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Influence of Fishery Subsidies on Fishing: Empirical Test Based on China's Provincial Panel Data

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Abstract: Controversies surrounding fishery subsidy policies are widespread. Many stakeholders believe that fishery subsidies play an important role in ensuring the livelihood of fishermen. At the same time, fishery subsidies pose a threat to the stock of fishery resources and affect the sustainable development of fisheries. Based on the panel data of 30 provinces, municipalities, and autonomous regions in China from 2007 to 2017, the article empirically examines the influence of fishery subsidies on fishing. The results of the study show that China's fishery subsidies are negatively correlated with fishing. On average, for each 1% increase in fishery subsidies, fishing will decrease by 2.9%. That is to say, in general, fishery subsidies are conducive to the sustainable development of fisheries. The results of heterogeneity analysis based on geographic location and economic development level show that fishery subsidies do not have a palpable negative influence on fishing in coastal areas or developed regions, whereas have an obvious adverse influence on fishing in inland areas or underdeveloped regions. The deterioration of the fishing environment and the natural environment explains the occurrence of this differentiation.

Keywords: fishery subsidies; fishing; sustainable development; panel data model

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1. Introduction

With the continuous improvement of people's living standards, the demand for aquatic products is also increasing, which has brought huge pressure on the supply of aquatic products, followed by the continuous fishing of fishery resources [1]. According to data provided by the Food and Agriculture Organization of the United Nations, 90% of the global fishery stock has been fully exploited [2]. Among the top ten fishery species that account for 30% of global fishery production, most fishery species are overfished [3]. The status of China's fishery resources is not optimistic either [4]. China's fishery resources are mainly concentrated in coastal waters, and the phenomenon of offshore overfishing is serious [5]. According to the report of the Finance and Economics Committee of the National People's Congress of China, the current fishing volume of marine aquatic products in China is about 14 million tons per year, and 85.7% of the fishing volume occurs in coastal waters, which poses a serious threat to the sustainable development of China's fishery resources [6]. Among them, large fish resources in the Bohai Sea are nearly exhausted, small fish resources have been severely reduced, and "undersea deserts" have even appeared in some areas [7]. High fishery subsidies have persisted even as stocks have collapsed, and the subsidies have been cited as one of the main causes of overfishing [8,9]. The Chinese government has launched a large number of subsidies for fishery activities including employment, fishing boat purchase, ship insurance, fishing suspension subsidies, and various tax reductions [10]. In 2013, the Chinese government invested 40.383 billion yuan in fishery subsidies, of which 94% is a fuel subsidy [11]. According to economic theory,

fishery subsidies reduce the cost of the fishers' fishing activities and increase its profits while the price of aquatic products remains unchanged, which will encourage fishers to carry out more fishing activities, eventually contributing to overfishing and exacerbating the "tragedy of the commons" [12]. In this way, does China's fishery subsidy activities really result in an increase in fishing activities? Due to the complexity of China's institutional environment, the answer to this question may not be implemented through theoretical predictions, and further empirical testing based on data is needed.

The current main point of view on fishery subsidies is that it will result in the overfishing of fisheries, thereby endangering the safety of fishery ecosystems [13,14]. Zhu Lina and Huang Shuolin (2015) carried out an empirical analysis based on Rizhao city in Shandong Province of China, and the results showed that fishery fuel subsidies increased the amount of fishing [15]. Li Xiang et al. (2015), based on the data of Guangdong Province, also came to the conclusion that fishery fuel subsidies would increase fishing. However, the magnitude of the increase was small, and the fishery fuel subsidies increased the fishing amount while also promoting the development of fishing technology [16]. Mallory and Grace (2016) believed that 95% of China's fishery subsidies are not conducive to the sustainable development of fisheries [17]. Skerritt et al. (2020) examined the last 20 years of subsidies provided to the fisheries sector by the EU, from their viewpoint, the changes had partly occurred as a result of the removal of certain capacity-enhancing subsidies and partly due to additional funds being allocated to beneficial forms of public funding [18]. Skerritt and Sumaila (2021) believed that failure to eliminate harmful fisheries subsidies had ramifications across the SDGs and across global regions, regardless of the absolute amount of subsidies that were being provided therein [19]. However, the impact of fishery subsidies on fishing or fishery stocks would be affected by the types of subsidies and management methods. Wang, Y. and Wang, N. (2018) believed that cost-cutting subsidies were not conducive to fishery resource stocks, while general services were conducive to protecting resource stocks [20]. Cui, M.H. (2020) suggested that the effect of fishery subsidies on fishing would be influenced by factors such as the subsidy method and scale [21]. The above-mentioned studies involving China and other countries mainly used samples from local areas, which has some defects. Taking China as an example, fishery production is widely distributed in provinces, cities, and autonomous regions, and there are significant divergences in fishery production and management environment, natural conditions, and institutional environment among different regions, so it is difficult to reflect the overall situation of China only by using data from a local area. Therefore, to investigate the influence of China's fishery subsidies on fishing, we need to consider the situation of China's provinces, municipalities, and autonomous regions [22].

