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An Empirical Analysis of Non-fishery Work Participation as a Risk Management Strategy for Fishery Households

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어가의 위험관리 전략으로써 어업 외 활동 참여 행태 분석

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ABSTRACT : 기후변화 및 수산자원 보호 등으로 인한 어획량 감소 그리고 어업경영비의 증가에 따라 어가의 어업 소득 의존도는 낮아지고 있다. 2020년 어업총조사에 따르면 62.9%의 어가가 어업 외 경제활동에 참여하고 있는 것으로 나타났다. 본 연구는 어업 외 활동이 대체 소득원으로서의 역할 뿐만 아니라 어업 생산에서 발생되는 위험을 관리하는 수단으로도 기능할 수 있는지를 분석하였다. 어가의 경우 외생적 위험을 직접 통제하는 것에는 한계가 있으나 어업 외 활동 등 소득원 다각화를 통하여 어가경제의 총괄적 위험도를 관리할 수 있다. 본 연구에서는 생산 위험의 대리변수로 가격 위험을 사용하고 위계선형모형을 적용하여 가격 위험 변화에 따른 어업 외 소득 비중의 조정 여부를 분석하였다. 분석 결과, 어업 외 활동이 어업 생산과 관련된 위험을 관리하는 데 활용되고 있음을 확인하였다. 또한 어가의 규모에 따라 대응 양상이 다르게 나타났는데, 소규모 어가가 대규모 어가에 비해 어업 외 활동에 더 많이 의존하는 것으로 나타났다. 이는 어업 외 활동의 확대가 어업 생산의 축소 및 지속가능한 수산자원 관리의 직·간접적인 방법이 될 수 있음을 시사하기도 한다. 본 연구는 어업 부문의 생산 위험 관리 전략으로써 어업 외 활동의 잠재적 역할을 분석한 최초의 연구라는 점에서 의의가 있다.

Key words : Fishery Household, Hierarchical Linear Model, Non-fishery Work, Risk Management, Tobit Model

I. Introduction

The fishery industry has limitations in planned production due to nature-dependent characteristics such as seasonal concentration and fishery households are facing various risks and uncertainties accordingly. Due to the nature of this fishery industry, fishery households have limitations in directly reducing these various risks, while they may be able to manage risks through diversification of management by choosing other activities such as having non-fishery works. In general, fishery households tend to supplement this in the direction of expanding the scope of fishery activities or increasing the number of fishing species when fishery revenue fluctuates. However, it is difficult to explain that those methods are strategies to sustainably manage financial risks under the circumstances such as Catch Share Programs or conditions where climate change is accelerating(Anderson et al., 2013). Therefore, in the case of fishery households with low-revenue levels or easy access to alternative sources of revenue, there is a tendency to compensate for insufficient revenue through non-fishery activities (Kasperskia and Holland, 2013).

According to the “2020 Census of Fisheries” in Korea,

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62.9% of the domestic marine fishery households have non-fishery works, and about 33.9% have non-fishery works depending more on non-fisheries income than fishery one. Nevertheless, research on participation in economic activities other than fisheries or having non-fishery works is insignificant. In particular, as national projects related to fishing communities have been diversified to support the 6th industrialization of fishing communities and complex industrialization of fishing resources, accurate analysis of the activities and conditions of fishery households is needed to keep pace with these changes in a policy basis(Lee and Park, 2018).

In addition, non-fishery work in fishery households can be understood as a means to secure the stability of fishery household management by supplementing the highly volatile fishery revenue. This strategy aligns with recent international research on income diversification in fishing communities. For instance, Olale and Henson(2012) demonstrated how income diversification contributes to livelihood stability and economic resilience in Kenyan fishing communities. This study highlights the importance of non-fishing activities such as agriculture, small businesses, and wage labor in reducing dependence on fishing income.

Empirical studies explicitly analyzing non-fishery work of fishery households, particularly as a risk management strategy or means of revenue stabilization, remain limited. However, drawing from previous studies in the agricultural sector(Cheu and An, 2018), we can infer that fishery households aim to maintain an optimal risk level across their entire economic portfolio. The effect of participating in non-fishery work on the household's overall risk can influence decisions about engagement in riskier fishing activities or investments.

