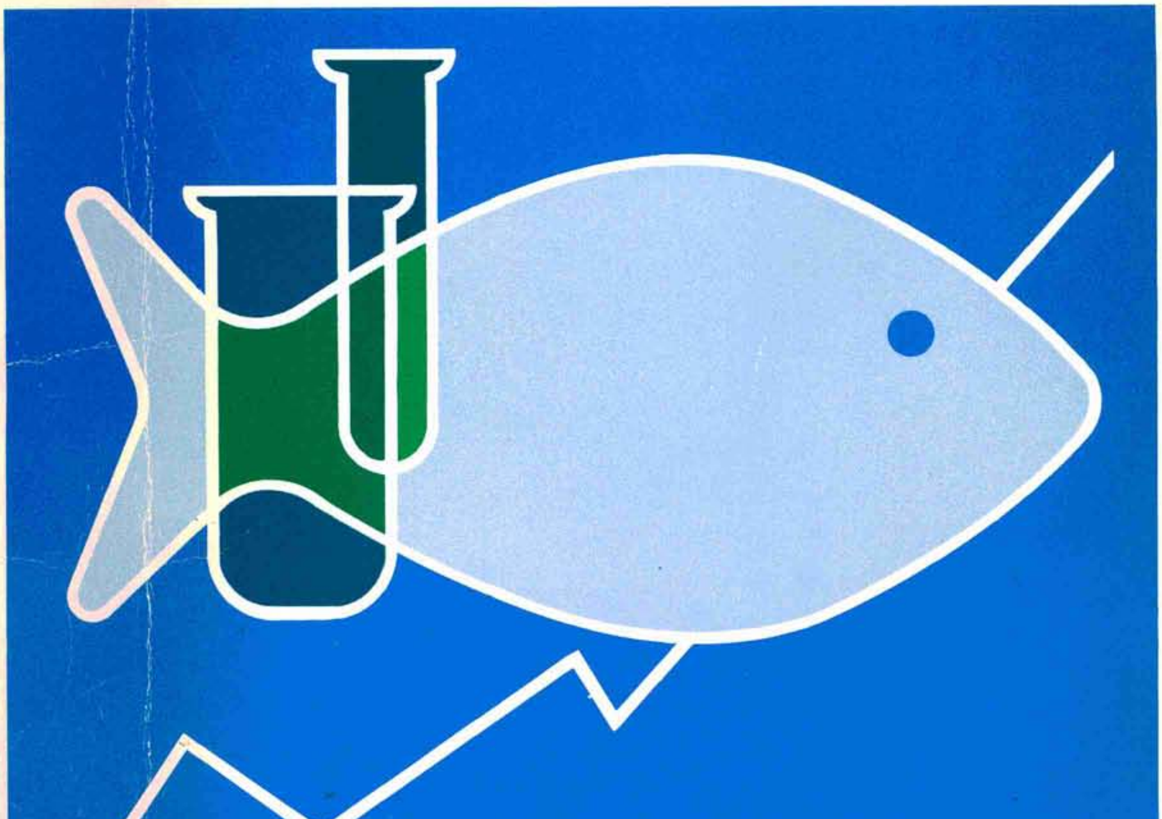
IDRC-193e

Aquaculture Economics Research in Asia



INTERNATIONAL DEVELOPMENT RESEARCH CENTRE • CENTRE DE RECHERCHES POUR LE DÉVELOPPEMENT INTERNATIONAL

CANADA

The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

IDRC, Ottawa CA
International Center for Living Aquatic Resources Management, Manila PH
IDRC-193e
Aquaculture Economics Research in Asia : proceedings of a workshop held in Singapore, 2–5 June 1981. Ottawa, Ont., IDRC. 1982. 128 p. : ill.

/Fishery economics/, /fishery research/, /social research/, /economic analysis/, /aquaculture/, /Asia/ — /fish culture/, /fish production/, /oyster culture/, /appropriate technology/, /experimental farming/, /cost analysis/, /welfare economics/, /glossary/, /fishery statistics/, /conference report/, /recommendation/, bibliography.

UDC: 639.3.003 (5) ISBN: 0-88936-330-7

Microfiche edition available

IDRC-193e

Aquaculture Economics Research in Asia

Proceedings of a workshop held in Singapore, 2–5 June 1981

Cosponsored by
International Development Research Centre
and
International Center for Living Aquatic Resources Management

Résumé

Cette publication contient une version revue des communications présentées à l'atelier sur la recherche intéressant l'économie de l'aquiculture en Asie, tenu à Singapour du 2 au 5 juin 1981. Les Divisions des sciences de l'agriculture, de l'alimentation et de la nutrition et des sciences sociales du Centre de recherches pour le développement international (CRDI) et le International Center for Living Aquatic Resources Management (ICLARM) ont conjointement réuni des biologistes et des économistes des pêches de neuf pays d'Asie du Sud et du Sud-Est. L'atelier visait à montrer l'utilité et à favoriser l'utilisation de l'analyse économique dans la recherche en aquiculture et à aider à augmenter les compétences de recherche en économie de l'aquiculture en Asie. L'atelier a traité surtout des analyses microéconomiques des systèmes de production aquicultur aux déjà implantés et au stade expérimental. Il a comporté aussi une revue et une discussion sommaires de quelques-unes des grandes considérations socio-économiques reliées à la contribution de l'aquiculture à la société en général et au rôle du système de marché dans l'affectation des ressources à l'aquiculture et aux autres secteurs de l'économie.

Resumen

Esta publicación es una version editada de los trabajos presentados en Singapur, del 2 al 5 de junio de 1981, durante el taller sobre investigación en la economía de la acuocultura en Asia. Las divisiones de Ciencias Sociales y de Ciencias Agrícolas, Alimentos y Nutrición del Centro Internacional de Investigaciones para el Desarrollo, en colaboración con el International Center for Living Aquatic Resources Management (ICLARM), invitaron a biólogos y economistas especialistas en piscicultura de los países del Sur y Sudeste Asiáticos. La meta del taller era demostrar el uso del análisis económico para la investigación en acuocultura y estimular su uso, así como mejorar la capacidad de investigación en economía de la acuocultura en Asia. Se prestó atención especial a los análisis microeconómicos de sistemas de producción de acuocultura experimentales y existentes, aunque también se presentaron una reseña y discusión limitadas, relativas a algunas consideraciones socioeconómicas más amplias de la contribución de la acuocultura a la sociedad como un todo y al papel del sistema de mercado en la distribución de recursos a la acuocultura y a otros sectores.