2. Materials and Methods

Based on the questions raised in the introduction, this section sets up the panel dual fixed-effects model, and explains the dependent variable, independent variables, and control variables involved in the model.

2.1. Research Method

This article focused on investigating the influence of fishery subsidies on fishing. For this purpose, the following model was constructed for empirical testing:

$$lnCatch_{it} = \alpha_0 + \alpha_1 lnSubsidy_{it} + \beta X_{it} + \lambda_i + \nu_t + \mu_{it}$$

Among them, the subscripts i and t represent the i-th province and the t-th year, respectively; $Catch_{it}$ is the fishery catch output of province i (autonomous region or municipality) in year t; and $Subsidy_{it}$ is the core independent variable that the article focused on, representing the amount of fishery subsidies in province i (autonomous region or municipality) in year t. X_{it} is a series of control variables reflecting the characteristics of provinces (autonomous regions or municipalities) including per capita GDP, the proportion of secondary industry in GDP, the proportion of tertiary industry in GDP, and the

urbanization rate (different countries have different standards for the classification of the three industries, but China's standards are as follows: primary industry mainly refers to agriculture including forestry, animal husbandry, fishery, etc; secondary industry mainly refers to industry including extractive, manufacturing, electricity, etc, and construction; tertiary industry mainly refers to other industries except for the primary and secondary industries already mentioned) [23]. At the same time, considering that the heterogeneity between different provinces in China does not change over time, the article added the province fixed effect λ_i to avoid the endogenous problem caused by heterogeneity [24]. In order to further control those factors that change with time but not with region, the article added the time fixed effect v_t [25]. μ_{it} is a random disturbance term, which is used to reflect the influence of other factors that can explain the fishery catch production aside from independent variables and the control variables. α_0, α_1, and β are the estimated coefficients of intercept term, independent variables, and control variables, respectively. In order to avoid too large numerical gaps between variables, the variables of fishery catch output, fishery subsidy amount, and GDP per capita are processed in logarithm.

2.2. Variable Description

2.2.1. Dependent Variable

The article examined the influence of fishery subsidies on fishing, so the dependent variable was fishery catch production (*Catch*). In order to reduce the heteroscedasticity, logarithmic processing was performed. Fishery catch output can reflect the intensity of development and utilization of fishery resources, and will be affected by many factors.

2.2.2. Independent Variables

The independent variable in this article is the logarithm of the amount of the fishery subsidy (*lnSubsidy*). The types of fishery subsidies are diversified, but limited to the availability of data; this article only used the statistics of the amount of fishery subsidies as an independent variable. Generally speaking, fishery subsidies including fishers' employment, fishing boat purchase, ship insurance, fishing ban subsidy, and various tax exemptions are characterized by cost reduction, so they can cover part of the cost of the fishers' production [26]. Based on this, most scholars believe that the reduction of the fishers' production costs caused by fishery subsidies will greatly increase the fishers' fishing output, making them as close as possible to the critical point of their profit maximization. Therefore, the traditional view is that increased fishery subsidies will increase fishery catch production.

