The Potential for Cooperation in Shared Fisheries – Theory and Application to Vietnam's Fisheries Strategy in the South China Sea

Le Kim Long

A dissertation for the degree of philosophiae doctor

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Preface

This dissertation is for the degree of Doctor of Philosophy in Social Science, at the Norwegian College of Fishery Science, University of Tromso. I have benefited from the cooperation, help and support of many people and institutions for my PHD work.

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Nha Trang, March 2009
Le Kim Long

Contents

List of papers

Paper I: Regional fisheries management organization with an endogenous minimum participation level for cooperation in straddling stock fisheries. *Fisheries Research* 2009 *(forthcoming).*

Paper II: A Stackelberg analysis of the potential for cooperation in straddling stock fisheries. Submitted to a journal. The Best Student Paper Award at the International Institute of Fisheries Economics and Trading (IIFET), Nha Trang, Vietnam, 2008.

Paper III: Economic performance of open-access fisheries: the case of Vietnam's longliners in the South China Sea. *Fisheries Research* 2008, 93, pp 296–304.

Paper IV: On the shared fisheries in the South China Sea and possible strategies for Vietnam's fisheries. Submitted to a journal.

Summary

Since the end of the 20th century, many shared fish stocks throughout the world have been found in extreme danger of collapse. There are many calls for cooperation in utilizing and conserving the shared fish resources including the 1982 UN Convention on the Law of the Sea and the 1995 UN Fish Stock Agreement. This study provides an important rationale for cooperation in utilizing a shared fish stock with several interested parties. The rationale is that an increase in the cooperation level leads to an increase not only in the steady-state fish stock, but also in total rent of the fishery. Moreover, the possibilities for cooperation in utilizing shared fisheries are examined. Some measures are also proposed to improve the cooperation level. According to this study, the prospects of cooperation in utilizing a straddling fish stock are not unlikely if a Regional Fishery Management Organisation (RFMO) forms with a leading role in a Stackelberg game or with an endogenous minimum participation level in a Cournot game. However, if the cost of enforcing RFMO members' compliance with the terms of the agreement is high enough, there may not be any incentive for fishing countries to establish an RFMO for managing a straddling fish stock. This is one of the reasons for pervasive over-fishing around the world. For an actual example, the South China Sea (SCS) fishery, which is harvested by about ten countries including Vietnam, will be discussed as an application. An empirical investigation of the profitability and remuneration of an offshore long-line fishery demonstrates slightly above-average earnings even under the current open-access regime. Finally, the study will propose some fishery strategies for Vietnam, which is a country with heavy inshore fishing, the second largest catch in the South China Sea and where large-scale illegal fishing takes place.

Introduction

Internationally, shared fish resources account for as much as one-third of the world marine capture fish harvest (Munro, Van Houtte and Willmann 2004). Many shared fish stocks throughout the world have been found in extreme danger of collapse since the end of the 20th century. The 1982 UN Convention on the Law of the Sea (LOS), came into force in 1994 and set new legal frameworks for marine fisheries and environmental protection (UN 1982). Besides the definition of exclusive economic zone (EEZ), the LOS has called for cooperation in managing the shared fish resources of high seas and semi-closed seas (UN 1982). Moreover, the 1995 UN Fish Stocks Agreement (UNFSA) came into force in 2001; this is an implementation agreement for the LOS with respect to the conservation and management of one type of shared fish stocks – straddling and highly migratory fish stocks (UN 1995). The UNFSA provides for an implementation framework for Articles 63 and 64 and relevant provisions of the LOS. At the heart of the UNFSA is the establishment of the Regional Fishery Management Organisations (RFMOs) to manage straddling and highly migratory fish stocks. The RFMOs and its arrangements were recognized as the primary mechanism for international cooperation in conserving and managing straddling fish stocks and highly migratory fish stocks.

