Available online at www.sciencedirect.com
SCIENCE DIRECT®
Aquaculture 221 (2003) 115–124
Aquaculture
www.elsevier.com/locate/aqua-online

The competitiveness of the eel aquaculture in Taiwan, Japan, and China

Wu-Chung Lee[a,b], Yu-Hui Chen[c,*], Ying-Chou Lee[a], I. Chiu Liao[b]

[a] Institute of Fishery Science, National Taiwan University, Taipei 106, Taiwan
[b] Taiwan Fisheries Research Institute, Keelung 202, Taiwan
[c] Department of Agricultural Economics, National Taiwan University, Taipei 106, Taiwan

Received 14 October 2001; received in revised form 6 December 2002; accepted 8 December 2002

Abstract

The competitiveness of eel aquaculture in Taiwan, Japan, and China was investigated using the net private profitability (NPP) and the domestic resource cost (DRC) approaches. Estimated results show that Japan is the least competitive. The competitiveness between Taiwan and China has changed in the last decade. Between 1990 and 1993, the Taiwanese DRCs were lower than those of the Chinese, implying that Taiwan led in competitiveness. After 1994, however, the Taiwanese eel aquaculture lost its position to China. According to the analyses mentioned above, it does not matter which approach is adopted in assessing competitiveness. Our findings suggest that the Chinese eel aquaculture possesses competitive advantage over Taiwan and Japan.
© 2003 Elsevier Science B.V. All rights reserved.

Keywords: Net private profitability; Domestic resource cost; Competitiveness

1. Introduction

Among the many aquaculture species, eels appear to have a strong potential for further development in Asia (Liao, 2001). Eels are highly valued cultured species because of their high market price, high yield, high survival rate, and well-studied pathology. Of the 19 anguilla species, the Japanese eel (*Anguilla japonica*) and the European eel (*Anguilla anguilla*) are the most important in East Asia (mainly Japan, Taiwan, and China) and Europe (mainly Italy and the Netherlands) (Liao, 2002). Total eel production in 1998 was

* Corresponding author. Tel.: +886-2-2369-7301; fax: +886-2-2362-8496.
E-mail address: yhc@ccms.ntu.edu.tw (Y.-H. Chen).

0044-8486/03/$ - see front matter © 2003 Elsevier Science B.V. All rights reserved.
doi:10.1016/S0044-8486(03)00004-8

222,547 metric tons and valued at US$1.3 billion (FAO, 2000). The Japanese eel accounts for about 80% of the total eel production and about 60% of the total consumption in Japan. Eel production in Japan has decreased by almost 40% in the last decade from 38,885 metric tons in 1990 to 22,836 metric tons in 1999. In contrast, the eel consumption in Japan has steadily increased from 104,460 metric tons in 1990 to 129,794 metric tons in 1999 (Satoh et al., 2001). The difference between the consumption and the production of eel in Japan is filled by imports.

In Taiwan, eel aquaculture is one of the most important aquaculture industries. The species cultured are mainly the Japanese eel. Taiwan used to be the major supplier of eels to the Japanese market. Before 1987, Taiwan supplied more than 90% of the Japanese annual import. In 1993, Taiwan exported 49,547 metric tons to Japan, then decreased annually since that time. In 1999, eels exported to Japan dropped to 8765 metric tons, which was only 6.80% of the total consumption in the Japanese market. Taiwanese eel aquaculture, like its Japanese counterpart, has reached its peak of growth and has entered a period of decline (Liao, 1999, 2001).

The decline of the eel production in Taiwan has been mainly caused by the rise of eel aquaculture in China and the concomitant increase in glass eel price. The eel aquaculture in China has grown because of relatively cheap labor and the technical and financial assistance from Taiwanese and Japanese investors. The eel aquaculture area in China has spread from the coast of Fu-Chien province to Kuang-Tung and other northern provinces (Shi et al., 1999). China's eel export has increased considerably from 3.55% in 1985 to 73.39% in 1999 of the total eel imports in Japan (Table 1). Its total production is much higher than the combined production from all other Asian countries.

