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The Role of Tax in Managing Offshore Fishing Activities: An Application of Bioeconomic Model

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Abstract
The paper's purpose is to light up the role of tax in managing offshore fishing activities. It was conducted by considering two management regimes; (1) assumes that the number of fishing firms is finite and defined as a restricted access regime, and (2) the number of fishing firms is infinite, which is regarded as an open access regime, to enter into a coastal nation's fisheries. Each management regime is linked to two policy goals; namely, the maximum sustainable biomass yield and maximum sustainable economic yield goal. The Verhulst Schaefer model and Wachsman model were employed to estimate the biological parameters and economic analysis. The results of empirical analysis indicated that a coastal nation could control the effort and stock through adjusting the fishing fee that can be determined as a tax policy. More especially, if a coastal nation didn't charge any fee level on fishing firms, even though the number of firms was restricted, the stock still was under acceptable level, which leads to the depletion and potential collapse risk of fisheries. Additionally, a coastal nation could adopt one of four fee levels such as r_{MSBY} *(0.3378)*, r_{MSEY} *(0.5071)*, r'_{MSBY} *(0.3623)*, and r'_{MSEY} *(0.5165)* depending on each management regime and policy goal selected. However, it would be better if the coastal nation selects the open access regime, and then charges on fishing firms at level of r'_{MSBY} or r'_{MSEY}.
Keywords: Tax, Fishing Management regime, Policy goal
Classification: *JEL, Q 22*

1. Introduction

Towards a sustainable exploitation regime of fisheries, it has long becomes a key strategic goal for almost all of coastal nations in the world. Many regulations for fishing were suggested by managers, policy makers, and scientists. Most these regulations virtually were derived from controlling inputs, as regulations of vessel power, vessel size, gear, mesh size, seasonal fishing, and age-based fishing (Cochrane *et al.,* 2002), or controlling outputs as regulations of fixed total allowable yields through issuing quota and licenses (Alverson *et al.*, 1994). Although multiple stringent regulations on the fishing were enacted, but the stock size is being still continuously depleted over time (ISU, 2012; Caddy and Cochrane, 2001), which leads to our skepticism of the current management scenarios. The fact that the demand of fisheries still continuously upwards rapidly due to the growth of human population and high needs of inputs as materials for industries (Caddy and Cochrane, 2001), which can leads to the growth of price. On the other hand, when the fisheries are exploited commercially, the fishing firms' goal maximizes profit achievable from fisheries. This means that the exploiting pressure on fisheries decreases, if and only if, the demand for fisheries declines or the earnable profit from fisheries is much lower than other sectors. Therefore, in order to manage marine fisheries more effectively, it is necessary to be taken into account from fishermen's core goal and how their response will look like when their profit is alternated. In this context, the tax policy can become a more effective management tool, because it relates closely to input cost and influences directly on fishermen's profit.

For the tax policies, some models were suggested by scientists. Charles (1986) developed a model in which a fixed Total Allowable Catch could be divided into two parts, one for a domestic fleet and other for a foreign fleet. He indicated that a coastal nation may use one of four policies depending on the fishing fee, which was assumed an exogenous factor. Clarke and Munro (1987) considered a model that allows a coastal nation to impose a fishing fee on a single Distant Water Fishing Nation according to a same rate of discount. They suggested that instead of only one tax, the coastal nation could increase its discounted net return by using contemporaneously both a tax on harvest and a tax or subsidy on effort. Raissi (2001) set up a model that a coastal nation could use a dual tax system on both foreign firm and domestic firm, with an inferior fishing technology. He showed that the foreign firm would remove its competitors by maximizing its fishing effort if the coastal nation has had not any regulations imposed to them. The Model of Fishing Conflicts in Foreign Fisheries suggested by Wachsman (2002) could be regarded as most complete model up to now. He employed a game-theoretical model to build up his model in which a coastal nation attempts to maximize the revenue that it receives from foreign fishing firms that operate in its fishery. One of his initial goals is to determine whether there is a fishing fee that maximizes the coastal nation's revenue when the number of firms is fixed and whether that fee is socially optimal. He also investigated how many firms the coastal nation admits into its fishery and what the fishing fee is that it selects when it can choose both the number of firms and the fishing fee that each firm must pay. Consequently, he has shown that there exists a fishing fee that maximizes the coastal nation's revenue. However, the coastal nation generally selects a fee that is higher than socially optimal levels causing the firms to exert a level of fishing effort that is undesirably low. When the coastal nation can choose both the number of firms and the fishing fee, the best solution for the coastal nation is to not place any restrictions on entry to the fishery and to select a fishing fee that is based on the difference between the marginal benefit of effort and the marginal cost of effort. In 2013, Wachsman's model developed by Shao *et al.* (2013). He released the zero-fixed-cost assumption and gives a snap-shot of the dynamic process the model to estimate some optimal fee levels for each policy goals.

As discussed in above paragraph, although such literatures have mentioned to the reference points of fishing fee that can be definite as a tax policy, but it still lacks of intensive researches of the relationship between fishing fee with effort, stock, harvest, and profit, which can lead to a vague understanding in implementing and applying the tax policies. This paper, therefore, aims to shed more light on the role of tax policy in managing fishing activities. To do so, we employ Wachsman's (2002) model, as a main tool to analyze the impact of fishing fee-defined, with a little modifying, as a tax policy issued by government -on the stock, total fishing effort, total harvest, and net profit. This is done by considering two management regimes; (1) we assume that the number of fishing firms is finite, which is defined as a restricted access regime, and (2) the number of fishing firms is infinite, which is regarded as an open access regime, to enter into a coastal nation's fisheries. For each management regime, it is linked to two policy goals; namely, the maximum sustainable biomass yield and maximum sustainable economic yield goal. The biological parameters are estimated, based on the time series catch and effort data of Vietnam's fisheries, by using the Verhulst Schaefer model. The role of tax and proper fishing regime will be suggested, after the results of empirical analysis are discussed, as useful inputs to marine policy makers, resource managers, and researchers in designing sustainable resource management for marine fisheries.

