DEMAND, SUPPLY AND PRICE PREDICTION OF RICE

IN TAIWAN FROM 1976 TO 1985

By

Wun-chi Lee

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To

My Parents

ACKNOWLEDGMENTS

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CHAPTER I

INTRODUCTION

General Description of the Rice in Taiwan

Taiwan, an island of 13,892 square miles, is located in the subtropical area of the Far East. With the benefit of suitable weather, average temperature just under 71°F in the north and nearly 76°F in the south,[1] and with the yearly precipitation around 75 inches,[2] rice has been the self sufficient staff crop in Taiwan. Even in early eighteenth century, Taiwan exported rice to support the supply in Mainland China.[3]

The cultivated area of Taiwan was 876,100 hectare in 1952 and 917,111 hectare in 1975. It has been around 900,000 hectare since 1970 (Table 1). There are some programs undergoing for the recovery of tidelands and expanded cultivation of uplands. The total production area of rice was 785,729 hectare in 1952 and 790,200 hectare in 1975 (Table 1). On the average, it was 773,269.58 hectare per year from

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[1]Chung Hwa Information Service, "141 Questions and Answers About the Republic of China," Taipei, 1975.

[2]Ming-wu Wu, "Farm Organization and the Feasibility of Agricultural Mechanization in the Rice Region of Taichung Area, Taiwan," Unpublished Thesis M.S., Michigan State University, 1970.

[3]Han-sheng Chuan and Richard A. Krans, "Mid-Ch'ing Rice Market and Trade, An Essay in Price History," East Asia Research Center, Harvard University, 1975.

TABLE 1.—Total Cultivated Area, Rice Area and Production in Taiwan in Recent Years

Year	Cultivated Land Total (1,000 Ha)	Rice Acreage (Ha)	Rice Production (M.T.)	Average Yield per Ha (kg)
1952	876.1	785,729	1,570,115	1,998
1953	872.7	778,384	1,641,557	2,109
1954	874.1	776,660	1,659,107	2,183
1955	873.0	750,739	1,614,953	2,151
1956	875.8	783,629	1,789,829	2,284
1957	873.3	783,267	1,839,009	2,348
1958	883.5	778,189	1,894,127	2,434
1959	877.7	776,050	1,856,316	2,392
1960	869.2	766,409	1,912,018	2,495
1961	871.8	782,510	2,016,276	2,577
1962	871.9	794,228	2,112,874	2,660
1963	872.2	749,220	2,109,037	2,815
1964	882.2	764,935	2,246,639	2,937
1965	889.6	772,918	2,348,041	3,038
1966	896.3	788,635	2,379,661	3,017
1967	902.4	787,097	2,413,790	3,067
1968	899.9	789,906	2,518,103	3,188
1969	914.9	786,592	2,321,633	2,952
1970	905.3	776,139	2,462,643	3,173
1971	902.6	753,451	2,313,802	3,071
1972	898.6	741,570	2,440,329	3,291
1973	895.6	724,164	2,254,730	3,114
1974	917.3	777,849	2,452,417	3,153
1975	917.1	790,200	2,700,000	3,429

Data Source: Taiwan Statistical Data Book, 1976 and Food Production and Activities of PFB.

1952 to 1975. It is about 87.11% of the total cultivated land. The production of rice was 1,570,000 M.T. in 1952 and 2,494,000 M.T. in 1975 (Table 1), the average annual increasing rate was 3% for 1953-1962, 0.9% for 1965-1974 and 2% for 1953-1974.[4] The yield per hectare was 1,988 kg in 1952 and 3,156 kg in 1975 (Table 1). From the above figures, it can be seen that rice is the leading agricultural product in Taiwan.

Over 90% of Taiwan's total rice production is for domestic consumption, leaving only a small portion for export.[5] The exported amount varies greatly from year to year due to the variations in production caused by weather condition.[6] The population of Taiwan was 8,128,000 in 1952 and 16,150,000 in 1975. The growth rate was 3.3% in 1952 and 1.9% in 1975. This rate has been decreasing gradually. The per capita consumption of rice was 126.06 kg in 1952 and 130.39 kg in 1975 (Table 2). Rice consumption varies between rural and urban areas. The reason is that the urban people of Taiwan are now substituting more and more wheat flour and animal protein foods for rice,[7] and the rural area is the production area. Therefore, the per capita consumption of rice for urban people is less than that of rural people.

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[4]Economic Planning Council, Executive Yuan, "Taiwan Statistical Data Book, 1975," Taipei, Republic of China, 1976.

[5]Te Tsui Chang, "Long-term Projections of Supply, Demand and Trade for Selected Agricultural Products in Taiwan," the Research Institute of Agricultural Economics, College of Agriculture, National Taiwan University, Taipei, Taiwan, 1970, p. 72.

[6]Te Tsui Chang, op. cit., p. 77.

[7]Te Tsui Chang, op. cit., p. 72.

TABLE 2.--Per Capita Consumption of Rice in Taiwan in Recent Years
(Unit: kg.)

Year	Per Capita Consumption
1952	126.06
1953	141.19
1954	124.85
1955	134.18
1956	132.59
1957	133.91
1958	131.74
1959	135.31
1960	137.74
1961	136.78
1962	132.10
1963	134.36
1964	129.87
1965	132.85
1966	137.42
1967	141.47
1968	139.93
1969	138.74
1970	134.45
1971	134.28
1972	133.52
1973	129.84
1974	134.15
1975	130.39

Data Source: Taiwan Food Balance Sheet (1952-1975). Prepared by
Joint Commission on Rural Reconstruction.

Since rice is the primary food crop of Taiwan, the stabiliza-
tion of its price affects the whole economy of this island. Fluctua-
tions in rice prices result in fluctuations in the general price level
which in turn changes the real income level. Thus, economic conditions
are tied to the price of rice. Grain has been the staple food in China
since early history. There is an old proverb: "It hurts farmers if
the grain price is cheap, and it hurts people if the grain price is
expensive." This saying indicates the significant position of the grain
price. In order to keep a certain level of rice production and protect
the farmers for their minimum benefit and raise their living standard,
a series of farm land policies have taken place. For instance, the
three stage program of land reform: (1) in 1949, the farm rents were
reduced from the prevailing level of 50% or more to 37.5% of the annual
yield of the principal crop, (2) in 1951, lands owned by the government
were sold to tenant farmers, and (3) in 1953, the Land-to-the-Tiller
Act was enacted.[8] For the stabilization of the food price, Taiwan
Provincial Food Bureau (PFB), a government agency was established,
which is in charge of the implementation of policies related to food
crops, mainly paddy rice. Its functions are to encourage and direct
rice production by granting production loans and offering services and
technical assistance, to collect and purchase by mandate a part of the
rice for the distribution to some special domestic consumers, to control
domestic rice marketing channels as well as to handle the rice export

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[8]Chung Hwa Information Service, op. cit., p. 47.

business, and to operate an agricultural price stabilization program
through stabilizing rice prices in domestic markets.[9]

There are some competitive crops of rice in Taiwan. Sugar cane
and bananas are competing for the production factors of land and labor.
The competition depends on the comparative profitability of the previous
period of each commodity. In consumption, from the late thirties
through the forties, sweet potatoes were commonly consumed accompanied
with rice. When, from the early fifties, the living standard rose
because of farm land reform and economic growth, people consumed more
wheat flour associated with rice. But rice is still the staff of
life and there is no other food crop that can take its place as the
main food material in Taiwan.

Statement of the Problem

Rice is a necessity for Taiwanese. A sufficient supply and
stabilization of its price are relevant to the whole economy and
society. Because of the development of industry and economic growth,
a lot of cultivated land has been transferred from rice production to
industrial or architectural utilization under the principle of compara-
tive advantage since 1958. The benefit per hectare for industrial
utilization is much higher than that of rice production under some
circumstances. Therefore the production area of rice changes annually
are at a different rate (Table 3).