Taiwan, Japan, and China contribute to more than 85.00% of the total world production as well as consumption. Moreover, the eel aquaculture in these countries is competing

Table 1
Annual market shares of Taiwan, China, and Japan in the Japanese eel market

Year	Taiwan		China		Japan[a]		Others		Total consumption (metric tons)
	Metric tons	%	Metric tons	%	Metric tons	%	Metric tons	%	
1985	36,170	45.11	2844	3.55	41,094	51.25	81	0.10	80,189
1986	37,044	48.19	1675	2.18	38,025	49.46	134	0.17	76,878
1987	35,157	46.61	1879	2.49	38,311	50.79	87	0.12	75,434
1988	44,133	47.08	8639	9.22	40,893	43.63	66	0.07	93,731
1989	45,888	47.92	8601	8.89	40,976	42.79	292	0.30	95,757
1990	54,786	52.45	9559	9.15	39,983	38.28	132	0.13	104,460
1991	58,850	51.53	14,496	12.69	40,098	35.11	763	0.67	114,207
1992	58,966	51.34	16,012	13.94	37,391	32.55	2491	2.17	114,860
1993	49,547	43.51	25,113	22.05	34,830	30.59	4377	3.84	113,867
1994	31,471	28.29	45,073	40.52	30,380	27.31	4308	3.87	111,232
1995	20,320	19.87	49,041	47.96	29,496	28.84	3407	3.33	102,264
1996	18,817	16.11	66,104	56.60	29,517	25.27	2358	2.02	116,796
1997	17,331	13.25	86,188	65.90	25,031	19.14	2242	1.71	130,792
1998	13,016	10.62	83,432	68.08	22,845	18.64	3255	2.66	122,548
1999	8765	6.75	95,255	73.39	23,637	18.21	2137	1.65	129,794

[a] Including cultured and wild eel.

fiercely in the Japanese market. The shift in the competitiveness of the eel aquaculture in Taiwan, Japan, and China not only influences the profits of eel production but also affects the economic development of the countries involved (Chou and Lee, 1993). Therefore, the government and the industry must be prepared for such shift in competitiveness.

Although the domestic resource cost (DRC) approach has been widely used in the analysis of the competitiveness of agricultural commodities, only a few studies have been conducted on fishery products because of difficulties in collecting reliable data (Ling et al., 1999). The purpose of this research is to use the concepts of opportunity cost and comparative advantage theory to investigate the competitiveness of the eel aquaculture in Taiwan, Japan, and China.

2. Materials and methods

The data of the production costs and market prices for the eel aquaculture in Taiwan, Japan, and China were obtained from various sources (JETO, 1986–2000; MAFF, 1986–2000; FA, 1986–2000; MFJ, 1986–2000). Since official statistics for Chinese eel production costs and markets prices are not available, the statistical data used in this study were from the survey data collected by the Taiwanese commission of eel production and marketing. Externalities were ignored in this study due to a lack of reliable statistical data.

The net private profitability (NPP) and the domestic resource cost (DRC) were employed to investigate the competitiveness of the eel aquaculture in Taiwan, Japan, and China. NPP measures the returns of production activities, which is defined as total revenue minus total production cost. It indicates the profitability of firms when devoted to production (Tsan, 1978; Chen, 1989, 2000). DRC represents the value of domestic resources spent in saving or earning a unit of foreign exchange (Pearson, 1973).