This perspective is supported by Tyler Treakle et al. (2022), who analyzed how fishers on the U.S. West Coast manage economic risks through non-fishing income. Their research suggests that non-fishery work is a crucial strategy for mitigating the volatility and uncertainty inherent in fishing income. Similarly, Anderson et al.(2013) emphasized the importance of income diversification as a response to environmental risks such as climate change and resource depletion. They found that as uncertainty in fishing activities increases, the proportion of non-fishing income tends to rise, underscoring income diversification as a key risk management strategy.

Furthermore, if having non-fishery work stabilizes the overall economic performance of fishery households, it may expand their capacity to engage in more risky fishing management activities or investments. This is particularly relevant for individual fishery households facing highly volatile fishing revenues, who may turn to non-fishery work as a means to secure financial stability. These international research examples not only corroborate the importance of income diversification in fishery households but also highlight the global relevance of this strategy in managing economic and environmental risks in fishing communities.

The composition of the study is as follows. First, in chaper II, theoretical framework of the research is elaborated. In Chapter III, we provide a detailed explanation of the data and methodologies utilized in this analysis. In Chapter IV, the factors that determine the proportion of non-fishery income by fishery households are analyzed, At last, a summary and conclusions of research results are derived in Chapter V.

II. Theoretical Framework

1. Concept of income diversification and decision model

This study builds its theoretical framework based on the research of Olale and Henson(2012) to analyze the determinants and impacts of income diversification among fishery households.

In this study, income diversification is defined as fishery households engaging in additional non-fishery activities beyond their primary income source of fisheries. This strategy aims to enhance household economic stability through the diversification of income sources.

To model the income diversification decisions of Korean fishery households, we propose the following utility maximization problem:

$$Max\, U(C,L;Z) = E[U(C,L;Z)] \tag{1}$$

Subject to the constraints:

$$T = L + T_f + T_n \tag{2}$$

$$C = Y = W_f(\sigma_f^2)\, T_f + W_n(T_n) + O \tag{3}$$

$$T_n \geq 0 \tag{4}$$

Where,

U: Expected utility
C: Consumption
Y: Total household income
L: Leisure time
Z: Household characteristics
T: Total available time
T_f: Time allocated to fishing activities
T_n: Time allocated to non-fishing activities
W_f: Hourly returns from fishing activities (a function of fishing income volatility σ_f^2)
W_n: Hourly returns from non-fishing activities
O: Other income

2. Optimization process

To solve this optimization problem, we construct the Lagrangian function:

$$L = E[U(C,L;Z)] + \lambda(T - L - T_f - T_n) + \mu(C - W_f(\sigma_f^2)T_f - W_n(T_n) - O) - \tau T_n \quad (5)$$

Where λ, μ are Lagrange multipliers, and τ is a Kuhn-Tucker multiplier.

The optimal solution must satisfy the first-order conditions and complementary slackness conditions. This allows us to derive the optimal time allocation decisions T_f, T_n, L* for fishery households. Finally, the net effect of income diversification cam be expressed as:

$$\Delta Y = Y_d - Y_s \quad (6)$$

Where ΔY is the change in income, Y_d is the total income after diversification, and Y_s is the total income when specializing in fisheries.

3. Income diversification and reduction of income volatility

This model allows us to analyze the impact of income diversification on total income volatility. However, it is important to consider that these effects may vary depending on household characteristics and regional contexts.

Based on this theoretical framework, our study aims to empirically analyze the determinants and impacts of income diversification among Korean fishery households. Through this, we seek to broaden the theoretical understanding of income diversification and derive policy implications.

Ⅲ. Data and Methodology

As described above, more than 60% of fishery households participate in having non-fishery works other than fisheries, and about 34% of fishery households have non-fishery incomes greater than fishery incomes. In fact, the non-fishery activities of a fishery household can be affected by the presence and degree of fishery activities, and it is thought that non-fishery activities can affect decision-making about fishery activities. For example, securing stable income through non-fishery activities can lead to the expansion of investment in fishery activities.