Since Taiwan is an island, the area is limited for agricultural
production. With the constraint of terrain, the irrigatable area is

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[9]Te Tsui Chang, op. cit., p. 75.

TABLE 3.--Changes of Rice Production Area

Year	Rice Acreage (ha)	Area Change from Previous Year (ha)	Change in % of Previous Year	Index 1946 = 100
1952	785,729			139
1953	778,384	−7345	−0.9348	138
1954	776,660	−1724	−0.2215	138
1955	750,739	−25921	−3.3375	133
1956	783,629	32890	4.3810	139
1957	783,267	−362	−0.0462	139
1958	778,189	−5078	−0.6483	138
1959	776,050	−2139	−0.2749	138
1960	766,409	−9641	−1.2423	136
1961	782,510	16101	2.1008	139
1962	794,228	11718	1.4975	141
1963	749,220	45008	5.6	133
1964	764,935	15715	2.0975	136
1965	772,918	7983	1.0436	137
1966	788,635	15717	2.0335	140
1967	787,097	−1538	−0.1950	140
1968	789,906	2809	0.3569	140
1969	786,592	−3314	−0.4195	139
1970	776,139	−10453	−1.3289	138
1971	753,451	−22688	−2.9232	134
1972	741,570	−11881	−1.5769	131
1973	724,164	−17406	−2.3472	128
1974	777,849	53685	7.4134	138
1975	790,200	12351	1.5878	140

Data Source: Food Production and Activities of Taiwan Provincial Food Bureau and Taiwan Statistical Data Book, 1976.

also limited. The population in 1975 was 16.1 million, and the growth

rate was 1.9%, which means the population is still growing by at least

0.306 million per year. Consequently, to be able to produce sufficient

food to meet the demand of the total population is a serious challenge.

Objectives of This Study

The major purpose of this study is to analyze rice prices in

Taiwan. The market mechanism still prevails even with government

intervention. It is not a study to examine or evaluate existing rice

programs or policies, but rather an analysis of the equilibrium demand

and supply relations according to the economic theory and to predict

prices from equations specified to define these relations.

The objectives of this study are stated as follows:

1. Select appropriate variables to establish an estimated demand
   equation,

2. Select appropriate variables to establish an estimated supply
   equation,

3. Apply these two estimated equations to make demand, supply projec-
   tion and price analysis.

Methodology and Data Collection

Methodology

The purpose of this study is to make price analysis of rice in

Taiwan. In order to get the equilibrium position, both demand and

supply equations must be established. The procedure is to apply the

econometric method of finding the regressions for demand and supply

separately, then combining them together, using these equations for

price prediction. An evaluation of these equations will follow

according to the statistical properties and economic theories.

Data Collection

The 1955-1975 time series data used in this analysis are

secondary data obtained from the Taiwan Statistical Data Book,

Statistical Yearbook of the Republic of China, and the publications

of JCRR (Joint Commission on Rural Reconstruction) and PFB (Taiwan

Provincial Food Bureau). The reason for starting from 1955 is that

at that time there was a normal situation in both rice production and

consumption. Taiwan was returned to the Republic of China by Japan

in 1945 and the government retreated from Mainland China in 1949 to

this island. Following the government, thousands of people went to

Taiwan at that time. These data attempt to include the necessary in-

formation of the factors that influence both consumption and production

of rice in Taiwan. Variables selected include per capita consumption,

area on rice production, level of fertilizer utilization, average

yield, different level of price, etc. All the data used in this study

are stated in tables and figures.

CHAPTER II

THE ROLE OF GOVERNMENT IN DEMAND, SUPPLY,

AND MARKETING OF RICE IN TAIWAN

As the staff of life in Taiwan, rice provides the main food
material for Taiwanese people. A sufficient production and stable
price of rice is very important to the society and to the economy.
In order to maintain a sufficient rice supply and to reduce the fluctua-
tions of rice price, the government in Taiwan intervenes regarding the
demand, supply and marketing system of rice market. The Provincial
Food Bureau (PFB) is a government agency with an original function to
keep the prices of main food sources fluctuating within stable limits.
This special government agency may operate in the open market to in-
fluence prices, that is through purchasing and sale of the commodity
and supervision of the wholesale and retail merchants. According to
the characteristics of a competitive market, the price is determined
by the intersection of demand and supply. Therefore, the rice market
in Taiwan is competitive but under government interference.

A. Demand

A part of wages and salary of the government employees, school
teachers, military personnel is paid in rice, wheat flour, vegetable
oil and gas. Therefore the government needs much of rice to support

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the paid in kind system. On the other hand, the PFB needs rice on hand

to prevent big fluctuations of rice price. From this stock, rice can

be sold to the market when a shortage of supply between two harvests

exists. Government is the most important buyer of rice, controlling

almost one third of the production of Taiwan rice.[10]

About three fifths of the rice taken off the farms is collected

by the PFB by means of land taxes, barter for chemical fertilizers,

cotton goods and farm implements, repayment of government rice produc-

tion loans (such loans must be paid back in kinds of rice), and compulsory

purchase from rice field owners, etc.[11]

B. Supply

Over one-third of the total amount of rice produced in Taiwan
is under government control. Of the government-owned rice, about
one-half is used for rationing (payment in kind) to armed forces,
public servants of all levels together with their families, and
school teachers with their dependents; nearly 20% is injected
into the free retail and wholesale levels to stabilize prices
when market prices rise too much; and the balance is for exports
or as gifts to friendly countries as aid or disaster relief.[12]

This is a statement of how the government distributes its con-

trolled rice.

To encourage rice production, government puts emphasis on the

improvement in the production methods through the Farmers' Association.

Farmers are taught how to use modern and efficient agricultural imple-

ments and machines and agricultural loans by attending training

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[10]Te Tsui Chang, op. cit., p. 75.

[11]Te Tsui Chang, op. cit., p. 75.

[12]Te Tsui Chang, op. cit., p. 75.

programs in technical agriculture. The government concerns not only

the expansion of agricultural education in training farmers to have

modern agricultural techniques and knowledge, but also on the expansion

of cultivated land so as to increase the production area. Many water

and soil engineering projects are established to improve and expand

the irrigation area and to raise land productivity. The purpose of

these activities is to increase and maintain certain level of rice

production as to meet the demand of rice owing to the increasing

population.

Taiwan is an island of 13,892 square miles, but the population

is 16.1 million and growing continuously. The cultivated land is

about one third of the total area in this island. Recently, because

of the development of industry and increasing area of economic crops,

some of the rice area has been transferred to other utilization under

the principle of comparative advantage, such as the establishment of

industrial factories, buildings and production of economic crops other

than rice. Sometimes the land of industrial utilization will cause

lots of inconvenience in the production of agricultural crops. For

instance, the operation of irrigation will be impaired, or the pol-

lution of air and/or water, will prevent the natural growth of crops,

especially where these industrial lands are close to the crop area.

Therefore, in 1973 the government made a regulation regarding land

use. The transfer to other uses of land with quality for agricultural

production is restricted. This regulation prevents the reduction of

rice producing area. It could be said that government is the rice

supplier of servicemen, officials and school teachers. But for farmers

and general consumers, the government stands on a super position to control the supply of rice. The government can apply its superior power to improve the production methods, establish the water and soil engineering, which is hard to be done by farmers alone, and make regulations to maintain a certain level of rice production.

C. Marketing

Taiwan Provincial Food Bureau is a special government agency. On the basis of economic characteristics and functions of competitive market, this government organization has the financial base and storage equipment to purchase and keep a certain amount of rice after harvests so as to keep the rice price above the minimum level. The official price level will influence the real market prices determined by demand and supply in the free market under some circumstances. Usually the market price rises above the average official price level, the reason is that official price level is determined with the specific purpose of protecting the farmers.

