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ORIGINAL ARTICLES

Evaluating the Productivity of Prawn Farms Using Malmquist Index in Guatr Gulf, Iran

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ABSTRACT

This study intend to assess prawn farms performances in Guatr gulf, Iran via FGLR and FGNZ approaches, total factor productivity changes and its component. The data analyzed by input distance function considering the Malmquist index (MI). In order providing data, total of 25 prawn active farms were interviewed. The results showed the majority of farms face decrease in Total Factor Productivity (TFP). So that, TFP growth discerned only for 36% of farms and 64% of the units had TFP decline which due to decrease both technological changes (TC) and efficiency changes (EC). Pure efficiency change is the main factor to diminution efficiency change and therefore productivity growth. Total productivity depends on improving organizational structure, procedures, policy and decision-making process. Training courses on techniques in prawn culture is offered to improve inputs management in order to increase productivity. Furthermore, farmers should share their experiences in a mutual advantage. Moreover, Creating and managing a reward and punishment system on the farms should be selected. Regarding to scale efficiency change, strategic planning to change farms scales and making some fundamental changes in the production process could be adopted as well. For instance, to ameliorate productivity, it offers to equip farms with aeration systems. However, the most farmers need more financial assistance from government agencies.

Key words: DEA, Distance Function, prawn, Productivity, Malmquist Index.

Introduction

The worldwide industry of prawn growth had a rapid growth in the 1980s regarding to technological improvement, increasing the number of consumers and high profit of prawn farming, and government support; However its growth has slowed down since 1991 (Shang Yung *et al*., 1998). In fact, Competition amid prawn-producing countries, the rapid growth of technology and rising market demand express that the prawn industry needs to take the appropriate steps to remain viable and be able to be successful on a global scale (Martinez-Cordero, Leung., 2004). In this direction, Boosting sustainable productivity is one of the most important ways which optimizes factors production, reduces the cost of production staff, expanding markets and increasing employment rate by a scientific method.

Attention of the international community to productivity on the one hand and consider the policies of economic development programs on the other hand, express the importance and necessity of productivity. Units active in prawn breeding and production are not separated from it. Regarding few number of active farms- in spite of susceptible conditions for prawn production- in farms of Sistan & Baluchistan province, Iran, it seems due to low efficiency and productivity. In this direction, it needs to measure productivity.

In following, abstract of the most important researches is expressed.

Tung, Pham (2010) has estimated technical efficiency of improved extensive prawn farming in Ca Mau province, Vietnam. A comparison between the technical efficiency results of the districts showed that the farms in Cai-Nuoc were more highly efficient than farms in Dam-Doi District.

Sumy and *et al* (2009) have assessed Performance of participatory and non-participatory farmers of integrated crop management project at Pirganj upazila. Sixty farmers of which 30 participatory & 30 non-participatory were selected following stratified random sampling technique from four villages under pirganj upazila in Thakurgaon district. The results showed Participatory farmers were technically more efficient than non- participatory farmers.

Unal and *et al* (2009) evaluated the performance of fishery cooperatives in six selected fishing areas along the central and southern Aegean coasts of Turkey in 2002–2003. The results showed that there is a notable different among these cooperatives in the aspect of limitations and powerfulness so that in some cases the performance below full potential could lead to lack of feeling of togetherness, unity, community and qualified

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business management skills which are internal factors, as well as inadequate support of the government like tax laws and insufficient training which are external factors.

Ogunleye and Akinbile (2008) assessed food crops productivity of tobacco and non-tobacco farmers in Iseyin and Atisbo local government areas of Oyo state, Nigeria. This study was measured the level of productivity as the mean annual yield of food crop per unit farm size. The results indicated that tobacco farmers had better performance in comparing with the non tobacco farmers.

Gordon and *et al* (2008) reported the production characteristics of prawn farming, based on a panel of farms for the period 1998 to 2002 in Bangladesh. The results indicated pond size is the most important factor in determining profitability and that the largest farms are the most profitable. However, productivity measured as profit per hectare is only weakly positively correlated with pond size.

Felthoven and *et al* (2009) obtained productivity and its components for fisheries units which are located at the Alaskan Pollock Fishery in1994–2003. The results indicated the productivity is enhanced over the years, due to climate changes and fishing strategies which are statistically significant. Moreover, catch patterns and productivity is affected by direct and indirect impacts of regulatory changes.

Hanna and *et al* (2006) measured performance and management options of Torres Strait prawn fishery. It was analyzed alternative management arrangements applicable to fishery. Finally they conclude potential ways toward fishery.

Santopietro (2006) has investigated that whether Privatization Increase Productivity in a Nation's Fisheries. Evidence suggested that a positive relationship between aquaculture and labor productivity exists in only some of the countries' fisheries.