The exploitation of a fish stock, shared by a limited number of fishing countries, involves strategic choices. Before 1993, the theory of fishing games considered cases of just two players (see e.g. Kaitala (1986), Munro (1991), Sumaila (1999) and Lindroos et al. (2007) for

reviews). Munro (1979) and Clark (1976) were the first to provide an analysis of a fishing game with two players. They demonstrated that cooperation in utilizing a shared fishery leads to both higher fish stock and total rent of the fishery. For an application, Armstrong and Flaaten (1991) showed that there is a significant cooperative surplus for the case of Arcto-Norwegian cod-stock sharing between Norway and Russia. However, many important stocks in the EEZs are shared by two or more coastal states and the straddling of some fish stocks outside the EEZs means they are accessible by fleets of any nationality (Hannesson 1997). Kaitala and Munro (1993), Kaitala and Munro (1995), Bjorndal et al. (2000) and Bjorndal and Munro (2007) have considered the management issues of a shared fish stock with several interested parties. The last decade has produced literature using the cooperative approach to deal with the potential of cooperation when three or more countries utilize a fish stock. For example, Kaitala and Lindroos (1998) and Lindroos (2004) use the characteristic function game to obtain fair-sharing solutions of surplus benefits from full cooperation. Once the number of players exceeds two, however, the possibility of sub-coalitions forming among players arises. Therefore, the non-cooperative approach is also needed to understand the possibility of cooperation in utilizing shared fish stock with several fishing countries. On the other hand, literature examining cooperative and non-cooperative consequences of a shared fishery adopts both dynamic and static games (see e.g. Paper (II) for a review). Kaitala and Lindroos (2007) argued that the advantage of static games over dynamic games is that analytical results are easier to derive and interpret. Moreover, since the static approach gives a good long-term prediction, it is consistent with the calls for cooperation of the LOS and the UNFSA to sustain long-term stability of shared fish stocks. Thus, the first part of this study will focus on the theoretical aspects of the potential for cooperation when several fishing

countries are involved in a shared fish stock within the non-cooperative framework of static fishing games.

The second part of this study concentrates on the South China Sea (SCS), where the marine resources are harvested by about ten countries – an actual example of utilizing shared fish resources with several interested parties. Currently, the SCS fisheries are open-access and over-fishing is a serious problem (UNEP 2005). Since the SCS is a semi-closed sea, any changes in the ecosystem of this semi-enclosed sea will have a considerable impact on the whole SCS. The fish resources in the SCS area are generally recognized as migrating from one EEZ to another and also to international waters, particular the pelagic species such as tuna, mackerel and scads (see ICLARM/ISEAS 1978). Hence, the question may arise as to whether each country's management policy of these fish stocks is effective.

Moreover, the SCS is one of the world's most contentious areas in both maritime boundary and territorial disputes (Wang 2001). The establishment of EEZs increases the possibility for overlapping territorial claims in this sea. Countries in the SCS have tried to establish settlements – in most cases, military outposts – on the small rocky islets of Spratly Islands and Paracel Islands, in order to set up unique territorial claims to both an EEZ and a continental shelf. This leads to territorial overlapping margins, and various conflicts of sovereignty. Territorial issues are mainly in the Spratly Islands and the Paracel Islands, which not only are believed to contain oil and gas deposits, but also are rich fishing grounds. There are six countries involved in these disputes, including Vietnam. It would be preferable for them to initiate cooperation from the least complicated items (SCSW 1999). Wang

(2001) proposed that fisheries cooperation can serve as a viable starting point, from which the cooperation experience can spill over into other areas of cooperation.

When countries sharing a fishery have different fishing situations, especially fishing cost, their optimum conditions of the fishery are different. Moreover, each country should have suitable strategies for each future scenario of the SCS fishery, such as the continuation of the status quo or a move towards cooperation. For an example, some fishery strategies of Vietnam, the country with heavy inshore fishing, the second largest catch in the SCS and large-scale illegal fishing, are proposed in both these scenarios. Thus the second part of the study will deal with shared fisheries in the SCS and possible fishing strategies for Vietnam.