> For marketing control, all business activities of farmers'
> associations and private rice dealers are strictly under govern-
> ment supervision. All rice dealers must be licensed and must
> follow regulations set by the PFB.[13]

This is not to explain that the rice market in Taiwan is either monopolistic or completely competitive. The purpose of government is to ensure that there is orderly marketing of rice and no speculative manipulation by rice merchants. The rice merchant and dealer cannot

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[13]Te Tsui Chang, op. cit., p. 75.

control or operate the rice price. Strictly speaking, even under government control, the price of rice is determined according to the nature of demand and supply.

Taiwan is a small island but with so many people. The economic growth and industrial development has been considered very important. Therefore, the government supervises the price level very carefully. Since rice is the staff of life, the rice market could be said as the target market dominating all the grain commodities that are supervised by the government. There are many programs held by the government to improve the production and marketing of rice, such as the programs for farmers training, establishment of dam, reservoirs, and soil conservation, etc. The most recent program introduced is the establishment of storage equipment for rice.

CHAPTER III

THE FACTORS OF DEMAND AND THE ESTABLISHMENT

OF THE DEMAND EQUATION FOR RICE

While establishing a demand equation, several procedures should
be considered. It includes the definition of the problem and state-
ment of the objectives under investigation, the selection of variables
and econometric models, data collection, and the procedure of evalu-
ating the equations on the basis of statistical properties and the
appropriate economic theories.

The definition of the problem and the statement of objectives
were presented in Chapter I. This chapter is devoted to analytical
procedures.

I.   The Factors of Demand for Rice

According to Tomek and Robinson in "Agricultural Product
Prices," the major factors influencing the level of demand may be
grouped under four headings:[14]

1)   population size and its distribution by age, geographic area, etc.,

2)   consumer income and its distribution,

3)   price and availability of other commodities and services,

4)   consumer taste and preferences.

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[14]Tomek and Robinson, "Agricultural Product Prices," Cornell
University, New York, 1975, p. 14.

These factors are common for general agricultural commodities. As to rice, especially rice in Taiwan where it is considered the satff of life, the following factors are most concerned to its level of demand.

(1) Population

Usually there is a positive relationship between the demand of food and the size of population. The larger the population size, the more food are demanded. Under normal conditions, which means the price of other goods and consumer preference keep constant, and the society is stable, etc., the demand for those commodities treated as the staff changes related to the population size unless there is a close sub-stitute or the price of this commodity rises sharply. In which case people will get used to other substitutes with less regard to their former consumption behavior or preference. In general, the demand of food is positively related to the population size. Food is a necessity of life. The growth rate of population in Taiwan is 1.9% recently which means there will be at least a 0.306 million people increase annually according to the population of 1975. Because the government plays a very important role in controlling the price of rice, there are certain limits set for the price fluctuations, and according to the consumption behavior, there are some commodities such as sweet potato and wheat that can be used as the substitutes of rice, but they cannot be expected to replace rice completely. Therefore population size is one of the major factors that influence the level of demand for rice.

(2) Price

According to economic theory, there exists an inverse relation-
ship between price and the quantity demanded in general. The higher
the price, the less is demanded. Exceptions are those inferior goods,
called Giffen goods, or those special commodities being indicated to
have Veblanesque effect, which is under the emotion "show-off." This
kind of demand cannot be treated as the normal demand. In Taiwan, rice
is a necessity for life. Recently because of the rapid economic
growth and an increase in the standard of living, there is a tendency
for rice to become somewhat like an inferior good for the urban people.
The level of demand will change because of the fluctuations in price,
but with the low price elasticity, the change in demand will not be
large.

(3) The Price of Substitute

Grain has been the staff of life through Chinese history. Be-
cause of the suitable subtropical weather and geographical location,
rice has been the main crop produced in Taiwan. In the previous time,
because of easy growing, sweet potato was used as the substitute of
rice. People sometimes consumed it with rice. Later, owing to the
economic growth, sweet potato was used as livestock feeds, or fertilizer
gradually. People still consume it as food but not so much as before,
and wheat has become the substitute depends on the consumer's preference.
Recently, people have consumed more protein food, such as dairy products,
meats, eggs and vegetables. There is usually a positive relationship
between the level of demand and the price of the substitute. The

position of rice in consumption is solid because of the consumption

behavior and its stable price, but the price of its substitutes do

influence its level of demand somewhat.

(4) Consumer's Income

There is a very close relationship between income and purchasing

power, especially the real income. Variance in income will cause a

variance in consumption. Recently because of the gradual emphasis on

protein food consumption, there has been a tendency for rice to become

somewhat like an inferior good. This circumstance happens in the urban

area gradually, but not so obviously in the rural area. If the income

effect is positive, there is a positive relationship between the level

of demand and income, otherwise there will be a reverse relationship.

For the inferior goods, the income effect is negative.

(5) Consumption Behavior and
Consumer's Preference

The sale of agricultural products is influenced very much by

the consumption behavior, especially by the consumer's customs.

Taiwanese are used to consume rice as the staff of life. When govern-

ment of Republic of China retreated from mainland China in 1949, there

were thousands of people came to this island following the government.

Those people who originated in north mainland China were accustomed to

consuming wheat, kaoliang, or millet as the staple food. Owing to the

restriction of environment, they became accustomed to eating rice

gradually. There is no longer a strong objection to consuming rice or

wheat in general. The consumption behavior of rice has remained

dominant even as protein food has been consumed more and more recently. For example, on most occasions, although there are a lot of dishes, Taiwanese still like to take a bowl of rice. Otherwise they do not think they have completed a meal. Previously, Taiwanese consumed rice with sweet potato together, but presently, because of the emphasis on nutrition, the consumption of wheat has become greater and greater.

(6) Expectation

The future expectation of consumers is also an important factor that will influence the level of demand. In general, there are two kinds of expectations discussed in economics for the level of demand. One is price, the other is income. Assuming other elements such as political and social constant, for an expected increase in income, there will be an increase in demand for normal goods. Being a necessity of life, the income elasticity of rice is small. The expectation is that income would influence the level of demand but not very strongly. Price expectation is important. If there is an expected increase in price, the demand at present will increase, because rice is necessary for life, and it is storable if there is available storage room. The government puts emphasis on the price of rice in order to reduce inflation and protect both consumer and producer, but the price expectation is still a factor that will influence the demand of rice.

The above six factors are the most relevant ones that will influence the level of demand for a staple food. In establishing the demand model for rice, they are considered.

II. Demand Equation

A. Selection of Variables

In the process of establishing the demand equation, only population, price, income and the price of substitute are quantitative, the other factors such as consumer's preference and expectation are assumed constant in the analysis. In this study, per capita consumption of rice is used as the dependent variable. Retail price of rice and wholesale price of wheat are deflated by the index of consumer prices. Consumer real income per capita is used as an independent variable. The reason for using wholesale price of the substitute is because the retail price is not available. Therefore this demand equation includes population, price, income, and price of substitute. This demand equation is derived from time series data started from 1955 to 1975. The data are shown in Table 4 to Table 6.

B. Methodology

The demand equation is one equation in the simultaneous equations system. Multiple regression is used for the demand equation. While a classical normal linear regression model is used, there are some basic assumptions for the full specification of the regression model. These assumptions are taken to apply to all observations. They are stated as follows:

(1) Normality: ξ_i is normally distributed, (ξ_i is the disturbance term)

(2) Zero mean: $E(\xi_i) = 0$

(3) Homoscedasticity: $E(\xi_i^2) = \sigma^2$

TABLE 4.--Annual Farm Level, Retail and Official Price of Rice in Taiwan

Year	Farm Price Paddy (NT$/kg)	Retail Price Polished (NT$/kg)	Official Price (NT$/kg)
1955	1.98	3.17	1.46
1956	2.19	3.43	1.56
1957	2.35	3.65	1.63
1958	2.46	3.77	1.76
1959	2.59	3.99	1.87
1960	3.85	5.52	2.24
1961	4.11	6.02	2.78
1962	3.79	5.93	2.88
1963	3.94	5.94	2.94
1964	4.10	5.96	3.00
1965	4.12	5.99	3.06
1966	4.15	6.04	3.15
1967	4.41	6.32	3.32
1968	4.63	6.70	3.54
1969	4.50	6.92	3.73
1970	4.87	7.26	3.96
1971	4.66	7.42	4.15
1972	4.94	7.86	4.41
1973	5.67	8.95	4.97
1974	10.18	17.51	8.51
1975	10.98	17.88	10.73

Data Source: Rice Review, No. 52, October 1967-April 1968 and
No. 59, July 1975-December 1975.
Compiled by Rural Economics Division, JCRR, Taipei.