Martinez-Cordero and Leung (2004) measured the performance of prawn farms in one of the states in Mexico. Results reported that the components of adjusted Total Factor Productivity (TFP) were lower than the common TFP scores in all years but 1994 so that Technical Efficiency (TE) and TFP had a conflict behavior than yields over time.

Torres-Lars (2000) had a survey on three main factors that can affect on the performance of fishing cooperative units of Yucatan in Mexico. The results showed that the productivity has an important role in aquaculture products so that, in developing countries, it can help to more food security, a higher income, as well as higher standards of living. Prawn production is an important source of production in aquaculture as martinez-Cordero and Leung (2004) concluded which competition among prawn producing countries, a rapid growth in technology as well as boosting the conditions in market demand express that this industry needs to high productivity. Considering few numbers of active farms in spite of susceptible conditions for prawn production, it seems due to low productivity. In this content, productivity of prawn farms is measured by Malmquist index based on distances function at Guatr gulf in Sistan and Baluchistan province, Iran. This district is the first site that has identified almost 16 years ago, and finally it was exploited in 1998-1999. This area is located in the northwest of Guatr Gulf and the West River of Bahukalat which is placed in province of Sistan and Baluchistan, Iran.

Materials and Methods

Effectiveness, efficiency and productivity are main factors to assess performance. Productivity can be ultimate goal for a firm .It includes both effectiveness and efficiency indicators. In fact, it means the quality of being productive. In other words, productivity is a measure relating a quantity or quality of output to input system that it calls average productivity in microeconomics. Effectiveness is doing things right and efficiency is doing the right things. But productivity is doing things right and doing the right things at the same time. So, it expresses that the effectiveness and efficiency are necessary condition for productivity. In general, to measure the productivity of an organization, it uses the following formula (Kaveh, 2006):

Productivity = Total weight outputs/ Total weight inputs (1)

Productivity measures a relation between outputs and inputs which assesses the progress of a firm. There are some ways to measure productivity. Productivity indicators use to measure productivity. In general, any proportion which consists of outputs in the numerator and inputs in the denominator fraction is called productivity.

Total Factors Productivity (TFP):

This index is used to compare two by two when two time periods or two firms are compared with each other. The index for two periods or two firms ***t***, ***s*** is defined as follows (Emami-Meybodi, 2000):

$$\text{Ln TFP}_{s,t} = [\text{output index}_{s,t}] / [\text{input index}_{s,t}] \quad (2)$$

Although to calculate this indicator use different methods such as Tornquist, Fisher and Distance Function or Malmquist Index it requires to price statistics of all inputs and output in the Fisher and Tornquist methods, hence distance function approach has the most application. Theoretical this index, returns to Sten Malmquist (1953), which were expressed in consumption theory. This indicator refers to productivity based on efficiency that compares to a firm which has two different times. By this index, total productivity as well as its components -efficiency changes and technical changes- is achieved. Analysis of numbers obtained for this index is according to the chosen method of Input oriented or output oriented.

$$M_i^{t+1} = \sqrt{\left(\frac{D_i^t(q^{t+1},x^{t+1})}{D_i^t(q^t,x^t)} \cdot \frac{D_i^{t+1}(q^{t+1},x^{t+1})}{D_i^{t+1}(q^t,x^t)}\right)} \quad (3)$$

$$M_i^{t+1} = \frac{D_i^t(q^{t+1},x^{t+1})}{D_i^t(q^t,x^t)}\left(\frac{D_i^t(q^{t+1},x^{t+1})}{D_i^{t+1}(q^{t+1},x^{t+1})} \cdot \frac{D_i^t(q^t,x^t)}{D_i^{t+1}(q^t,x^t)}\right) \quad (4)$$

$$M_i^{t+1} = E_i^{t+1} \times T_i^{t+1} \quad (5)$$

Where, E_i^{t+1} and T_i^{t+1} are called, technical efficiency change and technological change, respectively. Technical efficiency change, has expressed that Decision Making Unit (DMU), has been closer or farther the frontier in the interval t to t+1. Also Technical Change shows the amount of displacement of this efficient frontier. This decomposition related to research of Fare and *et al* (1989, 1992 and 1994).

