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**“TRANSACTION COSTS IN FISHERIES CO-MANAGEMENT:
A COMPARATIVE STATICS FRAMEWORK”**

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management body as in Nik Mustapha *et. al* (1998), namely information costs (*I*), decision costs (*D*) and enforcement costs (*E*). We assume that the co-management objective is to minimise these costs subject to providing a specified level of service (output) rendered. We formalise this main objective as a constrained optimisation problem in which the body seeks to minimise its operating costs, and we outline a preliminary comparative statics framework of the optimisation exercise. In laying out the basic model, our concern is not to “find the minimum,” but we assume that an optimum is achieved and we seek to base predictions of behavioural responses in the assumption that optimisation will continue. In assuming the attainment of this minimum, our interests' lies in the consequences that can be deduced namely, how changes in each component's costs will affect the behaviour of the co-management especially in context of the body's secondary objective of minimising or reducing its enforcement costs.

I. INTRODUCTION

Fisheries co-management as an alternative to centralised command and control fisheries management is often suggested as a solution to the problems of fisheries resource use conflicts and over exploitation. One of the major function of fisheries co-management systems is the shifting of some extent of control, administration and enforcement from the central authorities to the users (fishers) and user community. This reduction in both authority and responsibility by the central agencies through co-management is alleged to lead to improved resource use outcomes as measured by economic efficiency, equity and ecosystem (natural and human) sustainability.

One of the purported advantages of co-management compared to centralised management is that it will reduce transaction costs. Hanna (1995) points out that a centralised approach is often associated with low programme design cost, but high implementation, monitoring, and enforcement costs as the management regime may have little legitimacy with user groups. A co-management approach, on the other hand, is associated with high programme design costs, as effective participation is time consuming and therefore costly. However, co-management is likely to lead to lower implementation, monitoring, and enforcement costs as legitimacy of the regime is greater.

Nik Mustapha et. al (1998) broadly categorised transaction costs in fisheries co-management into three major categories namely information costs, collective fisheries decision-making, and lastly collective operational costs. The latest cost item comes in three forms: (i) monitoring, enforcement, and compliance costs (ii) resource maintenance costs, and (iii) resource distribution costs. It is well documented that monitoring, enforcement and compliance costs in fisheries management can be substantial. The ability to minimise these transaction costs is therefore critical towards the sustainability of the fisheries co-management.

Our objective of this paper is therefore to develop a preliminary comparative statics framework towards operationalising earlier conceptual analysis of these transaction

costs in fisheries co-management. A constrained optimisation approach will be used in the analysis and behavioural responses will be deduced when the management objective is set towards minimising or reducing enforcement costs, which forms the most significant component of transaction costs in fisheries co-management.

II. THE MODEL

We begin with the problem description. A co-management body (hence to referred as the agent) sustains costs in maintaining a fisheries co-management. It sustains three (3) types of transaction costs, respectively information (I), collective decision (D) and enforcement (E)¹. We assume that the agent attempts to minimise these transaction costs subject to maintaining a certain level of service (output).

We next introduce the possibility of conducting an analysis of the above decision variables within a comparative static framework. The agent sustains a specified level of transaction costs in providing a specified level of operation or service. It seeks to spread out the costs of each respective components of these transaction costs in an optimal way with its main objective being that of minimising its total transaction costs. In context of the above statements, the agent's attempt can be represented mathematically as a single constrained optimisation problem.

Having said above, let r , v and w be the respective per unit costs of the factors I , D , and E . The agent's objective is thus to minimise the transaction costs function² subject to the constant level of service (output) provided i.e.

$$(1) \quad \text{Min } C = rI + vD + wE \quad \text{subject to}$$

$$(2) \quad S_0 = F(I, D, E)$$

¹ See Nik Mustapha et. al (1988) for a heuristic outline and documentary evidence of these types of transaction costs.

² We assume for simplicity initially that this transaction cost function is linear.

Forming the Lagrangean, we have:

$$(3) \quad L(I, D, E, I) = C(I, D, E) + I(S_0 - F(I, D, E))$$

Alternatively, we can also let vector Z represent the optimal levels of the types of service costs (I, D, E) and vector x the unit cost of each cost component (r, v, w). In this form, the agent's objective function becomes

$$(4) \quad \text{Min } C = \sum_{i=1}^3 x_i Z_i \text{ subject to}$$

$$(5) \quad S_0 = F(Z_i)$$

$$\text{i.e. } x_1 = r, x_2 = v, x_3 = w \text{ and } Z_1 = I, Z_2 = D, Z_3 = E$$