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FIGURE 1.
ANNUAL ACTUAL RICE PRICE OF DIFFERENT LEVEL (NT$/kg.)

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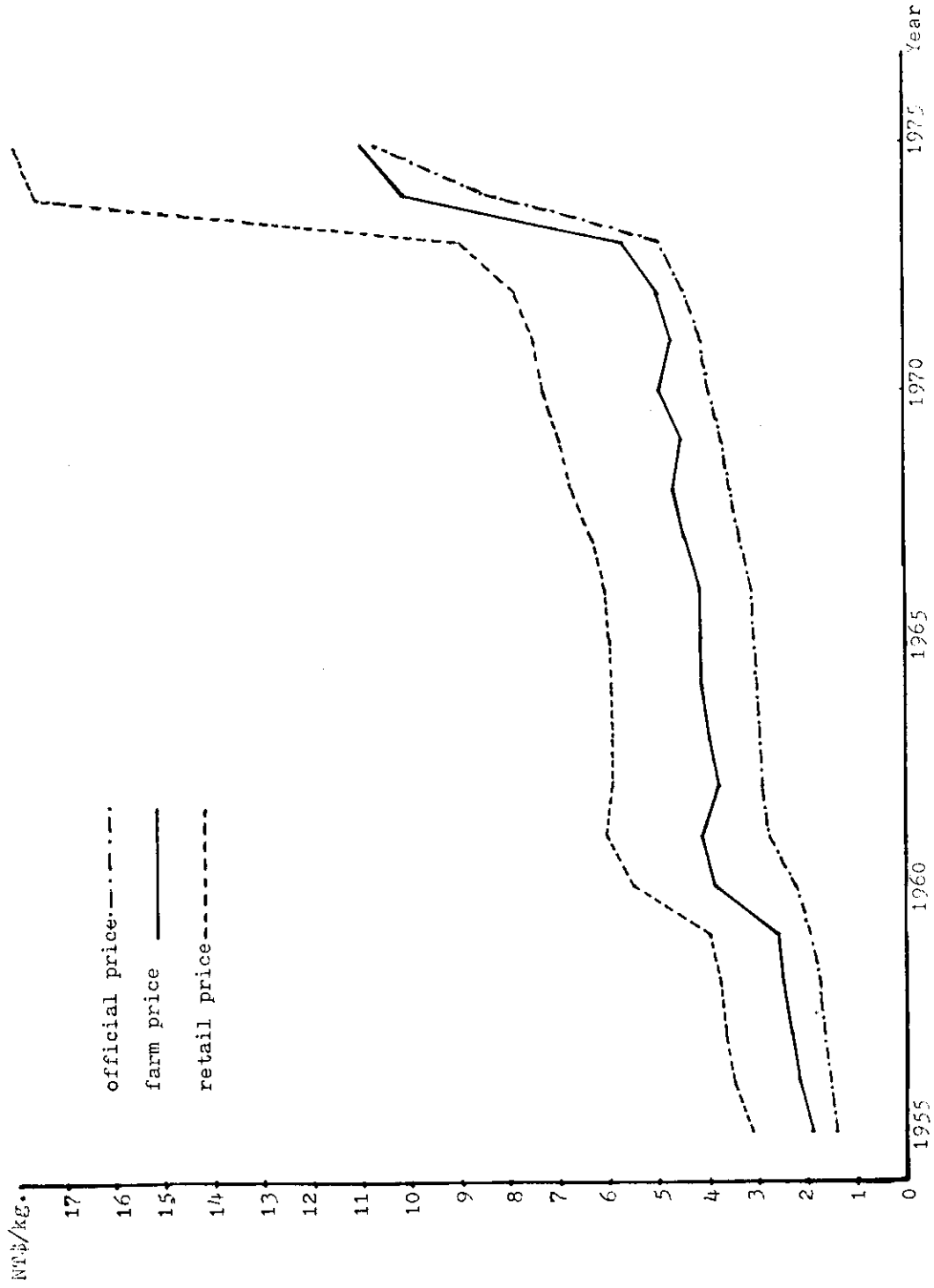
TABLE 5.--Annual per Capita Real Income and Consumer Price Index

Year	Per Capita Real Income (NT$)	Consumer Price Index (1952 = 100)
1955	6450	132.74
1956	6526	146.69
1957	6766	157.73
1958	6841	159.74
1959	7080	176.62
1960	7236	209.21
1961	7508	225.60
1962	7697	230.93
1963	8335	235.96
1964	9290	235.54
1965	9495	235.39
1966	9929	240.13
1967	10629	248.18
1968	11201	267.75
1969	11697	281.32
1970	12710	291.35
1971	13863	299.56
1972	14927	308.52
1973	16088	333.77
1974	15612	492.21
1975	15390	517.80

Data Source: Taiwan Statistical Data Book, 1976.

TABLE 6.--Annual Price of Wheat and Sugarcane in Taiwan

Year	Wholesale Price of Wheat (NT$/22kg)	Farm Level Price of Sugarcane (NT$/kg)
1955	70.39	181.82
1956	76.51	204.91
1957	84.64	255.85
1958	92.45	247.39
1959	103.84	274.48
1960	108.63	283.67
1961	105.74	302.94
1962	110.56	320.00
1963	117.47	433.10
1964	122.88	659.90
1965	126.28	400.66
1966	125.87	383.10
1967	116.55	383.10
1968	98.83	383.10
1969	95.37	383.10
1970	100.07	390.00
1971	99.06	400.00
1972	104.53	400.00
1973	105.88	400.00
1974	178.93	1279.74
1975	219.43	2059.10

Data Source: Taiwan Statistical Data Book, 1976, Rural Economic Statistic in Taiwan District (1949-1975), and PFB.

TABLE 7.—Estimated Regression Coefficients for Demand Equation

Dependent Variable		Constant	Pr	DPr	Pw	DPw	I	CPI	POP	R^2	D.W.
Per Capita Consumption	Coef	152.285		0.0060773		-23.7034	-0.00067475			14.123%	1.0634
	S.D.	10.87107		3.0568015		16.525374	0.0052927				
	t	14.008		0.001988		-1.4343688	-1.274575				
	Coef	138.873	-0.1095		-0.055587		-0.011269	0.08441		12.728%	1.17072
	S.D.	5.45141	0.081605		0.073323		0.0087356	0.059828			
	t	25.47476	-1.341579		-0.758112		-1.289994	1.411009			
	Coef	140.185		-1.5999335			0.0007839			5.039%	1.14878
	S.D.	6.5527465		1.7031394			0.0002517666				
	t	21.393342		-0.9394025			-0.3113677				
Total Demand	Coef	158604.75		-17928.189		-157106.48	-7.60526		138.19303	98.259%	1.089
	S.D.	30374.64		31401.846		249399.18	14.270066		22.622659		
	t	0.5221296		-0.57092787		-0.629939	-0.532952		6.1186113		

Coef.: Coefficient
S.D.: Standard Error
t: t Value
Pr: Price of Rice

DPr: Deflated Pr
Pw: Price of Wheat
DPw: Deflated Pw
I: Per Capita Real Income

CPI: Consumer Price Index
POP: Population
D.W.: d Statistic of Durbin-Watson Test
R^2: Coefficient of Determination

where PCC: Per capita consumption of rice (kg),

   DP_r: deflated retail price of rice (NT\$/100 kg)

   DP_w: deflated wholesale price of wheat (NT\$/22 kg)

   I: per capita real income.