This analysis is based on constant returns to scale (CRS) and variable returns to scale (VRS). According to the name of the researchers, Analysis based on CRS is called FGLR and based on VRS is called FGNZ. Malmquist index is defined based on input or output distance function:

$$m_0(Y_s, X_s, Y_t, X_t) = [d_0^s(Y_t, X_t) / d_0^s(Y_s, X_s) \times d_0^t(Y_t, X_t) / d_0^t(Y_s, X_s)]^{0.5} \quad (6)$$

$$m_0(Y_s, X_s, Y_t, X_t) = d_0^t(Y_t, X_t) / d_0^s(Y_t, X_t)\,[d_0^s(Y_t, X_t) / d_0^t(Y_t, X_t) \times d_0^s(Y_s, X_s) / d_0^t(Y_s, X_s)]^{0.5} \quad (7)$$

Where Output distance function is defined by the following equation:

$$d_0(X, Y) = \min \{\partial: Y/\partial) \in P(X)\} \quad (8)$$

So that, P (X) shows the production possibilities curve and it is representative of all inputs vectors which may be produced by the X vector. So $d_0^s(Y_t, X_t)$ shows time interval of observations t to s. Thus $d_0^t(Y_t, X_t) / d_0^s(Y_t, X_t)$ expresses efficiency changes, $d_0^s(Y_t, X_t) / d_0^t(Y_t, X_t)$ shows technology at the time of ***t***, $d_0^s(Y_s, X_s) / d_0^t(Y_s, X_s)$ shows technology at the time of ***s*** and finally $[d_0^s(Y_t, X_t) / d_0^t(Y_t, X_t) \times d_0^s(Y_s, X_s) / d_0^t(Y_s, X_s)]^{0.5}$ expresses geometric mean of technological change in period of t to s. Generally, it denote in output-oriented:

$M_0 > 1 \Rightarrow$ Productivity growth in t to s

$M_0 < 1 \Rightarrow$ Reduced productivity in t to s

Distance functions are measured by different approaches. One of the most popular techniques is linear programming (LP).

To calculate the productivity per unit in time period T, (3T-2) time linear programming is calculated for each firm. Therefore, we have (3T-2) of distance function for each firm. It means that for ***i*** firms it is estimated [(3T-2) × I] distance function for all units.

To calculate the productivity a DMU at least two-period data is required. In this direction, it uses data from 2009 to 2010. Productivity has been estimated by FGLR and FGNZ models. FGLR method obtains the efficiency pay attention to CRS assumption -by multiplying two factors, efficiency changes (EC) and technological change(TC)- based on the index MI. FGLR method obtains the efficiency pay attention to VRS assumption -by multiplying three factors, scale efficiency changes (SEC) and pure efficiency change(PEC) and technological change(TC)- based on the index MI.

Results and Conclusion:

At least two-period data is required to calculate productivity. Total factor productivity is calculated by Malmquist index with regard to the distance functions for each firm. It is estimated by four LPs. According to CRS assumption, it is expressed as following formulas:

$[d_0^t(Y_t, X_t)]^{-1} = \max \varphi$
$-\varphi Y_{it} + Y_t\lambda \geq 0$
$X_{it} - X_t\lambda \geq 0$
$\lambda \geq 0$

$[d_0^t(Y_s, X_s)]^{-1} = \max \varphi$
$-\varphi Y_{is} + Y_s\lambda \geq 0$
$X_{is} - X_s\lambda \geq 0$
$\lambda \geq 0$

$[d_0^s(Y_s, X_s)]^{-1} = \max \varphi$
$-\varphi Y_{is} + Y_t\lambda \geq 0$
$X_{is} - X_t\lambda \geq 0$
$\lambda \geq 0$

$[d_0^s(Y_t, X_t)]^{-1} = \max \varphi$
$-\varphi Y_{it} + Y_s\lambda \geq 0$
$X_{it} - X_s\lambda \geq 0$
$\lambda \geq 0$

According to FGNZ approach -VRS assumption- distance functions are obtained by adding the convexity constraint to each equation. In following, total factor productivity Changes has been calculated by FGLR model.

FGLR calculated TFPG by multiplying the efficiency changes and technological changes. According to input-oriented assumption, values more than one shows reduction of total factor productivity over time. TFPG, TC and EC respectively show the total factors productivity growth, technological change and efficiency change. Table 1 results indicate that the average total productivity changes of DMUs is roughly equal to one over time; So that improvement of TFP is for only 36% of DMUs; and 64% of the units confront decreasing the TFP. Range of TFP is 0.876 to 1.398 and Standard Deviation (SD) is 0.143. Range of technological change is 0.899 to 1.483 with 0.158 SD. Also Efficiency Changes is banded 0.871 to 1.458 with 0.125 SD. According to table 1, decline of TFP returns to both technological changes and efficiency changes. Table 2 shows process of TFP changes and its component which obtained by FGNZ model.

