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Subsidies, Fisheries Management, and International Trade

JINJI Naoto
Kyoto University

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Kyoto University

Abstract

The WTO members are conducting negotiations to clarify and improve disciplines on fisheries subsidies at the Doha Round. In this paper, I investigate how worldwide subsidy reform in the fisheries sector could affect fisheries output and resource stocks in a trading equilibrium. Using a simple static model of variable labor supply, I demonstrate that the effects of a reduction in subsidies on fisheries output will differ, depending on the conditions of the economy and fisheries management in different countries. A possible outcome of a reduction in non-capacity-enhancing subsidies is that fisheries output will rise in countries where catch quotas are not enforced and remain the same in countries where catch quotas are strictly enforced, expanding the total supply of fisheries products and reducing world fisheries resource stocks. Thus, this paper suggests that reducing some types of fisheries subsidies may yield unexpected and undesirable outcomes if fisheries resources are not properly managed.

Key words: Fisheries; Subsidies; WTO; SCM Agreement; Variable labor supply
JEL classification: F13; F18; Q22; Q27

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1 Introduction

Enormous amounts of money have been spent worldwide on subsidies for the fisheries industries. Many of those subsidies are possibly detrimental to resource conservation and management (Clark et al., 2005). This is mainly because the subsidies support overcapacity in the fisheries.

While it is not easy to define and obtain accurate data on fisheries subsidies, some estimates are available.[1] According to the Organisation for Economic Co-operation and Development (OECD, 2006), government financial transfers (GFTs) to marine capture fisheries in OECD countries amounted to US$6.47 billion in 2003 (see Table 1). This represented about 20% of the value of world production (i.e., landings) in the industry. As shown in Table 2, most of the GFTs were devoted to management, research, and enforcement (38%) and infrastructure (35%). Funds were also spent on decommissioning schemes (7%), income support (6%), and other cost-reducing transfers and direct payments (7%). The last item includes price support schemes.

Table 1: GFTs to the Fisheries Sector in OECD Countries, 1996–2003

(Unit: Millions of USD)

	1996	1997	1998	1999	2000	2001	2002	2003
OECD Total	6,836	6,479	5,428	6,125	6,166	6,127	5,761	6,472

Source: Table 1.2 in OECD (2006).

Based on case studies of Japan, the European Union, Norway, the United States, Russia, and China, Milazzo (1998) estimates the aggregate level of subsidies to fisheries in the world as US$14.0–20.5 billion annually.[2] He categorizes fisheries subsidies into (i) budgeted subsidies, (ii) unbudgeted subsidies, (iii) cross-sectoral subsidies, (iv) conservation subsidies, and (v) resource rent subsidies.[3]

[1] Detailed discussions on how to define fisheries subsidies are provided by OECD (2006) and Khan et al. (2006).

[2] Data include different years in the 1990s.

[3] Budgeted subsidies include development grants, state investments, foreign access payments, market promotion, and price supports. Unbudgeted subsidies include subsidized loans, fuel tax exemptions, and income tax deferrals. Cross-sectoral subsidies include aids to shipbuilding and aids to fisheries infrastructure, such as fishing ports. Conservation

Table 2: Shares of GFTs by Program Objectives (2003)

	USD million	%
Management, research, and enforcement	2,508	38.8
Infrastructure	2,263	35.0
Access payments	194	3.0
Decommissioning payments	432	6.7
Investment and modernization	206	3.2
Income support	435	6.7
Other cost-reducing transfers	454	7.0
Total	6,472	100.0

Source: Table 1.1 in OECD (2006).

Khan et al. (2006) and Sumaila et al. (2006) provide another estimate. Khan et al. (2006) estimate global non-fuel fisheries subsidies for 11 subsidy types from the database of subsidy programs reported in marine capture fisheries for 144 coastal countries (both developed and developing countries) from 1995 to 2005.[4] They estimate that global non-fuel subsidies are US$25.7 billion annually. About 49% (US$12.7 billion) is provided by 38 developed countries and the remaining 51% (US$13.0 billion) by 103 developing countries. In developed countries, subsidies for fisheries management programs and services are the major program (US$5.1 billion). In developing countries, on the other hand, fishing port construction and renovation programs (US$7.3 billion) and fishery development projects and support services (US$2.2 billion) are the major programs. Moreover, Sumaila et al. (2006) estimate global fuel subsidies at US$4.2–8.5 billion per year.

subsidies include vessel and fishing permit buybacks, stock enhancement, and R&D in clean harvesting gear. Finally, resource rent subsidies include user fees.

