39] and used *OLS*[40]. According to the analysis above, estimations are divided into adaptive and rational expectation hypothesis. Table 6 shows the estimated result of *M*2 in Table 3 added *GAM*1[41]. The result shows that the coefficient on *GAM*1 is significant at 10% level. It implies that *GAM*1 dose not affect on mean equation with 10% level.

Table 6. Spillover effect on mean equation (1)

C	LAM	LP_{t-1}	LQ_{t-1}	DLY	D_2	$GAM1$	R^2(DW)
10.11 (3.73)	0.394 (1.06)	0.358 (3.34)	0.306 (3.02)	1.039 (4.18)	0.109 (3.49)	−2.088 (0.75)	0.393 (1.677)

( )=t-statistic 10%=1.645, 5%=1.96, 1%=2.58

Table 7. Spillover effect on mean equation (2)

	C	LAM	LQ_{t-1}	DLY	D_2	$GAM2$	$AR(1)$	R^2(DW)
M1	12.658 (3.56)	0.548 (1.16)	0.073 (0.65)	0.966 (4.26)	0.129 (3.73)	−8.876 (2.83)	0.267 (2.25)	0.440 (1.886)
M2	12.67 (3.40)	0.623 (1.30)	0.904 (4.32)	0.138 (4.19)	-9.103 (2.82)	0.304 (3.00)	0.437 (1.863)	

( )=t-statistic 10%=1.645, 5%=1.96, 1%=2.58

Table 7 presents the estimated result in the case of rational expectation hypothesis. *M*1(Method 1) expresses that the coefficient on *GAM*2 is significant at 10% level but coefficient on trading quantity at previous period (LQ_{t-1}) is not significant at 10% level.

Thus, we estimated the equation excluding this variable again and *M*2(Method 2) expresses the result. The coefficient on independent variable *GAM*2 is significant at 10% level and has a negative value. This means that sale revenue is related to production trading quantity in the mean equation negatively.

2) Spillover effect on sale revenue volatility

In this paragraph we verified the spillover effect of quantity volatility on sale revenue volatility using Granger Causality Test. Estimation has 6 lag length based on *HQ* in *VAR*.

Null Hypothesis(H_0) is : X does not Granger cause Y.

In this estimation, X represents *GARCH* of trading quantity, and it equals to *GAM*1 according to adaptive expectation hypothesis and to *GAM*2 according to rational expectation hypothesis[42]. Y expresses *GARCH* of

38) It has the same value of trading quantity in the equilibrium of flatfish production.
39) They are *GAM*1 and/or *GAM*2 in Table 3.
40) There are no auto-correlation and heteroscedasticity in error term.
41) *GAM*1 is the quantity volatility, which is resulted by the case of adaptive expectation hypothesis.
42) See Table 3 for *GAM*1 and *GAM*2.

Table 8. Granger Causality Test

GCT		*F-statistic*	*Probability*
$M1$	$GAM1 \nrightarrow GAMR1$	2.679***	0.007
$M2$	$GAM2 \nrightarrow GAMR2$	0.923	0.483

sale revenue and it equals to $GAMR1$ according to adaptive expectation hypothesis and $GAMR2$ according to rational expectation hypothesis[43].

Table 8 indicates the result of Granger Causality Test. $M1$(Method 1), which applied the adaptive expectation hypothesis, shows that trading quantity volatility($GMA1$) is related to sale revenue volatility($GMAR1$) positively, while $M2$(Method 2), which employed the rational expectation hypothesis, displays that trading quantity volatility($GMA1$) has no effect on sale revenue volatility($GMAR1$).

Ⅴ. Conclusion

This paper has analyzed trading quantity volatility and sale revenue volatility of flatfish farming. Theoretical study deducted functions for trading quantity and sales revenues using supply and demand function, which are induced from expectation hypothesis. Dummy variable is added as independent variable to represent supply and demand fluctuation, which occurs in certain months. Other volatilities are estimated with GARCH model.

Theoretical study says that equilibrium quantity is influenced by all factors of supply side and demand side in adaptive expectation hypothesis, while it has normal production quantity and change of production cost as independents variables because factors of demand side are eliminated by the information abstraction process.

Statistical Analysis employed proxy variables when independent variables did not have material data for itself. We used fish farming area as proxy variable for normal production quantity because fish farming area means capital input for production, and industry production index as proxy variable for income, since income has only quarterly data. Statistical analysis is carried out during the period from January 2006 to December 2015 with monthly data. We changed the data, which are only announced annually, into monthly values with proper calculation.

Results of statistical analysis indicated that fish farming area, income change and production cost change influences treading quantity properly, as theoretical study in this paper implies. Equilibrium quantity is negatively related to price at previous period and it means the effect of the price on demand is larger than that on supply.

According to White-test, conditional dispersion exists, and it means that the volatility of trading quantity are large in the case of flatfish. This study says that the mean equation is not related to quantity volatility in adaptive expectation, while it is related to quantity volatility negatively in rational expectation. Spillover effect, trading quantity volatility influences revenue volatility, exists in adaptive expectation hypothesis, but

43) See Table 5 for $GAMR1$ and $GAMR2$.

it does not exist in rational expectation hypothesis.

This paper contributes to the development of economic theory in that supply and demand functions of flatfish were induced logically using expectation hypothesis. We investigated factors which have an impact on demand and supply theoretically and statistically. Moreover, economic causality was found between production and revenue in fisheries industry. An academic contribution of this paper was to find that there are trading quantity volatility and sale revenue volatility, and that a spillover effect exists between these variables. The results of this work can be used for estimation of income volatility, which occurs by fisheries production and for establishment of insurance system that stabilizes fisherman income.

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