2.2.3. Control Variables

The article selected control variables from two levels of demand and supply. The selected control variables include:

First item: resident income level. The income level of residents plays a vital role in the development of fisheries [27]. Generally speaking, with the continuous improvement of the residents' income level, their demand for fishery products will continue to increase. On one hand, it comes from the income effect. On the other hand, the increase in the residents' income level will increase the residents' demand for diversified fishery products. The increase in demand for aquatic products will further encourage the market to increase the supply of aquatic products through the adjustment of prices, thereby increasing fishery production. According to the usual practice in the existing literature [15], the paper used the per capita GDP (*lnPerGDP*) to measure the income level of residents, and the consumer price index was used for deflation.

Second item: industrial structure. As the income level of the residents increases, the demand for aquatic products will become more diversified, but only when the processing capacity is enhanced, the market can provide more diversified aquatic products, which can increase the fishing output. Therefore, in this paper, the proportion of the secondary industry in GDP (Second) was used to measure the processing capacity. The improvement in the industrialization level often reflects the spread of machines instead of human labor,

which can increase the processing capacity of products [28]. Once the processing capacity is improved, coupled with a large amount of demand, the fishery catch production can be increased when the stock of fishery resources does not reach the critical value. Fishing requires a large amount of labor. According to economic theory, when labor can flow freely, it will choose between different industries in order to maximize profits. Similarly, the aquatic product market does not exist in isolation, but will be affected by other markets. The article added the tertiary industry as a percentage of GDP (Third) to measure the attraction of the service industry to fishery labor. With the vigorous development of the tertiary industry, the employment options of the fishery labor force will be more diversified. Some of the labor force may switch to the tertiary industry, which reduces the number of fishers in the aquatic product industry, thereby reducing the yield of fisheries.

Third item: the level of urbanization development. One of the manifestations of the improvement in urbanization level is the concentration of the rural population to cities. In this process, the original rural lifestyle will gradually be assimilated by the urban lifestyle, and consumption will become more diversified, which may cause an increase in the demand for aquatic products [29]. From another perspective, the agglomeration of population to cities will also promote the development of the catering industry and provide more diversified aquatic products. The superposition of supply and demand factors has promoted the continuous increase in fishery production.

There may be other factors influencing fishing, but this paper mainly focused on the influence of fishery subsidies on fishing. Considering the availability of data, we selected these control variables to reduce the error of missing variables as much as possible.

2.3. Data Sources

The data collected in this paper span from 2007 to 2017, covering 30 provinces, cities, and autonomous regions in China (Tibet was excluded due to lack of key data). Fishery production and fishery subsidies come from the "China Fishery Statistical Yearbook". Per capita GDP, urbanization, the proportion of secondary industry in GDP, and the proportion of tertiary industry in GDP were all from the "China Statistical Yearbook". Among them, in order to eliminate the impact of inflation, the CPI was used to deflate fishery subsidies, social relief and policy subsidies, and per capita GDP. Table 1 shows the descriptive statistical results of each variable.

Table 1. Descriptive statistics of variables.

Variable	Variable Meaning	N	AVG	SD	Min	Max
lnCatch	Logarithm of fishery catch	296	11.13	2.696	3.401	15.21
lnSubsidy	Log value of fishery subsidy amount	261	6.439	1.830	1.626	10.23
lnPerGDP	GDP per capita	310	10.39	0.492	9.012	11.52
Second	The proportion of secondary industry in GDP	310	45.99	8.449	19	61.50
Third	The proportion of tertiary industry in GDP	310	43.52	9.412	28.60	80.60
Urbanization	Urbanization rate	310	53.75	14.03	22.30	89.60

3. Results

This section conducts an empirical test on the impact of China's fishery subsidies on fishing. First of all, the regression was performed using the full sample to grasp the influence of China's fishery subsidies on fishing in general. Second, based on the geographical location and economic development level, a sub-sample regression was performed to investigate the heterogeneous influence of fishery subsidies on fishing.