[4]The eleven subsidy types are (i) fisheries management programs and services; (ii) fishery research and development; (iii) boat construction, renewal and modernization programs; (iv) fishing port construction and renovation programs; (v) marketing support, processing and storage infrastructure programs; (vi) tax exemption programs; (vii) fishing access agreements; (viii) fishery development projects and support services; (ix) fisher assistance programs; (x) vessel buyback programs; and (xi) rural fishers community development programs. Khan et al. (2006) call (i) and (ii) "good subsidies," (iii) to (viii) "bad subsidies," and (ix) to (xi) "ugly subsidies." *Good subsidies* are defined as subsidies that lead to investments in natural capital assets to a socially optimal level. *Bad subsidies*, on the other hand, lead to disinvestments in natural capital assets. *Ugly subsidies* may lead to investment or disinvestment in fisheries resources.

The use of fisheries subsidies has also been discussed in the field of international trade. Members of the World Trade Organization (WTO) are currently conducting negotiations to clarify and improve disciplines on fisheries subsidies in the Rules Negotiations at the Doha Round (WTO, 2007, 2008). At present, there are no specific regulations on fisheries subsidies in the WTO. The new regulations on fisheries subsidies are planned as additions to the Agreement on Subsidies and Countervailing Measures (SCM Agreement) as Annex VIII. In the negotiations, the prohibition on certain forms of fisheries subsidies that may contribute to overcapacity and overfishing was discussed. At the same time, the establishment of appropriate and effective special and differential (S&D) treatment for developing and least-developed countries is also discussed in the new regulations.

However, there are conflicting views over several issues. First, there are two basic approaches to the prohibition on subsidies: a top-down approach and a bottom-up approach. Under the top-down approach, all fisheries subsidies are prohibited and those exempted from the prohibition are listed. Under the bottom-up approach, in contrast, only specific subsidies that are prohibited are listed. Second, one view is that allowable subsidies should be restricted to those not contributing to overcapacity and overfishing. Another view is that some subsidies that may contribute to overcapacity and overfishing should be exempted from the prohibition because of their importance to development priorities. Third, in the draft of the new regulations (WTO, 2007), exceptions (both general and S&D) are conditioned upon the establishment and operation of fisheries management systems and measures. It is, however, controversial whether the WTO, which is not a fisheries management organization, should use binding conditionality concerning fisheries management.

As is clear from the negotiations at the WTO, it is important to determine the impacts of fisheries subsidies on the capacity and incentives of people in the fisheries sector, resource management, and resource stocks. A common view is that some subsidies are actually beneficial to fisheries management and conservation. Those subsidies include subsidies for conserving the marine environment and enhancing resource stocks and research.

The main purpose of this paper is to analyze how fisheries subsidies will affect the incentive of people in the fisheries sector. I focus on two types of subsidies: one type is subsidies for income support; another type is subsidies for price supports that raise the domestic producer price of fisheries products. In the Draft Consolidated Chair Texts of the AD and SCM Agreements (WTO, 2007), which is currently the basis for negotiations at the Doha Round of the WTO, these two types of subsidies are included in subsidies that should be prohibited.[5] Thus, an analysis of these two types of fisheries subsidies could provide some implications for negotiations at the WTO. I illustrate how the effects of *reducing* existing fisheries subsidies on fisheries output will differ, depending on the conditions of the economy. I construct a simple general equilibrium model of two sectors: fisheries and manufacturing. A key element is variable labor supply. Each worker chooses the optimal supply of labor by taking into account the substitution between consumption of goods and leisure.

The main results are as follows. First, in a small open economy (SOE) where catch quotas are not enforced and there are no alternative employment opportunities for workers in the fisheries sector, a reduction in subsidies for income support will increase fisheries output. This is because workers in the fisheries sector try to partially offset reductions in income from cuts in subsidies by increasing labor, which results in a longer time spent fishing. A reduction in subsidies for raising the domestic producer prices of fish has a similar effect if the elasticity of substitution between leisure and the aggregate consumption goods is low. Second, in an SOE where catch quotas are strictly enforced and there are alternative employment opportunities for workers in the fisheries sector, a reduction in fisheries subsidies has no effect on total fisheries output as long as catch quotas are binding. However, in such an SOE, a reduction in fisheries subsidies causes fewer workers to remain in the fisheries sector because workers who can earn higher incomes in another sector will change occupations. A further reduction in fisheries subsidies may result in the number of workers in fisheries becoming so small that catch quotas are no longer

[5] In the Chair Texts, Annex VIII (pp. 87–93) of the SCM Agreement addresses fisheries subsidies. In Article I.1, "income support for natural or legal persons engaged in marine wild capture fishing" and "price support for products of marine capture fishing" are identified as (e) and (f) of subsidies that shall be prohibited (WTO, 2007).

binding. In such a case, a reduction in subsidies reduces fisheries output. Third, in the trade between two countries, the world relative price of fisheries product is endogenously determined and hence is affected by any change in fisheries subsidies. If the relative supply of fisheries product increases, then the world relative price will decrease. This indirect effect through price changes reinforces the direct effect of reducing fisheries subsidies. Consequently, even in the case of trade between two countries, subsidy reform that reduces either income supports or price supports can expand the world catch of fish. Thus, the results in this paper suggest that proper management of fisheries resources is important for subsidy reform to mitigate overfishing and conserve fisheries resources.