2. Theoretical model

2.1 The Verhulst Schaefer model

The growth rate of fish population has been determined by many ways. One of the most commonly used ways is based on the logistic model of population growth. According to Verhulst-Schaefer (1838), surplus production model was defined as change in population biomass per unit of time (Clark 1990; Flaaten 2004), and described by the logistic equation,

$$F(X) = \alpha X\left(1 - \frac{X}{K}\right) = \frac{d(X)}{d(t)} \tag{1}$$

, where, X is stock biomass, α is the stock's intrinsic rate of growth equals the birth rate of the stock minus its mortality rate, and K is the carrying capacity of the fishery. Both α and K are referred as positive constants. $F(X)$ is natural population growth. If the X is smaller than K then $F(X)$ will increase over time and if X is larger than K then $F(X)$ will decrease over time. Thus, if the fishery is not commercially exploited the size of the stock will eventually converge to the carrying capacity of the fishery, $lim_{t\to\infty}X(t)=K$. When the fishery is exploited commercially by fishermen, then the change in the stock biomass at a given point in time, $d(X)/d(t)$, equals the stock's natural population growth, $F(X)$, minus the sum of the total harvests of fishery(H) (Schaefer1957),

$$\frac{d(X)}{d(t)} = F(X) - H = \alpha X\left(1 - \frac{X}{K}\right) - H \tag{2}$$

$H$is suggested as a production function that depends on total effort of catch (E) and stock biomass (X) in one given region and H can never exceed X, $H \leq X$,

$$H = \beta XE \tag{3}$$

, where, β is the catchability coefficient, $0<\beta<1$. This means that β doesn't depend on the size of stock. Substituting *Eq.(3)* into *Eq.(2)*, we have a stock's population growth function including the total effort (E) as

$$\frac{d(X)}{d(t)} = \alpha X\left(1 - \frac{X}{K}\right) - \beta XE \tag{4}$$

The stock biomass or the size of stock will reach a steady state when $d(X)/d(t)=0$. In order to determine the steady state stock $X(E)$ by setting *Eq.(2)* equal to zero and solving for X.

$$X(E) = K\left(1 - \frac{\beta}{\alpha}E\right) \tag{5}$$

Replacing *Eq.(5)* into *Eq.(3),* we obtain catch per unit effort (CPUE). A CPUE production function implies that the portion of the stock that catch per unit of effort is constant and it is represented by *Eq.(6).*

$$CPUE = K\beta\left(1 - \frac{\beta}{\alpha}E\right) \tag{6}$$

2.2 The Wachsman Model

In this study, the model of fishing conflicts in foreign fisheries suggested by Wachsman (2002) is regarded as a main tool to analyze the impact of fishing fee on the stock, effort, harvest, and net profit. Wachsman begins his work by an assumption is that in one given region includes n of fishers, each fisher i has a harvest (h_i) corresponding to the fishing effort (e_i), $i=[1,.., n]$.Total fishing effort equals to the sum of each firm's effort, *e.t*, $E=[e_1+, \ldots, +e_i, \ldots, +e_n]$. Replacing E for *Eq.(5)*, the steady state stock including n of fishers is given as

$$X = K\left(1 - \frac{\beta}{\alpha}\sum_{i=1}^{n} e_i\right) \tag{7}$$

When coastal nation charges the fishing fee (r) for all the fishers, r is suggested as a harvest rate at given price P and $0<r<1$, then the profit π_i of the i^{th} fisher from the fishery equals its revenue after paying the fishing fee *(r)* minus marginal cost *(C)*of effort as

$$\pi_i = (1-r)Ph_i - Ce_i \tag{8}$$

, where, h_i is that the harvest of the i^{th} fisher dependents on both the steady state stock *(X)* and its catch effort *(e_i)* of the i^{th} fisher, e.t, $h_i=\beta X(e_i)e_i$. Each fisher will attempt to maximize the profit that it earns from fishery when the size of the stock reaches a steady state. Fishers take the effort levels of other firms and the fishing fee as given when deciding on their effort. Each fisher takes into account the effect of its own effort on the steady-state stock but must take the effects of the other fishers' efforts as given. Replacing h_i and *Eq.(7)*for *Eq.(8),* rewriting *Eq.(8)* as

$$Max\pi_i = (1-r)b\left(1 - \frac{\beta}{\alpha}e_i - \frac{\beta}{\alpha}\sum_{j=1}^{m} e_j\right)e_i - Ce_i\,,\ with\ b = P\beta K \tag{9}$$

, where, b is the marginal revenue of effort. It implies that an increase in effort will leads to an increases in revenue, but the steady-state stock does not change. Therefore, the fisher must choose the same levels of effort in subgame perfect Nash equilibrium. Let e_j represents the effort that any other fisher j, $j = [1,\ldots, m]$, $m=n-1$, $j\neq i$, selects in equilibrium. We derive the best response of the i^{th} fisher to the effort levels chosen by all other fisher, $e_i(e_j)$, by rearranging the first order conditions of the i^{th} firm's objective function given by

$$e_i(e_j) = \frac{1}{2}\left[\frac{\alpha((1-r)b-C)}{\beta(1-r)b} - (n-1)e_j\right] \tag{10}$$

