Trade and fisheries subsidies

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Abstract

World Trade Organization members included fishery subsidies in the Doha round of trade negotiations. This paper develops a simple model to show why prospects for a deal on fisheries subsidies may be difficult. To focus on trade issues, we consider fisheries that do not fall under the jurisdiction of more than one country. Typically governments using subsidies find themselves in a Prisoner's dilemma. If two countries use subsidies to promote employment in some sector, then one country's subsidy will push down the world price, undermining the other country's attempt to promote its output. This creates incentives to negotiate to curtail subsidies. These incentives may not exist in fisheries for 3 reasons. First, if fisheries are severely depleted, one country's subsidy reduces its long run supply of fish, raising prices and benefiting other fish exporting countries. Hence the usual Prisoner's Dilemma does not exist. Second, if governments use other policies (such as season closures) to control fish stocks, then changes in subsidies may not affect harvests and hence may not generate international spillover effects. And third, even if governments were compelled to reduce fishery subsidies, there may be little real effect because governments would be motivated to weaken other regulations targeting the fish sector.

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1. Introduction

Fisheries are heavily subsidized in many parts of the world and yet many fisheries are being harvested at a rate that is unsustainable. This suggests that there ought to be potential for international agreements to curtail the use of subsidies; and indeed the Doha conference launched negotiations to clarify and improve World Trade Organization (WTO) disciplines on fishery subsidies. However the negotiation process has stalled.[1] This paper develops a simple model of trade in fisheries, building on Bagwell and Staiger's (2001a; 2001b) work on international trade and subsidy agreements, to explore reasons why achieving an agreement to reduce subsidies may be difficult.

The coexistence of depleted fisheries and extensive subsidization is well documented. Worm et al. (2009) report that 63% of assessed fish stocks worldwide require rebuilding, and the FAO (2011) reports that approximately 87% of the world fish stocks are fully exploited or overexploited. As depletion rates have increased, fishery subsidies have grown substantially, particularly in Europe and the East Asia. They reached levels of US$ 30-34 billion per year in the period 1995-2005 (Sumaila et al., 2006).[2] The majority of these fishery subsidies are non-fuel subsidies, 49% of them being provided by 38 developed countries and 51% by 103 developing countries.[3] About two-thirds of the total subsidies (US$ 20 billion) are estimated to be of the type that result in an increase in fishing effort. Many analysts argue that the subsidization is contributing to the high rate

[1] The Hong Kong Conference (2005) attained a broad agreement on strengthening those disciplines, including the prohibition of certain forms of fishery subsidies that contribute to overcapacity and overfishing. This conference led to a new Annex VIII to the Agreement on Subsidies and Countervailing Measures. However the negotiation process had stalled and achieving agreements to reduce subsidies has been difficult. Only a 'road map' of key issues rather than a new draft text has emerged in December 2008 (Young, 2009).

[2] There have been other estimates of fisheries subsidies worldwide: Milazzo (1998), OECD (2006), and Khan et al. (2006).

[3] OECD (2006) offers a different categorization of fisheries subsidies provided in 2003: management, research, and enforcement: 38.8%; infrastructure: 35%; decommissioning schemes: 6.7%; income support: 6.7%; investment and modernization: 3.2%; access payments: 3%; and other cost-reducing transfers and direct payments (including price support schemes): 7%.

of fisheries depletion (see for example, Sumaila et al., 2007). Why then is it so difficult to negotiate agreements to reduce subsidies?

We develop a model of endogenous fisheries subsidies in which governments motivated by political objectives implement subsidies, perhaps in conjunction with other resource management tools (such as restrictions on season length, fishing gear, etc.). We focus on fish stocks that lie entirely within the jurisdiction of single countries. There are well-known international coordination issues that arise from transboundary fish stocks that have been considered elsewhere. Here we wish to focus on purely trade-related issues and hence consider local fish stocks. We assume that governments care about employment in the fishery in addition to resource rents. With a sufficiently strong employment motive, governments will find it to be in their interest to subsidize the fishery. We take government preferences as given and focus on the question of whether (given their political objectives) there are incentives to negotiate reductions in subsidies. We embed this structure in an international trade model that allows us to analyze the spillover effects of subsidies across countries, both through the effects on global fish prices, and via resource depletion effects.

In the standard trade agreement literature (such as Bagwell and Staiger, 2001a) the key channel via which countries are linked is world prices. Domestic policies such as subsidies create global price spillover effects, and this creates incentives to negotiate, regardless of what government objective functions look like. Bagwell and Staiger (2001b) consider politically motivated governments that use agricultural subsidies to redistribute income to farmers. Each country's subsidy generates increased output, which lowers world prices, making it harder for other govenrments to achieve their redistribution objectives. They therefore show how even politically motivated governments have an incentive to implement an agreement to limit their use of subsidies to curtail the price spillover effects. In the case of fisheries, this channel also exists, but will behave much differently because of resource depletion effects. Because depleted fisheries have backward bending supply curves, an increase in one country's subsidy can lead to long run reductions in harvest rates, which raises prices, thus benefiting other

exporting countries. Put another way, an increase in one country's subsidy can lead to positive price spillover effects for other countries, which is opposite to the usual presumption in global subsidy negotiation models. Hence the incentives to negotiate an agreement to internalize price spillover effects may either be non-existent or perverse.

The presence of multiple regulatory instruments for fisheries also complicates matters. We consider various scenarios in which governments use both subsidies and other regulatory instruments to achieve their political objectives. In some cases, governments turn over the protection of fish stocks to managers who adjust policies in response to government subsidies to protect fish stocks. If these targets are rigid (for example if they are determined by biologists who are not subject to political influence), then changes in subsidies will affect employment in the fishery, but do not affect harvests. And hence there is no international spillover effect from the subsidies, which means there is little incentive to negotiate agreements to deal with subsidies. We also consider a case where a commitment to reduce subsidies is imposed on a government, perhaps as part of a large trade deal. We show that this can create incentives to weaken other forms of fisheries regulation and possibly lead to greater stock depletion.