Since the expenses of inputs are required in calculating the NPP and the DRC, the categories of inputs used in production and their costs are discussed first. In general, inputs applied to production activities can be divided into two factors: tradable and nontradable. Tradable factors are those that are either exported to earn foreign exchange, or used domestically to save foreign exchange. Nontradable factors represent those inputs that cannot be traded and can only be used domestically. Moreover, the concept of opportunity cost is employed in evaluating commodity prices and input costs. According to economic theory, the opportunity cost is defined as the value of the next best alternative use of a resource. The opportunity cost of a tradable commodity is equal to its border price, that is, the price of an export or import converted into domestic currency at a given exchange rate (Chenery, 1981). An export border price is the domestic price at the point of export, free on board (fob) the carrier (the fob price). An import border price is the domestic price at the national border, inclusive of cost, insurance, and freight (cif price) (Chen, 2000). The opportunity costs of nontradable commodities are domestic shadow prices. For any commodity with no alternative use, its shadow price is zero. If the contribution of the nontradable input to the alternative use has a higher value than its current use, then the shadow price is positive and greater than its actual observed price. If the market is purely competitive, the market price is equal to the shadow price (Tsakok, 1990).

2.1. Net private profitability (NPP)

The definition of the net private profitability is (Tsan, 1978):

$$\mathrm{NPP}_i = \text{Domestic Market Price} - \text{Tradable Factors at Market Price} - \text{Nontradable Factors at Market Price} \quad (1)$$

When $\mathrm{NPP}_i > 0$, the producers make profits from the production; $\mathrm{NPP}_i = 0$, the production is at breakeven point; and $\mathrm{NPP}_i < 0$, the producers face a deficit in the production.

2.2. Domestic resource cost (DRC)

According to Pearson and Meyer (1974), DRC can be defined as:

$$\mathrm{DRC}_i = \frac{\text{Domestic resources and nontradable inputs valued at opportunity costs or shadow price}}{\text{Net foreign exchange earned or saved by producing the good domestically}} \quad (2)$$

The formula used in calculation can be expressed as:

$$\mathrm{DRC}_i = \frac{\sum_{j=k+1}^{n} a_{ij} V_j + E}{P_i^{\mathrm{b}} - \sum_{j=1}^{k} a_{ij} P_j^{\mathrm{b}}} \quad (3)$$

where a_{ij} = the quantity of the jth tradable input needed to produce a unit of output, $j = 1,\ldots,k$ and the quantity of the jth nontradable input needed to produce a unit of output, $j = k+1,\ldots,n$; V_j = the opportunity costs of domestic resources and nontradable inputs; P_j^{b} = the border price of the jth input; P_i^{b} = the border price of the ith output; and E = the externality cost in the production of the ith output.

When $\mathrm{DRC}_i = 1$, the industry is at the breakeven point of benefit and cost; $\mathrm{DRC}_i > 1$, the industry is noncompetitive in the market; and $\mathrm{DRC}_i < 1$, the industry is competitive in the market.

In short, NPP can be used to assess the profitability of a firm and serves as an indicator for future development of a private firm. DRC, on the other hand, evaluates an industry's competitiveness from the viewpoint of domestic resource.

3. Results and discussion

In this study, all input factors, except seed and feed, are assumed as nontradable inputs and their shadow prices are equal to their domestic market prices. Seed is treated as a tradable factor, primarily because the supply of glass eel is totally dependent on natural harvest in many countries, which may not be enough for their own use, and they have to import seeds from other countries. Feed, either produced domestically or imported, is treated as a tradable factor, primarily because it cannot be produced sufficiently in many countries. Thus, imported seed and feed increase the foreign content of the final output of eel. The cif prices in foreign markets are treated as shadow prices of eel exports, taking into account opportunity costs of transport, distribution, and quality differences (Ling et al., 1999).

3.1. The production costs of the eel aquaculture in Taiwan, Japan, and China

Major expenses for eel production in Taiwan, Japan and China include costs of seed, feed, and labor. Other expenses are summarized in Table 2. In 1990, eel production cost in Taiwan was US$6.25/kg, while that of Japan was US$9.89/kg, and that of China was US$7.00/kg. Feed expense contributed to 37.80% (Taiwan), 32.40% (Japan), and 37.20% (China). Since the scale of Chinese eel aquaculture is not substantial at this time, the glass eel supply is abundant and the seed price is low. Seed costs were 21.30%, 26.50%, and 21.50%, respectively, of the total production cost.