Contents

Foreword 5

Introduction 7

Participants 11

Session I: Microeconomic Analysis of Existing Production Systems
Microeconomics of Existing Aquaculture Production Systems: Basic Concepts and Definitions **Ian R. Smith** 15
The Economics of Aquaculture: The Case of Catfish in Thailand **Sarun Wattanutchariya and Theodore Panayotou** 26
Input-Output Relationships of Philippine Milkfish Aquaculture **Kee-Chai Chong and Maura S. Lizarondo** 35
Economics of Taiwan Milkfish System **Chaur Shyan Lee** 45
General Discussion 57

Session II: Microeconomic Analysis of Experimental Production Systems
Microeconomic Analysis of Experimental Aquaculture Projects: Basic Concepts and Definitions **Yung C. Shang** 61
An Analysis of the Economics of Farming Green Mussels in Singapore Using Rafts **L. Cheong and W.S. Loy** 65
Economic Analysis of Integrated Pig-Fish Farming Operations in the Philippines **Ruben C. Sevilleja** 75
Economics of Cage Culture of Tilapia in Sri Lanka **D.C. Galapitage** 82
An Economic Analysis of Composite Fish Culture in India **S.D. Tripathi and M. Ranadhir** 90
General Discussion 97

Session III: Socioeconomics of Aquaculture
Socioeconomics and Aquaculture: Informal Presentations 101
Social Welfare Economics and Aquaculture: Issues for Policy and Research **Theodore Panayotou** 103
General Discussion 117

Conclusions and Recommendations 118

Appendix 1: Working Definitions of Economic and Statistic Terms 119

Appendix 2: Selected Bibliography 122

Economics of Taiwan Milkfish System[1]

Chaur Shyan Lee[2]

This paper examines the entire milkfish system in Taiwan, including fry gathering and marketing, baitfish production, market-size rearing, and marketing. A constant elasticity of substitution (CES) production function is used to estimate input-output relationships for baitfish and market-size production systems, with all inputs classified into labour and capital. An important finding is that the elasticity of substitution between labour and capital exceeds unity indicating rather easy substitutability between the two inputs. Rates of return to marketing intermediaries were found to be high for both fry and market-size milkfish.

The fisheries sector, including aquaculture, has played a significant role in the agricultural development of Taiwan. The relative importance of this sector can be seen in the fact that its share of total agricultural production increased from 11% in 1950 to 21% in 1979, while the share of crop production declined from 64% to 48%.

Intensive land use is a tradition in Taiwan. Farmers have found it necessary to grow crops and raise animals year-round wherever possible and have changed from crops to fish culture to maximize the profit from their farmland and to sustain their levels of living. The area devoted to fish culture has increased from 38 148 ha in 1965 to 60 460 ha in 1979. Milkfish is the most important species cultured in Taiwan; in 1979, 15 346 ha, or about 26% of the total area was used for milkfish.

Basic biological research on milkfish in Taiwan has been intensive, but there have been few economic studies of production. Moreover, there has been no economic analysis of the fry input sector nor of the marketing of milkfish in Taiwan. The Taiwanese milkfish industry faces a chronic shortage of fry and must rely on imports from the Philippines and Indonesia for almost half its annual requirements. Demand for milkfish fingerlings has grown because the fish has been found to be a suitable baitfish for the tuna long-liners based in Kaohsiung and Tung-Kang, the southern parts of Taiwan. However, many milkfish producers are finding that the rearing of shrimp and other freshwater fish is more profitable than rearing market-size milkfish. Because of the importance of milkfish as a protein source, the government is anxious to maintain production. Thus, a systematic economic analysis of production and marketing of milkfish is needed to assist the government in its programs to sustain milkfish production and the incomes of producers and other support groups within the sector.

This research was undertaken to produce an economic analysis of the production and marketing of milkfish, and specifically to: (1) examine the gathering and marketing of milkfish fry; (2) measure the production efficiency of the baitfish industry; (3) analyze the input-output relationship of production of market-size milkfish; and (4) understand the marketing of market-size milkfish.

Methods

A number of indicators can be used for an economic analysis of production and marketing of milkfish and they will be discussed separately.

Production Aspects

Benefit–Cost Ratio

Benefit–cost analysis has become increasingly popular and useful because it can be used to compute the direct and indirect costs and benefits of a specific enterprise. The benefit–cost ratio of a

[1]Research for this paper was supported by a grant from the International Center for Living Aquatic Resources Management (ICLARM) Manila, Philippines. The complete results of this study will be published at a later date by ICLARM.

[2]Research Institute of Agricultural Economics, National Chung Hsing University, Taichung, Taiwan 400.

specific enterprise is: $K = FI/TC$, where FI is farm income and is equal to the difference between farm receipts and production costs, and TC is total cost of production.

Rate of Farm Income

The rate of farm income is also an indicator of production efficiency and can be computed using the formula: $R = FI/FR$, where FI is farm income and FR is farm receipts. From the point of farm management, FR is equal to farm income and farm expenses. Based on this equation we can see that the larger the rate of farm income, the greater the production efficiency.