3.1. Benchmark Regression

In this paper, the panel double fixed effects model was used to test the impact of fishery subsidies on fishing. The regression results of the model are shown in Table 2. In Table 2, (1) and (2) are the regression results of excluding control variables and including control variables, respectively. The results show that the influence of fishery subsidies on

fishing was negative and passed the test at the significance level of 1%, indicating that the fishery subsidies implemented by China not only did not lead to an increase in fishery catch, but reduced it. On average, for each 1% increase in the amount of fishery subsidies would reduce the fishery catch by 3.8%. According to the existing economic theory, fishery subsidies reduce fishing costs and should promote the increase in fishery catch production. However, this theoretical hypothesis has a premise that the fishers will behave consistently to increase the fishing catch only when they expect that the fishery subsidies would be provided continuously in the future. If the fishers expect that the fishery subsidy policy is unstable, they will not increase the fishing catch. In contrast, the fishers will reduce the fishing catch and use the fishery subsidy funds to transfer to other industries, which may lead to a decline in the fishing catch. In order to protect fishery resources, China has implemented "a fishing moratorium system" in the Bohai Sea, Yellow Sea, and East Sea during the summer season. During the critical growth and breeding period of fish, fishery production is closed and fishers are given fishery subsidies, so that fish have enough time to grow and reproduce, thus leading to a decline in fishing volume. At the same time, fishery subsidies support aquaculture, resulting in a decline in fishing.

Table 2. Regression results of the full sample data.

	(1) lnCatch	(2) lnCatch
lnSubsidy	−0.038 ***	−0.029 **
	(0.014)	(0.011)
lnPerGDP		0.253 ***
		(0.085)
Second		−0.022 **
		(0.011)
Third		−0.019 *
		(0.010)
Urbanization		0.008
		(0.005)
Constant	11.848 ***	10.638 ***
	(0.085)	(1.041)
Province fixed	Yes	Yes
Year fixed	Yes	Yes
N	255	255
r2_w	0.235	0.191
Sargan–Hansen Statistics	1.1×10^5 ***	1.5×10^4 ***

Note: *, **, and *** indicate that the significance test passed the significance level of 10%, 5%, and 1%, respectively; the standard error of Driscoll–Kraay is in parentheses; the Sargan–Hansen statistic was used to judge the panel regardless of whether the data were suitable for a fixed-effect model or a random-effect model, and the test results indicate that the fixed-effect model should be used.

3.2. Sub-Sample Inspection

China has a vast territory and there are significant differences in geographic location and economic development level among the different regions. Therefore, the implementation status of fishery subsidies in different regions may also have differences, and its impact on fishery catch will be heterogeneous. To this end, the article divided the full sample into coastal areas and inland areas from the perspective of geographic location. In addition, the full sample was divided into developed regions and underdeveloped regions from the perspective of the level of economic development and estimated, respectively. The estimated results of the sub-samples under the two division methods are shown in Table 3. In Table 3, (1) and (2) give the estimated results of samples from coastal areas and inland areas. It can be found that the influence of fishery subsidies on fishing has failed the test of statistical significance in coastal areas, while it is negative and has passed the test of statistical significance in inland areas. On average, for each 1% increase in the amount of fishery subsidies in inland areas would reduce fishery catch by 3.9%. In Table 3, (3) and (4) provide the estimated results of samples from developed regions and underdeveloped

regions. Similarly, the influence of fishery subsidies on fishing failed the test of statistical significance in developed regions, while the estimated coefficients of fishery subsidies in underdeveloped regions were negative. On average, for each 1% increase in the amount of fishery subsidies in underdeveloped regions would reduce fishery catch by 3.5%. From the perspective of economic significance, fishery subsidies have a greater influence on fishery fishing in inland areas and underdeveloped regions. Due to the different stages of development in the region, the influence situation is different. There are significant differences in fishery subsidy structure between coastal developed areas and inland underdeveloped areas. In coastal developed areas, fishery subsidies are mainly used for fuel oil, fishing boat construction, freezing, fishing gear, safety equipment, infrastructure support, and fishery management measures, which further improve fishing skills. However, the limitation of the coastal fishing moratorium has caused fishing to decrease; moreover, in underdeveloped inland areas, fishery subsidies are mainly used for the direct transfer of public services such as infrastructure, research and development, and fisheries management measures, rather than for actual fishing, resulting in a decline in fishing volume.