The Chinese eel culture area increased substantially, as well as the demand for glass eels since 1993. The limitation of seed harvest and the overdemand for glass eels resulted in a significant increase of seed price. From that time on, the seed cost became the major component of eel production cost. In 1993, eel production costs were US$10.89/kg, US$14.81/kg, and US$10.62/kg in Taiwan, Japan, and China, respectively. Seed expense contributed to 50.78% (Taiwan), 39.10% (Japan), and 39.55% (China) of the total production cost.

The shortage in seed harvest and the increase in price of glass eel caused a significant increase in production cost in Taiwan in 1998, amounting to US$13.87/kg, 61.79% of which was seed cost (Table 2). Japanese total production cost was US$17.51/kg, and 51.46% accounted for seed expense in the same year; while Chinese production cost reached a record high of US$11.30/kg, in which seed expense contributed to 60.88%.

In 1999, due to the abundant supply of glass eel, total production cost in Taiwan was lowered to US$7.57/kg and the seed cost was only 33.55% of the total expenditure. A great harvest of glass eels also resulted in a low seed expense in Japan, which in turn made the total production cost drop to US$12.29/kg. In the same year, the Chinese production cost was US$6.09/kg, of which 27.75% was accounted for seed expense.

It is apparent that the seed price plays the most important role in eel production cost. That is the reason why Taiwan, Japan, and China are devoting a great deal of effort in seeking a technological breakthrough in eel artificial propagation.

Compared with China and Taiwan, the eel aquaculture in Japan has the highest production cost due to environmental, climatic, and resource limitations. Japan has shifted from being a producer to a major eel importer (Satoh et al., 2001). The production costs in Japan and Taiwan are higher than that in China since 1993. On the other hand, the cheap labor, rich resources, and technology improvement have lowered the eel production cost in China and increased its output, making it the top eel producer at present.

Further analyzing the components of production cost among these countries, we found that because of the weather and climate limitation, the eel-growing season in Japan is fairly short. To cope with the market demand, eel farmers in Japan have to pay more for the early