Factor Productivity

Factor productivity is a reciprocal concept of production efficiency and is measured as output per unit of input. Setting farm output as Q, input of farmland as D, labour as N, and capital as C, land, labour, and capital productivity can be explained by Q/D, Q/N, and Q/C, respectively. Factor productivity can be derived from the relationship between factor productivity and the factor–factor ratio. For example, land productivity can be explained by: (1) the relationship between land productivity and labour productivity and the labour–land ratio; or (2) the relationship between land productivity and capital productivity and the capital–land ratio. The factor productivity can be explained by the following formulas:

$$\text{Land productivity}: \frac{Q}{D} = \frac{Q}{N} \cdot \frac{N}{D}; \frac{Q}{D} = \frac{Q}{C} \cdot \frac{C}{D}$$

$$\text{Labour productivity}: \frac{Q}{N} = \frac{Q}{D} \cdot \frac{D}{N}; \frac{Q}{N} = \frac{Q}{C} \cdot \frac{C}{N}$$

$$\text{Capital productivity}: \frac{Q}{C} = \frac{Q}{D} \cdot \frac{D}{C}; \frac{Q}{C} = \frac{Q}{N} \cdot \frac{N}{C}$$

From the first of these equations, land productivity from labour used, we can see that if the labour–land ratio is held constant, the increase of land productivity (Q/D) is entirely due to the increase in labour productivity. For land productivity from capital input, if the capital-land ratio (C/D) remains constant, the increase in land productivity (Q/D) is totally due to the increase in capital productivity.

Elasticity of Substitution

With two factors of production, labour (N) and capital (C), the elasticity of substitution is:

$$\sigma = \frac{(C/N)\ d\ (N/C)}{(f_n/f_c)\ d\ (f_c/f_n)}$$

where f_n and f_c are the marginal products of labour and capital, respectively. The elasticity of substitution is the proportional change in the relative factor inputs to a proportional change in the marginal rate of substitution between labour and capital (Brown 1968, p. 18). The elasticity of substitution is an important indicator of production efficiency.

A CES (constant elasticity of substitution) production function was used to measure elasticity of substitution in this study. The CES production function is:

$$Q = \gamma\ (k\ C^{-\rho} + (1 - k)\ N^{-\rho})^{-v/\rho}$$

where Q, C, and N represent output, capital, and labour inputs, respectively, and γ is a scale parameter denoting the efficiency of a production technology, k is the distribution parameter indicating the degree to which technology is capital intensive; v represents the degree of homogeneity of the function or the degree of return to scale; and ρ is the substitution parameter equal to $(1 - \sigma)/\sigma$, where σ is the elasticity of substitution. Then we can estimate σ, where $\sigma = 1/(1 + \rho)$.

Marketing Aspects

Marketing Channels

Marketing channels must be studied to understand the marketing system and the relation of markets and market agencies to one another. The channel represents the movement of products from producers to consumers and involves several market agencies. The farmers use different marketing channels depending on the quantity of product they have for sale. Small producers of milkfish may sell to dealers or wholesalers, whereas large producers may ship directly to one of the city markets.

Marketing Margins

In the agricultural sector, the marketing margin is the retail price less the farmgate price. Margins at different market agencies vary widely with the type of products handled. Generally, they are higher for perishable products.

Marketing Costs

Marketing costs are service charges on marketing. Generally speaking, marketing costs reflect the country's economy and are closely related to the degree of industrialization of the economy. These costs can be calculated from the price paid at the point of production, the wholesale and retail prices paid where the goods are consumed, and the marketing expenses, such as assembly, transportation, freezing, profit, and market management fees. We can then determine what share of the consumer's dollar goes to the producer and how much goes for marketing.

Price Variation

Price variation can be explained by an index of seasonal variation and by price instability measured by the Michaely index and Von-Neumann ratio (Michaely 1962; UNCTAD 1968). The data for this study were gathered in a field survey of approximately 220 fry gatherers and dealers, baitfish producers, milkfish producers, and marketing intermediaries in 1979. In addition, secondary data on production and prices were obtained from various publications of official institutions in Taiwan.

Gathering and Marketing of Milkfish Fry

Fry Gathering

Milkfish fry are procured from coastal waters. The main sources of fry are located on the southern and eastern coasts of the island. However, there are significant regional variations in procurement and during 1977–79 the eastern coast accounted for about 83% of the total fry catch. The total procurement of fry varies widely from year to year due to meteorological and oceanic changes that affect milkfish spawning and consequently the distribution of eggs and fry. In addition, fry procurement is influenced by the techniques of fry gathering and the degree of water pollution in the coastal areas.

There is an important relationship between techniques of fry gathering and fry procurement, and this relationship has great historical significance (Chen 1952; Lin and Chen 1980). Fry gathering can be increased by gear improvement. There are a number of different methods used to catch fry, ranging from the simple hand-operating scoop nets and sweepers that can easily be handed by one person to motorized rafts and boats (Table 1).

Variation in Fry Procurement

Fluctuations occur from year to year in fry supply, for instance, during 1965–79, the catch varied from a low of 33.96 million (1967) to a high of 234.87 million (1970). Since 1970, fry procurement has decreased year by year, reaching 61.85 million in 1979 (Taiwan Fisheries Yearbook).

The trend in fry procurement can be represented by regression equations for the years 1965–79 and 1970–79. On average, the trends for fry procurement over the two periods were:

$$Q = 143957.88 - 3005.34\,t; \ (1965\text{–}79),\ R^2 = 0.2660$$
$$Q = 202063.93 - 14309.72\,t; \ (1970\text{–}79),\ R^2 = 0.8284$$

Table 1. Fry gathering techniques.

Gear	Years used	Cost (N.T.$)[a]	Fry caught per day
Sweeper	3	1500	150–200
Fixed net	2	700	300–400
Motor rafts	7	45000	1500–2000
Boat	10	200000	3000–4000

[a]N.T.$36 = U.S.$1.00.

where Q stands for the quantity of fry caught and t shows the number of years. This means that the number of fry caught decreased annually by 3005 and 14310 thousand pieces during these periods.

In addition to annual fluctuations, the number of fry caught for a given level of effort varies from day to day and from month to month. Peak procuring days occur at the times of high tides associated with full and new moons, and the peak months are May and June. Taiwanese fry procurement is characterized by extreme seasonality reflected in marked peaks and slack periods. The index of seasonal variation reached 578.03% and the standard deviation of seasonal variation was 120.90.

Marketing and Distribution of Fry

Fry marketing and distribution are the core of the procurement subsystem and involve methods of transportation, marketing channels, marketing margins, regional distribution, and price variation.