When other fishers increase their effort fisher i's best response is to reduce its effort. Symmetrically, in equilibrium the effort level that the fisher (*i*) selects must be the same as the effort levels selected by all other fishers. The effort level obtained that any of the n fishers will select in subgame perfect Nash equilibrium by substituting e_i for e_j in *Eq.(10)*and solving for e_i (Wachsman 2002).

$$e_i(r) = \frac{\alpha}{(n+1)\beta}\left(1 - \frac{C}{(1-r)b}\right) \tag{11}$$

, where $e_i(r)$ is the equilibrium effort of fisher *(i)*, which fisher i chooses in subgame perfect Nash equilibrium given r. From *Eq.(11)*, observe that $(1-r)b>C$, then $e_i(r)>0$, $(1-r)b=C$, then $e_i(r)=0$, and $(1-r)b<C$, then $e_i(r)<0$. None of the fishers exploit at $e_i(r)\leq 0$. Because, if $e_i(r)\leq 0$, then $h_i\leq 0$, so that the fishers will remove from fishery, whereas the fisher will attend to exploit as long as $(1-r)b>C$. This means that the coastal nation can only charge the fishing fee that is at level r in interval of $[0;\ 1-c/b]$, in the other word, $r_{Max}=1-c/b$ is the maximum fishing fee that the coastal nation doesn't allow to charge. Since the firms' equilibrium efforts are identical by symmetry the total equilibrium effort, $E(r)$, must equal $ne_i(r)$,

$$E(r,n) = ne_i(r) = \frac{n\alpha}{(n+1)\beta}\left(1 - \frac{C}{(1-r)b}\right) \tag{12}$$

2.3 Restricted access regime

In order to solve for the stock, the size of stock is often referred to as the bionomic equilibrium stock since it is the biologically stable size that the stock reaches when the fishers that utilize the fishery achieve an economic equilibrium. Substituting *Eq.(12)* into *Eq.(5)*:

$$X(r,n) = K\left(1 - \frac{n}{(n+1)}\left(1 - \frac{C}{(1-r)b}\right)\right) \tag{13}$$

The harvest that each firm removes from the fishery when the fishery reaches a bionomic equilibrium, $h_i(r)$, is found by substituting *Eq.(12)* and *Eq.(13)* into *Eq.(3)*. Define the bionomic equilibrium harvest, $H(r)$, as the total harvest that will be removed from the fishery when the fishery reaches a bionomic equilibrium.

$$H(r,n) = K\alpha\left(\frac{n}{n+1}\right)\left(1 - \frac{C}{(1-r)b}\right)\left(1 - \frac{n}{(n+1)}\left(1 - \frac{C}{(1-r)b}\right)\right) \tag{14}$$

The total net returns profit Π equals the total harvest multiplying the given price P minus the total cost of effort unit, i.e., $\Pi=PH-CE$. Replacing *Eq.(14)* and *Eq.(12)* for Π (.) as

$$\Pi(r,n) = \frac{\alpha n}{(n+1)}\left(1 - \frac{C}{(1-r)b}\right)\left[PK\left(1 - \frac{n}{(n+1)}\left(1 - \frac{C}{(1-r)b}\right)\right) - \frac{c}{\beta}\right] \tag{15}$$

a) The maximum sustainable biomass yield fee

As shown in *Eq.(14)*, the total harvest dependents on both the number of fishers and the fee that is given by the coastal nation, which implies that the coastal nation can maintain the maximum sustainable yield level through the fishing fee and choosing the number of the fishers in owning coastal region. Setting the derivative of $H(r)$, *Eq.(14)*, with respect to r, and then setting it equals to zero, we find the fishing fee r_{MSBY}, that can ensure the maximum sustainable when the number of fishers is to identify, as *Eq. (16)*.

$$r_{MSBY} = 1 - \frac{2cn}{b(n-1)} \tag{16}$$

From *Eq.(16)*,observe that when $n=1$, then r_{MSBY} is infinity and $n>1$, then $r_{MSY}<1-C/b$. So that, in order to obtain revenue from fisheries in the maximum sustainable biomass yield goal, the coastal nation can only select the number of fisher $n>1$. This means that r_{MSBY} satisfies the condition of $r_{MSY}<1-C/b$ that points the fishers will not remove from fishery.

b) The maximum sustainable economic yield fee

According to Wachsman (2002), a maximum sustainable economic yield set of strategies is that maximizes the net return from the fishery. Therefore, the maximum sustainable economic yield fee (r_{MSEY}) is one that can maximize the net return from the fishery. The net return from the fishery, $\Pi(E)$ equals the total revenue from the harvest minus the marginal cost of effort of all the firms, is represented by *Eq.(17)*.

$$\Pi(E) = b\left(1 - \frac{\beta}{\alpha}E\right)E - CE \tag{17}$$

In order to determine the maximum sustainable economic yield fee(r_{MSEY}), setting the first derivative of $\Pi(E)$ with respect to E equal to zero, we find the total effort that will maximize the return from the fishery, E_{MSEY}.