Part 1: The potential for cooperation in straddling stock fisheries

There are four non-mutually exclusive categories of shared fish stocks (see Bjørndal and Munro 2007). They are (i) transboundary stocks – fishery resources moving from one EEZ to one, or more neighbouring EEZs; (ii) highly migratory stocks (tuna primarily), which because of their nature, cross the EEZ boundary into the adjacent high seas where they become subject to exploitation by so-called distant water fishing states (DWFS); (iii) straddling stocks – all other fish stocks crossing the EEZ boundary into the adjacent high seas; (iv) discrete high seas stocks – those few stocks remaining wholly in the high seas (see Bjørndal and Munro 2007). Since the UNFSA focuses on managing highly migratory stock fisheries and straddling stock fisheries, category (ii) and (iii) will be considered in this part of the study and are simply called, straddling fish stock (see also Bjørndal and Munro 2007).

According to Article 8 of the UNFSA, only member states of RFMOs and states that apply the fishing restrictions adopted by them shall have access to the regulated fishery resources. The UNFSA is, however, binding only upon those states that are party to it. As of 25 September 2008, there are 71 states party to the UNFSA (UN 2008). Moreover, FAO (2001) has showed that the incidence of illegal, unreported and unregulated (IUU) fishing is pervasive over many parts of the world. Therefore, RFMOs managing a straddling fish stock should be modelled with the equilibrium concept of a self-enforcing or stable agreement. A stable agreement made between parties, proposed by D'Aspremont et al. (1983), is defined as a single coalition from which no member wishes to withdraw (the cooperative coalition is internally stable) and no non-member wishes to join (the cooperative coalition is externally stable).

Pintassilgo and Lindroos (2006) used the static Cournot non-cooperative game combined with the classical Gordon–Schaefer model for several homogenous players to analyse the possibility for cooperation in straddling stock fisheries. They have, however, demonstrated that a non-cooperative solution is the inevitable outcome when there are more than two players and the grand coalition is a stable Nash equilibrium outcome, only if there are two players involved in a shared fishery. Their result raises the question of whether the establishment of RFMOs to manage straddling stock fisheries under the UNFSA, is stable and successful. Pintassilgo et al. (2008) have shown that the success of RFMOs is related to the level and asymmetry of harvesting costs in the static Cournot game. To investigate the potential for cooperation in straddling stock fisheries, Paper (I) will add the assumption of

establishing the RFMO with an endogenous minimum participation level within a Cournot game in both cases of costless and costly enforcement; alternatively, Paper (II), assumes that an RFMO for managing a straddling stock fishery is sophisticated and acts as a Stackelberg leader and that the singletons are naïve and act as the Stackelberg followers.

Both papers provide an important rationale for the UNFSA's call for cooperation in the utilization of a straddling fish stock. The rationale is that an increase in the cooperation level in straddling stock fisheries within both the Cournot game and the Stackelberg game, leads to an increase not only in steady-state fish stocks, but also in total rent of the fishery. This means that the improved level of cooperation is preferred from a social point of view, and this is an important rationale for the establishment of RFMOs to manage straddling stock fisheries. The ambition of the UNFSA is to create a duty, on all the states engaged in fisheries activities in waters under the management authority of an RFMO, to cooperate through the RFMO in the conservation of the relevant fish stocks (Örebech et al. 1998). Therefore, how to increase the level of cooperation and then to reach full cooperation is a very important question for policymakers.