Previous theoretical work has considered the effects of fisheries subsidies, but has not explicitly focussed on the incentives to negotiate that we emphasize.[4] Clark et al. (2005) analyze the potential negative effects of anticipated buyback subsidies on economic performance and on resource conservation. Jinji (2012) considers potential perverse effects of an exogenous reduction in subsidies when fishers' labour supply is endogenous. He shows how a reduction in subsidies aimed at income support can lead to an increase in

[4] There is also a literature documenting the effects of existing subsidies. Munro and Sumaila (2002) estimate that one-third of the total fisheries subsidies paid by governments for North Atlantic fisheries are buyback subsidies. Sumaila et al. (2010) estimate the extent of the fisheries subsidies paid to bottom trawl fleets operating in the high seas. They show that the industry would make negative profits in the absence of subsidies. Carvalho et al. (2011) estimate, using a dynamic CGE model based on a social accounting matrix the impact of the fisheries subsidies removal on the small island economy of Azores.

labour supply to the fishery, leading to a reduction in the steady state fish stock. Neither of these papers considers spillover effects across countries or incentives to negotiate.

There is a large literature on shared fisheries that focuses on cross-country stock externalities, which is a different channel than we highlight. A couple of these papers consider subsidies. Ruseski (1998) studies a two-stage non-cooperative game to explain the persistence of subsidies for two countries having fleets that exploit international fish stocks. The rationale for the existence of subsidies here is strategic rent shifting. Quinn and Ruseski (2001) use a similar model with heterogeneous countries to highlight the strategic entry-deterrence role of domestic effort subsidies. A country having an effort cost advantage may provide a positive effort subsidy to its domestic fleet in order to deter entry by rival foreign fleets. These papers help to explain the persistence of subsidies in high seas fisheries where there is a threat of foreign fleet entry. However they do not explain the persistence of large subsidies for national fisheries.

In what follows, we set out the model and its assumptions in Section 2. Section 3 presents the results when the politically motivated government only uses subsidies. We extend the model, in Section 4, to the case of endogenous regulations with exogenous stock targets, and in Section 5, to the endogenous choice of subsidies and stocks targets. Section 6 reports the results in the presence of an externally-imposed commitment to reduce subsidies. Section 7 summarizes our main results and draws some policy conclusions.

2. The Model

We develop a simple model in which governments care about both rents and employment in the fishery sector. Government policy instruments include taxes, subsidies, and a set of regulations that raise the cost of fishing. We assume that individual harvest quotas are not available - this may be justified by appealing to monitoring costs and political

constraints.[5] We focus on the steady state and implicitly assume that the discount rate approaches zero.[6]

We adopt a partial equilibrium framework to focus on the fisheries sector. Markets are competitive. The price of fish is endogenous and determined by global supply and demand. The (exogenous) opportunity cost of labour is w, and prices of all other good and inputs (which are suppressed here) are treated as given.

There are 3 countries: Home, Foreign and the rest of the world (ROW). Home and Foreign export fish; ROW imports fish. For clarity we assume that that there is no domestic consumption of fish in Home and Foreign. This highlights international price spillover effects and follows the approach taken in other analyses of international subsidy agreements (such as Brander and Spencer, 1985, and Bagwell and Staiger, 2001b).

There is a continuum of potential fishers in each of Home and Foreign indexed by *i*. Each fisher has an endowment of 1 unit of labour per period. Two types of regulation are available to government: (1) taxes or subsidies for fishers; and (2) regulations that increase cost of fishing (here we are influenced by Homans and Wilen, 1997, and Grainger and Costello, 2012). We use a slightly generalized version of the Schaeffer fisheries model. The harvest (per period) for a typical fisher i is

$$h_i = \alpha(R)XL_i \tag{1}$$

where X is the stock of fish (harvesting productivity is increasing in the stock), L_i is labour supply of fisher i (which we have set equal to 1), and R is an index of the intensity of regulations. We assume that regulation raises the cost of fishing. In practice, regulations involve rules such as restricting the length of the season, restrictions on the types of gear that can be used, restrictions on where and when fishing can take place,

[5] In practice, less than 2% of the world's fisheries are regulated with individual transferable quotas.

[6] This approach has also been taken in other work analyzing trade and fisheries such as Brander and Taylor (1997) and Ruseski (1998).

restrictions on the size of fish than can be caught, and so on. We do not focus on the details of each of these different types of regulations, but simply assume that they reduce productivity for a given level of the stock. We assume that $\alpha \in [\bar{\alpha}, 0]$, with $\alpha(0) = \bar{\alpha}$, and with $\alpha' < 0 \; and \; \alpha'' > 0$. That is, more stringent regulation lowers productivity in fishing. We assume for simplicity that monitoring and implementing regulations is costless.

With N fishers active, the aggregate harvest is

$$H(N, X, R) = \alpha(R)XN. \tag{2}$$

The stock of fish is endogenous and depends on annual harvesting. We assume a logistic growth model for the fish stock:

$$\frac{dX}{dt} = rX\left(1 - \frac{X}{\bar{X}}\right) - H(N, X, R) \tag{4}$$

where r > 0 is the intrinsic growth rate of the stock and $\bar{X}$ is the carrying capacity of the environment (the steady state stock in the absence of human intervention).

In steady state (dX/dt = 0), this implies that the fish stock is

$$X(N, R) = \bar{X}\left[1 - \frac{\alpha(R)}{r}N\right] \tag{5}$$

Using (2) and (5), the steady state harvest is therefore

$$H = \alpha(R)\bar{X}\left[1 - \frac{\alpha(R)}{r}N\right]N \tag{6}$$

To determine the steady state number of fishers N, recall that each potential fisher has 1 unit of labour with opportunity cost w, so the net return per period of fishing is

$$\pi(p, X, R) = ph(X, R) - w + s \tag{7}$$

where s is a subsidy (or tax if s < 0) available for each fisher per period of fishing.[7]

Given X, fishers will enter as long as net returns are positive. Hence the marginal fisher N is determined by a zero profit condition:

$$\pi[p, X(N, R), R] = ph[X(N, R), R] - w + s = 0 \tag{8}$$

That is, entry continues until the value of the average product of labour is equal to the wage less the subsidy.

Government objective

Governments use subsidies for a variety of reasons, but a reading of the literature on fisheries subsidies indicates that one of the main motivations for subsidies is to promote and maintain employment in the fishery sector (see for example Hilborn, 2007, and World Bank, 2009). In some cases this is driven by pressure to maintain the viability of communities dependent on the fishery, in others it reflects the role of the fishery as source of employment for the poor. We will therefore assume that the government weighs both social surplus and employment in the fisheries sector when choosing policy.