$$E_{MSEY} = \frac{\alpha}{2\beta}\left(1 - \frac{C}{b}\right) \tag{18}$$

Let $E(0)$ is the total equilibrium effort that the fishers exert in an unregulated fishery, that is a fishery where $r=0$ and there are no other restrictions on the firms' behavior. By substituting 0 for r in *Eq.(12)*, we find that if $n\geq 1$ then $E(0)\geq E_{MSEY}$. Specifically, when $n=1$ then $E(0)=E_{MSEY}$ and when $n>1$ then $E(0)>E_{MSEY}$. These findings are consistent with other game-theoretical models of fishing conflicts (Levhari and Mirman 1980, Dockner et al.1989), which conclude that when two or more firms compete over the same stock of fish they will exert more effort than is socially optimal. Since total equilibrium effort is decreasing in r, there exists a socially optimal fee, r_{SO}, such that r_{SO} induces the firms to select E_{MSEY}. The fishing fee that the owner charges essentially acts as a tax by reducing the marginal benefit from effort for each firm. To find the socially optimal fee set *Eq.(12)* equal to *Eq.(18)* and solve for r.

$$r_{MSEY} = \frac{(b-c)(n-1)}{b(n-1)+c(n+1)} \tag{19}$$

From *Eq.(19)* one can show that when more than one firm operate in the fishery, $n>1$, then $0<r_{MSEY}<r_{Max}$. When only one firm operates in the fishery, $n=1$, then the socially optimal fee is zero. An increase in the number of firms will increase the socially optimal fee. Essentially, the more intense the competition between firms the more strictly they need to be regulated through the imposition of a higher fishing fee.

2.4 Open access regime

Note that, when $n\rightarrow+\infty, n/(n+1)\rightarrow 1$, which implies that if the number of fishing firms is infinite, then the total effort will be large. Replacing 1 for $n/(n+1)$ into *Eq.*(12), (13), (14), (15), and (16), the relationship between the fishing fee (r) and the total fishing effort (E) will be

$$E(r, n=+\infty) = \frac{\alpha}{\beta}\left(1 - \frac{C}{(1-r)b}\right) \tag{20}$$

Similarly, the relationship between the fishing fee (r) and the steady-state stock (X) will then be given as

$$X(r, n=+\infty) = K\left(1 - \left(1 - \frac{C}{(1-r)b}\right)\right) \tag{21}$$

The relationship between the fishing fee (r) and the total harvest (H) will be represented as

$$H(r, n=+\infty) = K\alpha\left(1 - \frac{C}{(1-r)b}\right)\left(\frac{C}{(1-r)b}\right) \tag{22}$$

And finally the relationship between the fishing fee(r) and the net return profit (Π) will be explained as

$$\Pi(r, n=+\infty) = PK\alpha\left(1 - \frac{C}{(1-r)b}\right)\left(\frac{C}{(1-r)b}\right) - \frac{C\alpha}{\beta}\left(1 - \frac{C}{(1-r)b}\right) \tag{23}$$

Eq.(20), (21), (22), and (23) imply that if the number of fishing firms is infinite, the coastal nation can choose the appropriate management regime depending on its strategic goal by adjusting the fishing fee as discussed below.

a) The maximum sustainable biomass yield fee

If on the other hand the coastal nation selects the management regime with the maximum sustainable biomass yield target, the fishing fee can be found by taking the derivative of H with respect to requiting it to zero, and solving for r'_{MSBY}.

$$r'_{MSY} = 1 - \frac{2C}{b} \tag{24}$$

Form *Eq.*(25), it is easy to notice that $0<r'_{MSBY}<r_{Max}$, if and only if, $b>2C$, which implies that there exist a maximum sustainable biomass yield fee that maximizes the total harvest.

b) The maximum sustainable economic yield fee

If the coastal nation selects the management regime with the maximum sustainable economic yield target, the fishing fee can be obtained by setting the first order condition of Π with respect to r equal to zero, and then solving for r'_{MSEY} as

$$r'_{MSEY} = \frac{b-C}{b+c} \tag{25}$$

In order to ensure that r is within interval of *[0, 1-C/b]*, then the condition $b>C$ must hold, which implies there will exist a maximum sustainable economic yield fee where the total profit will attain a maximum value.

3. Types of data

The data used for this study is a time-series of 12 years from 2000 to 2012. The data was gathered on the variables such as catch and effort those were provided by the General Statistic Office of Vietnam. The price and cost are calculated by average cost and price of all fisheries in 2012, they were found to be 30,838,020 VND/tone of the average cost and 54,424,700VND/tone of the average price.

To get one measure of fishing effort for the annual total catches, the effort values from individual exploiting areas had to be converted into standard units of effort. According to Mark and Andre (2004), various methods for standardizing catch and effort data have been developed by Gulland (1956). However, the approach developed by Beverton and Holt (1993) was commonly applied. This method involves selecting a *'standard vessel/gear'* and determining the relative fishing power of all other vessels/gears. In this study, we have divided Vietnam's sea into 27 zones corresponding with 27 coastal provinces of Vietnam.

The fishing effort is measured by the capacity of vessel, and the effort values from individual fishing areas are converted into standard effort units. The set of fishing areas are labeled 1 to 27, and the total catch from each fishing area are denoted by H_i, respectively, and the corresponding levels of fishing effort as E_i, for i running from 1 to 27. Therefore, the catch per unit of effort (CPUE) of i^{th} fishing area is given by H_i/E_i, where H_i and E_i are catch and effort of i^{th} area respectively. Assuming that the stock follows logistic growth, a year-by-year procedure is used to obtain the standardized effort values. Then the total standardized fishing effort can be calculated as

$$E_{Std} = E_1 + \sum_{i=1}^{6} \frac{CPUE_i}{CPUE_1} E_i \tag{26}$$

, where E_{Std} is total standardized effort, E_1 is effort of Mekong River, and E_i is effort of ith area. Based on *Eq.*(26), the Std.CPUE, Std.catch, and Std.effort were calculated, as presented in Appendix 1.

