Production and Price Changes in Tilapia Industry : The Case of Taiwan, 1965—1982

Chaur-Shyan Lee*
(李 朝 賢)

I. Introduction

Fisheries sector has played a significant role in the process of agricultural development in Taiwan. The relative importance of this sector can be seen in the fact that its share of total agricultural production increased from 10.61% in 1950 to 21.55% in 1982, while the share of crop production declined from 63.79% to 48.78% in the same time.[1)]

In recent years, since all the contries have explanded their economic areas on high seas to two hundreds nautical miles and the influece of energy crisis, the cost of deep-sea fishery has been so greatly increased that its development becomes slower and slower. Whereas in aquaculture, the improvements of breedings, production technique, and fishpond management have been greatly increased the yield per hectare, this sector developed relatively fast thereby. Under such circumstances, the aquaculture development in Taiwan has enjoyed the situation of comparative advantage in the past years.

The tilapia industry is characterized by rapid expansion in production and cultivated area during the past two decades in Taiwan. However, this rapid expansion has associated with high and substantial changes or variations in production and prices

* The author is a professor of agricultural economics, Research Institute of Agricultural Economics, National Chung Hsing University.

1) See Taiwan Agricultural Yearbook, Department of Agriculture and Forestry, Taiwan Provincial Government, R.O.C.

which influenced to the decision making of producers in this sector.

The purpose of this paper is to explore the changes of production and price in tilapia industry. For the production aspect, the trends in total production, cultivated area and yields will be reviewed in the first place, and then an estimation on relative influence of cultivated area and yield changes upon total production changes will be followed. After presenting this background material, the regression analysis will be used to measure the factors which affect the changes of production of tilapia. For the price aspect, it also will be reviewed the trends in average, wholesale and retail prices and then the comparison of price between tilapia and other fish culture will be made. Finally, this analysis will measure the determinants of price changes with a statistical test.

II. Production of Tilapia

This section aims at making a general explaination on production of tilapia in Taiwan, in which the main items touched upon are total production, cultivated area and yields per hectare. The total production have marked a great increase resulted in both of rearing area and yield per hectare in the past 18 years. As production is determined by rearing area and yield, the question arises whether changes in rearing area or changes in yield are more or less instrumental in causing variation in total production. This section will try to estimate the relative influence of rearing area and yield changes upon total production changes.

1. Trends in Total Production, Cultivated Area and Yields

Based on the data of Fisheries Yearbook, as shown in Table 1. Total production of tilapia increased from 7,683 metric tons in 1965 to 51,504 metric tons in 1982. The cultivated area also increased from 2,393 hectares in 1965 to 10,460 hectares in 1982. Yield per hectare increased from 3,178 kg/ha to 4,872 kg/ha during the same period.

In explaining the relation between cultivated area and produc-

Table 1 Production of Tilapia in Taiwan, 1965—1982

	Total production		Cultivated area		Yield per hactare	
	M. T.	Index	Ha	Index	Kg	Index
1965	7,683	100.00	2,393	100.00	3,178	100.00
1966	8,331	108.47	2,624	109.65	3,152	99.18
1967	8,810	114.66	2,556	106.81	3,421	107.64
1968	9,232	120.16	2,481	103.67	3,692	116.17
1969	9,596	124.89	2,622	109.56	3,636	114.09
1970	11,362	147.88	2,162	90.34	5,211	163.97
1971	11,361	147.91	2,502	104.55	4,476	140.84
1972	10,923	142.17	3,443	143.87	3,108	97.79
1973	13,154	171.20	4,528	189.21	2,836	89.23
1974	15,192	197.73	4,874	203.67	3,031	95.37
1975	18,696	243.34	5,415	226.28	3,372	106.10
1976	22,222	289.23	5,648	236.02	3,845	120.98
1977	22,245	289.53	5,932	247.88	3,663	115.26
1978	28,112	365.89	8,230	343.91	3,343	105.19
1979	34,652	451.02	8,756	365.90	3,898	122.65
1980	34,781	452.70	9,072	379.10	3,716	116.92
1981	48,481	631.01	9,113	380.81	5,264	165.63
1982	51,504	670.36	10.460	437.10	4,872	153.30

Source: Fisheries Yearbook Taiwan Area, Taiwan Fisheries Bureau, Department of Agriculture and Forestry, Provincial Government of Taiwan, R.O.C.,

tion, different types and forms of cultivation will serve as bases to illustrate the tilapia production for the past 18 years.