We focus on steady states and assume that the government discount rate approaches zero. That is, the government is concerned with sustained surplus and employment in the fishery. In the absence of political pressure to maintain employment and terms of trade effects this would mean that the government would maximize sustained surplus from the fishery as in Brander and Taylor (1997).

Total surplus generated by the fishery is given by

[7] One could alternatively consider subsidies and taxes targeting harvests. These however are more difficult to monitor and implement. The results would not be significantly different.

$$\Pi = pH(N, X, R) - wN. \tag{9}$$

Total private surplus accruing to fishers is $\Pi + sN$, but the revenue requirement to fund the subsidy is sN. We assume that the subsidy is raised via lump sum taxation from the rest of the economy so that the social return to the fishery net of subsidies or taxes is given by Π. The government is assumed to weigh both social surplus and employment in the fisheries sector when deciding on policy; hence we assume an objective of the form $W(\Pi, N)$. For simplicity we will work with a simple quasilinear objective function:

$$W(\Pi, N) = \Pi + \lambda\varphi(N), \tag{10}$$

where φ is increasing and strictly concave in N, and λ is a parameter that captures the weight placed by the government on fisheries employment.

3. Subsidies with no other regulations in place

We begin by focusing on subsidies (or taxes) alone and assume that other regulations are exogenous (that is, in this section of the paper, we set $\alpha = \bar{\alpha}$).

The government chooses the subsidy s to maximize its objective (10) subject to the steady state fish stock constraint (5) and the free entry condition (8). The first order condition yields[8]

$$[pH_X X_N - s + \lambda\varphi'(N)]\frac{dN}{ds} + H\frac{dp}{ds} = 0 \tag{14}$$

[8] Note that for given R, (8) can be written as $pH_N - w = -s$ and this has been used in obtaining (14).

An increase in the subsidy has two effects: an entry effect (a change in N) and a terms of trade effect.

The entry effect of the subsidy has three components. First, the induced entry leads to more sustained pressure on the fishery and this reduces the stock. This is an externality because the fall in the stock size reduces the productivity of all fishers. The social cost of this loss in productivity per entrant is $pH_X X_N$. Second, the induced entry creates the same type of production distortion as would with any production subsidy – the social marginal costs of the extra production (the opportunity cost of labour) exceeds the marginal benefit even if the harvest externality were controlled. The social cost of this per entrant is given by the level of the subsidy s. Third, the induced entry increases employment in the fishery and this employment effect is valued by the term $\lambda\varphi'(N)$. The employment benefit of the subsidy would disappear if there were no political motive to protect fishers; that is if $\lambda = 0$.

The final term in (14) is the terms of trade effect. Since all of the harvest is exported in this simple framework, the production subsidy is in fact an export subsidy. If the subsidy reduces the world price of fish, then this would be one of the costs of the policy. However, as we show below, an export subsidy in the fishery can in some cases improve the terms of trade.

We can use (14) to solve for the government's optimal subsidy, which has three terms, reflecting the three issues discussed above:

$$s = pH_X X_N + \lambda\varphi'(N) + H\frac{p_s}{N_s} \tag{15}$$

We discuss the properties of *s* in what follows.

Policy in a small country with no terms of trade effects

It is instructive to begin by considering a case where the country is small in the world fisheries market so that there is no terms of trade effect. That is, suppose for now that dp/ds = 0. In this case were are left with two terms in (15) and the sign of the subsidy depends on the strength of the employment motive (the magnitude of λ). If $\lambda = 0$ so there is no pressure to protect fishers, then (15) reduces to

$$s = pH_X X_N < 0 \tag{16}$$

In this case the optimal policy is a harvest tax that fully internalizes the harvest externality. The tax reflects the cost of the stock depletion caused by an additional entrant.

The tax implied by (16) maximizes the total social surplus generated by the fishery. However, this surplus does not accrue to fishers since (because of free entry and our assumption of homogeneous fishers) the entire surplus is extracted as tax revenue. Moreover, the tax induces exit from the fishery relative to the case where there is no government intervention. That is, there is a conflict between the objectives of maximizing social surplus and maintaining employment in the fishery.

We next show that if the employment motive is sufficiently strong (i.e., if λ is sufficiently large), then the government will choose to subsidize rather than tax the fishery. Again we continue to assume that the country is small so that there are no terms of trade effects. To see this, suppose that initially we have s = 0 and consider the effects of a small change in *s* on the government's objective function:

$$\left.\frac{dW}{ds}\right|_{s=0} = \left[pH_X X_N + \lambda\varphi'(N)\right] N_s = \left[w - p\alpha\bar{X} + \lambda\varphi'(N)\right] N_s \tag{17}$$

where we have used the free entry condition (8) and the steady state stock level to solve for $pH_X X_N = w - p\alpha\bar{X}$ at the point where there is no subsidy.

Since the free entry condition implies $N_s > 0$,[9] then we can see from (7) that if the weight on employment (λ) is sufficiently large, introducing a positive subsidy increases the government's payoff despite the fact that it exacerbates the stock externality.

Terms of trade effects

Let H*(p) denote the foreign supply of fish (it has properties analogous to H(p)). The demand for fish from the rest of the world is given by D(p), which is assumed to be decreasing in p. The world price of fish is determined by

$$D(p) = H(p,s) + H^*(p) \tag{20}$$

We assume that $H_p^* + H_p - D_p > 0$; that is we assume stability so that an outward shift in supply lowers prices and an inward shift raises prices.

The effect of an increase in Home's subsidy on the world price of fish is given by

$$\frac{dp}{ds} = -\frac{H_s}{H_p + H_p^* - D_p} = \frac{\alpha \bar{X}\left(\frac{2\alpha N}{r} - 1\right) N_s}{H_p + H_p^* - D_p} \tag{21}$$

As is well known in the fisheries literature, supply curves are backward bending in open access fisheries. Increasing the return to fishing encourages entry, and for given stock levels, this increases output. But increased harvesting also depletes the stock, and eventually the stock depletion effect dominates. Hence the effect of a subsidy increase on prices depends on how depleted the stock is. Referring to (21), if N is small (i.e. harvesting levels are low so the stock is in good shape), then an increase in the subsidy will lower the price of fish because it increases supply. But if N is large, then an increase in the subsidy leads to a lower long run harvest level (because the stock depletion effect dominates) and hence the price rises.