4. Result and discussion

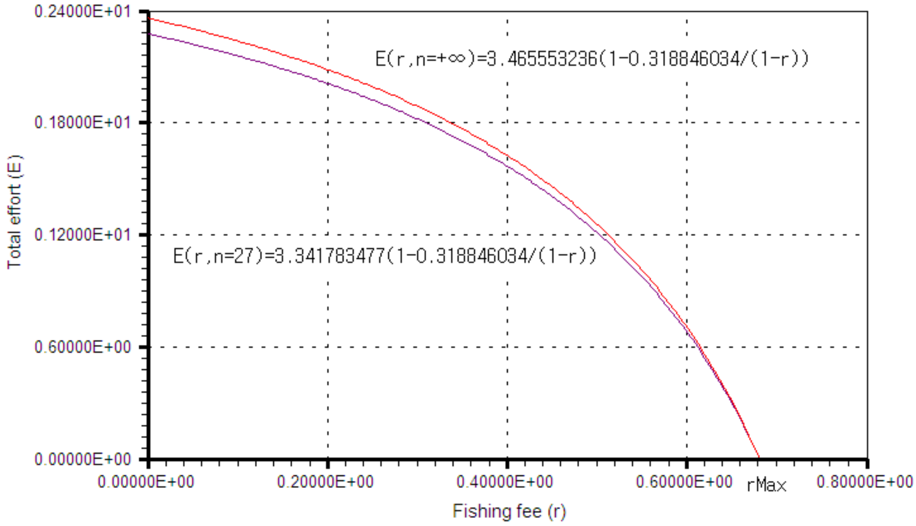
The parameters in *Eq.*(6) were estimated using a time-series data on the Std.CPUE and Std.effort of Vietnam from 2000 to 2012 (see Appendix 1). "The SPSS Version 16 Software" was used for the analysis of the data, as reported in Table 1. The results of the nonlinear regression analysis indicated that the Verhulst Schaefer model was statistically significant with the R^2 value of 0.901, which implies that 90.1% of CPUE's variation is explained by the model. All the parameters were statistically significant with K of 1.855, β of 0.958, and α of 3.320. Since β(=0.958) was in interval of [0, 1], K(=1.855) and α(=3.320) was greater than 0, the values of K, β, and α satisfied the condition of the Verhulst Schaefer model, so that they can be used for research purpose. The price, cost, and biological parameters were put into *Eq.*(12), (13), (14), (15), (16), (19), (20), (21), (22), (23), (24), and (25) to analyze the relationship of fishing fee with the total effort, stock, total harvest, and net profit and to calculate the reference points and economic rents. The number of firms, n, is assumed by 27 firms corresponding with 27 coastal provinces of Vietnam, which implies that the current context of Vietnam's offshore fishing activities is being reflected by the restricted access regime of research side. The acceptable limitation level of stock is calculated by $K/2$(0.9275x10^9 tons) used to compare to the reference points of two hypothetical management regimes for the policy implications. $K/2$ is defined as an under limitation level of stock, where the fisheries must face with the depletion and potential collapse risk if the size of fish population is under $K/2$ (Verhulst, 1838).

Table 1 Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
α	3.320	1.252E7	-2.791E+7	2.791E+7
K	1.855	6.992E6	-1.558E+7	1.558E+7
β	0.958	3.613E6	-8.051E+6	8.051E+6
ANOVA				
Source	Sum of Squares	df	Mean Squares	
Regression	7.750	3	2.583	
Residual	0.104	10	0.010	
Uncorrected Total	7.854	13	*R- squared = 0.901*	
Corrected Total	1.049	12		

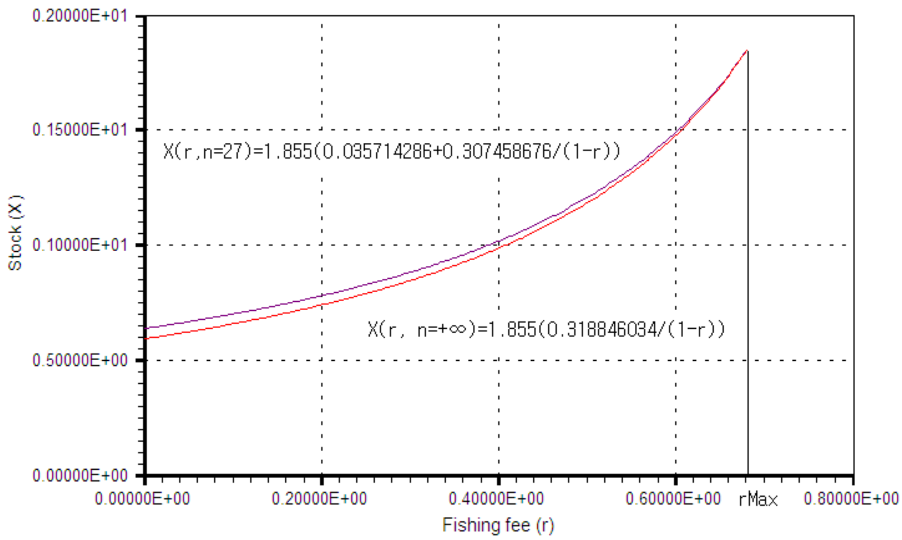
Figure 1 and 2 shows the progress of the total effort curves and of the stock curves for both management regimes. In which the open access regime (OAR) is being modeled by the red curves and the restricted access regime (RAR) is being simulated by the purple curves. They are observed that when the fishing fee increases in interval of [0, r_{Max}], the curves of stock tend to grow up from 0.6365858x10^9 tons to 1.8485500x10^9 tons for the RAR and from 0.591459x10^9 tons to 1.848311x10^9 tons for the OAR, as consequence of the reduction in the total effort from 2.2762691 tones/capacity for the RAR and from 2.360575 tones/capacity for the OAR to zero (see Table 2), respectively.