This chapter investigates regional characteristics, households' characteristics, and management characteristics that affect the proportion of income other than fisheries in fishery households. In particular, the producer price variation coefficient of varieties mainly handled by fishery households was used as the independent variable. Through this, we want to examine whether the instability and risk experienced by fishery households from the price volatility of handling varieties actually result in a behavior that increases the share of non-fishery income.

1. Analysis data

For the analysis, we used Statistics Korea's "2020 Census of Fisheries". The subjects of the study are fishery households with non-fishery work engaged in offshore fishing or aquaculture for 18 major items. The main items were selected by referring to the target items observed by the Korea Maritime Institute, and these items are shown in Table 1 below."

Table 2 is the basic statistics of dependent variables and explanatory variables used to analyze the determinants of the non-fishery income share. Non-fishery income ratio, which is a continuous variable, was used as a dependent variable, and explanatory variables were composed of variables that reflect regional characteristics, households'

Table 1. 18 major items

Manner	Item
Coastal fishing, sea surface aquaculture	Cutlassfish, black sea bream, mackerel, oyster, seaweed, flatfish, bass, anchovy, pollack, sea mustard, squid, sea squirt, abalone, Korean rockfish, red sea bream, yellow corvina, mussel

Table 2. Basic Statistics of Variables Used in Analysis

Classified		Average	Standard deviation	Min	Max	Remarks
Dependent Variables	Proportion of Non-fishery income(%)	23.63	29.49	0	100	Continuous Variables
Regional characteristics	Proportion of full-time fishery households in the region	44.65	22.53	0	100	Continuous Variables
	Fishery-related facilities in the region*	0.95	0.21	0	1	1=Yes, 0=No
	Fishery corporation in the region**	0.85	0.35	0	1	1=Yes, 0=No
	Urban-rural exchange activities in the region***	0.84	0.36	0	1	1=Yes, 0=No
Households' Characteristics	Gender	0.84	0.37	0	1	1=male, 0=female
	International age	60.87	11.49	21	94	Continuous Variables
	Education level	3.30	1.19	1	8	1=No education, 2= Elementary School, 3= Middle School, 4= High School, 5= University (less than 4 years), 6= University (over 4 years), 7= Graduate School Master's Course, 8= Graduate School Doctor's Course
	# of household member	2.35	1.12	1	10	Continuous Variables
Characteristics of Fishery Management	Management type	0.47	0.50	0	1	1=fishing, 0=aquaculture
	Possession of fishing boat	0.73	0.44	0	1	1=Yes, 0=No
	Fishery employment	0.46	0.50	0	1	1=Yes, 0=No
	Fishery revenue	6.62	3.29	1	13	1 = Less than 1.2 million won, 2 = 1.2 to 3 million won, 3 = 3 to 5 million won, 4 = 5 to 10 million won, 5 = 1,000 to 20 million won, 6 = 2,000 to 30 million won, 7 = 3,000 to 50 million won, 8 = 5,000 to 70 million won, 9 = 70 million won ~ 100 million, 10 = 100 million ~ 200 million won, 11 = 200 million to 500 million, 12 = 500 million or more, 13=none
	Producer's coefficient of variation of main varieties (CV)	0.37	0.34	0	1.62	Continuous Variables
	CV*fishery revenue	2.25	2.17	0	21.11	Continuous Variables

* Fisheries Cooperatives joint market, Auction market, Fishery products origination distribution center(FPC), Fishery products center, Refrigerated and frozen warehouses, Fishery products processing facilities

** Fishery association corporation, Fishery company

*** Sisterhood relationship, Agricultural/Fishing experience tour, Direct trade in agricultura/fishery products, Agricultural fishery products and special product outlet operation, Food sales and lodging, Local festivals for visitors

characteristics, and fishery management characteristics.

Regional characteristic variables included the proportion of full-time fishery households by region, the presence or absence of fishery-related facilities in the region, the existence of fishery corporations in the region, and the presence or absence of urban-rural exchange activities in the region. Gender, international age, education level, and the number of household members was adopted as variables for the characteristics of households. This refers to the categories used in the studies of Kang(2008) and Kim (2009). Management type, ownership of fishing boats, fishery employment, fishery revenue, producer coefficient of variation(CV) of main varieties, and CV*fishery revenue variables were used as fishery management characteristic variables.