Full cooperation is the optimum scenario in utilizing a straddling stock fishery in both games since it gives not only the highest level of steady-state fish stock, but also the highest levels of total rent and participants' rent. However, Paper (II) shows that there exists an incentive for any participant to defect from full cooperation when five or more countries are sharing a fish stock in a Stackelberg game. This is also found in a Cournot game when the number of countries involved in a straddling stock fishery is greater than two (Pintassilgo and Lindroos

2006). Even the restrictions set by the UNFSA – prohibiting non-member states that do not abide by the regime of the regional fishery organization in exploiting the fish resources – are binding only to those states that are party to it. Some states may refuse to be party to the UNFSA to gain the advantage of being free riders. This may be an explanation for the recommendation that the RFMO members should recognize the grave threat to the stability of the cooperative regime posed by IUU fishing and work vigorously towards the suppression and elimination of such fishing (Lodge et al. 2007). To attack this problem, FAO (2001) has proposed a set of voluntary International Plans of Action on IUU fishing (IPOA-IUU). The IPOA-IUU proposes some important responsibilities of fishing countries, which hope to prevent, deter and eliminate IUU fishing (see also Tsamenyi et al. 2004).

Paper (I) also examines the effect of establishing an RFMO with an endogenous minimum participation level on cooperative possibilities in straddling stock fisheries within the Cournot game in both cases – costless and costly enforcement for compliance of RFMO's members. The minimum participation level for the existence of an RFMO is unanimously chosen by fishing countries when negotiating the establishment of the RFMO. In comparison with Pintassilgo and Lindroos (2006), the establishment of an RFMO with an endogenous minimum participation level, in the case of costless enforcement, is firstly considered in Paper (I). The result shows that if an RFMO forms with an endogenous minimum participation level, the RFMO is stable at the equilibrium of the minimum participation level at which this RFMO is the smallest size of a profitable coalition. In particular, full cooperation is a stable coalition when four or fewer countries share a fish stock. In addition, a stable partial cooperation with more than 80% of countries involved will exist when five

countries or more share a fishery. This finding contrasts with the findings of Pintassilgo and Lindroos (2006), who demonstrate that non-cooperation is the unavoidable outcome when the number of fishing countries is greater than two. The reason for the difference is that an RFMO only enters into force if there is a minimum participation level. This changes the incentives facing the fishing countries in straddling stock fisheries.

If the cost of enforcing RFMO members' compliance with the terms of agreement is not high enough, Paper (I) demonstrated that an RFMO, with costly enforcement, will typically require a greater cooperative level at the equilibrium of the minimum participation level than an RFMO that could be enforced without cost. As a result, if an RFMO forms with an endogenous minimum participation level, in the case of costly enforcement, it not only results in a higher level of steady-state fish stock, but it also may improve the rent of a participant. In addition, the bio-economic parameters and the number of countries involved in straddling stock fisheries have a significant effect on the set of situations at which an RFMO, with costly enforcement, becomes worthwhile.

Paper (II) studies the potential for cooperation in straddling stock fisheries when the cooperative coalition of countries acts as a Stackelberg leader against the remaining singleton countries. It demonstrates that the outlook for cooperation is better within the Stackelberg game, where the cooperative coalition acts as a leader, than within the Cournot game in which the cooperative coalition and the singletons simultaneously maximize their payoffs, taking the effort levels of the others as given. In particular, when the cooperative coalition acts as a leader, the grand coalition is a stable Nash equilibrium outcome only if

there are no more than four countries involved in a straddling fish stock. In addition, there is always a stable partial coalition for the exploitation of a straddling fish stock when the number of countries involved in the fishery is more than four. At the stable equilibrium of a Stackelberg game, not only is the steady-state fish stock higher, but also the total resource rent, participants' rent and non-participants' rent are higher than those of the stable Cournot–Nash equilibrium. Furthermore, Paper (II) shows that although some fishing countries may not commit to cooperation because of the unregulated fishing possibility, the goal of expanding the cooperative coalition can be reached in a Stackelberg game by means of a self-financed transfer with commitments proposed by Carraro and Siniscalco (1993).