Figure 1. The relationship between the fishing fee and total effort



In order to gain insight into reason leading to the reduction of effort, it needs to consider the total cost of one firm. When owner charges a given fee on the firm, its included total cost will occur two components; (1) the rent that the firm must pay for the owner to enter into its fisheries, is identified as an exogenous factor and extracted from firm's revenue according to a certain proportion, and (2) the cost that the firm must pay to perform its fishing activities (so called is the cost of fishing activities), is defined as an endogenous factor including expenses such as the investments for fishing equipment, labor cost, energy cost, and so on. It is obvious that the growth of the fee will lead to the growth of the rent, which causes the growth of total cost. When the total cost increases, it will leads to the reduction of profit. For a commercially exploited fishery, the profit is usually a leading core goal of the firm. If the profit reduces due to the growth of fishing fee, the firm will attempt to maintain its profit maximally by cutting down the costs of fishing activities. As mentioned in theoretical model, the cost of fishing activities of the firm is measured by integration of the cost unit of effort and total effort of the firm in which the cost unit of effort is that the firm usually uses at minimum cost level, even though the owner doesn't charge any fee, due to its maximum profit goal. Therefore, in order to maintain the profit, the firm must the reducing the fishing effort as a sole solution that the firm can choose to reduce its cost of fishing activities and it is why reason the growth of fishing fee leads to the reduction of effort.

Figure 2. The relationship with the fishing fee and stock



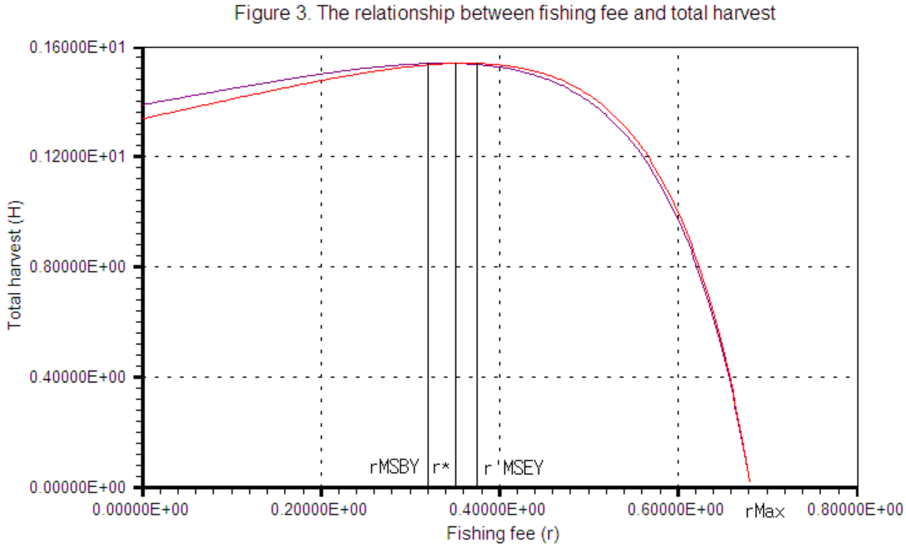
From figure 1 and 2, it is also easy to notice that the differences between two curves of stock and between two curves of effort are narrowed gradually when the fishing fee increases. In which the stock of the OAR was found to be smaller than that of the RAR and the total effort of the OAR is larger than that of the RAR. As Wachsman (2002) showed, an increase in the number of firms or an improvement in fishing technology would lead to an increase in the effort, which generates an added growing pressure on fish population and consequently the stock is reduced. Thus, this finding is relatively suitable with the Wachsman's finding and the situation of naturally hurting. This is one of reason that can explain why almost coastal nations in the world are running their fisheries with the restricted access regime. However, the calculated result of preference points indicated that at point where the fishing fee equals to zero, both 0.6365858x10^9 tons of the stock of the RAR and 0.591459x10^9 tons of the stock of the OAR are under acceptable level of stock of 0.9275x10^9 tons. This implies that if there is not any fee level charged on the fishing firms, the fisheries must face with the depletion of stock and it can lead to the collapse of fisheries sector in future, even though the number of fishing firms is restricted by the coastal nation to operate in its fisheries.

As discussed in above paragraph, owner can control the effort and stock in both management regimes through adjusting the fishing fee. However, it will be difficult for managers without a specific fee, which can leads to our disputable understanding in the process of implementing and applying policy and it is also harder to gain an agreement between the owner and fishing firms. Therefore, there is a need to definite how much the fishing fee is that owner can charge the fishing firms and which the trend of harvest and net profit will change when the fishing fee alters. As the calculated results of the reference points and economic rents showed in Table 2. An extreme scenario would be a situation where the government of coastal nation applies the maximum fee level (r_{Max}), which discourages firms' effort ultimately translating into loss of revenue for the government. In addition, at point where the fishing fee equals to zero, the coastal nation doesn't get any revenue from fisheries (Wachsman, 2002) and the stocks were found to be lowest, which lead to the depletion of fisheries. Therefore, both r_{Max}(=0.68) and r(=0.00) can't be adopted by the government. The other scenarios of practical significance for the government in terms of guiding various policy goals are given by the r_{MSBY} and r_{MSEY} levels of the RAR, and the r'_{MSBY} and r'_{MSEY} levels of the OAR. The government may choose any one of these levels depending on what policy goal it wants to pursue.