A number of existing studies are relevant to this paper. Munro and Sumaila (2002) and Clark et al. (2005) investigate the possible negative effects of subsidies for vessel decommissioning schemes. Both papers demonstrate that buyback subsidies generally have a negative impact on resource conservation, if they are anticipated by fishers. Lindebo (2005) examines the impact of the EU's fleet capacity policy. He argues that the misguided use of subsidies for fleet renewal and modernization in the past sent the wrong signal to fishers, but capacity-reducing subsidies had also achieved little success with regard to the long-term, sustainable use of fisheries resources. Using the framework of non-cooperative game theory, Ruseski (1998) demonstrates the strategic rent-shifting roles for fleet licensing and effort subsidies when two countries non-cooperatively harvest a single fish stock. He shows that strategic effort subsidies could only lead to incomplete rent dissipation, while strategic fleet licensing could lead to complete rent dissipation. However, none of these existing studies examine the effects of income support or price support subsidies in the fisheries sector.

The rest of the paper is organized in the following way. Section 2 sets up the basic framework of the analysis. Section 3 analyzes the effects of reducing fisheries subsidies in a small open economy in which the world relative price is exogenously given. I consider two different conditions. In one case, catch quotas of fishing are not enforced and there are no alternative employment opportunities for workers in the fisheries sector. In another case, catch quotas are strictly enforced and there are alternative employment opportunities for workers in the fisheries sector. Section 4 extends the analysis to trade between two countries. The two cases in Section 3 correspond to the two trading partners in Section 4. Section 5 provides some concluding remarks.

2 The Basic Model

In this section, I construct a simple static model of worker behavior with a variable supply of labor.[6] There are two goods: fish, F, and manufactures, M. Take good M as a numeraire and let the price of good M be one. Denote the price of fish as p.

There are N persons, indexed by $i = 1, \ldots, N$. Each is endowed with $\bar{x}$ units of labor and supplies x_i units of labor. Those persons endogenously supply labor to either the fisheries sector or the manufacturing sector. Note that $L_i \equiv \bar{x} - x_i$ denotes the leisure of person i. Let us consider the fisheries sector first. Suppose that the current fisheries resource stocks are S. By devoting x_i units of labor to fishing, a person can obtain $F_i = E_i(x_i; F_{-i}, S)$ units of fish, where $F_{-i} = \sum_{j \neq i} F_j$. I assume that $E_i(0; F_{-i}, S) = 0$, $E_i' \equiv \partial E_i(x_i; F_{-i}, S)/\partial x_i > 0$, and $E_i'' \equiv \partial^2 E_i(x_i; F_{-i}, S)/\partial x_i^2 < 0$. I also assume that $\partial E_i(x_i; F_{-i}, S)/\partial F_{-i} < 0$ and $\partial E_i(x_i; F_{-i}, S)/\partial S > 0$.[7] Denote that the total catch of fish as $F = \sum_{i=1}^{n} F_i$, where $n \leq N$ is the number of persons who engage in fishing. In this paper, I mainly focus on the analysis in the short-run by taking fish stock S as a given. This is because overexploitation of renewable natural resources is mainly caused by short-sighted behavior of people,[8] and hence it is important to see the effects on the incentives for those short-sighted people. However, since the way in which a change in policy will affect fisheries resource stocks is also an important issue, I will briefly discuss the effects on fisheries resource stocks in sections 3 and 4.

In the manufacturing sector, on the other hand, "human capital" is used as a production factor. Person i's supply of human capital is $h_i x_i$, where h_i is a parameter specific

[6] The structure of my model is similar to Chichilnisky's (1994) model of resource extraction by workers from the subsistence sector.

[7] An example of the function $E_i(x_i; F_{-i}, S)$ is $F_i = (S - F_{-i})(1 - e^{-x_i})$.

[8] Studies on open-access renewable resources demonstrate this mechanism. See, for example, Gordon (1954) and Brander and Taylor (1997).

to the person and is a draw from distribution $\Omega(h)$ with support on $[0, \bar{h}]$. One unit of manufacturing goods is produced by a units of human capital. This implies that the wage w per unit of human capital in the manufacturing sector is given by $w = 1/a$ (Recall that manufacturing goods are the numeraire). Thus, income for those employed in the manufacturing sector is given by $h_i x_i/a$. The production of manufacturing goods is given by $M = \sum_{i=1}^{m} h_i x_i/a$, where $m \leq N$ is the number of persons employed in the manufacturing sector.

To simplify the analysis, I assume that each person can only work in one sector. Consumer tastes for consumption goods are quasi-concave and weakly separable across the set of consumption goods and leisure.[9] Utility of consumer i is given by

$$u^i = u(\phi(f, m), \bar{x} - x_i),$$

where $\phi(f, m)$ is a linearly homogenous sub-utility function, and u is strictly increasing and strictly quasi-concave in ϕ and L_i.