Table 2
Eel aquaculture production cost in Taiwan, Japan, and China

Country	Year	Seed		Feed		Labor		Utility		Interest		Maintenance		Others[a]		Total
		Cost (US$/kg)	%	Cost (US$/kg)	%	Cost (US$/kg)	%	Cost (US$/kg)	%	Cost (US$/kg)	%	Cost (US$/kg)	%	Cost (US$/kg)	%	
Taiwan	1990	1.33	21.28	2.36	37.76	0.99	15.84	0.50	8.00	0.48	7.68	0.23	3.68	0.38	5.76	6.25
	1993	5.53	50.78	2.16	19.83	1.08	9.92	0.54	4.96	0.82	7.53	0.24	2.20	0.52	4.77	10.89
	1994	8.54	59.43	2.26	15.73	1.11	7.72	0.55	3.83	1.17	8.14	0.26	1.81	0.48	3.34	14.37
	1995	9.83	62.49	2.28	14.49	1.11	7.06	0.56	3.56	1.21	7.69	0.29	1.84	0.45	2.86	15.73
	1996	9.19	62.39	1.92	13.03	1.18	8.01	0.52	6.53	1.20	8.15	0.28	1.90	0.44	2.98	14.73
	1997	6.26	59.51	1.83	17.40	0.80	7.60	0.31	2.95	0.80	7.60	0.19	1.81	0.33	3.14	10.52
	1998	8.57	61.79	1.96	14.13	0.96	6.92	0.47	3.39	1.33	9.59	0.22	1.59	0.36	2.60	13.87
	1999	2.54	33.55	1.95	25.76	1.09	14.10	0.55	7.27	0.63	8.32	0.29	3.83	0.52	6.87	7.57
Japan	1990	2.62	26.49	3.20	32.36	1.23	12.44	1.37	13.85	0.43	4.35	0.25	2.53	0.79	7.99	9.89
	1993	5.79	39.10	3.59	24.24	1.80	12.15	1.87	12.62	0.51	3.44	0.36	2.43	0.89	6.01	14.81
	1994	8.74	46.91	3.68	19.75	2.01	10.79	2.26	12.13	0.62	3.33	0.40	2.15	0.92	4.94	18.63
	1995	10.21	51.95	3.65	18.44	1.89	9.55	1.98	10.01	0.63	3.18	0.41	2.07	1.02	5.15	19.79
	1996	9.48	50.19	3.81	20.17	2.03	10.75	1.64	8.68	0.59	3.12	0.37	1.96	0.97	5.13	18.89
	1997	6.89	45.96	3.27	21.81	1.65	11.01	1.53	10.21	0.48	3.20	0.34	2.27	0.83	5.53	14.99
	1998	9.01	51.46	3.26	18.62	1.61	9.19	1.71	9.77	0.56	3.20	0.43	2.46	0.97	5.54	17.51
	1999	2.80	22.78	3.52	28.64	1.78	14.48	1.98	16.11	0.59	4.80	0.46	3.74	1.16	9.44	12.29
China	1990	1.50	21.46	2.60	37.20	0.37	5.29	0.54	7.73	0.77	11.02	0.15	2.15	1.07	15.28	7.00
	1993	4.20	39.55	3.03	28.53	0.36	3.39	0.63	5.93	0.72	6.78	0.30	2.82	1.38	12.99	10.62
	1994	6.59	58.16	2.18	19.24	0.25	2.21	0.46	4.06	0.54	4.77	0.22	1.94	0.95	9.70	11.34
	1995	6.73	57.42	2.15	18.34	0.26	2.22	0.53	4.52	0.56	4.78	0.23	1.96	1.09	9.30	11.72
	1996	5.31	50.43	2.11	20.04	0.48	4.56	0.52	4.94	0.74	7.03	0.13	1.23	1.22	11.68	10.52
	1997	4.14	43.13	2.43	25.31	0.48	5.00	0.27	2.81	0.71	7.40	0.13	1.35	1.45	15.10	9.61
	1998	6.88	60.88	1.91	16.90	0.33	2.92	0.17	1.50	0.48	4.25	0.13	1.15	1.40	12.39	11.30
	1999	1.69	27.75	1.78	29.23	0.33	5.42	0.42	6.90	0.51	8.37	0.12	1.97	1.24	20.39	6.09

[a] Others include fuel, medicine, and rent.

harvest of glass eel from Taiwan, which elevates their production cost and lowers their profitability. The feed conversion ratio in Taiwan is better than that in Japan and China due to better feed production and management technologies (Chen and Yu, 1993). Therefore, the Taiwanese feed expense is relatively low when compared with the other two countries. In terms of labor expense, China has the lowest expense among three countries due to its abundant labor supply. In the aspect of utility expense, Taiwan and Japan have higher utility expense than China. Ground water, paddle wheel aerators, and other equipment adopted from Japan are commonly used in the Taiwanese eel culture, which requires more utility expenses compared to China.

3.2. The NPP of the eel aquaculture in Taiwan, Japan, and China

NPP is a major concern in producers' production decision. It is also the focal point influencing the development of eel aquaculture. Therefore, the NPPs of eel aquaculture in Taiwan, Japan, and China were compared to investigate their producers' profitability, which determines their competitiveness. The eel prices and production costs were used to calculate the profits of eel aquaculture.