[9] This will hold for $N < r/\alpha$, beyond which point sustained harvesting would extinguish the stock. In the next section we examine the case where higher levels of N can be supported if additional regulations that reduce α are implemented.

To summarize

$$\begin{aligned} \frac{dp}{ds} &< 0 \quad if \quad N < r/2\alpha \\ \frac{dp}{ds} &> 0 \quad if \quad N > r/2\alpha \end{aligned} \tag{22}$$

This is one of the important ways that the global impacts of fishery subsidies differ from other types of production subsidies such as agricultural subsidies. Normally we expect production subsidies to worsen an exporting country's terms of trade because the subsidy increases output which leads to a fall in the world price. However, because of the stock depletion effect, a distinctive feature of fisheries subsidies is that they can improve a fish exporting country's terms of trade. In this case, referring to (19), the beneficial terms of trade effect reinforces the employment motive for increasing the subsidy.

The result that fisheries subsidies can improve the terms of trade requires that the country be operating in the region where its harvest supply function is downward sloping. This will be the case if λ, the government' weight on employment, is sufficiently large.[10] That is, for a sufficiently strong employment motive, the government will choose a subsidy that is sufficiently high that it pushes the fishery into the region where the supply curve is downward sloping.

Spillover effects of Home's fishery subsidies on the rest of the world

Let us now consider the effects of Home's subsidy on the other fish-exporting country. The foreign government's objective function can be written as

$$W^* = \Pi^* + \lambda^* \varphi^*(N^*)$$

[10] To see this, suppose the government puts all of its weight on employment. Then it will always want to subsidize entry to increase employment beyond the open access level.

It does not depend directly on Home's subsidy *s*, but does so indirectly via the effect of Home's subsidy on the price of fish. Hence the effect of an increase in Home's subsidy on Foreign is:

$$\frac{dW^*}{ds} = W_p^* \frac{dp}{ds} = H^* \frac{dp}{ds} + W_{N^*}^* N_p^* \frac{dp}{ds} = H^* \frac{dp}{ds}$$

where the last step follows if we assume that the foreign country is choosing its own subsidy optimally (given the foreign government objective function). Hence the effect of Home's subsidy on the foreign government depends on the sign of the terms of trade effect. Since Foreign exports fish, then foreign terms of trade improve if p rises and deteriorate if p falls. And as we saw above, Home's subsidy causes the price to fall if the employment motive is relatively weak, but can cause it to rise if the employment motive is strong. That is, one country's subsidy may either benefit or harm the other exporting country depending on the strength of the employment motive.

If the employment motive in both countries is relatively weak, then we expect both countries to be operating in the region where their harvest supply curves are upward sloping. This is a case where the fish stocks in both countries are healthy and where the global spillover effects of subsidies are similar to the case of agricultural subsidies. Home's subsidy pushes down the world price and this undermines Foreign's attempts to support its own fishers. Foreign's subsidy has a similar effect on Home and so the countries find themselves in a Prisoner's dilemma. In the Nash equilibrium there will be excessive subsidization of the fisheries. There is an incentive for the two exporting countries to negotiate an international agreement to reduce subsidies; such an agreement would both reduce financing costs of the subsidies and allow some recovery of the fish stocks.

If instead the redistributive motive in both countries is strong, then both will be on the downward sloping part of their harvest supply curves. In this case each country's subsidy reduces the world supply of fish and hence improves the terms of trade of the rival exporting country. There is no incentive for the exporting countries to get together to work out a deal to reduce their subsidies - each government would be worse off from

such a deal. Instead, cooperation among the exporting countries would lead to higher subsidies. To confirm this, consider the effect of a change Home's subsidy s on the joint return (W+W*) to the governments of the two exporting countries:

$$\frac{d(W+W^*)}{ds} = W_s + W_p p_s + W_p^* p_s \tag{27}$$

At the non-cooperative equilibrium Home sets the sum of the first two terms equal to zero and ignores the final term, which is the effect of the subsidy on the foreign country. Hence if we evaluate at the non-cooperative equilibrium, we have:

$$\left.\frac{d(W+W^*)}{ds}\right|_{dW/ds=0} = W_p^* p_s > 0 \quad \text{if} \quad p_s > 0 \tag{28}$$

When countries are in the region where the harvest supply curve slopes down, then starting at the Nash outcome, a cooperative agreement that increased subsidies in both countries would benefit each.

To summarize, we have:

Proposition 1. There exist $\underline{\lambda}$ and $\underline{\lambda}^*$ such that if $\lambda > \underline{\lambda}$ and $\lambda^* > \underline{\lambda}^*$ (that is, if each government puts a sufficiently high weight on employment in their fishery), then
(i) Home and Foreign subsidize their fisheries
(ii) increases in either country's subsidy leads to a fall in long run fish stocks and an increase in the price of fish
(iii) Home and Foreign governments would not gain from an agreement to jointly reduce their subsidies.

We therefore obtain the paradoxical result that an international agreement among exporting countries to reduce subsidies can be most difficult in the case where fisheries are heavily exploited. A joint reduction in subsidies would be good for fish stocks, and it would improve economic efficiency, but it would not be in the interests of politically-motivated governments when they face strong redistributive pressures.

There is still, however, some scope for international agreements because of the spillover effects of the subsidies into fish importing countries. In the case where fisheries are seriously depleted, subsidies lead to reductions in long run harvest and hence higher long run fish prices, which harms importers. Thus importing countries have an incentive to offer Home and Foreign some concessions to reduce subsidies. This would require that the negotiations on fisheries be imbedded in a larger negotiation in which importing countries offer concessions in other sectors in return for a commitment to reduce fish subsidies. But this highlights again why negotiations on fish subsidies differ somewhat from subsidies in other contexts. Typically subsidies lower prices and benefit consuming countries and so the main driver of an agreement would be to curtail the Prisoner's Dilemma among exporters. In the case of fisheries, the Prisoner's Dilemma aspect may not be operative, and so concessions from importing countries would have to lie at the foundation of a potential deal. [11]

4. Endogenous regulations with exogenous stock targets

Up to this point, we have analyzed the case where governments have just one instrument available - a harvest tax or subsidy. That is, we have held other regulations (R) constant. We have shown that in the case where subsidies are especially harmful to fish stocks (i.e. where fisheries are seriously depleted in part due to subsidization) the spillover effects of subsidies across countries does not create any incentives for fish exporting countries to get together and agree to reduce subsidies.