Paper (II) also shows the negative effect of new entrants on the potential for cooperation if the new players act as singletons in a Stackelberg game. This is consistent with Pintassilgo et al. (2008) in the case of a Cournot game. Moreover, another important finding of Paper (II) is that at any cooperation level higher than or equal to its stable cooperation level, the participation of new players in the existing coalition leads to a higher steady-state fish stock, higher total rent and higher individual rent than if the new players act as singletons. This may be an important rationale for the suggestion of Lodge et al. (2007) that, in each RFMO, the members should seek means of accommodating new members, such as allowing new members to purchase or lease fishing rights from existing RFMO members. However, it is important to note that within a Stackelberg game, even if a stable coalition managing a straddling stock fishery with the open-membership rule exists, the new-entrant issue is still a problem for the conservation of this fish stock.

According to this study, the prospects of cooperation in utilizing a straddling fish stock are not unlikely if an RFMO forms with a leading role in a Stackelberg game or with an endogenous minimum participation level in a Cournot game. This is an important implication for policymakers when discussing an agreement for establishing an RFMO to manage a straddling fish stock. It is, however, important to note that there is an enforcement cost, which is levied to ensure that every member of the RMFO will comply with the terms of the agreement and this plays a significant role in the establishment of an RFMO. If the cost of enforcing RFMO members' compliance with the terms of agreement is high enough, there may not be any incentive for fishing countries to establish an RFMO for managing a straddling fish stock. This is one of the reasons for pervasive over-fishing around the world.

Part 2: Shared fisheries in the South China Sea and suggestions for Vietnam's fisheries strategy

It is generally recognized that the living resources in the SCS area migrate from one EEZ to another and also to international waters, particular the pelagic species such as tuna, mackerel and scads (see ICLARM/ISEAS 1978). Thus, any change in the ecosystem of this semi-enclosed sea will have a significant impact on the whole SCS region. Currently, the SCS fisheries are still open-access resources for fishing vessels from more than ten countries, including Vietnam. The UNEP (2005) characterizes the SCS as 'severely impacted' in terms of over-fishing, with severe socio-economic and community consequences, excessive by-catch and discards, and destructive fishing practices which include cyanide and dynamite fishing, and the use of small-meshed nets. Morton (2003) mentioned that the incidence of

IUU fishing is as pervasive, if not more pervasive, in this part of the world as it is in other parts of the world. This, in several cases, has created excess capacity (see e.g. Long 2003, Carmen et al. 2005, FAO 2005 and Khemakorn 2006).

Vietnam is located in the west of the SCS with 3260 km of coastline, and an EEZ of more than 1 million square kilometres. Vietnam's marine fish production has rapidly increased over the last two decades in parallel with a catch capacity increase. The marine catch amounted to about 1.6 million MT in 2003 (FAO 2005). Of the marine fish catch, 88% comes from the coastal fisheries and 82% of the fishers are fishing in the coastal areas. Since the mid-1990s, the government of Vietnam has made strenuous efforts to develop its offshore fisheries. The offshore fishing programme, by giving incentives for offshore fishing such as loans and low taxes (see e.g. Paper (III) for details), aims at attaining two broad policy objectives: first, to expand marine fish production for domestic consumption and for export; and second, to reduce the pressure on coastal fisheries resources. The non-industrial yellow-fin and big-eye tuna vessels of Vietnam are operating in waters of the Spratly Islands and the Paracel Islands where there are six countries involved in territorial disputes including Vietnam. Paper (III) provides an empirical study of this open-access offshore fishery in the disputed area of the SCS.

Based on data collected through a representative sample of 32 registered offshore longliners operating in the SCS – representing about 16% of such vessels in Khanh Hoa, Vietnam – Paper (III) raises the question of whether it is necessary for direct subsidies for offshore longliners, such as cheap loans and low taxes. There are two main reasons for this. First,

Paper (III) demonstrates that vessel-owners make a profit margin of 12.1%. Moreover, crew members earn an opportunity income or above. In particular, the average annual crew share is more than 90% of the average annual income of labour in the most productive industrial sectors in the Khanh Hoa Province; on a monthly basis, for the average vessel with an operating time of 8.5 months per year, the corresponding ratio is 130%. In light of the open-access characteristics of the fishery, the reasons for this interesting finding include (i) a risky longlining tuna fishery; (ii) high capital investment and operational expenses; (iii) imperfect national capital markets; (iv) low fishing costs compared with other countries involved in exploitation of this shared fish stock and (v) positive average intra-marginal rent. This gives a signal that the Vietnamese longline fishery for tuna may attract additional private investments in the near future and continue expanding.

