Journal of Sustainability Science and Management
Volume 9 *Number* 1, June 2014: 18-31

ISSN: 1823-8556

EMPOWERING SMALL FISHERMEN THROUGH SIMULTANEOUS AND SEQUENTIAL MARKETING STRATEGIES

NIK HASHIM NIK MUSTAPHA[1*], NIK MOHD HAZRUL HASHIM[2] AND RIDZUAN YACOB[3]

[1]School of Social and Economic Development, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu. [2]Graduate School of Business, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor. [3]Centre of Fundamental and Liberal Studies, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu.

**Corresponding author: nhm06@umt.edu.my*

Abstract: One of the socio-economic issues often discussed in marketing of marine catch of small-scale fishermen is the agent-principal relationship. They become socially obliged to the benefits and assistance provided by credit agents specifically when their credits accumulated. This asymmetric circumstance has empowered the credit agent to gain control over the marketing of fishermen daily catches. Another form of marketing strategy that has never been investigated before, at least in the fishing industry, is the way by which fishermen catches are brought to the market place. Specifically, we posit those who are dominant in the market will be affected by either simultaneous (collusive and non-collusive) or sequential marketing strategies. Drawing on strategic game theory using data from fisheries statistics, this study is aimed at identifying policies for the least advantaged small fishermen to improve their income and thus their livelihood. Efficient outcomes which are the net incomes derived from fishing activities of small versus medium, medium versus large and small versus large vessel fishermen were used in the analysis of marketing strategies. Evidently, whilst merging is profitable to the small fishermen, sequential with small fishermen as the first mover is also profitable but has more profound impact on the society's welfare.

KEYWORDS: Strategic games, non-collusive, collusive simultaneous strategy, sequential marketing strategy, first mover, followers.

Introduction

Small-scale capture, as a traditional fishing activity and its trade had been passed down from the earlier generation of fishermen to the current generation with socio-economic problem of poverty and the depleting fish resource as their livelihoods. Poverty among fishermen as a community constituted the salient socio-economic issue during the 1950s and 1960s. The vicious cycle hypothesis of low adoption of fishing technology among fishermen was assumed to be associated with low productivity and income that finally explained why technology adoption was depressed and poverty was rampant.

By 1980s and 1990s the poverty issue among fishermen community received greater attention and commitment from the government development programs. Later resource economists believed that since fishing operation had been in open-access for a long period of time, marine fisheries depletion due to overfishing became a new agenda for the nation (Nik Hashim, 2008a). Fishing activity had long been the livelihood of most fishermen. With growing commercialization of the industry more resource were being captured for human consumption. The encroachment of Malaysian exclusive economic zone (EEZ) by foreign vessels and the violation of large vessels like trawlers of the fishing zoning had worsened the issue of resource depletion along the coastal areas. In view of fisheries depletion, a shift in fisheries policy empowering the small-scale capture is coherent with the goal of sustaining the industry (Thomson and FAO, 1988; Pauly, 2006). Small-scale capture constitutes some 50-75% of the global fish production and trade. This subsector provides employment to millions of fishermen worldwide (Carvalho *et al.,* 2011).

The above issues revolved around the supply side namely production and productivity. On the demand side, Malaysian population is ever-growing calling for more food production, especially rice, fish, livestock, poultry and others. Consequently, the volume of trade in fish marketing is going to persist and become more important in the future. The involvement of small fishers referring to those operating vessel size below 25 GRT are likely to be marginalized in this competitive market by the larger vessel operators of 25 <70 GRT. Vessel size of 70 metric tons and above was not considered in the analysis since it activities are focused on deep sea fishing.

This paper uses game theory in the marketing of marine fisheries of small, medium and large fishermen in West Coast Malaysia. Categories of fisherman are defined in accordance with the size of vessel; small fishermen refer to the vessel operators of 0 > 25 GRT, medium fishermen 25 > 40 GRT, and large fishermen comprise those operating vessel size over 40 > 70 GRT. The current definition on size of vessel slightly differs from that used by Ruttan *et al.,* (2000) as referred by Therkildsen (2007, p. 289). They categorized the New England's small-scale (<50 GRT) and large-scale vessels (>50 GRT) in accordance with the value of cumulative fish landings. The basis for using GRT classification is that the cumulative value of fish caught was apparently equivalent to gross tonnage. Utne (2008, pp.466-467) classified small vessel by length (l), l <15 m, medium vessel l=15-27 m and for large conventional vessel l > 28 m. Catch used in the present investigation refers to twenty-six species of fish caught for the year 2009.

The objective of game theory does not end with the optimum conditions as the ultimate goal of disposing fishermen catches, but the focus is rather on identifying which category of fishermen is dominant in the choice of marketing strategies. These concepts of domination of one over the other could either be a dominant strategy, Nash equilibrium strategy or just the first mover in the sequential strategy. Alternatively this objective would imply small fishermen can be empowered through adopting a specific marketing strategy in order to sustain them in the fishing industry. Moreover, small scale fishers relative to larger scale operators are always welcome to the industry as they inflict the least impact on fishing mortality. This paper illustrates how the theoretical construct of game theory works in the real world application.

Theoretical Premise

Game theory began its application mainly in mathematics. Since 1944 its usage had advanced into a broad field of academia including economics, business administration, psychology, biology, sociology, politics and philosophy. Its popularity was immensely felt following John Nash Noble Price winner in 1994 with the well-known Nash equilibrium strategy. As a branch of applied economics game theory utilizes mathematics as the tools for analyzing possible strategic options in human interactions. The purpose of human interactions is seen as a way to trade and exchange goods in economics and business that yields benefits to the interacting players in terms of utility outcomes. These outcomes are generally expressed in the form of monetary returns. In any game, the choice of a decision is made strategically to attain the best outcome over the opponents. The best outcome to a particular player is arrived after considering the expectations and the likely actions of the other players. When game theory was first applied by Neumann and Morgenstern (1944) it was confined to mathematical outcomes, but now its philosophical and strategic aspects are becoming more complicated with nonparametric analyses.