In practice, however, most governments have available a set of regulations that are used in conjunction with subsidies. If efficiency is the sole objective, then in our simple framework the use of additional regulations is unnecessary and efficiency-reducing. We saw earlier the first best can be achieved by fully internalizing the harvest externality; that is the tax alone is sufficient to control the size of the fish stock.

[11] Section 6 considers how the exporting countries may respond to a commitment to reduce subsidies in a way that potentially would undermine any such agreement.

On the other hand the employment motive can conflict with the conservation motive: pressure to maintain employment in the fisheries sector can lead to stock depletion. In this case, the fish stock can be protected from the depleting effects of subsidies by introducing additional regulations that lower fishing productivity.

We consider two scenarios. In the first, we assume that fish stocks are protected by a branch of the government that is solely concerned with the health of the fish stock - this agency is immune from political control and does not give any weight to economic considerations. We assume that the agency sets a target X_T for the stock and adjusts the regulations to ensure that the target is achieved. Given the target, then the politically motivated government chooses subsidies. In the second scenario, the politically motivated government jointly chooses both subsidies and regulations so that the stock is endogenous.

Exogenous target for the fish stock

The steady state fish stock is given by (5). We assume that the stock target X_T is a binding constraint. This implies that regulations R must be adjusted so that

$$\alpha(R) = \frac{r}{N}\left[1 - \frac{X_T}{\bar{X}}\right] \tag{31}$$

Note that choosing regulations R is equivalent to choosing a productivity level $\alpha(R)$. If there are no other regulations, then $\alpha = \bar{\alpha}$, and (31) will imply some employment level $\bar{N}$ necessary to support the target stock. For this to be implemented, the free entry condition (8) must be satisfied:

$$p\alpha(R)X_T = w - s, \tag{32}$$

This (combined with (31)) will imply the subsidy or tax needed to support the target stock.

When governments care about employment, they will typically want to choose an N different than $\bar{N}$. Here we focus on the case where the government wants some N > $\bar{N}$. Referring to (31) this can be implemented by tightening up regulations R (reducing α) to reduce productivity to maintain the stock target. That is, from (31) we have

$$\frac{d\alpha}{dN} = \alpha_R R_N = -\frac{r}{N^2}\left[1 - \frac{X_T}{\bar{X}}\right] < 0 \tag{33}$$

Of course, once regulations are tightened up, the fishery is less profitable and so to support the desired level of employment N, the subsidy s must be increased to ensure that the free entry condition (32) is satisfied.

Combining (31) and (32) we can write N as a function of s (given that regulations are adjusted to satisfy the stock target constraint):

$$N = \frac{pX_T r\left(1 - \frac{X_T}{\bar{X}}\right)}{w - s} \tag{34}$$

Note that dN/ds > 0.

Let us now consider the government's optimal choice of the subsidy given the stock constraint. Given the constraint (31), the government chooses s to maximize its objective W (given by (10)) subject also to the free entry constraint. The effect of a change in s on the government payoff W is:

$$\frac{dW}{ds} = p\alpha_N XNN_s - sN_s + \lambda\varphi'(N)N_s + Hp_s \tag{35}$$

Comparing (35) with (14) reveals two differences. The stock depletion effect in (14) does not appear in (35) because the adjustment in regulations holds the stock constant. This is replaced by the first term in (35) which is the loss in harvest productivity when regulations are tightened in response to entry. This shows up as a social loss.

The optimal subsidy (or tax) balances the employment benefits against the efficiency losses, with an adjustment for any terms of trade effects.

$$s = \underset{(-)}{p\alpha_N NX_T} + \underset{(+)}{\lambda\varphi'(N)} + Hp_s / H_s \tag{36}$$

Note that if there were no employment motive and no terms of trade effects, then the optimal policy is a harvest tax. Regulations reduce productivity and are unnecessary if a harvest tax limits entry to a level that ensures sustainability of the stock at the desired target. However, if employment motives are important (i.e. if λ is positive), then more weight is put on the second term as the government is willing to sacrifice efficiency to increase the aggregate the number of fishers. The stronger is the employment motive, the more likely it is that the government will choose a subsidy.

Let us now turn to terms of trade effects. Recalling (4), a constant stock X_T implies that steady state aggregate harvest must also be constant:

$$H = rX_T\left[1-\frac{X_T}{\bar{X}}\right].$$

That is, changes in the subsidy do not affect the harvest (since regulations adjust to keep the aggregate harvest level constant). Hence changes in the subsidy do induce <u>any</u> terms of trade effects when regulations are adjusted to meet a stock target. This has two implications. The first is that the last term in (36) is zero - there is no terms of trade motivation for adjusting the subsidy. More important, however, is that Home's choice of subsidy has no effect on the foreign country or the rest of the world. In particular, (24) still applies and so the effect of Home's subsidy on Foreign is given by

$$\frac{dW^*}{ds} = W_p^* \frac{dp}{ds} = 0 \tag{37}$$

Since Home's subsidy does not induce any spillover effect in the rest of the world, there is no scope for international negotiation. That is, if countries cooperated and agreed to choose subsidies to maximize their joint welfare, the result would be the same as in the

non-cooperative Nash equilibrium. To confirm this, refer to (28). Starting at the Nash equilibrium, a change in Home's subsidy has no effect on joint welfare for the exporting countries:[12]

$$\left.\frac{d(W+W^*)}{ds}\right|_{dW/ds=0} = W_p^* p_s = 0 \tag{38}$$

A key point emphasized by Bagwell and Staiger in their analysis of international trade agreements is that, regardless of the political motivations of governments, there is always scope for international negotiations because country's policies have international spillover effects via the terms of trade. Here we find that the presence of conservation policies in each country generates inelastic supply curves, which means that subsidies do not generate international spillover effects.

Thus we have:

Proposition 2. Suppose that Home and Foreign endogenously adjust regulations R and R* to support exogenous targets for fish stocks X_T and X_T*. Then
(i) if the weights on employment in the fishery are sufficiently strong, each country will subsidize its fishery;
(ii) reductions in subsidies would have no effect on fish prices; and
(iii) neither Home nor Foreign nor ROW governments would gain from an agreement to reduce fish subsidies.