Person i chooses m, f, and x_i to maximize u^i subject to the budget constraint: $pf + m \leq I^i$, where I^i is income. When person i earns income in the fisheries sector, the income is given by $I^i = qF_i + t - \tau$, where $q = p + s$ is the domestic producer price of fish with s being subsidies to support the domestic price, t is income support from the government, and τ is the lump-sum tax. When the person earns income in the manufacturing sector, on the other hand, income is given by $I^i = wh_i x_i - \tau$.

The government's budget is balanced by spending the difference between tax revenue and subsidy payments as government expenditure g. Thus, τ is constant and unaffected by any changes in subsidy payments.

Since $\phi(\cdot)$ is linearly homogenous, it yields

$$u^i = u(I^i/\beta(p), \bar{x} - x_i), \tag{1}$$

where $\beta(p)$ is the true price index associated with $\phi(\cdot)$.

When person i engages in fishing, the optimal supply of labor is determined by maximizing Eq. (1) subject to $I^i = qF_i + t - \tau$. The first-order condition (FOC) is given

[9] The assumption of weak separability between consumption goods and leisure is popular in the literature of public economics. See, e.g., Bovenberg and de Mooij (1994).

by

$$u_\phi \frac{q}{\beta(p)} E_i' - u_L = 0, \tag{2}$$

where $u_\phi \equiv \partial u_i/\partial\phi$ and $u_L \equiv \partial u_i/\partial(\bar{x} - x_i)$. The second-order condition (SOC) is given by

$$\frac{\partial^2 u^i}{\partial x_i^2} = \frac{q}{\beta(p)} E_i' \left(u_{\phi\phi} \frac{q}{\beta(p)} E_i' - 2u_{L\phi} \right) + u_\phi \frac{q}{\beta(p)} E_i'' + u_{LL} \equiv \Delta, \tag{3}$$

where $u_{\phi\phi} \equiv \partial^2 u_i/\partial\phi^2$, $u_{L\phi} \equiv \partial^2 u_i/\partial(\bar{x} - x_i)\partial\phi$, and $u_{LL} \equiv \partial^2 u_i/\partial(\bar{x} - x_i)^2$. I assume that $\Delta < 0$ so that the SOC is satisfied.

When person i is employed in the manufacturing sector, on the other hand, the optimal supply of labor is determined by maximizing Eq. (1) subject to $I^i = wh_i x_i - \tau$. The FOC is given by

$$u_\phi \frac{h_i}{a} - u_L = 0. \tag{4}$$

Denote x_i that satisfies Eq. (4) by $\tilde{x}_i$. The SOC is given by

$$\frac{\partial^2 u^i}{\partial x_i^2} = \frac{h_i}{a} \left(u_{\phi\phi} \frac{h_i}{a} - 2u_{L\phi} \right) + u_{LL}.$$

I assume the right-hand side is negative so that the SOC is satisfied.

The FOCs (2) and (4) yield the demand functions for leisure $L_i^{f*}(p, q, I^i)$ and $L_i^{m*}(p, w, I^i)$ when a person works in sectors F and M, respectively. As is usually the case, I assume that leisure is a normal good in both cases, i.e., $\partial L_i^{f*}(p, q, I^i)/\partial I^i > 0$ and $\partial L_i^{m*}(p, w, I^i)/\partial I^i > 0$.

3 Fisheries Subsidies in a Small Open Economy

In this section, I examine the effects of reducing existing fisheries subsidies on fisheries output. The main purpose of this section is to illustrate that the effects of reducing fisheries subsidies on fisheries output are dependent on the economy. I consider two types of subsidies. The first is income supports for workers in the fisheries sector. The second is price supports for fish products. In this analysis, I consider two cases. The first case is that catch quotas are not enforced and there are no alternative employment opportunities for workers in the fisheries sector. The second case is that catch quotas are strictly enforced and there are alternative employment opportunities for workers in the fisheries sector.

In this section, I assume that the country is small in the international market, so that the price of fish, p, is fixed.

3.1 Unenforced catch quotas and no alternative employment opportunities

I first consider the case where catch quotas are not enforced and there are no alternative employment opportunities for workers in the fisheries sector. There are no alternative employment opportunities for workers in the fisheries sector if the country is completely specialized in producing good F.

Let $\bar{F}$ be the catch quota. If the total catch is below $\bar{F}$ without enforcement, there is no problem. Thus, the implicit assumption in this subsection is that the total catch is greater than $\bar{F}$ even in the absence of fisheries subsidies.