Methods of Transportation

As a general rule, the transport route for fry is short and usually involves only three transactions: from gatherers to middlemen; middlemen to dealers; and dealers to milkfish and baitfish rearing ponds.

The main methods used to transport fry from the fry catchers to the middlemen are bicycle (75%), walking (16%), and motorcycle (9%) and the distances of the fry middlemen from the seashore are short (average 4.8 km). The most common type of transaction is for the middlemen to go to the seashore where the fry are stored temporarily by fry gatherers (75%), but 14% of the middlemen go to the fry gatherer's house, and 11% of fry gatherers deliver their fry to the middlemen.

Short distances are also involved between the fry middlemen and dealers, and the fry are transported by taxi (55%), motorcycle (27%), truck (9%), and by train (9%). Transportation costs depend on the distance and transportation facility used, but average transportation costs per

10 000 pieces are N.T.$188 (N.T.$36 = U.S.$1.00) with a 98% survival rate.

The last phase involves moving the fry from the dealers to the milkfish-bait rearing ponds and market-size milkfish rearing ponds. Traditionally, the fishpond operators go to the dealers to buy the fry and handle transport themselves. Fry are most commonly transported by motorcycle and truck depending on the distance and the quantity of fry purchased.

Marketing Channels and Marketing Margins

Accurate data on imported milkfish fry are very difficult to assemble; therefore this study only focuses on domestic fry. The marketing channels for fry can be divided into two phases: (1) before the middlemen phase — where 100% of fry pass from the fry gatherers to middlemen; and (2) after middlemen. After the middlemen, the method of distribution is diversified: 3% are transported from middlemen to market-size rearing ponds; 92% go to fry dealers; and 5% move directly to baitfish rearing ponds. Finally, the dealers distribute their fry to market-size milkfish rearing ponds (58%), overwintered fry nursery ponds (23%), and baitfish rearing ponds (19%).

Because the marketing channels for fry are short, the marketing margins are also small. The prices per fry received by fry gatherers and dealers were N.T.$2.03 to N.T.$2.55, respectively.

Distribution of Fry

Fry mostly come from the eastern part of this island where the resources of fry are plentiful but milkfish rearing facilities are very limited. Because the milkfish rearing areas are centred on the southwest part of Taiwan, the distribution of fry is, therefore, focused on this part of the island.

Tainan city is considered the fry trading centre. Most of the fry come from the eastern (66%) and southern coast (31%). The primary demand for fry comes from the Tainan area: 44% of the fry go to Tainan Hsien, 24% to Tainan city, 14% to Chai-I Hsien, and 11% to Kaohsiung Hsien.

Price Analysis of Fry

The price of fry is determined by supply and demand. The demand for milkfish is relatively stable because the total milkfish production area has remained unchanged during the past decades; the price of fry is primarily influenced by supply. As the quantity of fry increases, the price of fry decreases. This relationship between the price of fry and supply can be represented by a regression equation for the years 1965–79:

$$P_f = 5.0849 - 1.1008\ Q_f;\ R^2 = 0.6299,\ \text{t-value} = 5.2161$$

where P_f stands for the price of fry (in real terms) and Q_f shows the quantity of fry caught. This equation indicates that the supply of fry is the main factor affecting their price.

To determine the long-term trend of fry prices, the least squares method was used to calculate the regression equations. The trends of fry prices are as follows:

$$P = 0.6987 + 0.0618\ t\ (1965\text{–}79)$$
$$R^2 = 0.5028\ \text{(current price)}$$
$$P = 2.5631 - 0.0941\ t\ (1965\text{–}79)$$
$$R^2 = 0.4254\ \text{(constant price)}$$

and

$$P = 0.1940 + 0.1862\ t\ (1970\text{–}79)$$
$$R^2 = 0.9902\ \text{(current price)}$$
$$P = 0.9720 + 0.0751\ t\ (1970\text{–}79)$$
$$R^2 = 0.6683\ \text{(constant price)}$$

where P stands for the price of fry and t is the number of years. This means that the price of fry has annually increased in terms of current price and annually decreased in terms of constant price during 1965–79. But during the last decade, the fry price has increased annually in terms of both current and constant prices. The seasonal variation in fry price is high because fry gathering is characterized by extreme seasonality. The total range of seasonal variation in the price of fry reached 200% and the standard deviation of the seasonal index was 52.02.

The price stability of fry can be computed using the Michaely Index and Von-Neumann ratio. The indices of instability of fry price (at current price) as measured by the Michaely index during 1965–79 and 1970–79 were 47.7% and 38.6%, respectively, which indicates extreme instability. In terms of constant price, the indices of instability were 28.1% and 17.6%, respectively, for the same periods, which indicates extreme instability and substantial instability.

In comparative terms, the regularity of fluctuation in the fry price, as measured by the Von-Neumann ratio, is modest and directional. During the periods 1965–79 and 1970–79, in terms of current prices, the Von-Neumann ratios were 1.25 and 2.01, respectively, whereas, in terms of constant prices, the ratios decreased sharply to 0.21 and 1.01, respectively.

An evaluation of this procurement subsystem must consider two points: (1) the stability of fry gathering — if the fry supply fluctuates, the price variation is high; and (2) an analysis of baitfish and market-size milkfish production because fluctuations in the price of fry may reflect price instabilities in baitfish and market-size milkfish.

Production of Milkfish Fingerlings for Baitfish Industry

Many factors, such as the demand for milkfish fingerlings for the deep-sea tuna fishing industry, the production environment of milkfish, and the relative profitability of market-size milkfish and milkfish-bait rearings, affect the rearing of milkfish fingerlings.

The rearing of fingerlings depends on a favourable rearing environment and a supply of new fry caught from the sea from early April to September. There are three periods for fingerling rearing during the year: (1) in early April for harvest before the end of May; (2) in early June for harvest within 60 days; and (3) in early August for harvest at the end of October (about 90 days are required because the weather is cooler and the fry grow more slowly).