Note that this does not imply that fishery management in either country is efficient. There are two potential sources of inefficiency. First, as noted above, subsidies induce entry of fishers and this forces regulators to tighten up regulations, which reduces productivity in harvesting. However, because of the maintenance of the exogenous fish stock target in each country, this is a purely domestic problem in each country. There is no scope for a mutually beneficial international agreement because each government is

[12] Similarly, the subsidy will not affect importing countries (ROW).

already at its most preferred point and there is nothing the other country can offer to improve on this.

The second source of inefficiency is with respect to the health of the fish stocks. We have assumed that each country has turned the management of the stocks over to scientists who choose a target that is then exogenous from the perspective of the government agency choosing subsidies. However, there may be international disagreement with respect to what that target should be. Changes in the target would induce terms of trade effects and hence potentially open up a channel for mutually beneficial negotiations. And countries may have concerns about biodiversity and other ecological factors that lead to differing views about a reasonable target for the fish stock. However, negotiations on subsidies alone would not address these issues - that would require international negotiation and agreement on domestic conservation policy within each country. That, however, would move the scope of negotiations far beyond traditional areas of trade-related negotiation and into the realm of domestic conservation and environmental policy. This would raise issues of sovereignty and enforceability that are significantly beyond the scope of an agreement on subsidies.

5. Endogenous choice of subsidies and stock targets

Suppose now that the politically motivated government chooses both a target for its fish stock and a subsidy. This amounts to choosing regulations (and hence α) and the subsidy to maximize W (given by 10) subject to the free entry constraint. Then we can show

Proposition 3. Suppose governments can choose both regulations and subsidies and that the target for fish stocks is endogenously determined by the governments' objectives. If governments put a sufficiently high weight on employment, then Home regulations, subsidies and employment are determined by:

$$\lambda\varphi'(N) = w \tag{55}$$

$$\alpha = \frac{r}{2N} \ . \tag{50}$$

$$s = -\frac{p\alpha\bar{X}}{2} + \lambda\varphi'(N) \tag{52}$$

Analogous conditions apply to Foreign.
Proof: See Appendix.

To interpret this solution, note that the government cares about two things: net subsidy payments (inclusive of any rent generated) to the fishery; and employment in the fishery. With two instruments, the government is able to target both of these more or less directly.[13] Equation (55) simply says that employment is chosen so that the marginal benefit of extra employment in the fishery (as perceived by the government) is set equal to its marginal social cost (given by the wage). Given this level of employment (and that all of these fishers will use all the labour for fishing effort), then (because the government cares also about rent and net subsidy costs) the government chooses regulations that maximize the value of fish harvested by these N workers. This amounts to choosing α to maximize sustainable harvest given that the number of fishers is N. The solution to this problem is (50). Finally, given the choice of regulations, then to implement the desired employment level implicit in (55), the government chooses a subsidy *s* to ensure that the free entry condition is satisfied - this is given by (52).[14]

One striking aspect of these results is that the model predicts that the government will end up choosing a stock level that maximizes the sustained yield from the fishery. This is a policy was often advocated by biologists and fishery managers but which has been criticized by economists as being inconsistent with economic efficiency.

[13] The solution is of course second best because of the restriction on the set of available instruments. If individual harvest quotas were available, then they could be employed instead of regulations that reduce productivity.
[14] If the employment motive is sufficiently weak, then we may be at a corner solution for regulations with $\alpha = \bar{\alpha}$ and may use a tax instead of a subsidy.

Negotiations on subsidies

Let us now consider the incentives to negotiate an agreement to reduce subsidies. Note that when both subsidies and regulations are chosen endogenously, governments choose to be at the maximum sustainable yield point. This is the point at which the first order effect of a change in policy on harvest (and hence on price) is zero. That is, the first order effect of a small change in Home's subsidy on the Foreign country is zero. Thus, there are no incentives for a mutual agreement among exporting countries for a small reduction in subsidies.

Moreover, we can show that if we consider the set of policies that is jointly optimal for the two exporting countries, it will be the same as the Nash equilibrium we found above. That is, it is jointly optimal for the exporting countries to choose regulations that maximize the sustained yield from the fishery and support employment levels that are consistent with (55) and its foreign analogue. The intuition is that each country would like to support employment at the level at which the government's perceived marginal benefit from employment in the fishery is equal to the opportunity cost of labour (which yields (55)). It then wants to minimize the cost of supporting this level of employment, which means governments want these fishers to harvest as much as possible, which occurs at the maximum sustained yield point.

Moreover, since we are at the maximum sustained yield point, long run harvests are as high as possible and so there is no incentive for consuming countries to try to negotiate a reduction in subsidies. Formally, we have:

Proposition 4. Suppose governments can choose both regulations and subsidies and that the target for fish stocks is endogenously determined by the governments' objectives. If governments put a sufficiently high weight on employment in the fishery, then
(i) The harvest levels that maximize the joint welfare of the Home and Foreign country are the maximum sustained yield points.
(ii) An agreement to reduce subsidies would not benefit Home, Foreign, or ROW.
Proof: See appendix.

Hence in the scenario where governments use both subsidies and regulations to regulate the fishery, and where these regulations are perfectly enforced, there is little scope for international negotiations to reduce subsidies. The outcome is not economically efficient because regulation is costly and governments are politically motivated. But given the government objective functions and the available set of policy instruments, there is no incentive to work out a deal to reduce subsidies.

6. Effects of an externally-imposed commitment to reduce subsidies.

Given that there appears to be a large consensus among conservationists that subsidies need to be reduced, it is nevertheless worth investigating what would happen if subsidies were indeed reduced. Suppose for example that the countries agree to reduce subsidies as part of a larger comprehensive trade deal. The idea here is that other countries pressure these governments to reduce their subsidies perhaps for ecological reasons to protect stocks of fish or because of an ideological opposition to subsidies. How would governments respond to a rule that required they reduce subsidies? The key point is that although international agreements may end up constraining subsidies, a subsidy agreement does not constrain the ability of governments to use other forms of regulation. So we need to determine how regulations respond to a requirement that subsidies be reduced.