In my model, a reduction in income support is measured by a reduction in t. This is qualitatively the same as an exogenous reduction in non-labor income. This change does not affect consumption allocation between good F and good M. However, it does affect the level of consumption of leisure. Since leisure is a normal good, a reduction in income leads to a reduction in leisure for an individual person. This implies that the person is willing to spend more time fishing. This effect can be obtained by totally differentiating the FOC for the optimal supply of labor (Eq. (2)):

$$-\frac{\mathrm{d}x_i}{\mathrm{d}t} = \frac{1}{\beta(p)\Delta}\left[u_{\phi\phi}\frac{q}{\beta(p)}E_i' - u_{L\phi}\right] > 0. \tag{5}$$

Note that $\Delta < 0$ by the SOC, $u_{\phi\phi} < 0$, $E_i' > 0$, and $u_{L\phi} < 0$. The overall sign of the terms in the square brackets is negative under the assumption that leisure is a normal good. This result implies that a reduction in t decreases L_i and increases x_i.

Since this is true for all workers who engage in fishing and since all workers in the economy work in the fisheries sector, I obtain the following result.

Proposition 1 *In a country where catch quotas are not enforced and there are no alternative employment opportunities for workers in the fisheries sector, a reduction in* *income support t leads to greater output in the fisheries sector.*

I next consider a reduction in subsidies s. Since $\mathrm{d}s = \mathrm{d}q$, a reduction in s is equivalent to a reduction in q. The effects of this price change on the optimal supply of labor can be decomposed in the following way:

$$-\frac{\mathrm{d}x_i}{\mathrm{d}s} = u_\phi \frac{E_i'}{\beta(p)\Delta} + \frac{F_i}{\beta(p)\Delta}\left[u_{\phi\phi}\frac{q}{\beta(p)}E_i' - u_{L\phi}\right]. \tag{6}$$

In the above equation, the first term represents the *substitution effect* between leisure and aggregate consumption goods. This term is negative because $\Delta < 0$ and $u_\phi > 0$, implying that a reduction in s will decrease the optimal supply of labor. Since a reduction in s decreases the opportunity cost of leisure, it is optimal for a person to increase leisure and hence to decrease the supply of labor.

The second block of terms, including terms in the square brackets in Eq. (6), measures the *income effect*, which is positive. The reason is the same as that in Eq. (5). Since a reduction in s decreases nominal income and since leisure is a normal good, then a reduction in s decreases leisure and hence increases the supply of labor. Therefore, the overall effect depends on the relative size of these two effects. Actually, if the elasticity of substitution between leisure and aggregate consumption goods is less than one, the substitution effect is relatively small. In such a situation, the substitution effect is dominated by the income effect and hence a reduction in s increases the supply of labor. Thus, the following proposition is obtained.

Proposition 2 *In a country where catch quotas are not enforced and there are no alternative employment opportunities for workers in the fisheries sector, a reduction in subsidies s leads to greater output in the fisheries sector if the elasticity of substitution between leisure and aggregate consumption goods is less than one.*

Using indifference curves and budget lines, Figure 1 illustrates how a change in s affects the optimal choice of leisure and supply of labor. In this figure, leisure, L_i, is taken along the horizontal axis and the aggregate consumption goods, ϕ, is taken along the vertical axis. E indicates an endowment point. Under the initial level of s, the optimal combination of leisure and consumption is at point A. The optimal choice of

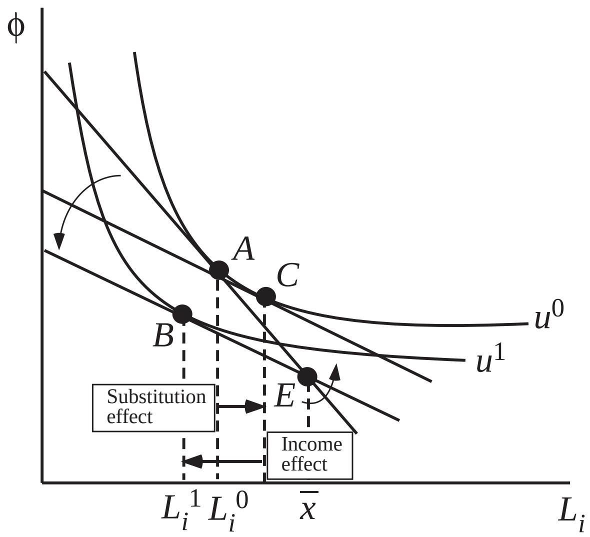

Figure 1: Substitution and income effects

leisure is L_i^0. Thus, the supply of labor is given by $x_i^0 = \bar{x} - L_i^0$. Then, a reduction in s causes the budget line to rotate around point E, as shown in the figure. The new optimal choice is at point B and L_i^1 is chosen, where $L_i^1 < L_i^0$. Thus, the supply of labor is $x_i^1 = \bar{x} - L_i^1$, where $x_i^1 > x_i^0$ holds. The change from A to B can be decomposed into two parts. The first part is the movement from A to C. This corresponds to the substitution effect. As is explained above, the substitution effect in this case tends to increase leisure and hence decrease the supply of labor. In the figure, this is illustrated by an arrow pointing to the right. The second part is the movement from C to B. This corresponds to the (negative) income effect. Since leisure is a normal good, the negative income effect tends to decrease leisure and increase the supply of labor. This is illustrated by an arrow pointing to the left. Figure 1 illustrates the case in which the income effect dominates the substitution effect.