Resource Use of Baitfish Farms

Baitfish rearing is a capital-intensive, labour-saving industry: on average, the land input per farm is 1.8 ha; the capital input per hectare is N.T.$114 703, and the labour input per hectare is 86 man-days. Capital inputs per hectare increase and labour inputs per hectare decrease as farm size increases. For farms of less than 1 ha the average direct capital investment is N.T.$111 141 and the labour input is 96 man-days. The figures for farms larger than 1 ha are N.T.$115 516 and 80 man-days.

The relationship between farm size and stocking rate per hectare for baitfish rearing is very significant. For farms under 1 ha, the stocking rate of fingerling per hectare is 37 091; for farms over 1 ha, the stocking rate of fingerling reaches to 41 621 pieces per hectare. The survival rates are 96% for farms under 1 ha and 92% for those larger than 1 ha.

Economic Analysis of Baitfish Farms

Baitfish rearing in Taiwan has significantly affected: (1) the benefit–cost ratio and rate of farm income; and (2) the factor productivity and elasticity of substitution.

Benefit–Cost Ratio and Rate of Farm Income

Milkfish fingerling rearing increases overall agricultural output and family farm income. Table 2 shows the benefit–cost ratio and the rate of farm income of different size baitfish farms in Taiwan. It is very difficult to estimate total family farm income, including off-farm income, because the extent of off-farm income depends on how many members of the farm family work outside the farm.

From the point of view of farm income, the B–C ratio is highly related to the size of the baitfish farm. Farms under 1 ha have lower farm income than larger farms. The rate of farm income increases with an increase in the size of the fingerling rearing farm. The rate of farm income was 27.79 for farms under 1 ha and 30.42 for farms over 1 ha.

Factor Productivity and Elasticity of Substitution

Baitfish rearing showed a significant relationship with factor productivity, which varied with farm size. Data from southern Taiwan (1979) indicate that the productivity of different size baitfish farms is closely related to land productivity, capital productivity, and labour productivity (Table 3). Factor productivity per hectare increased considerably with the adoption of intensive agricultural operations, such as capital intensive inputs and new rearing technologies.

The factor productivity of baitfish farms has advanced remarkably due to two major factors: (1) the increase of production per hectare; and (2) the price of baitfish compared with market-size milkfish. Factor productivities are usually considered as important indicators of the level of economic efficiency of production of small farms

Table 2. The benefit–cost ratio and rate of farm income per hectare for baitfish farms.

Farm size (ha)	(1) Farm receipts (N.T.$)	(2) Production costs (N.T.$)	(3) Farm income (N.T.$)[a]	Farm income/ production costs[b]	Rate of farm income[c]
< 1	162770	117531	45239	0.38	27.79
> 1	174097	121143	52954	0.44	30.42
Average	172153	120440	51712	0.43	30.04

[a]Equals column 1 minus column 2.
[b]Equals column 3 divided by column 2.
[c]Equals column 3 divided by column 1 times 100.

in Taiwan. One important implication of this analysis is that milkfish fingerlings for the baitfish industry have made a remarkable contribution to the growth of land, capital, and labour productivities. Hence, policymakers should place more attention on how this type of farming enterprise can be more effectively promoted within the milkfish sector.

The static CES production function was used to determine the elasticity of substitution of production on baitfish farms. The equation was estimated by ordinary least squares regression based on cross-sectional data from the farm survey (Table 4).

Based on the estimated parameters of the CES production function of baitfish farms, it is clear that the effect of technology (γ) on the production of baitfish farms was significant. With relative increases in capital inputs and relative decreases in labour inputs, capital was a significant substitute for labour, and labour-saving technology has been utilized in the baitfish farms.

The elasticity of substitution between capital and labour in baitfish farms was high (Table 4). On average, the value of elasticity of substitution was greater than one because capital input is growing more rapidly than labour input in this type of farming.

Table 3. Productivity and factor–factor ratio of baitfish farms.

	Farm size (ha)		
	< 1	> 1	Average
Per labour capital input C/N (N.T.$/man-day)	1120	1509	1398
Per capital labour input N/C (man-day/N.T.$)	0.000820	0.000663	0.000716
Per capital land input D/C (ha/N.T.$)	0.000009	0.000008	0.000008
Per land capital input C/D (N.T.$/ha)	117531	121143	120440
Per labour land input D/N (ha/man-day)	0.010378	0.012460	0.011605
Per land labour input N/D (man-day/ha)	96.36	80.26	86.17
Land productivity Q/D (N.T.$/ha)	162770	174401	172152
Labour productivity Q/N (N.T.$/ha)	1689	2169	1998
Capital productivity Q/C (N.T.$/N.T.$)	1.38	1.44	1.43

Table 4. Results of estimation of CES production function and estimated parameters for baitfish farms.

	Farm size (ha)		
	< 1	> 1	Average
β_1	2.8358	3.5711	2.7845
β_2	0.1095	0.6961	0.2635
	(6.0180)*	(0.1358)*	(0.3044)
β_3	0.6998	0.2912	0.6223
	(0.3710)	(5.7405)*	(0.6932)
β_4	9.2204	3.6017	1.4067
	(7.5015)*	(0.1172)	(0.2431)
F	54.2665	396.5886	295.7764
R^2	0.9585	0.9876	0.9715
n	11	25	36
γ	17.0442	35.5555	16.1914
k	0.1353	0.7051	0.2975
v	0.8092	0.9873	0.8858
ρ	–0.1948	–0.3509	–0.1520
σ	1.2419	1.5405	1.1793
R^2	0.9585	0.9876	0.9715
S	0.1293	3.5863	7.6406

Note: An asterisk denotes significance at 95% confidence level, numbers within parentheses are t-values, and number of farm households equals n.

Marketing Channels and Marketing Costs of Baitfish

The marketing channels are very short for milkfish used as baitfish. Baitfish producers buy fry from fry dealers. The fry, after being stocked in the nursery ponds for 60–90 days, become fingerlings that are suitable as baitfish for tuna long-liners. Some of the fingerlings are sold to market-size milkfish producers (about 35% of the total) because of the decline in demand for milkfish as bait for deep-sea fishing in recent years.