Proposition 5. Suppose governments put a sufficiently high weight on employment in the fishery and are free to adjust regulations R. Then in response to an externally imposed reduction in subsidies (starting that the Nash Equilibrium in regulations and subsidies) Home and Foreign governments will relax their fishing regulations. That is:

$$\left.\frac{d\alpha}{ds}\right|_{s=s_0;\,\alpha=\alpha_0} < 0. \tag{59}$$

where s_0 and α_0 are the Nash equilibrium levels of s and α.

Proof: See Appendix.

We therefore conclude that a small reduction in subsides will cause governments to respond by weakening regulations. That is, an agreement that puts international pressure on governments to reduce fish subsidies will be undermined by the affected governments because they have other instruments available to support fisheries employment. In our example, they respond by weakening regulations, which raises harvesting productivity and depletes stocks.

7. Conclusion

At first glance, the case for reducing subsidies in fisheries may seem to be compelling. Fisheries throughout the world have collapsed, and studies such as Worm et al. (2009) argue that current pressures on fisheries will increase and lead to further collapse. Standard economic analysis highlights stock externalities in fishing and typically calls for taxes (not subsidies) to internalize these externalities. And even if we concede that governments are motivated by political and redistributive motives, the standard analysis of trade agreements (Bagwell and Staiger, 2001a) points out that regardless of a government's objective function, there is always potential for international agreements to coordinate or at least partially constrain interventionist policies as long as international spillover effects exist.

We develop a simple model in this paper to show how achieving international agreements to reduce fishery subsidies may be more challenging than for many other types of subsidies. There are three reasons for this.

First, the usual argument for reducing subsidies in open economies is that it is in the interest of the subsidizing governments to do so. This is because of the Prisoner's dilemma. Governments subsidize to promote employment or output and one country's subsidy undermines other governments' attempts to achieve their employment and output targets by lowering prices. In the case of fisheries, this is unlikely to happen for heavily exploited fisheries because subsidies will lower long run output (via stock depletion) and *raise* prices. That is, one government's subsidy does not undermine other governments'

attempts to promote employment in their fisheries and so subsidizing governments need not stand to gain from an agreement to curtail their use. Instead importing countries would stand to gain and this will require a different set of concessions than in the typical case of subsidy negotiations.

Second, most fisheries are subject to some form of regulation in conjunction with subsidies. We show that if governments use both subsidies and other forms of regulation (even if inefficient), then subsidies may generate little or no spillover effect across countries. We give an example where fisheries are heavily subsidized but for which there is no incentive for the subsidizing countries to come to an agreement to reduce these subsidies. Each government is acting in accord with its objectives and there are no international spillover effects to internalize via global negotiations.

And third, an agreement to reduce subsidies may end up being at least partially undermined by the affected countries unless the WTO were to also get into the business of fisheries management. This is because a government that has a political objective to promote employment in the fishery can respond to a directive to reduce subsidies by weakening other forms of fisheries regulation. That is, once subsidies are constrained, governments can look for other ways to support fishers.

There is much scope for further work on these issues. The current paper considers only fisheries that do not fall under the jurisdiction of multiple countries. In ongoing work, we consider shared fisheries. In this case, countries are linked via two channels: terms of trade effects and stock effects; and hence the potential for international coordination is more complex. And while we focus on international spillovers as the motive for negotiation, there are other possibilities. International agreements can also be used as a commitment device by governments who anticipate being subject to political pressures in the future (see Maggi and Rodriguez-Clare, 1998). If the aggressiveness of fishery regulation is endogenous, then international agreements could potentially play a role in helping governments maintain more effective regulation.

Appendix

Proof of Proposition 3.

The first order conditions are

$$W_s = \left[-s - p\alpha^2 \bar{X}N / r + \lambda\varphi'\right] N_s + Hp_s = 0 \tag{39}$$

and (for the case of an interior solution):

$$W_\alpha = p\bar{X}N\left[1 - 2\alpha N / r\right] + \left[-s - p\alpha^2 \bar{X}N / r + \lambda\varphi'\right] N_\alpha + Hp_\alpha = 0 \tag{40}$$

where we have used the free entry condition to simplify. To determine the effects of policy on the price of fish, define M*(p) = D(p)-H*(p) to be imports of fish by the ROW. Then the price is determined by

$$H(p, N, \alpha) = M^*(p) \tag{41}$$

This implies

$$dp = -\frac{H_N N_s ds + H_N N_\alpha d\alpha + H_\alpha d\alpha}{\Delta} \tag{42}$$

where

$$\Delta = H_p + H_N N_p - M_p^* \tag{43}$$

As noted previously we assume stability; hence we assume $\Delta > 0$.

Using (42) in (39) yields

$$W_s = \left[-s - p\alpha^2 \bar{X}N / r + \lambda\varphi' - H\frac{H_N}{\Delta}\right] N_s = 0 \tag{44}$$

which yields a solution for the subsidy:

$$s = -p\alpha^2 \bar{X}N / r + \lambda\varphi' - H\frac{H_N}{\Delta} \tag{45}$$

To simplify (40) note that

$$p_\alpha = -\frac{H_N N_\alpha}{\Delta} - \frac{H_\alpha}{\Delta} \tag{46}$$

Using (46) in (40) yields

$$W_\alpha = p\bar{X}N\left[1-2\alpha N/r\right]+\left[-s-p\alpha^2\bar{X}N/r+\lambda\varphi'-H\frac{H_N}{\Delta}\right]N_\alpha - H\frac{H_\alpha}{\Delta}=0 \tag{47}$$

Note that

$$H_\alpha = \bar{X}N\left(1-\frac{2\alpha}{r}N\right) \tag{48}$$

Using (48) and (45) in (47) yields

$$W_\alpha = \bar{X}N\left[p-\frac{H}{\Delta}\right]\left[1-2\alpha N/r\right]=0 \tag{49}$$

This implies that at an interior solution (which we focus on here):

$$\alpha = \frac{r}{2N}\ . \tag{50}$$

We can further simplify by noting that

$$H_N = \alpha\bar{X}\left(1-\frac{2\alpha}{r}N\right) \tag{51}$$

and so using (50), at the optimal point we have $H_N = 0$ and hence the last term in (45) drops out. Using (50), we can write (45) as

$$s = -\frac{p\alpha\bar{X}}{2}+\lambda\varphi'(N) \tag{52}$$

The free entry condition is

$$p\alpha\bar{X}\left(1-\frac{\alpha}{r}N\right)=w-s \tag{53}$$

which using (50) becomes

$$\frac{p\alpha\overline{X}}{2} = w - s \tag{54}$$

And finally, combining (54) with (52) yields

$$\lambda\varphi'(N) = w \tag{55}$$

Proof of Proposition 4.