As shown in Table 3, the Japanese eel aquaculture has the lowest NPP in the late 1990s. During the period of 1995–1998, its NPP continued to show negative values, indicating a deficit in the industry. Because of this, the number of Japanese eel farms decreased from 974 in 1991 to 600 in 2000. China, on the other hand, had the highest net returns in the late 1990s. Since 1990, its profitability has been fairly stable. Net returns even reached US$2.26/kg and US$2.69/kg in 1993 and 1994, respectively. The high profitability induced the growth of the industry, which made China the largest eel exporter to the Japanese eel market. The number of eel farms in China has increased substantially since 1994. The NPP of the Taiwanese eel aquaculture is between Japan and China. The Taiwanese eel aquaculture had positive NPPs before 1995. However, NPPs became negative between 1996 and 1998 and turned to be positive in 1999. The number of eel farms decreased from 1300 in 1990 to 523 in 1999. Its eel cultured area also decreased from 3853 ha in 1990 to 2418 ha in 1999.

In the last decade, the average net return of the eel aquaculture in Japan showed a deficit of US$1.24/kg. For the same period, the average net return of the eel aquaculture in China was US$1.22/kg, which was six times that of Taiwan (US$0.19/kg). From the viewpoint of private firms, the profitability of eel aquaculture in China is higher than those in Taiwan and Japan. This phenomenon explains one of the major reasons why many Taiwanese businessmen shifted their investment for eel aquaculture to China.

3.3. The DRC of the eel aquaculture in Taiwan, Japan, and China

The DRC indices of the Taiwanese eel aquaculture are shown in Table 3. It was 0.73 in 1990, indicating that earning $1 of exchange (in local currency) costs $0.73 of the domestic resource. The DRC values were less than one in 1990–1997, indicating that the Taiwanese eel aquaculture had the competitive advantage during that period. The DRC index in 1998, however, was 1.22, indicating less competitiveness in that year. Due to a

Table 3
Benefits, costs, and competitive indices of eel aquaculture in Taiwan, Japan, and China

Country	Year	Domestic market prices of output, *a* (US$/kg)	Domestic market prices of tradable inputs, *b* (US$/kg)	Domestic market prices of nontradable inputs, *c* (US$/kg)	NPP, *d* (US$/kg)	World market prices of output, *e* (US$/kg)	World market prices of tradable inputs, *f* (US$/kg)	Opportunity costs of nontradable inputs, *g* (US$/kg)	DRC, *h*
Taiwan	1990	6.29	3.69	2.55	0.05	6.61	2.51	2.98	0.73
	1993	11.17	7.69	3.21	0.26	11.25	6.47	3.65	0.76
	1994	14.66	10.8	3.57	0.29	14.85	9.39	4.01	0.74
	1995	16.05	12.11	3.61	0.32	15.83	11.1	4.03	0.85
	1996	14.14	11.11	3.63	– 0.60	14.36	10.06	4.04	0.94
	1997	10.49	8.09	2.43	– 0.03	10.59	7.35	2.81	0.87
	1998	12.68	10.53	3.34	– 1.18	12.81	9.78	3.68	1.22
	1999	10.02	4.49	3.08	2.46	10.66	3.94	3.42	0.51
Japan	1990	10.13	5.82	4.08	0.24	8.45	4.36	4.08	1.00
	1993	14.38	9.38	5.42	– 0.43	12.79	7.86	5.42	1.10
	1994	18.87	12.42	6.22	0.23	16.52	10.99	6.22	1.12
	1995	18.02	13.86	5.93	– 1.77	17.62	12.27	5.93	1.11
	1996	15.65	13.29	5.60	– 3.24	14.62	11.26	5.60	1.66
	1997	13.56	10.16	4.84	– 1.44	11.70	9.37	4.84	2.08
	1998	16.20	12.27	5.26	– 1.32	13.60	11.37	5.26	2.36
	1999	13.85	6.32	5.96	1.56	14.83	5.41	5.96	0.63
China	1990	7.53	4.11	2.90	0.52	4.88	3.57	2.78	2.13
	1993	12.87	7.23	3.38	2.26	9.62	6.63	3.15	1.05
	1994	14.04	8.77	2.57	2.69	13.47	7.92	2.38	0.43
	1995	12.65	8.88	2.84	0.92	14.61	8.55	2.63	0.43
	1996	11.35	7.42	3.11	0.82	12.41	7.10	2.83	0.53
	1997	10.26	6.57	3.04	0.65	10.45	6.21	2.77	0.65
	1998	12.00	8.79	2.51	0.70	11.47	8.40	2.26	0.74
	1999	9.08	3.47	2.61	3.00	8.78	3.18	2.36	0.42