Producer coefficients of variation of the main handling varieties were established to reflect the difference in price risk faced by fishery households by the fishing method. The purpose of this is to control the risks in fishery production faced by fishery households, and the monthly price for each item was calculated based on monthly production and production data for a total of 4 years from 2016 to 2019 in the 'Fishing Production Trend Survey.' In order to reflect the difference in price risk according to the fishing method, a variation coefficient was established by dividing it into fishing and aquaculture business.[1] For the price risk of each fishery household, the price variation coefficient of the item with the largest sales by coastal fishing and sea surface aquaculture was selected, and then the weighted average variation coefficient was used according to the proportion of coastal fishing and sea surface aquaculture revenue.

The basic statistics of variables used in the analysis are as follows. The proportion of full-time fishery households by region was 44.65%, showing a higher proportion of having non-fishery works in fishery households. 95.28%, 85.28%, and 84.35% of fishery households responded that there were fishery-related facilities, fishery corporations, and urban-rural exchange activities in the region, respectively. Next, looking at the characteristics of household, the ratio of men was high at 83.83% for men and 16.17% for women, and the average age of householders was about 61 years. The level of education is 35.84 percent for high school graduation, 26.04 percent for elementary school graduation, and 27.77 percent for middle school graduation, and the household with 2 members is the highest with 54.69 percent. In terms of fishery management characteristics, the proportion of aquaculture fishery households was higher than that of fishery households(46.88%). In the case of the fishing boat possession and fisheries employment fish stocks, which are variables that can predict the size of household assets, 73%, and 46% were found, respectively. Fishery revenue was the highest at 11.20% with less than 100 million won to 200 million won, followed by 10.76% with less than 12 to 3 million won, 9.5% with less than 30 to 50 million won, and 9.46% with less than 200 to 500 million won.

1) The coefficient of variation was established only for fishing targeting cutlassfish, anchovies, pollack, and squid.

2. Empirical model

A hierarchical linear model was used to analyze the factors affecting the proportion of non-fishery income. The hierarchical linear model is an analysis method that compares how much the model explains dependent variables by introducing independent variables step by step based on the researcher's theoretical background or empirical grounds.

The data which we used has a naturally nested structure, with individual fishery households clustered within different regions. The hierarchical linear model allows us to account for both individual-level and regional-level factors simultaneously, providing a more accurate representation of the complex relationships in the data.

The hierarchical linear model is largely divided into 1) an unconstrained model, 2) a random intercept model, and 3) a random coefficient model. In this study, the analysis was conducted by applying the random intercept model. The random intercept model assumes that the constant term has a random effect and that the coefficients of the first-level variables have a fixed effect(Lee and Noh, 2010). In this way, independent variables of the second level affect the constant terms of the first level but do not affect the coefficients of the explanatory variables.

The random intercept model can be expressed as equations (7) and (8) below. i represents a 1st-level sample, j represents a 2nd-level sample, and in this study, each represents a fishery household and a region (Eup ·

Myeon · Dong). Y_{ij} is the dependent variables for i fishery household in region j, and X_{ij} represents the characteristics of i fishery household in region j. W_{oj} represents the characteristics of area j.

$$\text{1st level:} \quad Y_{ij} = \beta_{oj} + \beta_1 X_{ij} + \epsilon_{ij} \tag{7}$$

$$\text{2nd level:} \quad \beta_{oj} = \gamma_{oo} + \gamma_{o1} W_{oj} + v_{oj} \tag{8}$$

Through the hierarchical linear model, even after using variables corresponding to regional characteristics as control variables, we investigated whether independent variables corresponding to owner characteristics and fishery management characteristics affect the non-fishery income share of fishery households. As a result of ANOVA, the F statistic of [Model 1] was 495.895($p<.001$) and the F statistic of [Model 2] was 960.158($p<.001$), confirming that this regression model was appropriate. In addition, the R^2 value increased by 0.121 in [Model 2] compared to [Model 1], and the F change of significance probability was also 0.000, indicating that independent variables are statistically significant in explaining dependent variables after the introduction of control variables.