In terms of types of cultivation, there are brackish water cultivation, freshwater cultivation and reservoirs cultivation. The forms of rearing in tilapia industry are only mono-culture and poly-culture. Total production areas by different types and forms of cultivation are shown in Table 2.

In the different types of cultivation, the area for brackish

Table 2 Cultivated Area of Tilapia Culture by Different Rearing Types and Forms

	Total	Types of Rearing			Forms of Rearing	
	Cultivated Area	Brackish Water	Fresh Water	Reservoirs and Others	Mono-culture	Poly-culture
	Ha	%	%	%	%	%
1965	2,393	5.18	78.19	16.63	8.57	91.39
1966	2,624	3.62	70.05	26.33	4.92	95.08
1967	2,556	9.12	71.05	19.87	10.21	89.79
1968	2,481	17.96	61.56	20.48	5.32	94.68
1969	2,622	11.59	67.89	20.52	9.69	90.31
1970	2,166	12.32	69.07	18.61	9.97	90.03
1971	2,502	9.88	70.58	19.54	9.59	90.41
1972	3,443	8.95	72.84	18.21	6.71	93.29
1973	4,528	6.18	78.27	15.55	5.39	94.61
1974	4,874	5.33	78.44	16.23	2.24	97.76
1975	5,415	1.81	76.99	21.20	2.11	97.89
1976	5,648	2.53	76.35	21.12	2.27	97.73
1977	5,932	3.72	74.60	21.68	2.14	97.86
1978	8,230	3.30	83.06	13.64	2.03	97.97
1979	8,756	7.30	78.16	14.54	4.96	95.04
1980	9,072	7.32	78.71	13.97	5.27	94.73
1981	9,113	7.59	79.32	13.09	6.33	93.67
1982	10,460	5.90	77.12	16.98	8.18	91.82

Source: Computed based on data of Fisheries Yearbook, Taiwan Area.

water cultivation was 5.18% in 1965 increased to 17.96% in 1968 and then decreased to 5.90% in 1982. The area for fresh water cultivation in the same period were 78.19%, 61.56% and 77.12% respectively. While reservoirs for tilapia cultivation has shown a stable proportion in the past 18 years. Fresh water cultivation has played an important role in tilapia industry in Taiwan.

With regard to the forms of rearing, poly-culture is the

major forms of rearing for for tilapia cultivation. As indicated in Table 2, the area devoted to poly-culture compared with the total cultivated area has reached above 90% during the past decades.

The long-run trends in total production cultivated area and yield per hectare of tilapia computed based on data for 1965—1982 with the least square method are shown in Table 3.

Table 3 Trends in Total Production, Cultivated Area and Yields of Tilapia

	Equations	r^2	Annual Growth Rate
Total Productipn			
1965—1982	$TP_1 = -2067.9739 + 2360.0382\ t$ (8.8417)	0.8301	16.45
1973—1982	$TP_2 = 5512.0667 + 4253.0606\ t$ (9.0527)	0.9377	29.15
Cultivated Area			
1965—1982	$CA_1 = 381.0588 + 502.6429\ t$ (11.8980)	0.8985	11.32
1973—1982	$CA_2 = 3437.2000 + 684.6545\ t$ (8.3330)	0.9426	13.10
Yields			
1965—1982	$Y_1 = 3261.0588 + 52.6605\ t$ (1.6611)	0.1471	3.59
1973—1982	$Y_2 = 2600.2000 + 215.2364\ t$ (6.9053)	0.7294	7.17

Note: The t-values are given in the brackets.

As shown in Table 1 and Table 3, total tilapia production increased 5.7 times in quanitty during the past 18 years, the average annual growth rate was 16.45% for the last 18 years and was 29.15% for the last 10 years. The total production of tilapia estimated by the regression equation as shown in Table 3 which indicated that the total production increased annually at the constant amount of 2,360 m.t. and 4,253 m.t. during the two period studied.