Propositions 1 and 2 show that a reduction in the existing fisheries subsidies can increase rather than decrease fisheries output under certain conditions.

So far, I have not mentioned the effects on the fisheries resource stocks. By using a stock-recruitment model of fisheries economics, a change in the resource stocks can be formulated as follows.[10] Let S_t and S_{t+1} be the stocks at the beginning of the fishing period t and $t+1$, respectively. Let also R_t and $G(\cdot)$ be the stock left behind after fishing in period t and the growth function of the fish stocks, respectively. Then, it holds that $S_{t+1} = R_t + G(R_t)$ and $F_t = S_t - R_t$, where F_t is the total catch in period t.

If $S_{t+1} < S_t$, then the stock is reduced by fishing. This can be considered a case of overfishing. Then, if the catch quota $\bar{F}$ is set at the level that yields $S_{t+1} = S_t$, a total catch above $\bar{F}$ means overfishing. Thus, if that is the case in Propositions 1 and 2, a reduction in either t or s aggravates overfishing and causes the fisheries resource stocks to decrease.

3.2 Enforced catch quotas and the presence of alternative employment opportunities

I now turn to the case in which catch quotas are strictly enforced and there are alternative employment opportunities for workers in the fisheries sector. The country is diversified, and workers can move across sectors under the conditions specified in the previous section.

A catch quota, $\bar{F}$, is binding if $\bar{F} \leq F = \sum_{i=1}^{n} F_i$. Under the binding catch quota, the output per person is simply given by dividing the quota by the number of workers in the fisheries sector.

As was described in the previous section, the sectoral allocation of workers is determined by the relative level of individual income in the two sectors. As long as the catch quota is binding, the number of persons who work in the fisheries sector, n, is endogenously determined by

$$\frac{p\bar{F}}{n} + t \geq \frac{h_i \tilde{x}_i}{a} \qquad \text{for} \quad i = 1, \ldots, n, \tag{7}$$

where $\tilde{x}_i$ on the right-hand side satisfies Eq. (4). If the catch quota is not binding, on the other hand, n is determined by

$$pE_i(\hat{x}_i) + t \geq \frac{h_i \tilde{x}_i}{a} \qquad \text{for} \quad i = 1, \ldots, n, \tag{8}$$

[10] As for the stock-recruitment model, see, for example, Clark (1990, Chapter 7).

where $\hat{x}_i$ on the left-hand side satisfies Eq. (2).

Now, consider a reduction in t. If the catch quota is binding, as is obvious from Eq. (7), n decreases because those who have relatively higher human capital move to the manufacturing sector. Consequently, a reduction in t increases the quota per person. However, as long as $\bar{F} \leq nE_i(\hat{x}_i)$ holds, the total output of the fisheries sector remains the same. A further reduction in t may cause $\bar{F} > nE_i(\hat{x}_i)$ to hold. Then, the total output decreases. The following proposition summarizes the above analysis.

Proposition 3 *In a country where catch quotas are strictly enforced and there are alternative employment opportunities for workers in the fisheries sector, a small reduction in income support t does not change the total output in the fisheries sector if the catch quota is initially binding. A further reduction in t may decrease the total output in the fisheries sector.*

Consider next a reduction in subsidies s. If the catch quota is binding, the number of persons working in the fisheries sector, n, is endogenously determined by

$$\frac{q\bar{F}}{n} \geq \frac{h_i \tilde{x}_i}{a} \qquad \text{for} \quad i = 1, \ldots, n. \tag{9}$$

If the catch quota is not binding, on the other hand, n is determined by

$$qE_i(\hat{x}_i) \geq \frac{h_i \tilde{x}_i}{a} \qquad \text{for} \quad i = 1, \ldots, n, \tag{10}$$

Note that since s affects $\hat{x}_i$, in Eq. (10) $E_i(\hat{x}_i)$ also changes in response to a change in s. Otherwise, the effects of a reduction in s are qualitatively similar to those of a reduction in t, as summarized in the following proposition.

Proposition 4 *In a country where catch quotas are strictly enforced and there are alternative employment opportunities for workers in the fisheries sector, a small reduction in subsidies s does not change the total output in the fisheries sector if the catch quota is initially binding. A further reduction in s may decrease the total output in the fisheries sector.*

Unlike the case in the previous subsection, as long as the catch quota is properly set and strictly enforced, fish stocks are maintained. However, it is sometimes stated that catch quotas are set at levels that result in overfishing. If that is the case, then the fisheries resource stocks can be reduced even if catch quotas are strictly enforced. Therefore, it is important to note that the results in Propositions 3 and 4 do not guarantee that the fisheries resource stocks in this country are maintained at the appropriate level.

A comparison between Propositions 1 and 2 and Propositions 3 and 4 reveals that the effects of a reduction in some types of fisheries subsidies are significantly different, depending on the conditions of the country.