Furthermore, the Tobit analysis method, a nonlinear estimation method, was applied to test the robustness of the analysis method. This takes into account the high ratio of the fishery household with a non-fishery income ratio of 0. The estimation results of applying the Tobit model are presented in Section 4.

Ⅳ. Analysis for Determinants of Non-Fishery Income Ratio

1. Estimation results

As a result of the analysis of regional characteristics, the proportion of full-time fishery households by region, fishery-related facilities in the region were found to have a negative(-) effect on the non-fishery share of fishery households. This can be interpreted that the more fishery households in the area where fishery-related facilities and corporations are located, the more focused they focus on their full-time jobs using the fishery infrastructure. In addition, non-fishery income was lower on average in areas with fishery association corporations or fishery corporations.

Summarizing these results, it can be seen that full-time fishery households using such infrastructure are concentrated in areas where wholesale and retail distribution or processing facilities are located or where fishing organization rates are high.

The effect of the characteristics of fishery household owners on the non-fishery income share is as follows. The number of household members had a positive(+) effect on the non-fishery income share, and the larger the number of household members, the more the non-fishery income share increased by about 2%p. These analysis results are connected with the results of a previous study(Kim, 2009), which found that the male householder's fishery income is higher than that of the female householder, the younger the householder, the higher the fishery income, and the larger the number of household members, the lower the effect of increasing the fishery income. In addition, this seems to be consistent with previous studies(Kang and Kwon, 2008) that showed contrasting effects of factors that determine agricultural income and non-farm income even in the case of farm households. In the case of the education level of the owner of the fishery householder, it was found to have a positive(+) effect, and it was analyzed that the higher the education level, the higher the non-fishery income share, about 1.6%p. However, considering that more than 76% of fishery householder managers in this study are fishing householders, it is possible to further analyze the impact of the education level on fishery householder type compared to the results of Kim(2009) that the education level of aquaculture fishery householder has a significant effect on fisheries income.

It was analyzed that there is also a difference in the proportion of non-fishery income according to the fishing management type. Specifically, the proportion of the non-fishery income of fishery households engaged in the fishery was found to be about 5.9%p higher on average than that of aquaculture fishery households. Fishery households with fishing boats were estimated to have a non-fishery income ratio of about 8%p lower than those without. It can be expected that fishery households with fishing boats have larger assets on average and can earn more income through fishing, and these factors can act as limiting factors for participation in non-fishing activities. Fishery households that employed fishing labors have a

Table 3. The effect of each characteristic of the fishery household on the non-fishery income(Hierarchical Linear Model)

		Model 1		Model 2	
		Estimate	Standard deviation	Estimate	Standard deviation
Regional characteristics	Proportion of full-time fishery households in the region	-0.616***	0.010	-0.445***	0.023
	Presence of fishing-related facilities in the region	-4.884***	1.110	-1.338**	0.641
	Fishery corporation in the region	-2.626***	0.660	-0.335*	0.252
	Urban-rural exchange activities in the region	2.068***	0.648	0.011	0.342
Households' Characteristics	Gender			-1.751**	0.700
	International age			0.079***	0.024
	Level of education			1.571***	0.240
	# of household member			2.080***	0.201
Management characteristics	Management type(0=aquaculture, 1=fishing)			5.788***	0.607
	Fishing boat			-8.086***	0.635
	Fishery employment			-2.481***	0.607
	Fishery revenue			-2.113***	0.120
	Producer's coefficient of variation of main varieties (CV)			3.388***	1.231
	CV*fishery revenue			-0.670***	0.205
Intercept		56.276***	1.186	49.054***	3.083
F		960.158***		495.895***	
R^2		0.229		0.350	
adj. R^2		0.229		0.349	

*p<.05, **p<.01, ***p<.001

2.5%p lower non-fishery income share than fishery households that do not employ labors. It can be inferred that the proportion of fishing among the fishery household's economic activities is large, such as whether or not it owns a fishing boat, and accordingly, the proportion of non-fishery activities is interpreted as relatively low.[2)]