The demand equation can be examined in two ways to check whether it meets both the statistical properties and economic theories.

D. Evaluation of the Demand Equation

(1) Statistical Properties

(1) Coefficient of Determination (R^2).--The coefficient of determination (R^2) stands for the explainability of these independent variables to the variation of dependent variable. "The more of the variation in dependent variable that the equation explains, the closer R^2 will be to unity, and the weaker is the relationship between Y and X, the nearer will R^2 be to zero."[15] Y is the dependent variable, X is the independent variable. R^2 is very low in this demand equation, which means these independent variables give weak explanation for the variation in the dependent variable. The variation of per capita consumption of rice cannot be strongly explained by the deflated retail price of rice, deflated wholesale price of wheat, and per capita real income. It indicated that the selection of these independent variables does not explain variation in the dependent variable according to the statistical characteristics. The estimated relationship can only explain 14 percent of the variation in per capita consumption of rice.

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[15]Harry H. Kelejian and Wallace E. Oates, "Introduction to Econometrics Principles and Applications," Harper and Row, Publisher, 1974, p. 68.

(2) Significance of Coefficients.--t-value is an indicator to tell whether or not the parameter estimate is significantly different from zero. $t = \frac{\hat{b}}{\hat{\sigma}}$ where $\hat{b}$ is the parameter estimate, $\hat{\sigma}$ is the corresponding estimated standard error. The value $\hat{\sigma}$ of each coefficient is shown in the parentheses in the above demand equation. According to Kelejian and Oates, there is a rule of thumb to use while looking at an estimated regression equation. "The rule of thumb is that, if the ratio $\frac{\hat{b}}{\hat{\sigma}}$ exceeds two in absolute value, we reject the null hypothesis that b = 0 against the two-tailed alternative at a 5 percent level of significance."[16] If we reject the null hypothesis when this hypothesis is in fact true, this kind of mistake is called a type I error. The probability of making such an error is called the level of significance. From the above equation, except the constant, all the t ratios of the independent variables are less than two, meaning that these coefficients are not quite significant at the 5 percent level of significance. We cannot reject the null hypothesis b = 0, which means, we cannot reject the hypothesis that the coefficients of these independent variables equal to zero.

(3) Durbin-Watson test.--Durbin-Watson test is used for testing whether there is autocorrelation in the estimated equation. The d statistic of the above equation is 1.06347, from the Durbin-Watson table for d statistic, it falls in the uncertainty region, which means, from the d statistic, we cannot make sure that there is autocorrelation in the demand equation. The problem of an interdependence among successive values of the disturbance term is autocorrelation, which is against the basic assumption while developing a regression equation.

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[16]Harry H. Kelejian and Wallace E. Oates, op. cit., p. 91.

(4) Multicollinearity.--According to Kelejian and Oates, a recognizable set of symptoms for classic case of "imperfect" multicollinearity is a large coefficient of determination (R^2) accompanied by statistically insignificant estimates of the coefficients of the independent variables.[17] t ratios of the above equation are small and the value of R^2 is only 14 percent. If R^2 is relatively high, there is multicollinearity, otherwise there does not exist the problem.

(5) Heteroscedasticity.--Heteroscedasticity is against the basic assumption of homoscedasticity. According to R. S. Pindyck and D. L. Rubinfeld in "Econometric Models and Economic Forecasts"[18] heteroscedasticity, or unequal variance, does not usually occur in time-series studies, because changes in dependent variable and changes in one or more independent variable are likely to be of the same order of magnitude. How to examine whether there exists heteroscedasticity depends on a hypothesis testing. The method is beyond the scope of this paper. Therefore although there is time-series data applied in this demand equation, it is not sure to have heteroscedasticity or not.

Based on the above five statements, this demand equation does not meet the desired statistical properties well. The methods of handling such kinds of problem are beyond the scope of this paper. Therefore only the statements of problem are presented.

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[17] Harry H. Kelejian and Wallace E. Oates, op. cit., p. 186.

[18] R. S. Pindyck and D. L. Rubinfeld, "Econometric Models and Economic Forecasts," McGraw-Hill Book Co., 1976, p. 96.

(II) Economic Theories

Whether an economic equation is appropriate or not depends on both statistical properties and economic theories. For checking the economic theories, the simplest way is to look the signs of the coefficients first, then go further in checking their value as to tell the relationship between dependent variable and independent variable. From this demand equation, it is shown that:

(1) For DP_r.—The coefficient of DP_r is positive, which means there is a positive relationship between per capita consumption of rice and the deflated retail price of rice. This characteristic does not meet the economic theory for general goods. If other things are held constant, when price goes up, the quantity of demand will decrease. But there is a positive relationship between price and quantity of demand. From this coefficient, if the price of rice goes up, people will consume more quantity of rice. This condition is not for ordinary goods. The value of coefficient is small, which tells the price elasticity of demand for rice is small, the fluctuations in rice price will not cause much variation in per capita consumption. The main reason is because rice is the staff of life.

(2) For DP_w.—The coefficient of deflated price of wheat is negative, which means there is a reverse relationship between per capita consumption and the deflated price of wheat. When the price of wheat goes up, the quantity of per capita consumption of rice goes down. If wheat is the substitute of rice, there should be a positive relationship. Because when the price of wheat goes up, people will consume more rice instead of wheat, per capita consumption of rice should go up. But

from this equation, there is a negative relationship shown by the coefficient. The probable reason is that apparently wheat is not the proper substitute of rice. But according to the consumption behavior of Taiwanese and the trend in the emphasis of wheat consumption, there should be a positive relationship between the deflated price of wheat and per capita consumption of rice, otherwise there is no close substitute for rice in Taiwan.

(3) For I.--The coefficient of per capita real income is negative too. This negative sign means when per capita real income increases, per capita consumption of rice will decrease. The change of rice consumption and the change of real income are in opposite direction. According to economic theories, there should be a positive relationship between income and the quantity of demand if the goods are normal goods. When real income increases, this means purchasing power increases, and people will consume more. But from this equation, with increasing purchasing power, people consume less quantity of rice. Rice becomes an inferior goods according to the economic theory. In Taiwan, rice is the basic, staple, and starchy food. There is a tendency that rice will become an inferior good gradually, but from this equation, it is an inferior good already.

III. Discussion

After checking the coefficients of these independent variables, it is shown that per capita consumption of rice is influenced by deflated retail price of rice positively, wheat is not a suitable substitute of rice and rice is an inferior good in Taiwan. The major reason of such an equation is because rice is a staff food. It is

necessary to life that is why both its price elasticity and income

elasticity of demand are small. From the twenty one yearly time series

data, although there are variations in per capita consumption, the

range of these variations is very small. The variations are shown in

Figure 2.

Other reasons that lead to the incorrect signs of economic vari-

ables may be caused by the available data. It is not saying there are

problems about the data itself, but there are some shadow variables

behind the data, such as the institutional effect, government policies

or other social or economic situations that influence the data but they

are not involved in the equation. For example, the retail price of

rice jumped from 1959 to 1960, and it jumped again from 1973 to 1974.

The latter jump can also be shown from the increase of wheat price from

1973 to 1974. These conditions may be accompanied by inflation, which

made consumer price index increase and per capita real income decrease,

or the change is caused by the encouragement of government to attract

farmers for rice production, farm level price increases then retail

price increases.