In real world, parametric outcomes in mathematics and statistics are predictable because the results are calculable. In non-parametric game the outcomes cannot be easily formulated because the results are not quantifiable. A game involving a person with a still target is less challenging compared to the game of moving target like a game between persons. The decision in crossing a bridge from point x to point y will obviously differ between options of a plain crossing with zero risk, one with some degree of risk of steep slopes, and the riskiest route with the presence of dangerous opponents. From parametric decision under normal circumstances it is rational to choose the least dangerous route to achieve the best outcome. However, for non-parametric games the decision choice is more difficult because the decision-maker would consider threats of steep slopes and dangerous animals. A fugitive being charged by police would probably strategize to avoid the riskless route for his safety of being caught thus is not likely the best option. In real world, this kind of decision making has to be made strategically. The extant of risk involved in the game and the likely strategies chosen by the opponents have to be understood.

The Prisoner's Dilemma was one of the first responses to the Nash equilibrium, after John Forbes Nash the 1994 Noble Price winner for their outstanding contributions in the development of game theory, "…that contributed remarkably to the notion of equilibrium that has been widely applied and adopted in economics and other behavioral sciences."(Holt and Roth, 2004, p.3999). However, in the "*social dilemmas*" Nash equilibrium according to Dresher and Flood would not necessarily be a good predictor of behavior if the prisoners are allowed to cooperate (Adnan, 2005). Nash equilibrium refers to the game in which the non-cooperative player decides on a strategy given the decisions of opponent players (Nicholson, 1997).

The current study is basically a parametric decision-making which is evaluated at the optimal outcomes-net returns to the three categories of vessel operators; the small, medium and large fishermen. As envisaged, large fishermen relative to the small and medium counterparts varies in their ability to market their catches. One of these advantages is that large fishermen may engage market agents and they often have better access to market information and sale opportunities from outside buyers. In marketing management, the size of the firm is recognized as an essential variable that can affect decision-making and performance (Bluedorn 1993; Cohen and Klepper 1996). Large firms have greater market power as they will usually have wider assets, sufficient financial resources, a broad spectrum of products, and can endure risks compared to smaller firms. Therefore, they are more competent with broader product launching activities. In business, experience has been recognized as an important determinant of success (Denis and Depelteau 1985). Firms with experience in local and global markets will have better knowledge of market dynamics and more confident in risk takings.

In addition, merger was found to be profitable depending on cost and the market structure (Steffen and Konrad, 2001). Merger would benefit in terms of economic of scale, however, for every merger there is a possibility of blending different stages of research, development and growth. Level of efficiency achieved also differs within the merging firms. The larger firm with better profitability will have to sacrifice to smaller firm in terms of providing expertise and skills, sharing facilities for research and development, and perhaps training the new partner's personnel to keep up with the dominant firm's knowhow. Although it is possible for the smaller firm to excel in certain fields such as in management because of its small unit, generally the larger firm will have to bear the burden of merging. Profits of large firms may have reduced under collusion relative to their non-collusion condition.

Steffen *et al.,* (2005) found that mergers tend to reduce the firms' share in the industry despite increase in industry profits. Merger typically creates complex organizations which are more challenging to administer, it may need time to adjust to the new structural change rather than simply reducing the weight of competition. According to them, horizontal merging is profitable and welfare can be improved if costs are linear. Perry and Porter (1985) found that horizontal mergers reduce industrial competition that may lead to higher prices, increase merging firm profitability and a reduction in consumers' welfare. With a larger establishment efficiency can be realized through scale economies.

Moreover, merger is preferred because of the presumption that information and decision makings flow more freely and commitment is high within merging firms.

Steffen *et al.,* (2001) also found that Stackelberg beats Cournot on collusion and efficiency in experimental markets in terms of higher outputs. Nik Hashim (2008b) results seem to match that of Steffen and Normann (i.e., q_1=525.4 & q_2=525.4 metric tons for Cournot versus q_1= 685.96 & q_2 =1058.3 metric tons for the F1's (Firm's 1) first mover Stackelberg). Since profits were used as the final payoffs, the large quantity of output will result in lower efficient price. Evidence from earlier study also showed that the Stackelberg model is still superior to Cournot as the first mover in the sequential strategy (Hamilton and Slutsky 1990).

Methodology in Marketing Strategy

In general game theory, the non-collusive and collusive marketing strategies assumed that the players—the fishermen and their agents are marketing their catches at the same time and place or *simultaneously*. The simultaneous non-collusive mode of distribution which is the common method of marketing of fishermen daily outputs refers to the individual strategy whereby they do not cooperate. There is an absence of teamwork whatsoever between fisherman in the marketing of their daily catches. In collusive strategy, individual fishermen cooperate as a team in the marketing of their products. The objective of game theory in the simultaneous collusive and non-collusive marketing strategies is to verify that under these conditions economic return to the operators differs, given that their ultimate goal is to maximize returns.

The *sequential* marketing strategy refers to a system of distribution of fishermen's catches in chronological order, that is, if there are only two players there will be the first and then the second fisherman to market their catches. Economists believe that there are significant differences in economic returns accrued to the players in each order depending on the market domination of these individual operators. The first mover is the likely gainer because of the advantage of first hand market information and the ability to monopolize market demand before the arrival of second and succeeding players (Li *et al.,* 2003; Robinson and Min, 2002). Statistics from the Malaysian Annual Fisheries Statistics 2009 will be used to test the hypothesis that the first mover is better off than the second mover if the second player is non-dominant in the game.

General Model for Non-Collusive Simultaneous Strategy

Most sellers realize that they are competing among themselves, especially for those who are located side-by-side or in different locations but selling similar products of the same brands but they do not have the intention to collude. These sellers are considered as non-collusive and may exhibit their products to consumers either simultaneously or sequentially. For n number of person game, suppose p_i *and* q_i for i=1, 2,3, … , n represent the offered prices and quantities of individual consumers' demand for a commodity respectively the general case of non-collusive is:

$$p_1 = \alpha_0 + \sum_{i=1}^{n} \alpha_i q_i \; ; \; \alpha_1 < 0 \tag{1}$$

$$p_2 = \beta_0 + \sum_{i=1}^{n} \beta_i q_i \; ; \; \beta_2 < 0$$

$$p_3 = \gamma_0 + \sum_{i=1}^{n} \gamma_i q_i \; ; \; \gamma_3 < 0$$

. . . . .

$$p_n = \mu_0 + \sum_{i=1}^{n} \mu_i q_i \; ; \; \mu_n < 0$$

where α_i, β_i, γ_i and μ_i represent the coefficient of the quantity demanded from the first player q_1 and the rest of the quantities q_2 through q_n are possible competitors of the first player in the sale of this product. Equation (1) represents the indirect linear demand function for the first player and the possible competitors of firms operating in the industry. They may be intentionally competing each other or simply do not bother what the other parties are doing.