Fishery revenue variables is a proxy variable for the fishery management scale, and it was analyzed that the increase in the unit of fishery revenue decreased the non-fishery revenue ratio by 2.1%p. This illustrates that the larger the scale of fishing, the less incentive to participate in non-fishery activities.[3)]

The price risk variable as the price variation coefficient of major handled varieties shows a positive(+) relationship with the non-fishery income share, showing that participation in non-fishery economic activities is becoming a risk management tool for fishery household. In other words, it was found that the higher the price risk, the higher the non-fishery income share. However, the sign of the intersection term of the magnitude variable and the risk variable(price variation coefficient) is estimated to be negative, showing that the effect of the non-fishery income increase due to the increase in risk as the scale of fisheries management increases. These analysis results suggest that non-fishery income can act as a risk management tool for price risk, and the effect decreases somewhat as the size of fishery household increases.

2) <The status of full-time/having non-fishery work by management type, fishing boat ownership, employment status(2020)>

		Full-time (%)	Having non-fishery work (%)
Management type	Fishing	30.66	69.34
	Aquaculture	54.42	45.58
Fishing boat	Owned	48.73	51.27
	Not owned	28.22	71.78
Employment	Hired	58.27	41.73
	Not hired	30.43	69.57

3) There may still be endogeneity between fishery income and non-fishery activities, even though we used fishery revenue as a proxy for the scale of fishing.

2. Validation of the robustness of the analysis

In this section, the estimation results through the Tobit and OLS analysis methods are presented. The Tobit model is particularly suitable for our study as it effectively handles censored data. In our case, the dependent variable (non-fishery income ratio) is censored at zero, as many fishery households may not engage in non-fishery activities, resulting in a zero value. In the case of some estimates, the statistical significance was changed, but the direction and magnitude of the overall marginal effect were found to be similar to those of the hierarchical linear model. Through this, it can be confirmed that the estimation results of this study are robust to the analysis method.

Specifically, the coefficient of variation of price and the marginal effect of the cross term of the coefficient of variation and fishery revenue, which are the main explanatory variables of this study, were analyzed similarly to the Estimate of the hierarchical linear model. In the OLS model, both variables were found to be significant. However, in the Tobit model, the estimate for the coefficient of variation was not statistically significant, but the cross-term was estimated to be statistically significant within the 5% significance level. As described above, this indicates that fishery households

Table 4. The effect of each characteristic of the fishery household on the non-fishery income proportion (Tobit/OLS model)

Variables		Tobit	OLS
		Estimate (Std)	Estimate (Std)
Regional characteristics	Proportion of full-time fishery households in the region	-0.738*** (0.019)	-0.392*** (0.011)
	Fishery-related facilities in the region	-3.313* (1.635)	-4.223*** (1.024)
	Fishery corporation in the region	0.223 (1.032)	-1.321** (0.610)
	Urban-rural exchange activities in the region	1.228 (0.988)	1.647** (0.596)
Households' Characteristics	Gender	-2.311** (1.129)	-1.009 (0.960)
	International age	0.246*** (0.043)	0.034 (0.025)
	Level of education	2.571*** (0.402)	1.311*** (0.239)
	# of household member	4.463*** (0.349)	2.153*** (0.203)
Management characteristics	Management type	3.979*** (0.868)	3.264*** (0.520)
	Fishing boat	-7.761*** (0.986)	-8.597*** (0.599)
	Fisher employment	-3.966*** (1.003)	-1.735** (0.597)
	Fishery revenue	-3.481*** (0.198)	-2.211*** (0.118)
	Producer's coefficient of variation of main varieties (cv)	3.075 (1.983)	3.097** (1.234)
	CV*fishery revenue	-0.787** (0.345)	-0.804*** (0.201)
Intercept		41.039*** (4.359)	55.165*** (2.591)

with large fishery revenues increase the proportion of non-fishery income relatively less when price risk increases than fishery households with small revenues.