An observation of the cultivated area for the period from 1965 to 1982 indicates that trend is fast increasing, with the yearly increase rate of 11.32% or 503 ha each year. For the last 10 years, from 1973 to 1982, the trend shows that of more fast increasing, with the increase rate 13.10% annually or 685 ha each year, this growth rate is larger than that of the whole 18 years.

With respect to the trends in yield per hactare, Table 3 shows the increasing trends in yields, and the average annual growth rate were 3.59% and 7.17% for 1965—1982 and 1973—1982 respectively.

2. Relative Influence of Cultivation Area and Yield Changes Upon Total Production Changes

From Table 1, it is known that in the tilapia industry, the total production increased 5.7 times the cultivated areas increased 3.4 times and yield per hectare increased 0.53 times during the past 18 years. In this section, the ralative effect of changes in cultivation area and yield per hectare on the total production will be calculated by the quantitative methods.

For the calculation, the following method[2] is adopted.

$$P = N \times Y \tag{1}$$

where P=total production, N=cultivation area, and Y=yield per hectare, this relationship can be transformed into logarithms form

$$\log P = \log N + \log Y \tag{2}$$

From (2), the equation for the current year and the next year will be derived:

$\log P_t = \log N_t + \log Y_t$, $\log P_{t-1} = \log N_{t-1} + \log Y_{t-1}$

and by first difference

$$\triangle \log P = \triangle \log N + \triangle \log Y \tag{3}$$

separate first order equation can be fitted through least squares regression such as:

2) See Oury Bernard (1966), P. 74.

$$X_2 = a_{21} + b_{21} X_1 \quad (4)$$

$$X_3 = a_{31} + b_{31} X_1 \quad (5)$$

where $X_1 = \log P$; $X_2 = \log N$; $X_3 = \log Y$. Equation (2) and (3) being exactly additive relationship, we obtain $X_1 = X_2 + X_3$

therefore $dX_2/dX_1 + dX_3/dX_1 = 1$;

that is $b_{21} + b_{31} = 1$

in the above equation, the cofficients b_{21} and b_{31} indicate respectively in regression equation, the variable coefficients of X_2 and X_3, and the sum of the two coefficients equals to one.

In order to understand the relative effect of cultivated area and yield changes on total production changes, an estimation is made with the data of the past 18 years, and results of this estimation are shown in Table 4: In computing the relative effects, separate calculation are made on (1), the whole 18 years period and (2), the past 10 years period. In the total production from 1965 to 1982, the relative effect of changes in cultivation area was −20.5% while the effect of changes in yield per hectare was 120.5%; this means the increase of total production of tilapia was exclucively due to the increase in yield per hectare for the past 18 years. On the other hand, observed in the period of the last decade from 1973 to 1982; it is noted that the effect of changes in cultivated area on total production of tilapia was 18.85% and that of changes in yield per hectare was 81.15%. From the above, it can be concluded as: the increase of production of tilapia in Taiwan was mainly due to the increase of yield per hectare, which in turn achieved by the improvements of breeding and fish pond management during the past 18 years.

3. Factors Affecting the Changes of Production

As mentioned earlier, the tilapia industry is characterized by rapid expansion in production and cultivated area during the past 18 years. By now, we try to determine the factors which affecting the changes by using the method of regression analysis.

In order to have an adequate understanding of the production changes, the measurements of total production and cultivated

Table 4 Relative Influence of Cultivated Area and Yield Changes on Total Production Changes of Tilapia

	1965—1982		1973—1982	
	Effect of cultivated area changes	Effect of yield changes	Effect of cultivated area changes	Effect of yield changes
Total production	−20.50 (−0.3208)	120.50 (3.5521)	18.85 (0.5433)	81.15 (2.3235)
Brackish water	−59.73 (−1.7020)	159.73 (3.9692)	−59.80 (−1.3231)	159.80 (3.2200)
Fresh water	−16.72 (−0.4666)	116.72 (3.0545)	−11.02 (−0.1959)	111.02 (2.0252)
Reservoir and others	−23.88 (−1.3357)	123.88 (6.3891)	−20.72 (−1.3275)	120.72 (7.0021)

Note: The t values are given in brackets.

area are made separately which are considered as the changes of production.