Table 3. Analysis based on the heterogeneity of inland and coastal areas.

	(1) Coastal Area	(2) Inland Area	(3) Developed Area	(4) Less-Developed Area
lnSubsidy	−0.024	−0.039 ***	−0.022	−0.035 ***
	(0.016)	(0.012)	(0.015)	(0.011)
lnPerGDP	0.577 ***	−0.259	0.412	−0.008
	(0.167)	(0.225)	(0.318)	(0.170)
Second	−0.023 ***	−0.011	−0.056 **	−0.011
	(0.006)	(0.016)	(0.020)	(0.009)
Third	−0.015 ***	−0.012	−0.067 **	−0.001
	(0.005)	(0.012)	(0.022)	(0.006)
Urbanization	−0.006	0.021 *	−0.014	0.036 ***
	(0.007)	(0.011)	(0.012)	(0.009)
_cons	9.886 ***	12.962 ***	15.201 ***	10.203 ***
	(1.522)	(2.096)	(2.601)	(1.264)
N	107	148	97	158
r2_w	0.381	0.277	0.363	0.279
Sargan-Hansen Statistics	3.1×10^4 ***	1.2×10^4 ***	493.072 ***	3.3×10^4 ***

Note: *, **, and *** indicate that they passed the significance test at the significance level of 10%, 5%, and 1%, respectively; the robust standard error of the cluster to the province is in parentheses. The Sargan–Hansen statistic was used to judge whether the panel data were suitable for a fixed-effect model or a random-effect model. The test results indicate that the fixed-effect model should be used.

According to the estimation results of sub-samples, it can be found that fishery subsidies have a negative influence on fishing in both samples of inland areas and coastal areas, but the absolute value of the coefficient of fishery subsidies, which was estimated in inland areas to be greater than that in coastal areas. Similarly, fishery subsidies also have a negative influence on fishing in both samples of developed regions and underdeveloped regions, but the absolute value of the coefficient of fishery subsidies estimated in underdeveloped regions was greater than that in developed regions. The above results reflect that fishery subsidies have a greater negative influence on fishing in inland areas and underdeveloped regions.

4. Discussion

4.1. The Influence of Fishery Subsidy Policy Uncertainty on Fishing

According to the empirical results of the full sample, the fishery subsidies that are implemented by China reduce fishing, instead of increasing it. The possible explanation is that the uncertainty of China's fishery policies and measures is reflected in the fact that the introduction of policies often takes a top–down path, however, the ordinary fishers are unable to participate in policy making and lack the necessary understanding of the

policy itself. As a result, their uncertainty in the perception of the unknown will affect the expectations of the future. In addition, while providing fishery subsidies, the Chinese government has also continuously increased the protection of fishery resource stocks as well as restricted large-scale and high-intensity fishing activities. It has further increased the fishers' uncertainty of future fishery subsidies and industry development [30]. Therefore, from the perspective of fishers, they can use fishery subsidies as a transition to jump out of fishing, and then implementing conversion to production may be the best choice for them to deal with future uncertainties [31]. To be sure, although the total amount of fishing shows that there has been no reduction in fishing, it does not mean that the negative influence of fishery subsidies on fishing is not valid, because the increase in fishing may be caused by other factors. It is just that the reduction in fishery fishing caused by fishery subsidies is offset by the incremental effects of other factors.