Defining total revenue $TR(q_i)=p_i q_i$, total cost $TC(q_i)=c_i q_i$ and net revenue as $\pi(q_i)=TR(q_i)–TC(q_i)$, the net revenue equations for n fishing operators are:

$$\pi(q_1) = \alpha_0 q_1 + \sum^{n}_{i=1} \alpha_i q_i q_1 - c_1 q_1;\ \alpha_1 < 0 \qquad (2.1)$$

$$\pi(q_2) = \beta_0 q_2 + \sum^{n}_{i=1} \beta_i q_i q_2 - c_2 q_2;\ \beta_2 < 0 \qquad (2.2)$$

$$\pi(q_3) = \gamma_0 q_3 + \sum^{n}_{i=1} \gamma_i q_i q_3 - c_3 q_3;\ \gamma_3 < 0 \qquad (2.3)$$

. . . . . .

$$\pi(q_n) = \mu_0 q_n + \sum^{n}_{i=1} \mu_i q_i q_n - c_n q_n;\ \mu_n < 0 \qquad (2.n)$$

The general market structure of non-collusive without competition simultaneous strategy refers to the case whereby firms as players operate exclusively independent of their potential competitors. Their objective is to maximize individual net revenues disregarding what other operators are doing. Such form of market strategy is consistent with the management practices that accept the sovereign of consumer's choice. Sellers have not taken an effort to differentiate the specialty of their products. The market is assumed to operate in a perfectly competitive setting so that prices and costs of input are constants. This general form of non-collusive and non-competitive marketing strategy is a case of unconstrained maximization of individual operators' net returns which can be presented as:

$$Max\ \pi(q_i) = \sum^{n}_{i=1} (p_i - c_1)\, q_i \qquad (3)$$

$$\frac{\partial Q(\pi)}{\partial q_1} = \alpha_0 + 2\alpha_1 q_1 + \alpha_2 q_2 + \alpha_3 q_3 - c_1 = 0$$

$$\frac{\partial Q(\pi)}{\partial q_2} = \beta_0 + \beta_1 q_1 + 2\beta_2 q_2 + \beta_3 q_3 - c_2 = 0$$

$$\frac{\partial Q(\pi)}{\partial q_3} = \gamma_0 + \gamma_1 q_1 + \gamma_2 q_2 + 2\gamma_3 q_3 - c_3 = 0$$

. . . . . .

$$\frac{\partial Q(\pi)}{\partial q_n} = \mu_0 + \mu_1 q_1 + \mu_2 q_2 \dots + 2\mu_n q_n - c_n = 0$$

However, if these non-collusive marketing firms participate in contesting the other operators then the rivalry is depicted in their respective reaction functions. The linear reaction functions are obtained based on the partial differentiation of the net return equations with respect to each corresponding output which are presented as:

$$q_1 = \frac{\alpha_0 + \sum_{j=2}^{n} \alpha_j q_j - c_1}{2\alpha_1} \qquad (4.1)$$

$$q_2 = \frac{\beta_0 + \beta_1 q_1 + \sum_{k=3}^{n} \beta_k q_k - c_2}{2\beta_2} \qquad (4.2)$$

$$q_3 = \frac{\gamma_0 + \gamma_1 q_1 + \gamma_2 q_2 + \sum_{l=4}^{n} \gamma_l q_l - c_3}{2\gamma_3} \qquad (4.3)$$

. . . . .

$$q_n = \frac{\mu_0 + \mu_1 q_1 + \dots + \sum_{m=2}^{n-1} \mu_m q_m - c_n}{2\mu_n} \qquad (4.n)$$

The parameters α_1, β_1, γ_1 and μ_1 represent the coefficients of indirect demand functions which are negative. These reaction equations become constraints for the maximization objective of the non-collusive firms and the solution to the problem is given the matrix of equation (5),

$$\begin{bmatrix} 2\alpha_1 & \alpha_2 & \alpha_3 \dots & \alpha_n \\ \beta_1 & 2\beta_2 & \beta_3 \dots & \beta_n \\ \gamma_1 & \gamma_2 & 2\gamma_3 \dots & \gamma_n \\ \cdot & \cdot & \cdot & \cdot \\ \mu_1 & \mu_2 & \mu_3 \dots & 2\mu_n \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ \vdots \\ q_n \end{bmatrix} = \begin{bmatrix} \alpha_0 - c_1 \\ \beta_0 - c_2 \\ \gamma_0 - c_3 \\ \cdot \\ \cdot \\ \mu_n - c_n \end{bmatrix} \qquad (5)$$

Non-Collusive with Competitive Strategy

The strategy is similar to that of non-collusive without competition but they treat all sellers as competitors. The aim of this investigation is to evaluate the impact of these market strategies relative to sequential strategies in terms of output, price and the economic returns. In the non-collusive and competitive marketing strategy, each individual firm is aware of the possible competition from the other players in the market for a particular product and they are working dependently of the other players. This is a case of constraint maximization problem. The competitions between players (sellers) are expressed in terms of their reaction functions. Such non-collusive and competitive firm's behavior is referred to the Cournot equilibrium condition. In reality, competition may exist due to proximity, buying of inputs and materials, choice of reliable suppliers, ethnicity differences and strategic marketing locations of the opponents. The objective of these individual operators is to maximize net revenue subject to the competitors' reaction functions.