In 1979, marketing costs for 100 pieces of milkfish-bait were N.T.$198. Of this total, the profit of the middlemen accounted for about 51% of the total marketing cost. Salaries accounted for 12%, transportation 15%, oxygen 5%, losses 8%, and other expenses 9%.

Production of Market-Size Milkfish: Transformation Subsystem

Market-size milkfish rearing is considered as a subsystem that transforms milkfish fry to market-size fish. The milkfish industry, its resource use, and the input-output relationship of milkfish farms are briefly explained in this section.

Overview of the Milkfish Industry

Milkfish production is centred in the southern coastal areas of Taiwan. Production is entirely in the private sector, largely individual milkfish farmers whose ponds range from under 1 ha to 20 ha. A small number of companies are involved in milkfish production and their farms are larger than 50 ha.

The total production area in the past 15 years has shown a slight decrease from 15 616 ha in 1965 to 15 346 ha in 1979. Total milkfish production has been stable between 27 000 and 32 000 t/year from 1965 to 1979 although the annual fry catch has varied from 34 million to 235 million during the same years. Annual milkfish production per hectare increased from 1765 kg in 1965 to 2087 kg in 1979.

Not only is milkfish production influenced by the relative profitability of milkfish-bait rearing, it is also affected by the relative yields per hectare of other freshwater fish. The area devoted to milkfish production compared with the total aquaculture area has decreased from 41% in 1965 to 25% in 1979, while the production of other species has increased from 59% to 75% in the same period.

Resource Use of Milkfish Farms

For relatively small farms with large inputs of working capital, the relative importance of land in milkfish production has gradually decreased. Working capital is the major factor substituting for land in the expansion of milkfish production.

In 1979, the land input for milkfish farms ranged from 1.82 ha for farms below 3 ha, to 5.75 ha for farms between 3 and 10 ha, to 25.64 ha for farms above 10 ha. The average land input was 10.61 ha. The capital inputs of milkfish production consisted of 91% in direct costs and 9% in indirect costs. On average, the total capital inputs per hectare were N.T.$92 546. Labour inputs per hectare decreased relative to farm size from 117 man-days for farms of below 3 ha, to 84 man-days for farms between and 3 and 10 ha, to 71 man-days for farms above 10 ha. This trend was very significant.

Economic Analysis of Milkfish Production

Benefit–Cost Ratio and Rate of Farm Income

The benefit–cost ratio and rate of farm income for market-size milkfish farms are closely related to farm size (Table 5). This means that the large farms practice more effective farming, which results in higher farm income per hectare. The B–C ratio and rate of farm income increased as farm sizes grew, mainly because of smaller labour inputs per hectare and increased efficiency of capital and labour in the larger milkfish farms. Therefore, larger farms are useful because farmers can take advantage of technological change in combination with reduced labour inputs.

In comparing Tables 2 and 5, which show the B–C ratio and rate of farm income in baitfish and market-size milkfish farms, it is clear that production of milkfish fingerlings for the baitfish industry is more profitable and efficient than production of market-size milkfish. On average, the B–C ratio and rate of farm income for baitfish rearing are 0.43 and 30.04, respectively, whereas for production of market-size milkfish these figures are only 0.10 and 9.28, respectively.

Factor Productivity and Elasticity of Substitution

The productivity of a factor depends not only on the quantity of specific factor employed but also on the quantities of other resources used. Table 6 compares the factor productivities for different size milkfish farms. It is significant that the factor productivities are closely related to farm size. For instance, land productivity per

Table 5. Benefit–cost ratio and rate of farm income of milkfish farms.

Farm size (ha)	(1) Farm receipts (N.T.$)	(2) Production costs (N.T.$)	(3) Farm income (N.T.$)[a]	Farm income/ production costs[b]	Rate of farm income[c]
< 3	96625	91431	5194	0.0568	5.38
3–10	99886	92487	7399	0.0800	7.41
> 10	103195	92675	10520	0.1135	10.19
Average	102053	92546	9475	0.1024	9.28

[a]Equals column 1 minus column 2.
[b]Equals column 3 divided by column 2.
[c]Equals column 3 divided by column 1 times 100.

hectare ranged from N.T.$96 625 for farms below 3 ha, to N.T.$99 886 for farms between 3 and 10 ha, to N.T.$103 195 for farms above 10 ha. This increasing trend was very clear.

When compared with Table 3, it can be seen that the factor productivities are much higher in baitfish farms than in farms that produce market-size milkfish. If the purpose of using the milkfish resource is to maintain adequate resource returns and farm income in the face of growing competition from other freshwater fish rearings, a change from milkfish rearing to baitfish rearings, if the production environments are suitable, is necessary for increased productivity and efficiency of production. Capital inputs play a very important role in milkfish production; thus, analysis of the capital inputs and elasticity of substitution between capital and labour in milkfish farming is useful for examining resource use and technological change in milkfish production. The elasticities of substitution are shown in Table 7, which is based on the CES production function.

Table 6: Productivity and factor-factor ratio of milkfish farms.

	Farm size (ha)			
	< 3	3-10	> 10	Average
Per labour capital input C/N (N.T.$/man-day)	779	1106	1305	1218
Per capital labour input N/C (man-day/N.T.$)	0.00128	0.00090	0.00077	0.00082
Per capital land input D/C (ha/N.T.$)	0.000011	0.000011	0.000011	0.000011
Per land capital input C/D (N.T.$/ha)	91431	92487	92675	92546
Per labour land input D/N (ha/man-day)	0.00852	0.01196	0.01409	0.01316
Per land labour input N/D (man-day/ha)	117.41	83.62	71.00	75.98
Land productivity Q/D (N.T.$/ha)	96625	99886	103195	102053
Labour productivity Q/N (N.T.$/man-day)	823	1195	1454	1343
Capital productivity Q/C (N.T.$/N.T.$)	1.0568	1.0800	1.1151	1.1027

Table 7. Results of estimation of CES production function and estimated parameters of milkfish farms.