4 Subsidy Reform in Two-Country Trade

In the previous section, I examined the effects of reducing existing fisheries subsidies on the output of the fisheries sector in the framework of a small open economy. In this section, I extend the analysis to the case of two-country trade.

There are two countries: Home and Foreign. The basic structure of the economy in Section 2 is retained for both countries. Variables in Home are indicated with no asterisk and those in Foreign are indicated with an asterisk ($*$). I assume that Home has a comparative advantage in producing manufacturing goods and Foreign has a comparative advantage in producing fish. More specifically, I impose the following assumption.

Assumption 1 *Under free trade without subsidies, Home is diversified and Foreign is completely specialized in producing fish in equilibrium.*

Under this assumption, Home exports good M and imports good F and Foreign exports good F and imports good M. Moreover, world demand (i.e., total demand in the two countries) for good F is sufficiently strong to require that even Home, which has a comparative disadvantage in producing good F, produces good F in the trading equilibrium.

Moreover, with respect to the enforcement of catch quotas in the fisheries sector, I assume the following:

Assumption 2 *Catch quotas in the fisheries sector are strictly enforced in Home but are not enforced at all in Foreign.*

Then, consider a situation in which subsidies for income support, t is initially provided in each country (and $s = s^* = 0$). Since the subsidies encourage workers to enter the fisheries sector, Foreign continues to specialize in producing fish. In order for Home to produce both goods in the subsidy regime, t must satisfy

$$\frac{p\bar{F}}{n} + t < \frac{h_j \tilde{x}_j}{a}$$

for some j and $n < N$.

Now consider subsidy reform where t is reduced (but is still positive after the reform) in both countries. From Propositions 1 and 3, I know that a reduction in t^* increases output in the fisheries sector in Foreign and that a reduction in t keeps output in the fisheries sector constant or may decrease it in Home, holding p constant. In the framework of two-country trade, however, a change in t and t^* can also affect the world relative price p. If the catch quota is binding even after a change in t in Home, the effect on the world relative price is unambiguous. Thus, the following assumption is imposed:

Assumption 3 *In Home, the catch quota in the fisheries sector is binding even after a reduction in t.*

Under this assumption, a reduction in t does not affect the world supply of fish. On the other hand, a reduction in t^* unambiguously increases the world supply of fish for a given p. Thus, it causes p to fall. From Proposition 2, this price change further increases output in the fisheries sector in Foreign if the elasticity of substitution between leisure and aggregate consumption goods is less than one. The overall effect in Foreign can be obtained by totally differentiating Eq. (2):

$$\begin{aligned} -\frac{\mathrm{d}x_i^*}{\mathrm{d}t^*} &= \frac{1}{\beta(p)\Delta}\left[u_{\phi\phi}\frac{p}{\beta(p)}E_i') - u_{L\phi}\right] + \frac{1}{\beta(p)\Delta}\left[\left\{u_{\phi\phi}\frac{p}{\beta(p)}E_i' - u_{L\phi}\right\}\right. \\ &\quad \left. \times\left\{E_i - \frac{I^{i*}\beta'(p)}{\beta(p)}\right\} + u_\phi E_i'\left\{1 - \frac{p\beta'(p)}{\beta(p)}\right\}\right]\frac{\mathrm{d}p}{\mathrm{d}t^*}. \end{aligned} \tag{11}$$

In the right-hand side, the first block of terms, including those in the first square brackets, represents the direct effect of a change in t^* on x_i^*. As was discussed for Eq.

(5), the sign is positive. The terms in the second square brackets represent the indirect effects through a change in p. In the second square brackets, there are two elements. The first element measures the income effect. The income effect captures both the effect due to a change in the nominal income and the effect due to a change in the price index that affects real income. As long as t^* is sufficiently small, the income effect works to increase the supply of labor. The second element measures the substitution effect between leisure and consumption goods. Although an increase in p increases both the opportunity cost of leisure (pE_i') and the price of aggregate consumption goods ($\beta(p)$), the relative price of leisure to consumption goods increases. This result is obtained from the property $\beta'(p) < \beta(p)/p$ that comes from the concavity of $\beta(p)$. Consequently, the second element is negative, meaning that the substitution effect works to reduce the supply of labor. As was discussed in Eq. (6), if the elasticity of the substitution between leisure and aggregate consumption goods is less than one, the substitution effect is dominated by the income effect and hence a reduction in p increases the supply of labor. Since $-\mathrm{d}p/\mathrm{d}t^* < 0$, the overall effect of the indirect effect is positive and hence the indirect effect reinforces the direct effect.

In Home, on the other hand, a drop in t has no effect on x_i as long as the catch quota is binding. Thus, the following result is obtained.