and the Lagrangean becomes

$$(6) \quad L(Z, I) = xZ + I(S_0 - F(Z))$$

Differentiating (6) with respect to each of the endogenous variables, and equating the first order derivatives to zero, we have:

$$(7a) \quad x_i - I \frac{\partial F}{\partial Z_i} = 0,$$

$$(7b) \quad S_0 - F(Z_i) = 0$$

Mathematically, we want to solve (7a-b) for each of Z_i in terms of x_i . If we assume that the left side of each equation (7a-b) is continuously differentiable and that solutions exist, then by the implicit function theorem, Z^* will be continuously differentiable functions of x if the Hessian Matrix³ is non singular at the optimal costs $C^*(Z^*, s)$. Therefore if H is non singular⁴, we can then solve (7a-b), and we substitute these results in (1) to obtain the optimal values of the transaction cost function.

The values of Z_1 or I , Z_2 or D and Z_3 or E which solve (1) must also satisfy (7a,b) as from (7a) we have

$$(8) \quad I = \frac{x_i}{\partial F / \partial Z_i} \quad i = 1, 2, 3$$

³ The Hessian matrix or Hessian determinant is simply the matrix formed by the second partials of the Lagrangean FOCs.

⁴ Det H does not equal zero.

In (7a), these first order derivatives are the marginal cost of each transaction component and $\frac{\partial F}{\partial Z_i}$ is the service level extended by this extra cost. The ratio (equation 8) is thus the cost per unit of obtaining more service by using more of input i .

Solving (7a-b), we obtain the optimal values of Z , in terms of x , and s i.e.

$$Z^*(x, S_0)$$

and substituting the optimal cost components into (1) we have the agent's conditional (or indirect) transaction cost function:

$$C^*(r, v, w, S_0) = xZ(r, v, w, S_0)$$

i.e. $Z(r, v, w, S_0)$ is the vector consisting of $I^*(r, v, w, S_0)$, $D^*(r, v, w, S_0)$ and $E^*(r, v, w, S_0)$

However, it must be stressed here that in laying out this basic framework, our concern is not to “find this minimum”. Instead we assume that the agent achieves the optimum I_1^*, D^*, E^* , and we seek to base predictions of the agent's behavioural responses that optimising will continue⁵. Namely in “assuming” that this minimum is attained, our interests' lies in the consequences that can be deduced specifically, how changes in each component's costs will affect the behaviour of the agent. So in our three factor case, we hope to yield possible refutable implications for the response of any component namely I , D , and E to a change in the per unit cost namely r , v , and w . This will be conducted in section IV.

⁵ Of course solving for a constrained optimum is the usual norm in comparative statics exercise. However, this is not our objective in this paper. We therefore assume that the Hessian matrix is negative and this result enables us in section IV to use the implicit function theorem in order to conduct some preliminary comparative statics of the model.

III. Interpretation of the Lagrange Multiplier⁶.

The Lagrange Multiplier above can also be given an interesting interpretation in context of its usage. Consider

$$C(r, v, w, S_0) = xZ(r, v, w, S_0)$$

Differentiating with respect to S_0 , we have:

$$(9) \quad \frac{\partial C(r, v, w, S_0)}{\partial S_0} = \sum_{i=1}^3 x_i \frac{\partial Z_i(r, v, w, S_0)}{\partial S_0}$$

Since (6a) is satisfied, this gives us:

$$(10) \quad \sum_{i=1}^3 x_i \frac{\partial Z_i(r, v, w, S_0)}{\partial S_0} = I \sum_{i=1}^3 \frac{\partial F}{\partial Z_i} \frac{\partial Z_i(r, v, w, S_0)}{\partial S_0}$$

and similarly, differentiating (6b) with respect to S_0 , we have:

$$(11) \quad 1 = \sum_{i=1}^3 \frac{\partial F}{\partial Z_i} \frac{\partial Z_i(r, v, w, S_0)}{\partial S_0}$$

Hence, (9), (10), and (11) imply $\frac{\partial C(r, v, w, S_0)}{\partial S_0} = I$. Thus our Lagrange multiplier I

is the marginal cost of the service (output) rendered, $\frac{\partial C}{\partial S_0}$, that is, the increase in the agent's total transaction costs when one more unit of service is provided.

IV. Some Comparative Statics

Consider the agent now choosing the levels of I, D , and E the choice or endogenous variables, and r, v, w the parameters or exogenous variables determined by conditions beyond the agent's influence or control. We assume that the agent responds to changes in the exogenous variable(s) by making a different set of choices in order to

⁶ This Lagrange multiplier I is significant in our analysis. It is usually interpreted as the rate of change of the optimal value relative to some parameter.

re-minimise the costs in providing the specified level of services within the changed context⁷.