For simplicity, only three of these market operators are assumed to compete in the sale of marine fisheries-the small, medium and large fishermen. The small fishers would sell their daily catch directly to the buyers on arrival and p_1 represents on-shore fish price while the catch for small vessel (<25 GRT) is represented by q_1. The price and catch of medium size vessel (25 to < 40 GRT) is represented by p_2 and q_2. Due to their sizeable quantity of catch, this category of fishermen would usually sell their catch to the wholesalers. The fishermen of large vessel operators (40 to < 70 GRT) would normally engage the marketing agents to sell their catches (q_3) to the retailers who could be selling at the local markets or make shipments to the dealers outside the state at the retailing price level (p_3). In general on shore price is cheaper than the wholesale price while the retail price is generally the highest.

The indirect demand functions of fishing operators required for the case of three players; small, medium and large vessel operators are:

$$p_1 = f_1(q_1, p_2) = \varphi_0 + \varphi_1 q_1 + \varphi_2 p_2, \ \ \varphi_1 < 0 \qquad (6.1)$$

$$p_2 = f_2(q_2, p_3) = \eta_0 + \eta_1 q_2 + \eta_2 p_3, \ \ \eta_1 < 0 \qquad (6.2)$$

$$p_3 = f_3(q_3, p_1) = \sigma_0 + \sigma_1 q_3 + \sigma_2 p_1, \ \ \sigma_1 < 0 \qquad (6.3)$$

Where $\varphi_{i,}$ $\eta_{i,}$ σ_i for i=0, 1, and 2 represent the coefficients of quantity consumed (q_j) at the price (p_j) for j=1, 2 and 3 respectively. Equations (6.1) thru (6.3) show the indirect linear demand functions relating price (p_j) to quantity demanded (q_j) and the competitive nature of the players in prices.

The above game formulation indicates that small vessel operator in equation (6.1) is competing against the medium vessel operator such as the case in which traditional line fishing compete with the trawl fishing. As noted if the medium vessel price were to be reduced the small vessel operator would subsequently respond to the move by lowering its price as well and vice-versa. In equation (6.2) the medium vessel category competes against the large vessel fishing operator and equation (6.3) shows that the large vessel operator is expected to compete against the small vessel operator.

To express price in terms of quantity consumed for the first equation, substitute (6.2) into (6.1) and used the resultant equation to substitute p_3 from (6.3) and solve for p_1 and the result is shown in equation (7.1):

$$p_1 = \alpha_0 + \textstyle\sum^3_{i=1} \alpha_i q_i \ ; \ \alpha_i < 0 \qquad (7.1)$$

$$p_2 = \beta_0 + \textstyle\sum^3_{i=1} \beta_i q_i \ ; \ \beta_i < 0 \qquad (7.2)$$

$$p_3 = \gamma_0 + \textstyle\sum^3_{i=1} \gamma_i q_i \ ; \ \gamma_i < 0 \qquad (7.3)$$

Equations (7.1) thru (7.3) show all players in practice could have encountered possible competition from every operator in the market. For instance, the variation in price of p_1 is associated with its own quantity variation q_1 which is the demand for its product and the variations in the competitors' quantities of q_2, q_3 the demand for the similar products in the market. This market competitiveness is similarly applied to the other players as illustrated by prices of the second and third players respectively.

Using the information given in equations (7) the objective function of non-collusive and competitive firms marketing strategies is to maximize their respective net revenues subject to their competitors' reaction equations as shown in equations (8), (9) and (10) below:

$$Max\ \pi(q_1) = \alpha_0 q_1 + \alpha_1 q^2{}_1 + \alpha_2 q_1 q_2 + \alpha_3 q_1 q_2 - c_1 q_1 \qquad (8)$$

Subject to

$$q_2 = \frac{\beta_0 + \beta_1 q_1 + \beta_3 q_3 - c_2}{2\beta_2}$$

$$q_3 = \frac{\gamma_0 + \gamma_1 q_1 + \gamma_2 q_2 - c_3}{2\gamma_3}$$

$$Max\ \pi(q_2) = \beta_0 q_2 + \beta_1 q_1 q_2 + \beta_2 q^2{}_2 + \beta_3 q_2 q_3 - c_2 q_2 \qquad (9)$$

Subject to

$$q_1 = \frac{\alpha_0 + \alpha_2 q_2 + \alpha_3 q_3 - c_1}{2\alpha_1}$$

$$q_3 = \frac{\gamma_0 + \gamma_1 q_1 + \gamma_2 q_2 - c_3}{2\gamma_3}$$

$$Max\ \pi(q_3) = \gamma_0 q_3 + \gamma_1 q_1 q_3 + \gamma_2 q_2 q_3 + \gamma_2 q^2{}_3 - c_3 q_3 \qquad (10)$$

Subject to

$$q_1 = \frac{\alpha_0 + \alpha_2 q_2 + \alpha_3 q_3 - c_1}{2\alpha_1}$$

$$q_2 = \frac{\beta_0 + \beta_1 q_1 + \beta_3 q_3 - c_2}{2\beta_2}$$

The solution to the above constrained non-collusive and competitive simultaneous marketing strategy should be equal to the three matrix solution (5) for a 3x3 matrix. The different between the non-collusive with competition and non-collusive without competition is that they are rival firms, individuals or groups of fishers expected to response upon the action of the other firms in accordance with their reaction cures.

Collusive Simultaneous Strategy

The firms can choose to collude for several reasons such as to assist firms with financial problems, enlarge its working capital for viable investment undertakings, improve the performance of smaller firm under successfully proven new management groups and to merge for economic of scale or to take advantage of the government financial assistance for pioneer companies. In the current theoretical construct, the merging firms would come under a single management such that their net returns will be combined and they are forced to work as a team in an attempt to handle the market in formally organized production and marketing system. The decision making is made by the consensus of management personnel which is assumed to be superior to a one man system.