According to the ration system, a part of wages and salaries

of the government employees, school teachers and military servicemen

is paid in rice, wheat flour, vegetable oil and gas. This part of

rice under the ration system does not enter free market as to influence

the market price of rice. Therefore it could be another reason to

explain the positive coefficient of the deflated price of rice. Be-

cause per capita consumption is the dependent variable in the demand

equation, it is calculated by dividing total consumption of rice by the

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FIGURE 2.

ANNUAL OBSERVED AND ESTIMATED PER CAPITA CONSUMPTION OF RICE
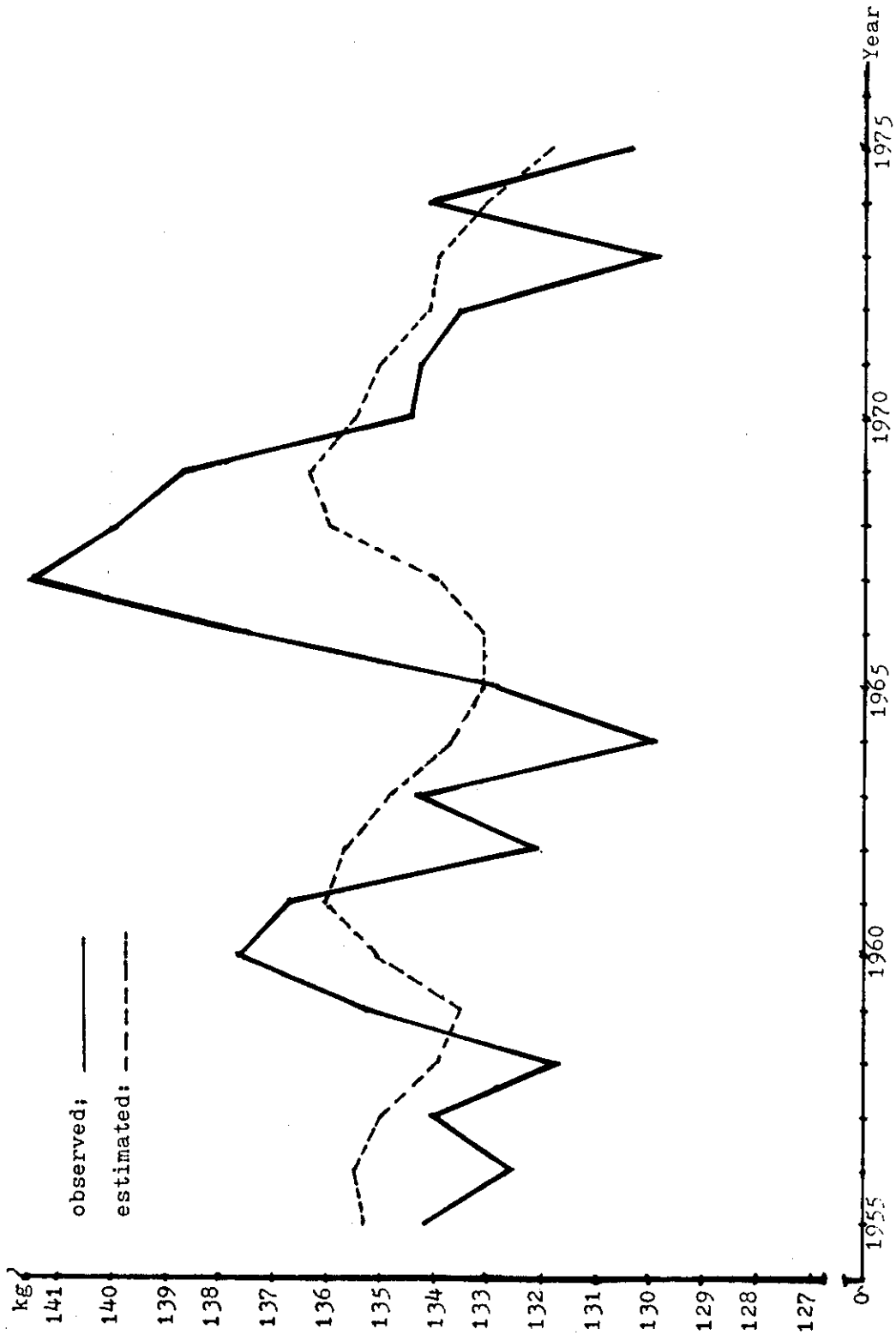
population. The total consumption includes the rice under ration
system, and the population includes the government employees, school
teachers and military servicemen. But the real price of the rice under
ration system is not determined by market mechanism. Only the rice
that enters into the free market has price effect. Therefore the
examination of the price and quantity demanded of rice for those people
who are not paid by the ration system is helpful in explaining the
relationship between the price and quantity demanded of rice. But
because of the lack of available information about the actual number
of people in the ration system, this examination can only be made
through the graph of market price and per capita consumption. It is
shown in Figure 3. Each dot represents an equilibrium condition.
Therefore there exists an identification problem, because these dots
do not make a demand curve.

As a whole, the estimated demand equation is not significant.
Those independent variables do not have much explanatory power for the
variation of per capita consumption of rice.

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FIGURE 2. COMBINATION OF DIFFERENT RETAIL PRICE AND PER CAPITA CONSUMPTION OF RICE
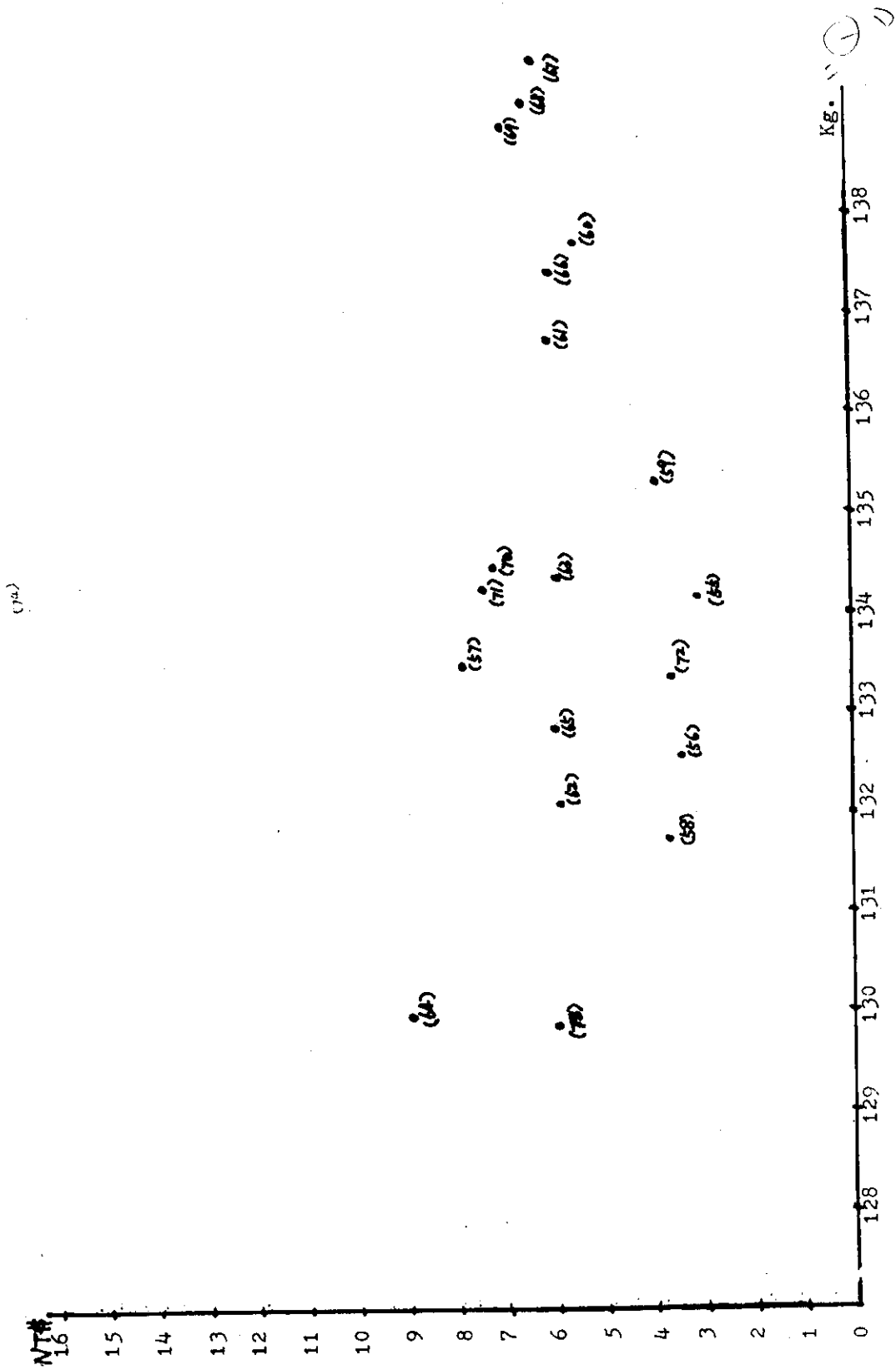
CHAPTER IV