The results of the regression analysis are summarized as follows:

(1) $TP_t = -10770.1319 + 2.0641\ Y_{t-1} + 1650.1510\ P_{t-1}$
(7.2525) (25.4977)
$R^2 = 0.9440$ $d = 2.0292$

(2) $CA_t = 256.3819 + 344.6378\ P_{t-1}$
(14.3601)
$R^2 = 0.9321$ $d = 1.7411$

where

TP: total production of tilapia (M.T.)

Y: yields per hectare of tilapia ((kg/ha)

P: average price of tilapia (NT$(kg)

CA: cultivated area of tilapia (ha)

the t-values are given in the brackets and d stands for Durbin-Watson statistics.

In these two regressions, we originally included the price ratio between tilapia and other fish culture as well. But, probably due to high intercorrelation between tilapia price and

tilapia-other fish price ratio, either the coefficients for the tilapia-other fish price ratio were insigni-ficant, or results in implausible results for the other coefficients. This variable was dropped in the analysis of production changes.

More than 90 percent of the variations in the total production and in the cultivated area are explained by the changes in their price and yield per hectare. The coefficients are all positive and are significantly different from zero at the standard level significance. Such results indicate that the marked increases in yield per hectare and price during the past 18 years have been closely associated with the changes of production in tilapia industry.

III. Prices of Tilapia

As of the present days, tilapia is mainly for consumption at domestic markets. Owing to the consumer's preference, this fish is seldom processed, but it is generally sold as fresh fish. This section is a general survey and analysis of the domestic market price of tilapia in Taiwan.

In this preliminary study, however, a comprehensive analysis will be made on the average price, wholesale price, retail price, and the comparative price of tilapia with other aquacultural fishes. It is hoped that factors affecting the variation of price might be pointed out in this study, so that they may serve as bases for further studies.

1. Market Price and Price Fluctuations

(1) Average Price, Wholesale Price and Retail Price

The price to which reference is made in this study comes from two sources: the first is the Commodity-Price Monthly, Taiwan Area, The Republic of China compiled by Directorate-General of Budget, Accounting & Statistics, Executive Yuan, (including wholesale price and urban consumer price); the second is the compilation from the Taiwan Fisheries Yearbook, published by Taiwan Fisheries Bureau, Department of Agriculture & Forestry, Taiwan Provincial Government. Between these two

different source, however, comparision seems difficults. So an observation is here made only on the price changes in time series presented in the two different data respectively. On the other hand, concerning the wholesale price and urban consumer price of tilapia, because of the difference in grade, sometimes a disparity exists between these two series of prices. Concerning the price of producing locality and consumption locality at fish markets in Fisheries Yearbook, there is only the producing locality price at Tainan taken as a reprenetative, and the data are not continuous in time series, therefore this part of data is not taken as basis here. As for the price of consumption locality at fish markets, Taipei, Taichung, Changhwa, Chiayi, and Pingtung are taken as representing cities. Among these cities because of the great difference in the amount of transaction, these prices of producing locality sometimes seem unreasonable, that is in smaller cities where are nearer to producer's markets, the prices may actually be higher than those in larger cities that are far away from the producers.

The average price of tilapia is shown in Table 5. In terms of the current price, it was NT$ 7.59 per kg in 1965, a gradual rise brought the price to NT$ 30.35 per kg in 1980, which was a peak price, and the price dropped to NT$ 27.08 per kg in 1981, and NT$ 29.40 per kg in 1982. In terms of constant price, however, the average price of tilapia in the past 18 years has shown a slight decreased from NT$ 21.96 per kg in 1965 to NT$ 18.62 per kg in 1982.

The phenomenon that wholesale prices of tilapia were even much higher than its average price was because this wholesale prices were for the first grade of the product, the best fresh fish. For instance, this wholesale price was recorded at NT$ 14.38 per kg in 1970, while its average price was only NT$ 8.29% per kg. In 1982 the wholesale price was NT$ 41.10 per kg., but the average was only NT$ 29.40 per kg.