With the assumption collusive management decision is to limit total production such that prices offered by these firms which operate independently and sell differentiated products will be increased in accordance with their respective demand functions. The objective of a collusive strategy is to maximize the total firm's net returns of three individual firms subject to the total potential output set at Q. This objective function with firms' output constraints can be written mathematically as:

$$Max\,\pi(Q) = \pi(q_1) + \pi(q_2) + \pi(q_3) + \lambda(Q - q_1 - q_2 - q_3) \quad (11)$$

$$\frac{\partial(\pi)}{\partial q_2} = \alpha_0 + 2\alpha_1 q_1 + \alpha_2 q_2 + \alpha_3 q_3 - c_1 - \lambda = 0$$

$$\frac{\partial(\pi)}{\partial q_2} = \beta_0 + \beta_1 q_1 + 2\beta_2 q_2 + \beta_3 q_3 - c_2 - \lambda = 0$$

$$\frac{\partial(\pi)}{\partial q_3} = \gamma_0 + \gamma_1 q_1 + \gamma_2 q_2 + 2\gamma_3 q_3 - c_3 - \lambda = 0$$

$$\frac{\partial(\pi)}{\partial \lambda} = Q - q_1 - q_2 - q_3 = 0$$

Solution to the collusive simultaneous marketing strategy for the case of three operating firms is given in the following matrix:

$$\begin{bmatrix} 2\alpha_1 & \alpha_2 & \alpha_3 & 1 \\ \beta_1 & 2\beta_2 & \beta_3 & 1 \\ \gamma_1 & \gamma_2 & 2\gamma_3 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ \lambda \end{bmatrix} = \begin{bmatrix} \alpha_0 - c_1 \\ \beta_0 - c_2 \\ \gamma_0 - c_3 \\ Q \end{bmatrix} \quad (12)$$

Sequential Strategy

The sequential strategy is a constrained maximization problem. The firm's objective is to maximize its net return subject to other firms' reaction functions that compete in the marketing of fishermen catch, namely the small, medium and large vessel operators as players in the game. In sequential strategy, there will be the first mover and then followed by the rest of the players. Suppose the small boat fishermen started first in the marketing of their catches that will be followed by the medium and subsequently by the large boat fishermen.

The first mover's objective function is identical to the constrained maximization problem shown in equation (8) subject to the constrained reaction equations of the second (medium vessel) and the third (large vessel) operators respectively. Unlike the case of two players, these reactions equations cannot be substituted directly into the objective function because of the presence of the third player, they need to be modified by substituting RHS of the third player reaction function into the second player. The result of the second modified reaction equation and the third operator reaction equations are shown as:

$$Max\,\pi(q_1) = \alpha_0 q_1 + \alpha_1 q^2{}_1 + \alpha_2 q_1 q_2 + \alpha_3 q_1 q_2 - c_1 q_1 \quad (13)$$

Subject to

$$q_2 = \frac{\rho_0}{\theta_0} + \frac{\rho_1}{\theta_0} q_1 - \frac{\rho_2}{\theta_0} \quad (13.1)$$

$$q_3 = \frac{\omega_0}{\theta_0} + \frac{\omega_1}{\theta_0} q_1 - \frac{\omega_2}{\theta_0} \quad (13.2)$$

Substituting equations (13.1) and (13.2) in the net return objective function and differentiating the equation with respect to the quantity of catch of small vessel fishermen q_1 and setting the result to zero (assuming that cost incurred in marketing is negligible since fishermen sold their catches directly after landing) we can obtain the quantity of output for small fishermen as the first mover as in equation (14.1), the second mover in (14.2) and third mover in (14.3) respectively:

$$q_1^* = \frac{\alpha_0\theta + \alpha_2\rho_1 + \alpha_3\omega_0 - (\alpha_2\rho_2 + \alpha_3\omega_2)}{2(\alpha_1 + \alpha_2\rho_1 + \alpha_3\omega_1)} \tag{14.1}$$

$$q_2^* = \frac{\rho_0}{\theta} + \frac{\rho_1}{\theta} q_1^* - \frac{\rho_2}{\theta} \tag{14.2}$$

$$q_3^* = \frac{\omega_0}{\theta} + \frac{\omega_1}{\theta} q_1^* - \frac{\omega_2}{\theta} \tag{14.3}$$

The optimal condition in equation (14.1) represents the quantity of sale for the first mover, while those optimal quantities in equations (14.2) and (14.3) are referred to sales of the second and the third movers respectively. The second and third movers are followers that sequentially come after the first mover which in this case is the small vessel operator. With the given scenario the previous results of the collusive, non-collusive simultaneous marketing strategy can be compared to the sequential outputs strategy. It is generally hypothesized that the first mover will have generated higher returns because of the opportunity to have the first hand on the market share.

Optimal quantities of q_1^*,$q_2^*$and q_3^*can be used to derive the net economic returns for the small size vessel as the first mover, medium size and large size vessel fishermen as the followers after obtaining the efficient prices for the respective operators. Being the first mover it is expected that small fishermen are able to benefit from potential price offered to the consumers due to the shortage and uncertainty of supply than the followers who will become price takers when the remaining market begins to rise as more fishermen landed their catches. This means the follower is left with lower price as market supply tends to increase subsequently as more fishermen return home.

The data for this analysis were reassembled from the Annual Fisheries Statistics 2009 published by the Department of Fisheries Malaysia, Kuala Lumpur. Prices were reported at the ex-shore, wholesale and retail levels and their trends were more or less fluctuated accordingly following the patterns set forth by the original shore prices. Twenty six fish species were selected for the analysis based on the intensity of these species caught as recorded by the Department of Fisheries Malaysia.

The distribution of data seems to explain the fact that prices offered to the market follow the law of demand. In general, the more the quantity of species of fisheries caught, the lower are their prices and vice-versa. In other words, fish species that are scarcely caught will generally fetch higher prices than those which are caught in plenty. Based on this assumption the relationship between price and quantity of fish caught is expected to be inversely related. The relationships between catches of large, medium and small vessels and the retail price of various species of fish caught during the year of 2009 reflect that of the demand equations.

Results and Discussion

This section is presented in two parts. The first part presents the results of the regression analyses using SHAZAM econometric package and the calculations using Excel spread sheet. Ex-shore, wholesale or retail prices were used as the dependent variable which were regressed against quantity demanded and the competing price of the other fisherman shown in Table1. The second part discusses the results of the simultaneous non-collusive and collusive games and the sequential strategy for deciding on a policy that should be most appropriate to improve the condition of the small fishermen in relation to medium and large fishermen.