Second, Paper (III) also shows that over-investment in vessels may lead to inefficiency and vessels financed partly by cheap offshore project loans have hull-length longer than the level that maximizes annual gross revenue and income of the vessel. This is an example of how direct subsidy for fisheries may lead to over-investment and then inefficiency. On the other hand, Ruseski (1998) has warned that direct fishing subsidies may fuel an international fishing war among countries involved in a shared fishery. The fishing war would lead to excess harvesting capacity in the fishery (see e.g. OECD 2003). In light of this, it is suggested that each country's management policy of a shared fish stock is inefficient.

There are many calls for cooperation in utilizing fish resources in the SCS, a semi-closed sea (see e.g. ICLARM/ISEAS 1978, SCSW 1999, Wang 2001, Carmen et al. 2005 and

Khemakorn 2006). Currently, the SCS fisheries are, however, still open-access resources for fishing vessels from more than ten countries, including Thailand and Cambodia which have not yet ratified the LOS. Paper (IV) gives an economic analysis of the potential for cooperation in utilizing shared fisheries in the SCS and suggests two possible fishery strategies for Vietnam in both scenarios of (i) the continuation of the status quo and (ii) the establishment of a SCS fishing cooperative regime. To achieve this, Paper (IV) first presents the prominent features and fisheries of the SCS region. The legal instruments and institution for regional fisheries management are also reviewed.

The economic analysis of the potential for cooperation in the utilization of the SCS fishery will be mostly based on three papers presented in this dissertation. Currently, there are about ten countries fishing in the SCS region. There clearly exists an incentive for jointly managing the SCS fisheries, since Paper (I) and Paper (II) have proved that an increase in the cooperation level in utilizing a shared fish stock leads to an increase in, not only steady-state fish stock, but also total rent. Beside territorial disputes, however, another reason for the non-cooperative behaviour of fishing countries in the SCS is an attractive incentive to become free riders because a large number of countries are involved in a shared fish stock. According to the result of Paper (I) and (II), a stable partial cooperation in utilizing the SCS fish resource may exist if a regional cooperative regime forms with an endogenous minimum participation level in a Cournot game or with a leading role in a Stackelberg game. However, full cooperation in the SCS fishery only exists if all fishing countries ratify the cooperative agreement and then it becomes legally binding to all signatories. Moreover, to establish a cooperative regime, with full or partial cooperation, for the SCS fisheries, an effective

enforcement mechanism is necessary. It is, however, important to note that if enforcement cost is too high, there is no rationale for cooperation. Paper (IV) also adopts the works of Munro (1979), Clark (1976) and Kaitala and Lindroos (1998) to discuss an example of a possible cooperative regime in the disputed area of the SCS for the non-industrial yellow-fin and big-eye tuna fishery.

Under the practical situation of the SCS, the future of its fisheries is still very difficult to predict. Therefore, the reactive Vietnamese strategies, in two possible scenarios of the SCS fisheries, are proposed. In the case of establishing a cooperative fishing regime, Vietnam should cooperate with the Philippines, Indonesia and Malaysia, which have a high capacity of offshore fishing, large EEZs and belong to the Association of Southeast Asian Nations (ASEAN) and should call for sharing total allowable catch (TAC) for involved countries based on zonal attachments and making quota tradable. The yellow-fin and big-eye tuna non-industrial fishery is a good example of a cooperative fishing regime in a disputed area. If the status quo still exists, on the one hand it would be wise for Vietnam to develop joint ventures with other countries, especially China and Thailand, which are mainly IUU fishers in Vietnamese EEZ, or to give permission for foreign vessels to fish in offshore of Vietnamese EEZ areas. On the other hand, it would be wise for Vietnam to enhance offshore fishing programmes or strategies to reduce the pressure on coastal fisheries resources through support that does not contribute to capacity and effort expansion, such as training fishermen to adopt new technology, providing information about the fish stock, forecasting weather and rescue and life-saving activities in high seas. However, these strategies would not limit the