Proposition 5 *When Home and Foreign are characterized by Assumptions 1, 2, and 3 and trade with each other, subsidy reform where t and t^* are reduced causes the world catch of fish to increase if t^* is initially sufficiently small and if the elasticity of substitution between leisure and aggregate consumption goods is less than one in Foreign.*

Contrary to conventional wisdom, this proposition shows that worldwide subsidy reform to reduce one type of fisheries subsidies could increase the world catch of fish. This counterintuitive result mainly arises from the endogenous supply of labor. In many developing countries, subsistence workers engage in fisheries, and it is likely that there are no alternative employment opportunities for those workers. In such a case, the result of Proposition 5 is not surprising.[11]

[11] The results are actually consistent with real world phenomena as presented by World Bank (1992). According to

The condition that the elasticity of substitution between leisure and the aggregate consumption goods is less than one is actually plausible and rather general, as Chichilnisky (1994) discusses. Therefore, the result of Proposition 5 is not a special case but a plausible case.

Subsidy reform to reduce subsidies s has a similar effect. Suppose that initially $s > 0$, $s^* > 0$ and $t = t^* = 0$ in both countries. Then, consider a reduction in s and s^*. Similarly to Assumption 3, a change in s has no effect on the world supply of fish under the following assumption:

Assumption 4 *In Home, the catch quota in the fisheries sector is binding even after a reduction in s.*

I then focus on the analysis in Foreign. Recall that in the case of Eq. (6), a change in s^* only changes the domestic producer price q^*. When the world relative price of fisheries product p is endogenously determined, the domestic *consumer* price and the domestic producer price changes due to a change in fisheries subsidies. Totally differentiate Eq. (2) and arrange terms to yield

$$-\frac{\mathrm{d}x_i^*}{\mathrm{d}s^*} = \frac{1}{\beta(p)\Delta}\left[u_\phi E_i' + E_i\left\{u_{\phi\phi}\frac{q^* E_i'}{\beta(p)} - u_{L\phi}\right\}\right]\left[1 + \left(1 - \frac{q^*\beta'(p)}{\beta(p)}\right)\frac{\mathrm{d}p}{\mathrm{d}s^*}\right] \qquad (12)$$

Recall that $\Delta < 0$ and from Eq. (6) the overall sign of the terms in the first square brackets is negative if the elasticity of substitution between leisure and aggregate consumption goods is less than one. Moreover, since $\mathrm{d}p/\mathrm{d}s^* > 0$ and $\beta'(p) < \beta(p)/p$, the overall sign of the second square brackets is positive as long as s^* is initially sufficiently small. Thus, it yields that $-\mathrm{d}x_i^*/\mathrm{d}s^* > 0$. Similarly to the case of a reduction in t, the effect through a change in p reinforces the direct effect of a change in s^*. Therefore, subsidy reform where s and s^* are reduced increases the world output in the fisheries sector, as is shown in the following proposition.

Proposition 6 *When Home and Foreign, characterized by Assumptions 1, 2, and 4, trade with each other, subsidy reform that s and s^* are reduced causes the world catch*

World Bank (1992), when the price of a resource good falls, low-income people work harder and extract more resources in order to meet consumption needs.

of fish to increase if s^* is initially sufficiently small and if the elasticity of substitution between leisure and aggregate consumption goods is less than one in Foreign.

As discussed at the end of section 3.1, if catch quota $\bar{F}$ is set at a level that keeps the stock at the beginning of the fishing period constant, i.e., $S_{t+1} = S_t$, in each country, a total catch above $\bar{F}$ means overfishing. Thus, Propositions 5 and 6 illustrate the possibility that subsidy reform will accelerate overfishing and reductions in stocks.

In summary, the analysis in this section shows that subsidy reform to reduce fisheries subsidies could expand the total supply of fisheries products and reduce world fisheries resource stocks under certain conditions.

5 Concluding Remarks

In this paper, I investigated the effects of reducing existing subsidies in the fisheries sector. The conventional wisdom is that fisheries subsidies cause overfishing and hence a reduction in fisheries subsidies will contribute to mitigating overfishing and conserving fisheries resources. Conversely, the analysis of this paper suggests that under some conditions the opposite result may be true. That is, a reduction in fisheries subsidies may accelerate overfishing and reduce fisheries resource stocks. The key is how the change in subsidies will affect the incentives of workers who engage in fisheries. If a reduction in subsidies causes workers to put more effort into fishing, it may yield unexpected and undesirable results in counties where fisheries resources are not properly managed. Therefore, in designing new regulations on fisheries subsidies at the WTO, the effects of reducing fisheries subsidies should be carefully examined after consideration of the conditions in different countries. Strengthening fisheries resource management will ensure that subsidy reform mitigates overfishing and conserves fisheries resources.

In this paper, I focused on an analysis of the short-term consequence. However, since the long-run implications of any policy reform are also important, the next step in the research is to extend the analysis to an examination of the transition and steady states of the dynamic framework. Also, in this paper, I focused on two types of fisheries subsidies.

It may be interesting to analyze the effects of reducing other types of fisheries subsidies. Moreover, empirical investigations to evaluate the theoretical predictions about the effects of reducing fisheries subsidies are very important in the design of new regulations governing fisheries subsidies.

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