For the maximum sustainable yield goal; as it is evident from the figure 3, which shows the trend of the total harvests of the RAR and of the OAR. In first stage, there is a gradual slight growth of the harvest curves from 1.3881810x10^6 tons for the RAR, and from 1.337545x10^6 tons for the OAR. The reason for this growth is the growth of stocks due to the reduction of fishing efforts. The curve maximums are achieved at highest capture yield levels of 1.53965x10^6 tons for the RAR and of 1.53965x10^6 tons for the RAR. The maximum sustainable biomass yield fees were found to be 0.3378 for the RAR and of 0.3623 for OAR corresponding with 0.9275x10^9 tons of the stock and 30359.566 billion VND of the net profit of the RAR, and 0.9275x10^9 tons of the stock and 30359.5894 billion VND of the net profit of the OAR. From this point, almost the strong reduction of harvest curves is evident, which is caused by the excessive reduction of the efforts. The fact that the growth rate of fish population will increase more slowly, and then it will reach a steady state, if the fisheries are not exploited or the exploited fisheries are lower level than the growth rate of its population due to the biological characteristics of species, environmental conditions, and food scarcity. Therefore, if the fishing effort reduces excessively, even though the stock increases, the harvest sill reduces.

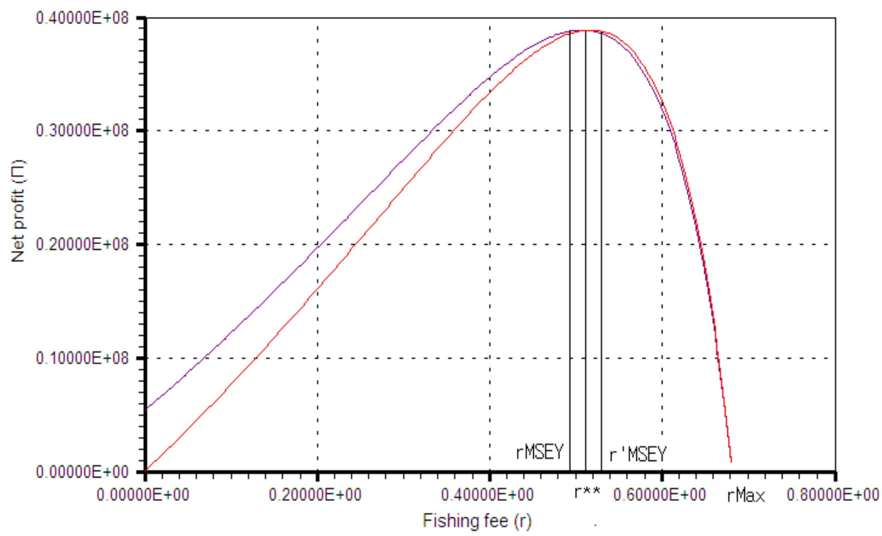
Another important characteristic was also investigated in this study, the harvest curve of the OAR, $H(r, n=+\infty)$, intercests that of the RAR, $H(r, n=27)$, at point, where the fishing fee (r*) was found to be 0.3505 that is greater than r_{MSBY} (0.3378) and less than r'_{MSBY} (0.3623). Notice that if the fishing fee is in interval of [r_{MSBY}, r*], then $H(r, n=+\infty)<H(r, n=27)$, whereas if the fishing fee is in interval of $[r^*, r'_{MSBY}]$, then $H(r, n=+\infty)> H(r, n=27)$. This implies that if coastal nations choose a goal that is the maximum sustainable biomass yield, the open access regime with the fishing fee level of r'_{MSBY} will be a best solution for their management of fisheries.

Figure 3. The relationship between fishing fee and total harvest



For the maximum sustainable economic yield goal; the trend of the profit of the RAR and of the OAR are stimulated in the figure 4. There is a gradual degressive growth of the profit curves from 53557.012 billion VND for the RAR and from 0.00 billion VND for the OAR. They stop at level of 388784.22 billion VND for the RAR and 388784.22 billion VND for the OAR, where the profits achievable from fisheries are largest corresponding with 1.22323x10^9 tons of the stock and 1.383124x10^6 tons of the harvest of the RAR, and 1.22323x10^9 tons of the stock and 1.383125x10^6 tons of the total harvest of the OAR (see table 2). The growth of net profit is caused by the growth of difference between the revenue and total cost. At first stage, when the fishing fee increases, it will lead to the total cost increases. In natural response, the firms will reduce their effort to maintain their profit, which leads to the stock increases. The growth rate of fish population increases more quickly than the reduction of the fishing effort, which leads to the growth of the harvest. This means that the revenue increases while the total cost reduces relatively. So that, the difference between the revenue and total cost increases, which leads to the profit increases. However, when the fishing fee continuously increases beyond the fee level of 0.5071of the RAR and of 0.5165 of the OAR, the growth rate of fish population increases more slowly than the reduction of the effort, which leads to the harvest reduces more quickly than the reduction of the effort. Therefore, the revenue reduces more quickly than the reduction of the total cost, which leads to the difference of the revenue and total cost reduce and consequently the profit reduces.