There is no great difference between the wholesale price and the urban consumer price. This is because of the difference

Table 5 Average Price, Wholesale Price and Urban Consumer Price of Tilapia

Unit: NT$/kg

	Average Price		Wholesale Price		Urban Consumer Price	
	current price	constant price	current price	constant price	current price	constant price
1965	7.59	21.96	—	—	—	—
1966	7.87	21.84	—	—	—	—
1967	7.13	19.33	—	—	—	—
1968	7.73	19.84	—	—	—	—
1969	8.55	20.84	—	—	—	—
1970	8.29	19.10	14.38	33.13	—	—
1971	9.42	19.33	17.66	36.24	—	—
1972	9.31	15.36	22.49	37.11	—	—
1973	11.82	16.78	24.90	35.34	—	—
1974	14.98	18.14	29.03	35.16	38.33	40.98
1975	12.95	14.45	33.68	37.57	43.37	43.18
1976	15.80	15.80	36.64	36.64	36.16	36.16
1977	21.40	18.32	42.97	36.79	42.64	39.33
1978	22.44	16.32	42.87	31.20	47.08	40.24
1979	27.00	18.79	46.80	29.78	47.58	37.99
1980	30.35	19.18	46.27	29.25	47.64	32.88
1981	27.08	15.94	49.26	28.99	51.07	30.02
1982	29.40	18.62	41.10	26.03	53.77	30.35

Notes: 1. Average price is equal to total production value divid by total production quantity, wholesale price of tilapia stands for the price of first grade of fresh fish while consumer price stands for the price of 0.3 kg per piece.

2. Average price and wholesale price are deflated by the index of marine products (1976=100).

3. Urban consumer price is deflated by the index of food (1976=100).

Source: 1. Average price comes from Taiwan Fisheries Yearbook.

2. Wholesale price and urban consumer price come from Commodity-price Monthly.

3. Price Index comes from Taiwan Statistical Data Book, CEPD, Taipei.

in grade of the product. The wholesale price represents that of the grade I or best fresh larger fish, while urban consumer price represents the price for smaller fish of 0.3 per piece.

(2) Price Fluctuation

The price fluctuation of tilapia will be discussed in this section in terms of long-run trends and seasonal variations.

Concerning the long-run trends of tilapia price, a calculation with the least square regression on such available data as average price, wholesale price and urban consumer price has been completed. The result, as shown in Table 6 is as follows:

The average prices in the period 1965—1982, as indicated in terms of current price, shown an increasing tendency with the annual increase rate of 9.62% or NT$ 1.48 per year. But at constant price, we can see that the price of tilapia decreased annually. Concerning the wholesale price and urban consumer price, Table 6 indicated that the price of tilapia increased

Table 6 Trends in Price of Tilapia

	Equations	r^2	Annual growth rate
Average Price, 1965—1982			
Current Price	$P_c=1.4325+1.4814\ t$ (10.7604)	0.8786	9.26
Constant Price	$P_r=20.5255-0.2311\ t$ (−2.7619)	0.3228	−0.84
Wholesale Price, 1970—1982			
Current Price	$P_c=14.6150+2.8358\ t$ (9.2190)	0.8854	10.88
Constant Price	$P_r=38.5435-0.7454\ t$ (−3.8293)	0.5711	−0.15
Retail Price, 1974—1982			
Current Price	$P_c=35.8967+1.8793\ t$ (5.4532)	0.8095	4.17
Constant Price	$P_r=44.2839-1.4983\ t$ (−4.5043)	0.7435	−2.88

Note: The t-value are given in the brackets.

annually at current price and decreased annually at constant price during the year 1970—1982 and 1974—1982 respectively.

The seasonal variation is one of the short-run changes. According to economics theory, when demand remains unchanged, the increase (or decrease) of supply will be a cause for price decrease (or increase). As far as tilapia priceis concerned, in the months March, April and May, because of the shortage of supply, the price often goes up. After this period the production of tilapia as well as other fishes becomes plentiful, so that the price drops down. David Method is here used to compute the indices of seasonal variation of tilapia price with the monthly price data of wholesale price during the years 1970—1981 and urban consumer price in the period 1974—1981. The results are indicated in Figure 1. The seasonal variation of tilapia price was not so high due to the tilapia prodnction is not characterized by extreme seasonality. The total range of seasonal variations of tilapia price reached 10.82% wholesale price and 7.90% for urban consumer price.