Total welfare of the countries is: $W + W^* = -sN + \lambda\varphi(N) - s^*N^* + \lambda^*\varphi(N^*)$.

The FOC with respect to s is: $\frac{d(\mathrm{W}+\mathrm{W}^*)}{ds} = -N + (\lambda\varphi'(\mathrm{N}) - \mathrm{s})\frac{dN}{ds} + (\lambda^*\varphi'(\mathrm{N}^*) - \mathrm{s}^*)\frac{dN^*}{ds} = 0.$

The FOC with respect to s^* is: $\frac{d(\mathrm{W}+\mathrm{W}^*)}{ds^*} = -N^* + (\lambda^*\varphi'(\mathrm{N}^*) - \mathrm{s}^*)\frac{dN^*}{ds^*} + (\lambda\varphi'(\mathrm{N}) - \mathrm{s})\frac{dN}{ds^*} = 0.$

The FOC with respect to α is: $\frac{d(\mathrm{W}+\mathrm{W}^*)}{d\alpha} = (\lambda\varphi'(\mathrm{N}) - \mathrm{s})\frac{dN}{d\alpha} + (\lambda^*\varphi'(\mathrm{N}^*) - \mathrm{s}^*)\frac{dN^*}{d\alpha} = 0.$

The FOC with respect to α^* is: $\frac{d(\mathrm{W}+\mathrm{W}^*)}{d\alpha^*} = (\lambda^*\varphi'(\mathrm{N}^*) - \mathrm{s}^*)\frac{dN^*}{d\alpha^*} + (\lambda\varphi'(\mathrm{N}) - \mathrm{s})\frac{dN}{d\alpha^*} = 0.$

At the symmetric equilibrium, we have: $\frac{d(\mathrm{W}+\mathrm{W}^*)}{d\alpha} = (\lambda\varphi'(\mathrm{N}) - \mathrm{s})\left[\frac{dN}{d\alpha} + \frac{dN^*}{d\alpha}\right] = 0.$

What are the expressions of $\frac{dN}{d\alpha}$ and $\frac{dN^*}{d\alpha}$?

$$\frac{dN}{d\alpha} = \frac{r}{\alpha^2}\left(\frac{2X}{\overline{X}} - 1\right)\left(1 + \frac{rX^2}{p\Delta\overline{X}}\right)$$

$$\frac{dN^*}{d\alpha} = \frac{r^*}{\alpha^*}\left(\frac{w^* - s^*}{\alpha^* p^2 \overline{X^*}}\right)\frac{dp}{d\alpha} = \frac{r^*}{\alpha^*}\left(\frac{w^* - s^*}{\alpha^* p^2 \overline{X^*}}\right)\left(\frac{1}{\Delta}\frac{rX}{\alpha}\left(1 - \frac{2X}{\overline{X}}\right)\right).$$

At the symmetric equilibrium, we have:

$$\frac{dN}{d\alpha} + \frac{dN^*}{d\alpha} = \left[\frac{r}{\alpha^2}\left(\frac{2X}{\overline{X}} - 1\right)\left(1 + \frac{rX^2}{p\Delta\overline{X}}\right)\right] + \left[\frac{r}{\alpha}\left(\frac{w - s}{\alpha p^2 \overline{X}}\right)\left(\frac{1}{\Delta}\frac{rX}{\alpha}\left(1 - \frac{2X}{\overline{X}}\right)\right)\right] \Leftrightarrow \frac{dN}{d\alpha} + \frac{dN^*}{d\alpha} = \left(\frac{2X}{\overline{X}} - 1\right)\frac{r}{\alpha^2}.$$

The FOC with respect to α then becomes: $(\lambda\varphi'(N) - s)\left(\frac{2X}{\overline{X}} - 1\right)\frac{r}{\alpha^2} = 0.$

We obtain as solution the stock which leads to the maximum sustainable yield: $X = \frac{\overline{X}}{2}$ and $X^* = \frac{\overline{X^*}}{2}$.

This is the same solution as that prevails for the Nash equilibrium.

Proof of Proposition 5:

The relevant first order condition for the choice of regulation is (47), but now we treat the subsidy s as exogenous (we assume that parameters are such that government want to subsidize and not tax the fishery). We consider the effects of an exogenous reduction in s, given that governments are free to adjust other domestic regulatory instruments. Write the government objective as

$$W(\alpha, N, p) = p\alpha\bar{X}\left(1-\frac{\alpha}{r}N\right)N - wN + \lambda\varphi(N) \tag{56}$$

and the first order condition for α as

$$W_\alpha(\alpha, N, p) = 0 \tag{57}$$

where N is determined by the free entry condition (53). We are interested in how α changes as subsidies change. Totally differentiating (57) yields

$$W_{\alpha\alpha}d\alpha + W_{\alpha N}\left[N_\alpha d\alpha + N_s ds + N_p dp\right] + W_{\alpha p}dp = 0 \tag{58}$$

If we evaluate at the initial unconstrained point (i.e. where (50) - (55) hold), then dp = 0. Hence

$$\left.\frac{d\alpha}{ds}\right|_{s=s_0;\,\alpha=\alpha_0} = -\frac{W_{\alpha N}N_s}{W_{\alpha\alpha}+W_{\alpha N}N_\alpha} = -\frac{W_{\alpha N}N_s}{W_{\alpha\alpha}} < 0. \tag{59}$$

where we have used the free entry condition to find

$$N_\alpha = r\left(1-\frac{2\alpha}{r}N\right)/\alpha^2 \tag{60}$$

and where

$$W_{\alpha\alpha} = -2p\bar{X}N^2/r < 0 \tag{61}$$

and

$$W_{\alpha N} = p\bar{X}\left(1-\frac{4\alpha}{r}N\right) \tag{62}$$

Using (50) in the above yields the sign result in (59) since $N_s > 0$.

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