The results of regression analyses of the indirect demand functions for the catch of small,

---

Notes:

$\rho_0 = \frac{\beta_0}{2\beta_1} + \frac{\beta_2\gamma_0}{4\beta_1\gamma_1}$, $\rho_1 = \frac{\beta_2}{2\beta_1} + \frac{\beta_2}{4\beta_1\gamma_1}$, $\rho_2 = \frac{\beta_2 c_3}{4\beta_1\gamma_1} - \frac{c_2}{2\beta_1}$, $\theta = 1 - \frac{\beta_3\gamma_2}{4\beta_2\gamma_3}$,
$\omega_0 = \frac{\gamma_0}{2\gamma_1} + \frac{\gamma_3}{4\gamma_1}\frac{\beta_0}{\beta_2}$, $\omega_1 = \frac{\gamma_1}{2\gamma_3} + \frac{\gamma_2}{4\gamma_3}\frac{\beta_1}{\beta_2}$, and $\omega_2 = \frac{c_2\gamma_2}{4\beta_2\gamma_3} - \frac{c_3}{2\gamma_3}$

medium and large vessels are presented in Table 1. Apparently, there is a high correlation between prices at the three marketing levels, that is, the ex-shore, wholesale and retail prices is observed. Evidently this is true since individual fish price movements tend to change in proportion with the marketing levels to which they are sold, that is, the highest for the retail price and lowest for the ex-shore price. High price correlation such as between the retail and the wholesale price is indicated by the large t-values of regression coefficients of the estimated regressions. As observed their coefficients are generally exhibited a high degree of statistical significant of 0.01 probability level. In all cases the estimated equations showing the relationship between price and quantity of fish sold as less significantly different from zero. Despite this shortcoming the results of the regression estimations between prices and quantities were inversely related and appropriate to represent the indirect demand functions for the current investigation.

Association between price at different levels shows that an increase in price of say retailer would initiate an increase in the price of the wholesaler. Similarly the price of ex-shore operating fisher would be raised following an increase in the price of the wholesaler, and the retail price would automatically be raised when the ex-shore price rises. The reason for an increase in the ex-shore price could have been caused by the shortage of catch that would affect the wholesale price and subsequently the retail price.

Information on the estimated regression equations of Table 1 will be utilized to express price as a function of small vessel catch (q_1), medium vessel catch (q_2) and the large vessel catch (q_3). The results of estimated price-quantity relationships are shown in Table 2. Transforming price as a function of all types of catch is necessary for the purpose of optimization and derivation of the reaction equations in association with collusive and non-collusive marketing strategy. The calculated price-quantity relationship equations provide approximations for prices related to all cases of non-collusive, collusive simultaneous and the sequential marketing strategy analyses.

The optimal catch based on reaction equations for non-collusive and collusive simultaneous strategy for small, medium and large fishermen are presented in Table 3. These optimal catches for the unconstrained non-collusive and non-competitive strategy are obtained from net revenues maximization objective shown in equation (5) for the case of three players. However, if fishermen were involved in the strategic game, then each player will react to other players simultaneously. In such a case, individual non-collusive fishermen become competitors with the reaction equations as shown in Table 3.

The reaction equations presented in the table are the simplified cases that show only the corresponding reactions of firm q_2 (medium) and q_3 (large) to the small catch (q_1) when maximization objective is π_1. Hence, given the optimal catch of small fishermen of 937.8 metric tons the optimal catch of sale for medium fishermen should be around 1,227.8 metric tons while large fishermen's optimal catch is 2,979.1 metric tons.

As shown in Table 3, the collusive simultaneous strategy is also presented for two cases of constrained maximization with the total catch of 4,550 and 5,050 metric tons respectively. One of the objectives of collusion for operating fishermen firms is to monopolize the market by manipulating price to move upward that could bring additional net return to the collusive firms. The concept of collusion used here is somewhat different from mergers and acquisitions. Merger is generally defined as the amalgamation of two or more firms of about equal size as a single entity and agreed upon appointment of a new CEO to manage the company. Acquisition involves the takeover or purchase of one company by another and the new ownership is established. In collusion individual firms still retain some control of the business and decided on the quantity of output assigned to produce for the market in the final analysis profits might

Table 1: Results of the Regression Analyses for Small, Medium and Large Fishermen.

	Constant	Catch of Small Vessel (q_1)	Catch of Medium Vessel (q_2)	Catch of Large Vessel (q_3)	Wholesale Price (p_2)	Retail Price (p_3)	Ex-Shore Price (p_1)	R^2	D-W
p_1	-0.75553	-2.962E-05			0.9153			0.999	1.825
	(-6.444)***	(-0.4059)^{NS}			(158.6)***				
p_2	-0.84651		-2.814E-05			0.89193		0.999	1.94
	(-10.280)***		(-1.232)^{NS}			(253.8)***			
p_3	2.0249			-1.46E-05			1.2189	0.998	1.778
	(8.716)***			(-0.2795)^{NS}			(101.3)***		

Notes: Figures in brackets denote t-values
*** Significant at 0.01 probability level
** Significant at 0.05 probability level
* Significant at 0.10 probability level
^{NS} Not significant

Table 2: Estimated Price-Quantity Relationships for Small, Medium and Large Fishermen.

	Constant	Catch of Small Vessel (q_1)	Catch of Medium Vessel (q_2)	Catch of Large Vessel (q_3)	Wholesale Price (p_2)	Retail Price (p_3)	Ex-Shore Price (p_1)
p_1	-0.75553	-0.00002962			0.91530		
p_2	-0.84651		-0.00002814			0.89193	
p_3	2.02490			-0.00001463			1.21890
p_1	25.00030	-0.0060320	-0.0052450	-0.0024325	0	0	0
p_2	28.13923	-0.0065576	-0.0057308	-0.0026576	0	0	0
p_3	32.49777	-0.0073522	-0.0063936	-0.0029796	0	0	0

be shared according to their size and cost. The firms can still be operating in a competitive environment to stimulate business activity and profitability. Under the above assumptions the optimal catch to collusive marketing strategy should be consistent to the matrix solution in equation (12).

As apparent the total catch is highest for the non-collusive strategy, while the constrained collusive strategy of Q=4550 MT has the lowest total catch. The reduction in total catch for a collusive marketing strategy may have the impact of raising price given the demand equation is downward slopping. It would then be meaningful to investigate which marketing strategy yields the highest economic return to the fishermen.