THE FACTORS OF SUPPLY AND THE ESTABLISHMENT

OF THE SUPPLY EQUATION OF RICE

Because of the characteristics of season and the time require-
ment for growth, agricultural commodities usually have small elasticity
of supply. That is, the change in the quantity of supply caused by
the change in price is generally small. According to Tomek and
Robinson in "Agricultural Product Prices," they explained "Empirical
studies of supply relationships for farm products, both in United States
and in other countires, indicate that changes in product prices
typically (but not always) explain a relatively small proportion of
the total variation in output which has occurred over a period of
years."[19] They also stated the principal causes of shifts in the
supply curve. These causes are:

(1) changes in input (or factor) price,

(2) changes in the profitability of substitute commodities (i.e.,

     those that compete for the same resources)

(3) changes in technology which influence both yields and costs of

     production or efficiency,

(4) changes in the prices of joint products (i.e., commodities which

     are produced together such as wool and mutton)

_____

[19]Tomek and Robinson, op. cit., p. 65.

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(5) institutional constraints as government acreage control program,
and changes in production resulting from "unusual" weather and insect
or disease damage also can be treated as temporary shifts in supply.

All the above factors are relevant in the changes in supply.
Because of the time requirements for growth and seasonal constraint,
the agricultural commodities is much more influenced by the weather
and natural factors than any other kind of commodities.

The prices of those commodities which can be treated as the
necessary food to meet the basic requirement of living will influence
the general price level of the society. Therefore, it happens fre-
quently that the government takes part in the market or marketing system
of agricultural commodities. Rice is the staple food in Taiwan, it
plays a very important role in the maintaining of life and the economy.
The government of Taiwan has undertaken a series of policies concerned
with rice production, such as the water and soil conservation, farm
land consolidation, programs for farmers training, the regulated re-
striction of certain level of land with higher quality in agricultural
production to be transferred to other utilization, etc. While con-
sidering the supply of rice, it is well to understand the factors that
will effect its change.

I.   The Factors of Supply of Rice

The above five causes indicated by Tomek and Robinson are
quite significant in considering the changes in the level of supply.
Rice itself is an important product but the economic value of its by-
product such as rice bran, or paddy chaffs, hence, will not be discussed
in this study.

The general factors that cause changes in supply can be stated as follows.

(1) Area

Taiwan is an island. There is a limited area of cultivated land used for rice production. Thus with a population of above 16 million people, rice is produced under an intensive way in order to maintain the vast demand. There are paddy rice and upland rice, one crop in north Taiwan and two or three crops in south Taiwan a year. Land is the most important factor for rice production. Recently because of the increasing economic growth, some land has been transferred from agricultural production to industrial or architectural utilization. In order to prevent the reduction in rice production, the government made a regulation in 1971 that certain level of land with fertility is limited for the agricultural utilization. These lands cannot be transferred to non-agricultural forms of utilization. This is an indication of the importance of area to the supply of rice.

(2) The Price of Rice

Under a free competitive market, price is an important index to tell the producer what to produce and how much to produce. Therefore price is a relevant factor to the supply of the commodity. It is assumed that pursuing the maximum profit is the motive of the producer. Price is a good indicator for the producer. The higher the price, the higher the possibility that the producer will make profits. For agricultural products, there exists a characteristic that they need a longer period for growth, ripen and harvest. Therefore there is a lag

effect of the price in production. The general length for rice pro-
duction is about five months. Usually in north Taiwan, rice is planted
in February or March and harvested in July or August. In south Taiwan,
the first crop is a little earlier than the time in the north, and the
second crop starts from August or September to March. Some tropical
area can make three crops a year.

(3) The Cost of Rice Production

The cost of rice production includes the expenses of seed and
seedling, fertilizer, labor, materials for farming equipment, insects,
pests and disease control, rent, depreciation and repairs of building
and equipment, farming tools, irrigation charges, land rents, farm
taxes and fee, etc. The major items of cost are the expenses of fer-
tilizer, labor, tax and the cost of land equipment.

(4) Government Policies

The production of agricultural commodities is much influenced
by government policies. Once the government decides to increase the
production of some agricultural commodity according to the economic
plan, there will be policies developed to encourage farmers to produce
this commodity. Such policies may include low interest loans, guidance
or help in production technology, etc. Because rice is the staple
food in Taiwan, the government monitors its production at all times.
Many policies have been implemented in order to maintain or increase
the production of rice. These policies include the land reform,
establishment of dam, reservoir, the abolishment of rice-fertilizer
barter system, the program of acceleration in rural economic structure,

etc. Such policies have had a significant effect on agricultural production.

(5) Technology

The development of agricultural technology also has a very significant effect on agricultural production. It may be directed either toward producing more efficiently or toward the reduction of cost. Examples of technology development include improvements in seed, the progress in agricultural mechanics, the effectiveness of insecticides, the precaution of natural damage, etc. These improvements in technology makes it possible to get more efficient production. Both quantity and quality of product will be improved.

(6) The Profitability of the Competive Crops

Bananas and sugarcane compete with rice in using land for production in Taiwan. They have different periods of growth and different seasons for growing. But these three products are the popular agricultural commodities in Taiwan. They occupy some part of cultivated land. A saying stated that rice and sugarcane "chase" the land, indicating that they compete in using land for production. Whether to produce rice, sugarcane or bananas depends on their profitability. The government puts emphasis on the rice production and Taiwan Sugar Company takes care of the sugarcane production, but the farmers have their own opinion in deciding what they want to produce. Because of the lack of information and traditional concept of production and different growth period, farmers do not change their crops frequently. But profitability

is a factor that will influence the production. The production area

of banana and sugarcane is much less than that for rice production

(Table 8).

(7) Weather Condition, Crop Disease and Others

Weather influences the production of most agricultural com-

modities. Taiwan is located in south Far East, which is in the sub-

tropical region. The heavy rainfall in springtime will postpone the

date of harvest and the typhoon attacks in summer and fall will damage

part of the harvest. Drought in summers may also harm rice production.

Rice diseases could happen all the time, such as rice blast disease,

insect diseases, etc. Precautions against rice disease and bad weather

are very important in rice production. These factors may cause a great

change in the quality and quantity of rice supply. Other factors

such as storage equipment of rice, transportation condition, processing

procedures may contribute to some problems of rice damage too, such

as rat damage, germination caused by unsuitable temperature, etc. All

the conditions may cause changes in the supply of rice.

II. Establishment of the Supply Equation

A. Selection of Variables

The above stated seven factors are the important variables

which will influence the level of supply. With the purpose to find a

complete and reasonable supply equation, these factors will be con-

sidered.