Table 1: Calculation of Total Factor productivity (TFP) Changes and its components by FGLR Model

DMU	EC	TC	TFPG	DMU	EC	TC	TFPG
DMU1	1.021	0.909	0.928	DMU14	1.103	1.231	1.199
DMU2	1.099	0.97	1.066	DMU15	0.931	0.955	0.876
DMU3	1.458	0.954	1.391	DMU16	1.159	1.481	1.398
DMU4	1.023	0.899	0.92	DMU17	1.047	1.303	1.205
DMU5	1.104	0.934	1.031	DMU18	0.911	1.133	1.065
DMU6	0.876	1.016	0.89	DMU19	0.956	0.901	0.948
DMU7	1.055	0.974	1.028	DMU20	1	1.273	1.074
DMU8	1.204	0.974	1.172	DMU21	0.997	0.956	0.955
DMU9	1.107	0.974	1.078	DMU22	0.958	1.29	1.158
DMU10	0.871	1.042	0.908	DMU23	1	1.281	1.224
DMU11	1.075	0.974	1.047	DMU24	0.963	1.135	1.036
DMU12	1.14	0.974	1.111	DMU25	0.993	1.029	0.926
DMU13	1.198	0.974	1.167	Mean	1.04996	1.06144	1.07204

In table 2 respectively TC, SEC and PEC, state technological change, scale efficiency change and pure efficiency change. FGNZ approach calculates value of TFP and its components, with regard to VRS assumption. Clearly, the results of both methods are similar; But in this model, changes in TFP is calculated by multiplying three factors. In fact, efficiency changes in FGLR are equal to multiply SEC and PEC. Pure Efficiency Changes in FGNZ approach is the result of management quality changes.

Range of pure efficiency change and scale efficiency changes, respectively are betweens 0.919 to 1.09 and 0.855 to 1.482. The average of PEC and SEC respectively, are 1.004 and 1.123 which regarding to input-oriented assumption both factors led to decrease of efficiency changes and consequently diminish the productivity

Conclusion:

The results showed that the majority of DMUs face decrease in total factor productivity. So that, TFP growth discerned only for 36% of DMUs and 56% of the units had TFP decline. Improving total productivity depends on improving organizational structure, procedures and process of decision-making. Technical

efficiency changes influences on TFP changes as one of the major factors. The average of this index shows that no improvement has been made. Improving the technical efficiency for a firm is subject to improve allocation of inputs that is used in the production process. Training courses on techniques in prawn culture is offered to improve total productivity. The content of these training courses can be included technical instruction considering optimum allocative factors. Furthermore farmers should share their experiences in a mutual advantage. Moreover, Creating and managing a reward and punishment system on the farms should be selected. Regarding to scale efficiency change, Strategic planning and making some fundamental changes in the production process could be adopted as well. For instance, to ameliorate productivity, it offers to equip farms with aeration systems. However, the most managers need more financial assistance from government agencies.

Table 2: Calculation of Total Factor Productivity (TFP) Changes and its components by FGNZ Model.

DMUs	*PEC*	*SEC*	*TC*	*TFPG*
DMU1	1.018	1.003	0.909	0.928
DMU2	0.946	1.162	0.97	1.066
DMU3	1.09	1.337	0.954	1.391
DMU4	1	1.023	0.899	0.92
DMU5	0.945	1.168	0.934	1.031
DMU6	1.025	0.855	1.016	0.89
DMU7	0.919	1.148	0.974	1.028
DMU8	1	1.204	0.974	1.172
DMU9	1.01	1.096	0.974	1.078
DMU10	1.001	0.87	1.042	0.908
DMU11	1	1.075	0.974	1.047
DMU12	0.969	1.176	0.974	1.111
DMU13	1.016	1.179	0.974	1.167
DMU14	0.957	1.286	0.974	1.199
DMU15	1	0.955	0.917	0.876
DMU16	0.999	1.482	0.944	1.398
DMU17	1.026	1.271	0.924	1.205
DMU18	0.961	1.179	0.94	1.065
DMU19	1	0.901	1.052	0.948
DMU20	1.06	1.201	0.844	1.074
DMU21	0.99	0.966	0.999	0.955
DMU22	1.086	1.187	0.898	1.158
DMU23	1.031	1.242	0.956	1.224
DMU24	1.058	1.073	0.913	1.036
DMU25	0.994	1.035	0.9	0.926
Mean	1.00404	1.12296	0.95316	1.07204

Considering the high price of aeration systems on farms, there is not any demand for applying this system. Therefore it recommends referring managers to banks by the relevant institutions to get low-interest loans. As Martinez-Cordero and *et al* (2004) indicated the prawn industry needs to take drastic measures if it wants to remain successful and able globally to competition. This can achieve by paying attention to make a better use of rare resources beside adequate technology. Decision makers such as policy-makers and managers can make meticulous planning in order to conducting aquaculture development in long run pay attention to sustainable development so that it considers all social and economic goals. To improve TC as a component of TFP - considering stable TE scores- increased government assistance to extend technological professional knowledge is required at a faster rate during the transition period. Increase interaction between farmers and policy makers is recommended to discuss strategies and options for practical approaches to improve productivity.

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