Table 3: Optimal Catches (in MT) Based on Operator's Reaction Equations.

Objective	Reaction Equations for Non-Collusive Strategy				Non-Collusive Simultaneous Strategy (Q)	Collusive Simultaneous Strategy	
						Q = 4550	Q =5050
Max π_1 s.t	q_2 =	1584.887	-0.38080	q_1	1227.8	1054.4	1200.1
	q_3 =	3752.994	-0.82520	q_1	2979.1	2762.2	2944.5
Max π_2 s.t	q_1 =	1294.886	-0.29082	q_2	937.8	733.3	905.3
	q_3 =	3855.852	-0.71411	q_2	2979.1	2762.2	2944.5
Max π_3 s.t	q_1 =	1337.634	-0.13420	q_3	937.8	733.3	905.3
	q_2 =	1689.765	-0.15508	q_3	1227.7	1054.4	1200.1

Notes: When production quota is set at Q=4550 MT the efficient price λ = RM3.904 and for Q = 5050 MT, the value of efficient price, λ = RM0.622.

A larger volume of total catch derived from maximization problem under the non-collusive marketing strategy has the possibility of leading fish resource to over-exploitation while leaving greater impact of waste and damages to the environment. Nonetheless, a greater volume of total catch would serve the economy precisely if food security were the objective of reducing food demand for the growing population.

In other words, there may be several criteria that can be considered in selecting a particular strategy. In game theory players normally choose the equilibrium strategy that yields the best outcomes to both parties. The decision to adopt a strategy with the highest return from the player's standpoint may not serve to give the best return to the society's welfare. The society's welfare can be measured by consumer surplus—the bigger the consumer surplus the better is the society. If the highest possible return to the economy such as its contribution to the gross domestic product (GDP) is the aim, then decision would most likely be different under these marketing systems. The ultimate policy objective is to help the small fishermen improve their livelihoods from fishing activities via choosing an appropriate marketing strategy that yields the highest return.

Table 4 illustrates average catch, price and return for small, medium and large fishermen under non-collusive and collusive simultaneous marketing strategy. As evident, the total annual catch potential among the fishing operators goes to the large vessel fishermen followed by medium vessel and small vessel fishermen. Since the demand function is downward slopping, the higher the total catch the lower is the price. This is noted from the average price per kg of catch of non-collusive relative to the collusive strategy. Combining total catch for small, medium and large the non-collusive (5114 MT) has the lowest average price per kg relative to collusive with Q=5050 MT and collusive Q=4550 MT.

Further it is clear that small (ex-shore), medium (wholesale) and large (retail) fisher prices are in the ascending order, that is, the highest price goes to retailers which is associated with the large vessel owners because they can afford to penetrate wider local and domestic markets. The wholesale price is assumed to be associated with the medium operators and the ex-shore price is generally refers to the small fishermen who sell their catch upon landing.

As noted from Table 4, the greatest volume of total catch does not necessarily yield the

Table 4: Catch, Average Price and Net Returns for Non-collusive and Collusive Marketing Strategies.

	Non-Collusive Strategy	Collusive Simultaneous Marketing Strategy	
		Q = 4550	Q =5050
Catch per year (MT)			
Small	937.76	733.33	905.31
Medium	1,227.76	1,054.43	1,200.15
Large	2,979.25	2,762.24	2,944.54
Average Price (RM/kg)			
Small	5.66	8.33	6.08
Medium	7.04	9.95	7.50
Large	8.88	12.13	9.39
Net Return (RM/yr.)			
Small	5,305.02	6,106.63	5,506.19
Medium	8,638.63	10,488.10	9,000.36
Large	26,445.05	33,517.71	27,663.81
Total Return	40,388.71	50,112.44	42,170.36

Table 5: Results of Sequential Marketing Strategy for Small, Medium and Large Fishermen.

		Catch (MT/yr.)	Price (RM/kg)	Return (RM/yr.)
(I) First Mover:	Small	1,864.22	3.78	7,044.77
Followers:	Medium	874.99	5.01	4,387.54
	Large	2,214.64	6.60	14,613.59
(II) First Mover:	Medium	2,440.55	4.70	11,471.40
Followers:	Small	585.12	3.53	2,065.10
	Large	2,113.03	6.30	13,303.46
(III) First Mover:	Large	5,921.88	5.93	35,115.10
Followers:	Small	542.89	3.27	1,777.78
	Medium	771.38	4.42	3,410.06

highest monetary return to the fishers under this optimum condition. Despite the influence of elasticity of demand equation the finding seems to support that the collusive simultaneous strategy with the lowest total catch Q=4550 MT could result in the highest total monetary return of RM50112.44 per annum. For collusive simultaneous strategy Q=5050 MT the monetary return is RM42170.36 and for non-collusive simultaneous strategy Q=5144.7 MT, the monetary return is approximated at RM40388.71 per annum.

Table 5 shows the results of catch, price and return for the sequential marketing strategy for small, medium and large fishermen. Under net revenue maximization problem an optimal sequential marketing strategy suggests that the first mover is always at the advantage in catch and monetary returns relative to the followers. For instance, if the Small fishermen were to take the lead as first mover the quantity of catch marketed would be 1,864MT per year in (I) compared to 585.2 MT and 542.9 MT per year as followers in (II) and (III) part respectively.

The first mover domination in amount of catch marketed is also observed in the case of Medium fishermen (II) 2440.6 MT per year as compared to 875 MT in (I) and 771.4 MT per year in (III). Similarly, the catch supremacy of first mover is evident for the large fishermen with 5921.9 MT per year in (III) relative to 2,214.6 MT in (I) and 2,113 MT per year in (II). By virtue of huge differences in the amount of catch marketed the monetary returns for all cases of the first mover dominate that of followers (Table 5). For instance, the first mover monetary return of RM7044.77 for small fishermen is significantly higher than RM2065.10 in (II) and RM1777.78 in (III) as followers respectively. This technical supremacy of the first mover over the followers suggests that things can work best under perfect conditions of optimality.