Let F be the vector-valued function defined for points $((I, I, D, E, r, v, w) \in \mathfrak{R}^7$ and taking values in \mathfrak{R}^4 whose components are given by the left sides of equation (12) below. By the implicit function theorem, the equation

$$(12) \quad F(I, I, D, E, r, v, w) = 0$$

may be solved in the form

$$(13) \quad \begin{bmatrix} I \\ I \\ D \\ E \end{bmatrix} = G(r, v, w)$$

The Jacobian matrix for G is given as in (14).

$$(14) \quad \begin{bmatrix} \frac{\partial I}{\partial r} & \frac{\partial I}{\partial v} & \frac{\partial I}{\partial w} \\ \frac{\partial I}{\partial r} & \frac{\partial I}{\partial v} & \frac{\partial I}{\partial w} \\ \frac{\partial D}{\partial r} & \frac{\partial D}{\partial v} & \frac{\partial D}{\partial w} \\ \frac{\partial E}{\partial r} & \frac{\partial E}{\partial v} & \frac{\partial E}{\partial w} \\ \frac{\partial r}{\partial r} & \frac{\partial v}{\partial v} & \frac{\partial w}{\partial w} \end{bmatrix} = -H^{-1} \begin{bmatrix} -I & -D & E \\ -I & 0 & 0 \\ 0 & -I & 0 \\ 0 & 0 & -I \end{bmatrix}$$

These partial derivatives are the comparative statics of this model that will be used to predict adjustments in the agent's responses⁸. The i th row in the last matrix on the right of (14) is simply obtained by differentiating the i th left side in (13) with respect to r then v , and then w .

Let C_{ij} be the cofactor (signed minor determinant) of the element in the i th row and j th column of H . Inverting H by using the method of cofactors gives us:

⁷ For example, if r should increase, with v and w constant, we may expect the agent's adjustment to be that of decreasing I and increasing D or decreasing E .

⁸ The usefulness of this model can be determined by how accurately it can predict adjustments in the agent's behaviour.

$$H^{-1} = \frac{1}{\det H} C^T \text{ where } C = C_{ij}.$$

Having done this, we are now in the position to derive some comparative static results. For example, how does I change when its costs per unit increases? We find that

$$(15) \quad \frac{\partial I}{\partial r} = \frac{-1}{\det H} [-IC_{12} - IC_{22}]$$

Computing C_{12} and C_{22} , we have,

$$C_{22} = -v^2 C_{EE} - w^2 C_{DD} + 2wv C_{ED}$$

and

$$C_{12} = r[C_{DD}C_{EE} - (C_{ED})^2] - v[C_{ID}C_{EE} - C_{ED}C_{IE}] + w[C_{ID}C_{DE} - C_{DD}C_{IE}]$$

Or we might also ask: How does the amount of service cost rendered upon E change when w change? We find that

$$(16) \quad \frac{\partial E}{\partial w} = \frac{-1}{\det H} [-IC_{44} + EC_{14}]$$

where

$$C_{44} = -(r^2 C_{II} + v^2 C_{DD}) + 2rv C_{ID}$$

and

$$C_{14} = r(C_{DI}C_{ED} - C_{EI}C_{DD}) - v[C_{II}C_{ED} - C_{EI}C_{ID}] + w[C_{II}C_{DD} - (C_{ID})^2]$$

At this stage, for example as in (15) signs of C_{EE} , C_{DD} , C_{ED} are crucial in order for us to determine as to whether $C_{22} > 0$ or otherwise. Without these signs posited from theory, this comparative static exercise will be futile. For instance, we can observe the neo-classical case of a consumer maximising utility $U = u(X, Y, L)$ under an income constraint where X , and Y are goods and L is leisure. As for the signs of U_{XX}, U_{YY}, U_{LL} , again neo-classical micro tells us that it is reasonable for us to assume them to be all negative simply meaning utility increases with higher level consumption of X , Y , and L but it increases at a diminishing rate. In other words this states the law of diminishing marginal utility. While the signs of U_{XL}, U_{YL} can

reasonably be posited to be greater than zero meaning that the satisfaction the consumer derives from consuming more of X (or Y) is enhanced by the availability of leisure time.

Thus in context of the above established relationships as we have demonstrated with the established signs with regards the neo-classical optimising consumer, further analysis of the theoretical relationship(s) between each of the transaction costs components needs to be done. This will then enable us to posit the signs of the second and mixed partials of I , D , and E before further comparative static analysis of the transaction costs model can be carried out.

[Further work and refinements of the model is in progress⁹].

References

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⁹ This includes modelling the agent's second objective function which is to contain or reduce E .