In the OLS model, all of the regional characteristic variables were found to be significant, but in the Tobit model, the estimated coefficients for the variables 'presence of fishery corporation in the region' and 'presence of urban-rural exchange activity in the region' were found to be statistically insignificant. On the other hand, the marginal effects of the 'proportion of full-time fishery households by region' and 'presence of fishery-related facilities in the region' were similar to the estimate of the hierarchical linear model. In the case of householders' characteristics, gender and age were found to have statistically significant effects in the Tobit model, while they were not significant in the OLS model.

V. Summary and Conclusions

Despite the characteristics of the fishing industry, which has limitations in planned production, the dependence of fishery households on fishery income is further weakening due to international efforts to reduce catches and protect fishery resources due to climate change. In fact, according to the 2020 Census of Fisheries, more than 60% of domestic fishery households have non-fishery works, and 33.9% of fishery households rely on non-fishery income more than fishery income.

Therefore, in order for the government's support policy for domestic fishery households to be effective, a customized fishing communities policy should be prepared considering the types and characteristics of fishery households engaged in income activities with fishery. Against this backdrop, this study categorizes fishery households in consideration of having non-fishery works, analyzes the factors that affect the share of non-fishery income, and examines the characteristics of fishery households.

In this study, factors determining the proportion of non-fishery income in the fishery household unit were analyzed. For the analysis, regional characteristics, households' characteristics, and management characteristics variables that affect the proportion of income other than fisheries were used. In particular, in this study, the producer price variation coefficient of varieties mainly handled by fishery households was used as variables to determine whether non-fishery income activities were used as a means of managing the risks faced in fishing production.

First, it was estimated that the larger the fishery household's fishery revenue, the lower the non-fishery income share. Large-scale fishery households are expected to have a large incentive to invest more in fishery production and input production factors, while small-scale fishery households are expected to have a large incentive to increase fishery household income through income activities other than fishing.

In addition, this study confirmed whether non-fishery income activities are used as a management tool for risks in fishery production. To this end, price coefficients of variation were used as variables, and when price risk increases, the proportion of non-fishery income in fishery households with large fishery revenues is estimated to be smaller than those in fishery households with small sales. This suggests that fishery households may respond differently to price risk by sales size.

Furthermore, the proportion of full-time fishery households by region, the presence of fishing-related facilities in the region, and the presence of fishery corporations were found to have a negative(-) correlation with the non-fishery income proportion of fishery households. In addition, it was analyzed that the proportion of non-fishery income was about 3.3% higher on average than that of aquaculture fishery households.

This study provides significant insights into the determinants of non-fishery income in fishery households, with crucial implications for both risk management and fisheries resource management policies. These findings demonstrate that relatively small fishery households, in particular, tend to engage in non-fishery activities as a strategy to mitigate price risks associated with fishing activities.

Importantly, the tendency towards income diversification could be leveraged as a tool for sustainable fisheries management. By encouraging and supporting non-fishery income activities, policymakers may indirectly reduce excessive fishery effort and pressure on marine resources. This approach presents a potential 'win-win' scenario: fishery households could reduce their economic vulnerability through income diversification, while simultaneously contributing to the conservation of fish stocks by reducing their reliance

on fishing activities.

Furthermore, the observed relationship between household characteristics and income diversification indicates that tailored support strategies may be more effective than a uniform approach. Particularly, our results highlight the importance of education and access to financial resources in facilitating non-fishery income activities.

Lastly, the effectiveness of such policies may vary depending on regional contexts and specific household characteristics. Therefore, any policy interventions should be designed with flexibility to account for these variations and should be subject to ongoing evaluation to assess their impact on both household economics and fishery resource sustainability.

Despite the valuable insights provided by this study, it is important to acknowledge its limitations. This study utilizes data from the '2020 Census of Fisheries', which inherently carries the limitations of cross-sectional data. As a result, we are unable to observe changes over time, and there are constraints in inferring causal relationships. Furthermore, the use of the price variation coefficient as a proxy for risk reflects only short-term fluctuations. This approach has limitations in encompassing long-term trends, structural changes, and other types of risks such as environmental and policy-related risks that fishery households may face. Lastly, another potential research topic could be the improvement of the estimation model by addressing possible endogeneity issues between fishery income and non-fishery activities.

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