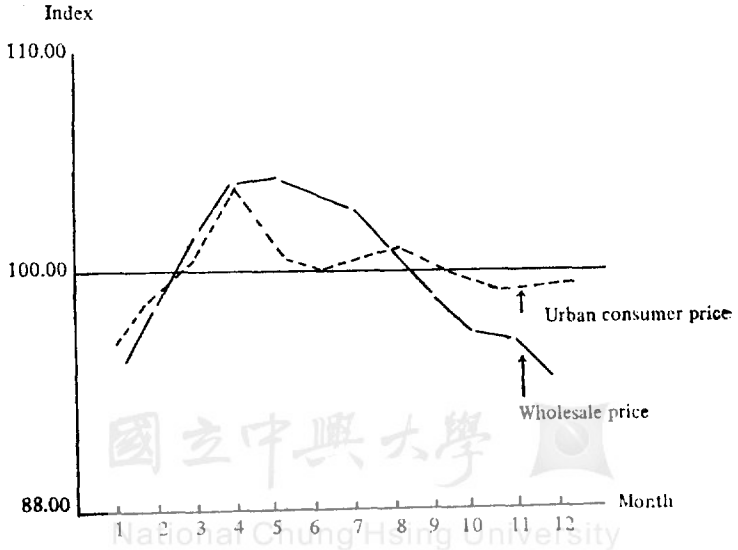

Figure 1 Seasonal Variations of Price of Tilapia

2. Comparison of Average Price Between Tilapia and Other Fish Culture

Besed on data available for the past 18 years, Table 7 shows the comparison of average price between tilapia and other fish culture. It should be noted that, on over-all basis, tilapia price is lower than all the other species, but on comparative basis, the price ratio between other fish sucsh as common carp, silver carp, and grass carp and tilapia show a tendency to defcrease, and the price ratio between milkfish, oyster and tilapia are increasing, while compared with price of shrimps, the ratio maintains fluctuated.

In this price comparison, the milkfish/tilapia ratio in the period 1965 to 1982 maintained at about 250%, and in the years 1977 and 1981, the ratio reached to 308% and 349% respectively. Based on the consumer's preference, milkfish has always been a better preference than tilapia. But for other fresh-water species such as silver carp and grass carp, the ratio is decreasing and this indicates, preference for tilapia is better than other fish water species. Only oyster price can maintain its superiority. Shrimps, owing to their greater price fluctuation, they could not maintain their price superiority during the whoie period studied.

As stated above, tilapia price has an increasing trend at current price, but in terms of constant price, the trend is decreasing. For other fish culture the average prices in terms of current price are all increasing. With regard to the annual increasing rate of price, the price of oyster marked the highest at 22.0% the next is milkfish at 13.98%, and next came that of tilapia, at 9.26%, the last was grass carp, only 8.01%. In terms of constant price, in the past 18 years, only prices of oysters, and milkfish had shown an increasing trend, while prices of tilapia, common carp, silver carp, grass carp and shrimps were decreasing. As to the average increasing rate per year, it was also oyster that had the highest rate of 9.88%, next came the milkfish, 2.22%. The average negative growth rate of grass carp was 3.96%, which was the greatest. For tilapia the negative

Table 7 Comparison of Average Price Between Tilapia and Other Fish Culture

	Tilapia	Milkfish	Common carp	Silver carp	Oyster	Shrimps	Grass carp
		Tilapia	Tilapia	Tilapia	Tilapia	Tilapia	Tilapia
	NT$/kg	%	%	%	%	%	%
1965	7.59	220.96	154.75	182.19	74.20	396.35	242.71
1966	7.87	217.73	173.66	180.41	79.03	419.76	238.53
1967	7.13	253.42	190.88	182.61	89.48	277.14	260.45
1968	7.73	260.28	185.25	170.76	113.20	257.44	247.61
1969	8.55	244.08	169.94	153.92	120.82	193.92	218.25
1970	8.29	256.81	180.82	150.78	234.02	246.68	234.50
1971	9.42	219.30	173.46	147.56	210.51	230.68	208.81
1972	9.31	248.45	162.08	134.59	237.92	233.30	220.52
1973	11.82	237.64	144.16	117.51	309.90	239.76	196.36
1974	14.98	246.55	126.57	112.02	279.51	209.88	177.50
1975	12.95	294.98	157.14	156.22	438.07	194.59	233.05
1976	15.80	257.40	153.23	106.96	370.06	184.43	206.01
1977	21.40	307.79	125.79	109.49	258.18	191.31	157.20
1978	22.44	264.69	132.09	111.50	337.97	176.52	152.32
1979	27.00	239.58	115.22	88.96	320.78	221.11	132.52
1980	30.35	297.66	129.00	97.69	326.46	230.54	135.82
1981	27.08	349.22	147.64	123.01	257.57	284.5	186.12
1982	29.40	230.72	143.75	122.06	374.63	979.82	186.90