The last observation about the sequential marketing versus the non-collusive and collusive simultaneous marketing strategy relates to the efficient price level under these strategies. As disclosed, efficient prices in the sequential marketing strategy are generally lower than those under the simultaneous non-collusive and collusive marketing strategy. As such, the monetary returns attained under the sequential are normally lower than the simultaneous marketing strategy.

However, this does not preclude the fact that in rare cases it is most likely the first mover monetary return might supersede the monetary return of any return obtained by simultaneous marketing operators. For example, large fishermen monetary return of the first mover is approximated at RM35,115 per year (Table 5) while the highest monetary return of the collusive simultaneous strategy recorded a value of RM33,517 per year (Table 4).

Conclusion

The application of game theory has become more diverse across multi-disciplines following the publication of popular Nash equilibrium strategy. In economics the theory has developed sufficiently, however, the application has been rather limited. A special attention is therefore given in this study. It is mainly focused on the parametric aspect of the game strategy namely that of non-collusive, collusive simultaneous and the sequential strategy in the marketing of small, medium and large boat-size fishermen's outputs.

The Steckelberg sequential model is generally superior to Cournot simultaneous collusive and non-collusive in terms of society's welfare since consumers' surplus for this model is highest by virtue of its lowest efficient price compared to other models considered in this study. Since the demand function is linear the value of consumers' surplus can be easily estimated. The message here is that if the society's welfare is of paramount importance in policy formulation than the individual's firm, the sequential model is most appropriate. The simultaneous, specifically the collusive strategy, in most cases tends to impose high efficient price because of the possibility of market manipulation on quantity-price relationship. The finding is consistent with experimental result found by Steffen *et al*., (2001) which stated that, "*Stackelberg markets yield higher welfare than Cournot markets. This is independent of the matching scheme*." (p. 757).

Finally, for a policy that favors the largest economic return to the economy as the ultimate goal we found the non-collusive competitive simultaneous strategy is most appealing. Under competitive market the dominant firms are free to choose the level that suit them best and the consideration for the smaller firms which are less dominant will have to bear the consequence of inefficiency in competition.

References

Adnan, H., (2005). Using Genetic Algorithms to Develop Strategies for the Prisoner's Dilemma, Munich Personal RePEc Archive (MPRA) Paper No. 28574, Pakistan Institute of Development Economics: Islamabad, 1-13.Online at http://mpra.ub.uni-muenchen.de/28574/

Bluedorn, A. C. (1993). Pilgrim's Progress: Trends and Convergence in Research on Organizational Size and Environments, *Journal of Management* 19 (Summer), 163-192.

Carvalho, N., Jones, G. E., & Isidro, E. (2011). Defining Scale in Fisheries: Small Versus Large-scale Fishing Operations in the Azores. *Fish. Research,* 109: 360-369.

Cohen, W. M., & Klepper, S. (1996). Firm Size and the Nature of Innovation within Industries: The Case of Process and Product R&D, *Review of Economics and Statistics,* 78(2): 232-243.

Denis, J. E., & Depelteau, D. (1985). Market Knowledge, Diversification, and Export Expansion, *Journal of International Business Studies,* 16(4): 77-89.

Hamilton, J. H., & Slutsky, S. M. (1990). Endogenous Timing in Duopoly Games: Stackelberg or Cournot Equilibria. *Games and Economic Behavior,* 2: 29-46.

Holt C. A., & Roth A. E. (2004). The Nash Equilibrium: A Perspective. *PNAS March,* 23. 101(12): 3999-4002.

Li, T., Nicholls, J. A. F., & Roslow, S. (2003). Organizational Motivation and the Global Concurrent Launch in Markets with Accelerated Technology: A Conceptual Framework and Research Propositions, *International Business Review,* 12(10): 563-579.

Neumann, J. V., & Morgenstern, O. (1944). *Theory of Games and Economic Behavior.* Princeton, NJ: Princeton University Press.

Nicholson, W. (1997). *Intermediate Micro-economics and Its Application* (7th Ed). Philadelphia: Dryden Press, 345-347.

Nik Hashim, N. M. (2008a). Steady State and Intertemporal Management Models for Marine Fisheries. *Journal of Natural Resource Modeling,* 21(1): 148-177.

Nik Hashim, N. M. (2008b). Strategies of Game Theory in Marketing of Marine Catch for Small, Medium and Large Fishermen, Achieving a Sustainable Future: Managing Aquaculture, Fishing, Trade and Development, NhaTrang,Vietnam.

Pauly, D. (2006). Towards Consilience in Small-scale Fisheries Research. *Maritime Stud. (MAST),* 4(2): 7-22.

Perry, M. K., & Porter, R. H. (1985). Oligopoly and the Incentive for Horizontal Merger. *American Economic Review,* 75(1): 219-227.

Robinson, W. T., & Min, S. (2002). Is the First to Market the First to Fail? Empirical Evidence for Industrial Goods Businesses. *Journal of Marketing Research,* 39(Feb): 120-128.

Ruttan, L. M., Gayanilo, F. C., Sumaila, U. R., & Pauly, D. (2000). Small Versus Large-scale Fisheries: A Multi-species, Multi-fleet Model for Evaluations and Potential Benefits. In Pauly, D., Pitcher, T. J., (eds.) *Fisheries Centre Research Reports,* 8(2): 64-75.

Steffen, H., Konrad, K. A., & Muller, W. (2005). Merger without Cost Advantages, *CESIFO* Working Paper No. 1461.

Steffen, H., Normann, & Hans-Theo. (2001). Stackelberg Beats Cournot: On Collusion and Efficiency in Experimental Markets, Economic Journal 111(474): 749-765.

Steffen, H., & Konrad, K. A. (2001). Big Fish Eat Small Fish: On Merger in Stackelberg Markets. *Economic Letters,* 73(2): 213-217.

Therkildsen, N.O. (2007). Small Versus Large-scale Fishing Operations in New England, USA. *Fish. Research,* 83: 285-296.

Thomson, D., FAO. (1988). The World's Two Marine Fishing Industries—How They Compare. Naga. *The ICLARM Quart*, 11(3): 17.

Utne, I. B. (2008). Are the Smallest Fishing Vessels the Most Sustainable?—Trade-off Analysis of Sustainability Attributes. *Marine Policy,* 32(3): 465-474.