Net private profitability (NPP) = $a - b - c$; NPP>0, the producers make profits from the production; NPP = 0, the production is at breakeven point; NPP < 0, the producers face a deficit in the production.

Domestic resource cost (DRC) = $g/(e - f)$; DRC = 1, the industry is at the breakeven point of benefit and cost; DRC>1, the industry is noncompetitive in the market; DRC < 1, the industry is competitive in the market.

great harvest of glass eel in 1999, the costs of tradable goods were reduced and the DRC dropped to 0.51.

Although high world market price has made the Taiwanese eel export become competitive since 1996, the Taiwanese eel producers are still facing the deficit (NPP < 0) due to export profitability obtained by exporters.

For Japan, the value of DRC was close to one in 1990, implying that earning $1 of exchange (in local currency) costs $1 of the domestic resource (Table 3). The DRCs were 0.81 and 0.91, in 1991 and 1992, respectively. During the period 1993–1998, the DRCs were always larger than one, indicating that the Japanese eel aquaculture has lost it leadership in the world eel market since 1993. The DRC was 2.36 in 1998, but was reduced to 0.63 in 1999 because of a great harvest of glass eel.

For the Chinese, eel aquaculture results show that the DRC indices were larger than one during the period of 1990–1993 (Table 3). Since 1994, the indices of the DRC have been less than one, suggesting an improvement in its competitiveness. The DRC further reduced to 0.42 in 1999 because of low seed price.

The estimated results suggest that the Japanese eel aquaculture has lost its competitiveness to the Taiwanese and the Chinese in the Asian eel market during the period 1990–1999. The competitiveness between Taiwan and China changed in the last decade. The DRCs of Taiwan were lower than those of the Chinese in the period 1990–1993, implying that Taiwan possessed the competitiveness in that period. After 1994, however, Taiwan has lost its competitiveness to China.

4. Conclusion

The results of using NPP and DRC in assessing competitiveness show that the Chinese eel aquaculture possesses competitive advantage over its counterparts in Taiwan and Japan. According to the findings from Lee et al. (in press), once successful larval rearing is achieved, the value of DRC indices will be altered as the seed prices will change. Using the average production cost during the period 1995–1999 as a basis, the DRC indices will become 0.35–0.77, 0.52–1.15, and 0.29–0.50 in Taiwan, Japan, and China, respectively, which would be lower than their current DRC indices. Since seed expense contributes to a large portion of the total production cost in eel aquaculture, if Japan and Taiwan seek to regain competitiveness in eel aquaculture, they will need to develop technological advances in artificial propagation.

Acknowledgements

The authors thank Dr. Hsi-Huang Chen (Department of Agricultural Economics, National Taiwan University, Taiwan) and Dr. Chi-Reng Chen (Council of Agriculture, Executive Yuan, Taiwan) for the guidance on modeling; and Dr. Chang-Tai Shih, Josephine N. Nocillado (Taiwan Fisheries Research Institute, Taiwan), and Ms. Chiung-Hsia Wang (Department of Agricultural Economics, National Taiwan University, Taiwan) for their constructive comments of an earlier version of the manuscript.

References

Chen, H.H., 1989. Economic liberalization and the adjustment of agricultural policies in Taiwan. Counc. Econ. Plann. Dev. (Taiwan) 127 (in Chinese).