Source: Fisheries Yearbook, Taiwan Area, Taiwan Fisheries Bureau, Department of Agriculture and Forestry, Taiwan Provincial Govrnment.

Table 8 Trends in Average Prices of Tilapia and Other Fish Culture, 1965—1982

	Current Price			Constant Price		
	Equations	r^2	Annual growth rate	Equations	r^2	Annual growth rate
Tilapia	$P_T = 1.4325 + 1.4814\ t$ (10.7603)	0.8786	9.26	$P_T = 20.5254 - 0.2311\ t$ (−2.7619)	0.3228	−0.84
Milkfish	$P_M = -0.1517 + 5.3403\ t$ (3.7149)	0.8463	13.98	$P_M = 45.2488 + 0.2556\ t$ (2.7321)	0.0318	2.22
Common carp	$P_C = 7.1832 + 1.3108\ t$ (4.3991)	0.8547	8.46	$P_C = 35.8036 - 1.0923\ t$ (2.4748)	0 7211	−2.05
Silver carp	$P_S = 7.8151 + 1.3485\ t$ (6.5355)	0.8727	8.25	$P_S = 33.9673 - 1.3783\ t$ (2.5802)	0.7648	−4.01
Shrimps	$P_{Sh} = 3.9238 + 3.2286\ t$ (2.7115)	0.7821	12.83	$P_{Sh} = 44.9424 - 0.7322\ t$ (2.3098)	0.4645	−0.46
Oyster	$P_O = -8.3094 + 6.7171\ t$ (5.7722)	0.9676	22.08	$P_O = 25.3154 + 2.5333\ t$ (2.2500)	0.3583	9.88
Grass carp	$P_G = 12.0241 + 2.2583\ t$ (3.5564)	0.8657	8.01	$P_G = 50.7474 - 1.8002\ t$ (2.0012)	0.8531	−3.96

Note: the t-values are given in the brackets.

growth rate was only 0.84% (Table 8).

3. Factors Affecting the Changes of Prices of Tilapia

With respect to the factors which contributing the changes of prices in tilapia industry, the method of regression analysis was used to measure the determinants.

First at all, we will measure the relationship between price and production, and then the other variables such as the price of tilapia fry and price ratio between tilapia and other fish culture are considered.

The results of the regression analysis regarding the variation of prices are summarized as follows:

$$(1)\ P_{At} = 27.1962 - 0.0004\ Q_t + 7.5472\ P_{Ft} - 0.1355\ \frac{P_{Tt}}{P_{Ct}}$$

$$(5.9257) \quad (0.9210) \quad (5.0168)$$

$$R^2 = 0.9592 \qquad d = 1.7932$$

$$(2)\ P_{Wt} = 39.3309 - 0.0002\ Q_t + 13.9605 P_{Ft}$$

$$(1.9429) \quad (1.5743)$$

$$R^2 = 0.7442 \qquad d = 1.4685$$

$$(3)\ P_{Rt} = 17.4627 + 0.8998\ P_{Wt} - 0.0355\ \frac{P_{Tt}}{P_{Mt}}$$

$$(3.3323) \quad (1.6029)$$

$$R^2 = 0.6538 \qquad d = 1.8692$$

where

P_A = average price of tilapia (NT$/kg)

P_W = wholesale price of tilapia (NT$/kg)

P_R = retail price of tilapia (NT$/kg)

Q = production of tilapia (M.T.)

P_F = price of tilapia fry (NT$/piece)

$\frac{P_T}{P_C}$ = tilapia − common carp price ratio

$\frac{P_T}{P_M}$ = tilapia − milkfish price ratio

all the prices are presented in real terms, the t- values are given in the brackets and d presents Durbin-watson statistics.