	Farm size (ha)			
	< 3	3-10	> 10	Average
β_1	2.6376	3.1691	2.5641	2.9078
β_2	0.5288	0.6793	0.7742	0.7660
	(1.2202)	(1.1070)	(1.0507)	(1.1968)
β_3	0.4051	0.1659	0.1216	0.0170
	(0.2829)	(0.0261)	(1.0079)	(1.0044)
β_4•	0.0234	-0.0019	-0.0070	-0.0033
	(0.1752)	(-1.0042)	(-0.9065)	(-0.9120)
F	143.7766	56.6120	64.6766	171.6590
R^2	0.9664	0.8457	0.9023	0.8788
n	19	45	31	95
γ	13.9797	23.7871	12.9883	18.3165
k	0.4337	0.8037	0.1358	0.6783
v	0.9339	0.8452	0.8958	0.7830
ρ	-0.2037	0.0286	0.1340	0.3998
σ	1.2556	0.9722	0.8818	0.7144
R^2	0.9664	0.8457	0.9023	0.8788
S	0.0830	0.0586	0.0643	0.0573

Note: Numbers within parentheses are t-values and number of farm households equals n.

The high elasticity of substitution between capital and labour in milkfish farming is primarily for farms under 3 ha, for which the value of elasticity of substitution (σ) is greater than one. The values of elasticity of substitution are less than one for the other two farm sizes.

Marketing of Market-Size Milkfish: Delivery Subsystem

Marketing of milkfish is considered as a delivery subsystem of the milkfish industry. The milkfish produced in Taiwan are consumed fresh; therefore, the analysis of milkfish marketing will centre on marketing channels, marketing margins, marketing costs, and price variations of fresh milkfish.

Marketing Channels and Marketing Margins

There are three major marketing channels that provide the link between producers and consumers:

(1) Producers → wholesalers → city fish markets → dealer-retailers → retailers → consumers.

(2) Producers → cooperatives → city fish markets → dealer-retailers → retailers → consumers.

(3) Producers → dealers → dealer-retailers → retailers → consumers.

Milkfish farmers sell 71% of their products to wholesalers, 15% to cooperatives, and 14% to dealers. Thus, the wholesalers play a very important role in milkfish marketing.

The farm-retail marketing margins show the share of the consumer's dollars going to each intermediary. Producers received 74% of the retail price, with the remaining 26% being absorbed in the marketing process. The wholesaler and retailer receive 79% and 89% of the city retail prices, respectively.

Table 8 compares the wholesale farm prices and retail city prices, which can be used to calculate the producer's share of the retail price during the period 1970–80. The producer's share of the retail price has generally decreased annually. This share was 81% in 1970, increased to 98% in 1972, decreased to 59% in 1978, which was the lowest share during the last decade, and then rose above 70% in the years 1979 and 1980. On the contrary, the marketing group's share rose from 19% in 1970 to 29% in 1980. The difference between the wholesale price of production and the retail price rose from N.T.$5.26/kg in 1970 to N.T.$32.86/kg in 1980, a trend that was very significant.

Marketing Costs

The average total marketing cost per 100 kg was assumed to provide a rough approximation of the efficiency of milkfish marketing. This assumption can only be verified using time-series data to compare marketing costs over previous years, but unfortunately, there are no available time-series data to support or contradict this assumption. Therefore, in this case the costs of marketing can only be analyzed using expenses.

Table 9 shows the marketing costs of milkfish in Taiwan. The total marketing costs per 100 kg were N.T.$2755 and the proportion of marketing costs to retail price of milkfish was 26%. Among

Table 8. Farm price and retail price (N.T.$/kg) of milkfish.

	(1) Wholesale price of production	(2) Retail price in cities	Difference in prices[a]	Producer's share[b]
1970	22.68	27.94	5.26	81.17
1971	25.61	31.46	5.85	81.40
1972	33.06	33.68	0.62	98.16
1973	32.11	37.34	5.23	85.99
1974	48.63	52.32	3.69	92.95
1975	37.87	63.32	25.45	59.81
1976	43.47	68.78	25.31	63.20
1977	49.34	82.81	33.47	59.58
1978	55.67	94.05	38.38	59.19
1979	77.05	104.60	27.55	73.66
1980	80.82	113.68	32.86	71.09

[a]Equals column 2 minus column 1.
[b]Equals column 1 divided by column 2 times 100.
Source: Taiwan Fisheries Yearbook.

the cost items, profits, market management and taxes, and freeze, package, and transportation costs were 48%, 17%, and 17% of total costs, respectively. Profits, therefore, account for the highest percentage of the costs incurred in marketing.

The marketing costs of milkfish in Taiwan can also be illustrated by the marketing costs of the different marketing agencies. The major marketing agencies of milkfish are dealers, wholesalers, and cooperatives. As shown in Table 10, the total marketing costs per 100 kg were N.T.$601, N.T.$907, and N.T.$723 from the dealers, wholesalers, and cooperatives, respectively. Dealers are considered as the lowest cost incurred in marketing. Because the dealers transport fish directly to dealer-retailers or retailers, there are no taxes, market management, and fisherman insurance fees during the marketing process.

Table 9. Marketing costs per 100 kg of milkfish by expenses.

	Marketing costs (N.T.$)	Percentage of marketing costs
Market management	269	9.78
Taxes	199	7.24
Fisherman insurance	111	4.04
Freeze	113	4.10
Package	143	5.20
Transportation	214	7.78
Miscellaneous expenses	372	13.50
Profits	1332	48.36
Total	2755	100

Note: Percentage of marketing costs based on Lin and Chen (1980).

Price Analysis of Milkfish

It is possible to explain the price variation of milkfish in the long-run by seasonal variations and price instability. The least squares method can be used to compute the regression equation for the period 1970–80. The trends in milkfish price are:

Current Price

Wholesale farm prices $P_1 = 13.6547 + 5.3957\,t$; $R^2 = 0.9329$

Retail city prices $P_2 = 9.4507 + 9.1815\,t$; $R^2 = 0.9865$

Constant Price

Wholesale farm prices $P_1 = 51.0833 + 0.1245\,t$; $R^2 = 0.4478$

Retail city prices $P_2 = 47.3238 + 3.2216\,t$; $R^2 = 0.9171$

where P is the price of milkfish and t is the number of years. From these equations, the prices of milkfish, whether in wholesale farm prices or retail prices, increased annually at both current and constant price. The seasonal variation in milkfish price was high because milkfish production is characterized by substantial seasonality. The total range of the indices of seasonal variation of milkfish price was 89% and 115% of the wholesale farm prices and retail city prices, respectively. This shows that the seasonal

Table 10. Marketing costs for 100 kg of milkfish by different agencies.