Figure 4. The relationship between the fishing fee and net profit



From figure 4, we also found that the net profit curve of the RAR, $\Pi(r, n=27)$, meets that of the OAR, $\Pi(r, n=+\infty)$, at point, where the fishing fee r^{**}(= 0.5119) is in interval of $[r_{MSEY}, r'_{MSEY}]$ (see Table 2). Notice that if the fishing fee is in interval of $[r_{MSEY}, r^{**}]$, then $\Pi(r, n=27) > \Pi(r, n=+\infty)$, whereas if the fishing fee is in interval of $[r^{**}, r'_{MSEY}]$, then $\Pi(r, n=27) > \Pi(r, n=+\infty)$. As it is empirical evident showed, the net profit will achieve at highest level of 388784.22 billion VND while the stock still maintains at relatively high level of 1.22323x10^9 tons, if a coastal nation selects maximum sustainable economic yield goal. Therefore, the open access regime with the fishing fee level of r'_{MSEY} will be a best solution for its management of fisheries.

Table 2. The reference points and economic rents

Items	The restricted access regime (n=27)					
Fishing fee	r(0.000)	r_{MSBY} (0.337)	r*(0.350)	r_{MSEY}(0.51)	r**(0.512)	r_{Max}(0.68)
Total effort (E)	2.27626	1.732777	1.701272	1.1802860	1.158828	0.000000
Stock (X)	0.63658	0.927500	0.944364	1.2232300	1.234716	1.848550
Total harvest (H)	1.38818	1.539650	1.539141	1.3831240	1.370729	0.000000
Net profit (Π)	53557.0	303595.6	313034.4	388784.22	388655.6	0.000000
Items	The open access regime (n=+∞)					
Fishing	r(0.000)	r*(0.350)	r'_{MSBY}(0.3623)	r**(0.5119)	r'_{MSEY}(0.51)	r_{Max}(0.68)
Total effort (E)	2.36057	1.76428	1.732777	1.201747	1.18028	0.0000
Stock (X)	0.59145	0.91064	0.9275	1.211743	1.2232	1.8483
Total harvest (H)	1.33754	1.539141	1.53965	1.395048	1.38312	0.0000
Net profit (Π)	0.00000	293603.4	303595.89	388655.69	388784.2	0.0000

Note: Total effort (tone/capacity); Stock (10^9 tons); Total harvest (10^6 tons); Net profit (billion VND)

5. Conclusion

Not only brings economic benefits, but also marine fisheries resource plays an important role in providing a considerable food volume to people and contributes significantly to world food security. At the same time, it also was recognized that fishery is a vulnerable-renewable resource. So that, if one chooses an inappropriate management regime, it will probably create potential risks that leads to the extinction and collapse of fisheries in future. In order to avoid the collapse of fisheries, almost all coastal nations in the world now are running their fisheries management system with several regulations of fishing effort, or capture yield (Cochrane *et al.,* 2002), or both. However, it will become more difficult and complex for some coastal nations, especially for poor and developing countries, where are not enough of means to inspect and monitor the offshore fishing activities. Moreover, if the demand of fisheries continuously increases and price is still pushed up, it can lead to illegal behaviors of fishers and the regulations of fishing effort are also easily ignored by them, EJF (2012) is a good example for this. Therefore, it will be more useful if an enacting regulation can instead of others that inherently are difficult to deployment and implement, whilst still maintains the management goals and ensures the sustainable development of fisheries sector in future.

By empirical analysis, the role of tax policy in managing offshore fishing activities has been further clarified in this study. It has shown that a coastal nation can control the effort and stock through adjusting the fishing fee level that can be determined as a tax policy. More especially, if the coastal nation doesn't charge any fee level on fishing firms, even though the number of firms is restricted to entry into fisheries, the stock still is under acceptable level, which leads to the depletion and potential collapse risk of fisheries. Additionally, the paper also shows that a coastal nation can adopt one of four fee levels such as r_{MSBY} (0.3378), r_{MSEY} (0.5071), r'_{MSBY} (0.3623), and r'_{MSEY} (0.5165) depending upon each management regime and policy goal. However, it should to be noted that the open access regime will be a best solution, if the coastal nation charges on fishing firms at level of r'_{MSBY} and r'_{MSEY}. In addition, for each fish species the growth rate of population is unlike depending on different biological characteristics. Therefore, identifying the fishing fee level for a specific species is necessary to be conducted for next studies and before applying the tax policy.

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Appendix:

Appendix 1. The harvest, effort, CPUE, St. effort in period of 2000 – 2012

Years	Total harvest (10^6 tones)	Capacity of vessel (10^6 capacities)	Total St. CPUE (10^3 tones/effort)	Total St. effort (Tone/capacity)
2000	1.02	1.35	0.38	2.72
2001	1.06	1.57	0.36	2.97
2002	1.13	1.83	0.39	2.89
2003	1.18	2.06	0.49	2.40
2004	1.28	2.44	0.59	2.17
2005	1.31	2.57	0.64	2.04
2006	1.34	2.81	0.76	1.77
2007	1.38	2.80	0.76	1.81
2008	1.42	2.99	0.79	1.80
2009	1.51	3.28	0.83	1.82
2010	1.56	3.99	0.93	1.67
2011	1.61	4.66	1.29	1.24
2012	1.68	5.35	1.19	1.41