danger of collapse in the fish stock of Vietnamese EEZ, if a regional cooperative regime did not exist.

Concluding comments and future research

The first part of this thesis considered the theoretical aspects of the potential for cooperation in utilizing shared fish stocks with several interested parties. Following the vein of Pintassilgo and Lindroos (2006), a static non-cooperative fishing game of several players with homogenous fishing costs and output price was adopted. The study focused on the question of whether the establishment of RFMOs to manage straddling stock fisheries under the UNFSA was stable and successful in the following two cases. The first is that an RFMO forms with an endogenous minimum participation level in both cases of costless and costly enforcement within a Cournot game (Paper (I)). The second is that an RFMO is sophisticated and acts as a Stackelberg leader, and the singletons are naïve and act as the Stackelberg followers in a Stackelberg game (Paper (II)). There are, however, a number of current topics in shared fisheries management that are not explicitly discussed. They include trigger threads for non-compliance to the terms of a cooperative agreement (see e.g. Hannesson 1997), heterogeneous fishing countries (Munro 1979 and Pintassilgo et al. 2008) and the fair sharing methods for cooperative surplus (Kaitala and Lindroos 1998).

To be consistent with the UNFSA's aim of establishing an RFMO to sustain the long-term stability of shared fish stocks, the static approach with a good long-term prediction is adopted in this study. Since a static game is a game of one period, the idea of placing trigger

threads for non-compliance in future periods into the models could not be directly adopted. Paper (I), however, explicitly discusses the effects of the cost of enforcing compliance with the terms of the agreement. Furthermore, an enforcement model that typically includes elements of illegal activities, punishments and probabilities of detection may also be an interesting topic for the future study of a static fishing game (see McEvoy and Stranlund 2008 for an environmental game). On the other hand, Hannesson (1997) explicitly used reciprocal punishment strategies in which parties to an agreement may punish violators in future rounds in a repeated game. The idea of trigger threads for non-compliance, of course, may be explicitly discussed in a dynamic game of several fishing countries.

Pintassilgo et al. (2008) extended Pintassilgo and Lindroos (2006) with the assumption of heterogeneous fishing costs of several interested countries to investigate the success and stability of RFMOs managing straddling stock fisheries in a Cournot game. Munro (1979) investigated the consequence of a dynamic fishing game for two countries with different fishing costs and output price and suggested the equal sharing of cooperative surplus. Kaitala and Lindroos (1998) discussed a fair solution for three cooperative fishing countries with different harvesting costs. Since fishing countries that share a fish stock with homogenous fishing costs and output price is assumed in this study, Paper (I) and Paper (II) implicitly imply equal sharing of the cooperative resource rent of the FRMO for its members. Hence, dealing with heterogeneous fishing costs and output price of fishing countries may be an extension of Paper (I) and Paper (II). A case study of more complex specifications of the resource rent, cost and harvest functions and dynamic analysis, may also be a natural extension of the present research.

The second part of this study was an actual example of several interested countries involved in a shared fish stock. It is the SCS, a semi-closed sea where the resources are harvested by about ten countries. However, due to lack of clear-cut information on the status of the fish stocks and scare fishing industry data of developing countries in the SCS, it is very difficult to predict the future of the SCS fishery. Therefore, the suggestions for Vietnam's fishery strategies, which are presented in this study as examples, are only preliminary.

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