	Dealer		Wholesaler		Cooperative	
	N.T.$	%	N.T.$	%	N.T.$	%
Salary	76	12.65	80	8.82	67	9.27
Transportation	125	20.80	124	13.67	173	23.93
Freeze	75	12.48	75	8.27	104	14.38
Package	38	6.32	38	4.19	57	7.88
Profit	260	43.26	218	24.04	—	—
Taxes	—	—	70	7.72	33	4.56
Market management	—	—	175	19.29	167	23.10
Fisherman insurance	—	—	91	10.03	87	12.03
Other expenses	27	4.49	36	3.97	35	4.85
Interest	20	3.33	19	2.10	7	0.97
Equipment depreciation	—	—	—	—	3	0.42
Water	—	—	—	—	1	0.14
Electricity	—	—	—	—	6	0.83
Fishery development funds	—	—	11	1.21	10	1.38
Mail and telegram	7	1.16	6	0.66	8	1.11
Total	601	100.00	907	100.00	723	100.00

variation of milkfish price is higher in retail city prices than in wholesale farm prices.

To measure the price instability of milkfish, the Michaely index and Von-Neumann ratio were adopted to compute the price data from wholesale farm prices and retail city prices at both current price and constant price. At current prices, the wholesale farm prices and retail city prices showed substantial instability (16.44 and 16.16, respectively), but in terms of constant prices both showed slight instability (6.42 and 5.91, respectively). With respect to the direction of change in price and regularity of variation, the milkfish price showed modest and directional variation (the values of the Von-Neumann ratio ranged from zero to one).

Finally, comparisons between the price of other fish and milkfish are required because milkfish is considered as a substitute for other fish. The trend in the freshwater fish–milkfish price ratio from 1965 to 1979 has decreased annually, except for shrimp where the price has increased annually faster than that of the milkfish. For example, the tilapia–milkfish price ratio decreased from 45% in 1965 to 42% in 1979 and the silver carp–milkfish price ratio decreased sharply from 82% to 37% in the same period.

The price ratio of milkfish to other freshwater fish has increased annually during the past 15 years because milkfish is considered a good fish in Taiwan. Nevertheless, the relative importance of milkfish in terms of production area relative to the total aquaculture area has been decreased from 41% in 1965 to 25% in 1979. This is because freshwater fish farms have adopted new fishpond management and rearing technology and the yield per hectare in these farms is higher than in milkfish production.

Policy Implications

As economic growth quickens and per-capita income increases in Taiwan, the demand for aquatic products increases. As a result, the aquaculture area has expanded rapidly during the past 15 years. However, the milkfish production area has remained at about 15 000 ha, and yields per hectare have increased slowly compared with other freshwater fish species. The revenue per hectare is also lower for milkfish production than for other freshwater fishes. Under such conditions, the growth in milkfish production has slowed. Improvement of fishpond management and the use of the new rearing technology are essential to avoid such inefficiencies in production and to increase the income of producers. However, because the milkfish resource system consists of three subsystems, procurement, transformation, and delivery, any suggestions for improvement should cover all three subsystems.

- *Procurement subsystem:* The main problems of this subsystem are the supply of fry and their price. To increase and maintain the source of milkfish fry and stabilize fry price, our efforts must emphasize: (1) the control of water pollution in coastal areas; (2) the improvement of fry gathering techniques: and (3) the development of artificial spawnings of milkfish fry.
- *Transformation subsystem:* A good resource system should provide flexibility for the adjustment of farm management in response to changes in economic and technological conditions. For economies of scale and production efficiency, the farmers should be encouraged to participate in group farming and contract farming to broaden their base of operations and to increase yields per hectare by adopting new rearing technology such as deep-water systems. This will allow them to meet the needs of dynamic economic and technological situations.
- *Delivery subsystem:* In 1979, the milkfish shipped to city markets through cooperative marketing by the Fisherman's Association accounted for only 15% of total milkfish production. Under cooperative marketing, fish products are collected and directly transported to market by the Fisherman's Association. In this way, some marketing costs can be saved and the producer's income can be increased. Therefore, cooperative marketing of milkfish could be an excellent system for increasing marketing efficiency and producer's income.

Brown, Murray. 1968. On the theory and measurement of technological change. New York, USA, Cambridge University Press.

Chen, T.P. 1952. Milkfish culture in Taiwan. JCRR Fisheries Series 1.

Lin, H.T. and Chen, C.T. 1980. Fisheries marketing in Taiwan (in Chinese). Chinese Economic Association Annual Conference Proceedings, December. pp. 143–169.

Michaely, M. 1962. Concentration in international trade. Amsterdam, pp. 68–69.

Taiwan Agricultural Yearbook, Department of Agriculture and Forestry, Provincial Government of Taiwan.

Taiwan Fisheries Yearbook, Department of Agriculture and Forestry, Provincial Government of Taiwan.

UNCTAD (United Nations Conference on Trade and Development). 1968. The development of an international commodity policy. New Delhi, India, UNCTAD, pp. 16–17.

Discussion

The demand for fish is rising in Taiwan, but the benefits are not going to milkfish production. Is this due to marketing problems or biological constraints to improving the technology in milkfish culture? Shrimp and crab production is more profitable in Taiwan than milkfish, and farmers are switching from milkfish. In this case, marketing research should proceed along with biological research.

Questions were raised concerning the ways of substituting labour for capital in milkfish culture. One could, for example, dispense feed by hand rather than a feed hopper.

How can the interaction between the different inputs in milkfish production be captured? One could do this rather easily by estimating a translog production function. At the same time, biologists could try to pinpoint the physical nature of these interactions.