Based on the statistical test, we found the factors affecting the variations of tilapia price; for the average price, the

determinants are: (1) total production of tilapia (negative), (2) price of tilapia fry (positive) and tilapia – common carp price ratio (negative); for the wholesale price, the determinants were: (1) total production of tilapia (negative) and (2) price of tilapa fry (positive); for the retail price, the determinants are (1) wholesale price of tilapia (positive) and (2) tilapia – milkfish price ratio (negative).

IV. Conclusion

In the process of aquaculture development in Taiwan, the tilapia industry is characterized by rapid expansion in production and cultivated area. However, this rapid expansion has associated with high and substantial variations in production and prices.

There are three major types of tilapia cultivation: the brackish water culture, the fresh water culture and the culture in reservoirs and two major forms of rearing: the mono-culture and the poly-culture. By now, the major types and forms in tilapia culture is the poly-culture in fresh water.

In tilapia industry, the total production increased 5.7 times, the cultivated areas increased 3.4 times and yield per hectare increased 0.53 times during the past 18 years. The relative effect of changes in cultivated area and yield per hectare on tonal production, we found that the increase of production of tilapia in Taiwan was mainly due to the increase of yield per hectare, which in turn achieved through the improvements of breeding and fish pond management.

Based on the empirical study, we found that the factors which affecting the variation of production are more emphasized in the tilapia industry itself, such as the yield per hectare of tilapia and the price of tilapia. However, when we measured the determinants of tilapia price, we found that the factors which affecting the variation of price were the production of tilapia, price of tilapia fry and tilapia – other fish (common carp and milkfish) price ratio. This indicated that the price of other fish culture have influenced the price of tilapia. Therefore, the

development of tilapia industry should emphasize not only on tilapia industry itself, but also on other aquaculture industries.

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臺灣吳郭魚生產與價格變動之研究

李 朝 賢

摘 要

漁業生產在臺灣農業發展過程中，扮演著很重要的角色，其生產佔整個農業生產值由1950年的10.61%逐漸增加到1982的21.55%，然而，作物生產在同期間却由63.79%降至48.78%。

近幾年來，由於世界各國逐漸宣佈 200海浬的經濟海域以及受到世界性能源危機的影響，使得遠洋漁業的生產成本增加，而使遠洋漁業的發展緩慢下來。然而，養殖漁業在魚種改良，生產技術以及魚塭管理上的進步，使得單位面積產量大爲增加，而使養殖漁業發展相對的快速。在此情況下，臺灣漁業發展，遠洋漁業方面面臨着生產成本增加的困境，而內陸養殖漁業，却快速的發展起來。

臺灣吳郭魚產業於過去20年來，其特性是生產及養殖面積的快速增加。此種快速增加必然造成生產及價格的變動，進而影響生產者的決策。

本文旨在探討臺灣吳郭魚產業之生產與價格變動情形。就生產方面，首先探討總生產量、養殖面積以及單位面積產量之變動情況。其次測定吳郭魚養殖面積變動與單位面積產量變動對總產量的相對效果。最後，以廻歸分析說明影響吳郭魚生產變動之因素。至於價格方面，首先探討平均價格、躉售價格以及零售價格的變動情況，其次進行吳郭魚價格與其他魚類價格之比較。最後，本研究以統計方法測定吳郭魚價格變動之影響因子。

由本文之研究，從過去18年的資料觀察，吳郭魚產量增加 5.7倍，其中養殖面積增加3.4倍，而單位面積產量增加 0.53倍。然就養殖面積變動與單位面積產量變動對總產量的相對效果而言，過去18年與10年間，吳郭魚生產的增加其大部份的貢獻來自單位面積產量的提高。其中單位面積產量的提高主要由魚種改良及魚塭管理之改進所造成。

另外，我們由本文研究可發現，吳郭魚產業中生產變動之影響因素，如吳郭魚單位面積產量及吳郭魚價格，皆爲很重要的因素。然而，影響吳郭魚價格變動之因素爲吳郭魚生產量，吳郭魚苗價格以及吳郭魚與其他魚類之價比。此即表示，其他魚類之價格影響吳郭魚價格。因此，吳郭魚產業之發展不僅應注意該產業本身的情況，還應注意其他養殖產業的發展變動情形，如此，才能瞭解與掌握吳郭魚產業的發展。