Chen, H.H., 2000. Taiwan's agricultural competitiveness. Ind. Free China 90 (5), 87–136.

Chen, Y.H., Yu, T.C., 1993. Methods to reduce eel production cost. Proceeding of the Symposium on Eel Research—Sustainability of Resource and Aquaculture of Eels. Taiwan Fisheries Research Institute, Keelung, Taiwan, pp. 65–73. In Chinese.

Chenery, H.B., 1981. Comparative advantage and development policy. Am. Econ. Rev. 51, 18–51.

Chou, Y., Lee, W.C., 1993. The competitive strategy analysis of the declining industry—an example of eel-cultivation industry. Chung-Hua Institution for Economic Research. Economic Papers, Taipei, Taiwan 144. 78 pp. (in Chinese).

FAO, 2000. Aquaculture Production Dataset. FAO, Rome.

Fisheries Administration [FA], 1986–2000. Fisheries Yearbook: Taiwan Area. Council of Agriculture, Executive Yuan, Taiwan. In Chinese.

Japan External Trade Organization [JETRO], 1986–2000. Agro-Trade Handbook. JETRO, Tokyo, Japan (in Japanese).

Lee, W.C., Chen, Y.H., Liao, I.C., 2003. Impact of successful larval rearing on the competitiveness of the eel aquaculture in Taiwan, Japan and China. J. Fish. Soc. Taiwan 30.

Liao, I.C., 1999. Status of aquaculture in Asia with a focus on ell aquaculture. In: Proceedings of FOID 99: New Technologies for Aquaculture in Fisheries and Ocean Industrial Development, Pusan, Republic of Korea, pp. 35–40.

Liao, I.C., 2001. A general review on aquaculture in Asia: a focus on *Anguilla* eel. Keynote Addresses: 5th and 6th Asian Fisheries Forums. AFS Special Publication, vol. 11. AFS, Manila, Philippines, pp. 39–54. I.C. Liao (compiler).

Liao, I.C., 2002. Aquaculture development strategies in Asia for the 21st century. In: Oliver, R.A.R. (Ed.), Report of the APO Study Meeting on Sustainable Fishery Management, Sustainable Fishery Management in Asia, Asian Productivity Organization, Tokyo, Japan, pp. 85–102.

Ling, B.H., Leung, P.S., Shang, Y.C., 1999. Comparing Asian shrimp farming: the domestic resource cost approach. Aquaculture 175, 31–48.

Ministry of Agriculture, Forestry, and Fisheries of Japan [MAFF], 1986–2000. Fisheries and Aquaculture Yearbook. MAFF, Tokyo, Japan (in Japanese).

Ministry of Finance Japan [MFJ], 1986–2000. Trade Statistics. Statistics Bureau and Statistical Center, MFJ, Tokyo, Japan (in Japanese).

Pearson, S.R., 1973. Net Social Profitability, Domestic Resource Costs, and Effective Rate of Production. Food Research Institute, Stanford University.

Pearson, S.R., Meyer, R.K., 1974. Comparative advantage among African coffee producers. Am. J. Agric. Econ. 56, 310–313.

Satoh, H., Suzuki, K., Yoshijima, S., 2001. Present status and aspect on eel aquaculture in Japan. J. Taiwan Fish. Res. 9 (1 and 2), 1–6.

Shi, G., Wu, C.Q., Wang, X., Zhu, T.W., 1999. Status, prospect and countermeasure of eel culture. Sci. Fish Farming 1999 (6), 3–4 (in Chinese).

Tsakok, I., 1990. Agricultural Price Policy. Cornell Univ. Press. 305 pp.

Tsan, C.C., 1978. A Comparative Advantage Analysis on the Production of Major Agricultural Products in Taiwan. Department of Agricultural Economics, National Taiwan University. 215 pp. (in Chinese).