4.2. The Influence of Regional Differences in Fishery Subsidies on Fishing

According to the empirical results of regional differences, the article has two explanations. First, a massive gap exists in the fishing environment of fishers in inland areas and coastal areas. Inland fishers mainly rely on lakes, while coastal fishers have the natural advantage of the ocean. The stock of fishery resources owned by the ocean is much higher than that in the lakes, which enables coastal fishers to continue to engage in fishing activities. However, inland fishers need to take up other work to supplement their households with the limited stock of lake fishery resources. Fishing may merely be a sideline. Second, compared with lakes, the ocean has a stronger ability to absorb pollution. At the same time, the types of marine fishery resources are more diverse. The extensive economic growth pattern of China has led to serious water pollution in lakes. The original "green mountains and clear water" have become "sewage bald mountains" under the influence of industrialization, which has caused a sharp deterioration in the living environment of fishery resources and the disappearance of natural fishery resources [32]. During the process of industrialization, the marine environment has also deteriorated, but compared with lakes, the ocean's greater pollution absorption capacity and diversified fishery resources have enabled the coastal fishers who use the ocean as a production environment to obtain their fishing capacity as ever. Nevertheless, inland fishers are faced with a situation in which there is no fish to catch and are forced to engage in other industries or make a living in other industries such as aquaculture. Under the impact of the fishery subsidy policy, due to the limitation of natural production conditions and the deteriorating living environment of fishery resources, the fishing in inland areas will decline at a faster rate with the continuous increase in the amount of subsidies compared with coastal areas [33].

4.3. Research Gaps and Limitation of the Present Study

The main substantive issue with the paper concerns the data used for the subsidies. The data on fishery subsidies in the China Fishery Statistical Yearbook series are not exhaustive and are not sub-categorized to a level of specificity that makes it possible to accurately assess impact. The subsidies data that the paper relied on only included the payments given to fishery households, and do not include subsidies given to fishing enterprises. The fishery subsidies themselves are not subcategorized into individual programs, so we do not know what proportion of them are capture fisheries versus aquaculture, or beneficial versus harmful (capacity-enhancing) subsidies. In addition, the concerns about the impact from subsidies are different for capture fisheries versus aquaculture as it would make sense that increased subsidies would lead to an increase in aquaculture production to a certain point, but overfishing is not a concern as much as it is for capture fisheries. These issues will be improved in subsequent research.

5. Conclusions

In the context of the continuous depletion of terrestrial resources, the sustainability of fishery output plays a vital role in national food security and sustainable development.

However, China's continuous increase in fishing has rapidly reduced the stock of fishery resources. Therefore, many scholars believe that China's fishery subsidy policy is one of the critical factors that has caused the sharp decline in China's offshore fishery resources. In the end, the article used panel data from 30 provinces, municipalities, and autonomous regions in China from 2007 to 2017 to test the influence of fishery subsidies on fishing, with a view to giving scientific conclusions from the perspective of quantitative analysis. There are three main conclusions as follows. First, China's fishery subsidies have a negative influence on fishing. The fishing has shown a downward trend as the amount of China's fishery subsidies increases. Second, the negative influence of fishery subsidies on fishing is heterogeneous. Specifically, it did not pass the statistical significance test in coastal areas or developed regions, while it passed the statistical significance test in inland areas or underdeveloped regions. As a result, with the amount of fishery subsidies in inland areas or impoverished regions increasing, the fishing in these areas will decline.

Based on the empirical results obtained in the article, the following policy recommendations are proposed. First, fishery subsidy policies should be focused on inland areas or underdeveloped regions and take the most advantage of the maintenance function of fishery subsidies on inland fishery resources to promote inland fisheries to shift to aquaculture and improve the efficiency of aquatic product supply. Second, the implementation of relevant fishery subsidy policies cannot adopt a "one size fits all" approach from the perspective of maintaining the sustainable development of fishery resources. The huge differences between regions in China should be taken into account. For the time being, fishery subsidies have a negative influence on fishing in inland areas or underdeveloped regions. Therefore, the focus of the fishery subsidy policy should concentrate on coastal areas or developed regions, and guide fishers to switch to other production through the fishery subsidy policy, rather than directly cancel the fishery subsidy policy. Third, the fishery subsidy policy needs to take the security of aquatic product supply into consideration. For the sake of avoiding the shortage of aquatic product supply, which is caused by the synchronous adjustment of fishery subsidy policy between different regions, it is not advisable to adjust fishery subsidy policy blindly only to maintain the sustainable development of fishery resources. For example, the government should adjust subsidy policies periodically according to regional differences, rather than a one size fits all approach. The government should adjust the fishery subsidy policy by considering fishery development and the fishers' production in an overall way, gradually promoting fishery transformation, upgrading, and green aquaculture under the condition of ensuring the safety of aquatic product supply.

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