TABLE 8.--Annual Acreage of Rice, Sugarcane and Banana in Taiwan

Year	Acreage of Rice	Harvested Acreage of Sugarcane	Harvested Acreage of Banana
1955	750,739	90,901	10,700
1956	783,629	98,231	9,600
1957	783,267	101,454	11,300
1958	778,189	99,219	13,800
1959	776,050	95,543	13,000
1960	766,409	100,180	12,700
1961	782,510	93,496	14,800
1962	794,228	94,100	14,900
1963	749,220	95,028	14,700
1964	764,935	110,694	18,100
1965	772,918	105,712	27,400
1966	788,635	90,180	36,500
1967	787,097	95,902	44,100
1968	789,906	93,341	43,800
1969	786,592	86,247	37,600
1970	776,139	88,764	39,000
1971	753,451	90,329	30,200
1972	741,570	98,128	22,800
1973	724,164	100,424	20,400
1974	777,849	99,200	15,800
1975	790,200		10,800

Unit: Ha

Data Source: Food Production and Activities of Taiwan Provincial Food Bureau, PFB, March 1976.
Taiwan Statistical Data Book, 1976.

In establishing the supply model, two basic relationships are developed. They are the relationships for area and yield separately. Total production is obtained by multiplying yield per hectare by the area.

In the first equation, area is the dependent variable. The area of previous time, the previous deflated farm level price of rice are the independent variables. In order to measure the important profitability, another equation for area as the dependent variable is also estimated. The difference is to apply previous deflated gross returns of rice per hectare instead of the previous deflated price. The purpose of this equation is to consider the relationship between area and profitability of rice, but not the profitability of its competitive crop. The reason for not choosing sugarcane and/or bananas as the competitive crop is because the area of sugarcane production occupies only about 10% of the total cultivated area in Taiwan even though it is the crop which has the second largest production area other than rice. Bananas lost their significant position gradually since late 1960's because of competition in the international market. There has been some encouragement for farmers to shift banana growing to the production of other crops. Therefore, bananas are not considered as a competitive crop of rice in this supply analysis.

In the yield equation, yield per hectare is the dependent variable. Serial time trend, the fertilizer consumption per hectare and deflated gross returns of rice in previous year are the independent variables. Serial time trend stands for the progress in technology, fertilizer consumption as the indicator of cost and technology, deflated previous gross returns effects the farmers' decision in production.

Weather should be an important factor that influences the yield. But weather data are not complete. Rainfall is very important to rice production. Data available for this study provided only two 10-year averages (1951-1960 and 1961-1970) computed as monthly averages. From 1972 to 1975, there are available monthly average data by years of rainfall. Therefore only these annual data were used (graphically) to explain the difference between observed value and estimated value in the yield equation.

B. Methodology

A multiple regression model is used for both demand and supply equation. There are some basic assumptions for the full specification of the regression model. The basic assumptions for regression analysis discussed earlier apply for the supply equation as well. With the basic assumptions in mind, using time series data for the period 1955 to 1975, the estimated supply equations came out as follows.

C. The Estimated Supply Equations

(1) $AREA_t = 445116.32 + 0.33036988\ AREA_{t-1} + 4398158.7\ DPR_{t-1}$

$\quad\quad\quad\quad (161276.18)\quad (0.20718467)\quad\quad\quad (2603961.1)$

$\quad$ t: $\quad$ 2.7599632 $\quad$ 1.5945680 $\quad\quad\quad\quad$ 1.6890263

$\quad\quad\quad\quad R^2 = 26.137\%\quad\quad$ Durbin-Watson d = 1.51

(2) $AREA_t = 484954.31 + 0.36749771\ AREA_{t-1} + 104.80836\ DGR_{t-1}$

$\quad\quad\quad\quad (173536.19)\quad (0.22243102)\quad\quad\quad (477.37894)$

$\quad$ t: $\quad$ 2.79454 $\quad$ 1.6521873 $\quad\quad\quad\quad$ 0.21954962

$\quad\quad\quad\quad R^2 = 13.986\%\quad\quad$ Durbin-Watson d = 1.55451

(3) $Y_t = 2041.3226 + 48.773422\ T + 0.284478\ F_t + 1.00606\ DGR_{t-1}$

   (234.81619)(11.052169)   (0.2756)   (8.1758153)

t: 8.693279 4.40939   1.03219   0.12305334

         $R^2 = 87.032\%$ Durbin-Watson d = 1.54978

where $AREA_t$: rice acreage of time period t, (ha.)

   $AREA_{t-1}$: rice acreage of time period t-1, (ha.)

   DPR_{t-1}: deflated farm level price of rice in time period t-1, (NT\$/kg.)

   T : serial time, 1955 = 1,

   F_t: fertilizer consumption per hectare of rice in time t.

Whether to treat sugarcane as a competitor of rice in land and labor utilization was considered. Trials included examinations of the relationship between rice production area and sugarcane production area, the influential ability of the deflated gross return and price of sugarcane on rice production, etc. Because the production area of sugarcane just occupies about ten percent of the cultivated area in Taiwan, which does not have such a significant position like rice which occupies eighty percent of the cultivated area, therefore the above stated equations are used in this study without regarding sugarcane, even which has the second largest production area in Taiwan.

The results of different trials are stated in Table 9.

D. Evaluation of the Supply Equations

These supply equations can also be checked for both their statistical properties and their economic logic.

TABLE 9.--Estimated Regression Coefficients for Supply Equation

		Constant	ARt-1	DPRt-1	DGRt-1	DPSt-1	DGSt-1	ASt	R^2	D.W.
Dependent Variable ARt: Rice Acreage of Time t	Coef	445116.32	0.330369	4398158.7					26.137%	1.51
	S.D.	161276.18	0.207185	2603961.1						
	t	2.759963	1.594568	1.6890263						
	Coef	484954.31	0.367498		104.80836				13.986%	1.55451
	S.D.	173536.19	0.22243102		477.37894					
	t	2.79454	1.6521873		0.2195496					
	Coef	445973.93	0.331678	3994214.7		306521.45			26.489%	1.57485
	S.D.	165872.12	0.213104	3049640.1		1107523.2				
	t	2.688661	1.5564161	1.309733		0.27676302				
	Coef	491336.66	0.3523628			-222.53104	16.835704		21.759%	1.82527
	S.D.	170677.59	0.219			536.33425	13.352883			
	t	2.87874	1.60896			-0.41491	1.260829			
	Coef	202396.19	0.61073423	4314016.9				0.27274318	32.219%	1.19163
	S.D.	310152.39	0.31782605	3644824.1				0.86204506		
	t	0.65257012	1.921599	1.1836008				0.31639086		
	Coef	386640.35	0.55885419		-409.69571			-0.29192161	27.664%	1.43197
	S.D.	331991.74	0.33565866		623.93482			0.96176931		
	t	1.1646084	1.6649479		-0.65663223			-0.3035256		

Independent Variables

Coef.:   Constant
S.D.:   Standard Error
t: t Value
ARt-1:   Rice Acreage of Time t-1
DPRt-1: Deflated Farm Level Price of Rice in Time t-1

DGRt-1: Deflated Gross Return of Rice in Time t-1
DPSt-1: Deflated Farm Level Price of Sugarcane in Time t-1
DGSt-1: Deflated Gross Return of Sugarcane in Time t-1
ASt: Sugarcane Acreage of Time t
R^2:   Coefficient of Determination
D.W.:   Durbin-Watson Statistic

(I) Statistical Properties

(1) Coefficient of Determination (R^2).--The explainability of the variation of dependent variable accounted for by these independent variables is indicated by coefficient of determination R^2. From the above three equations, the three different R^2's tell the following relations: In the first equation, changes in previous rice acreage and deflated price of rice can only explain 26.137% of the variation in rice acreage of the present time.

In the second equation, R^2 is 13.986%. It is even lower than that in the first equation. Which means, the changes of previous rice acreage and deflated gross returns of rice do not have high explain-ability in the variation of rice acreage. But in the third equation, R^2 is 87.032%, which means a high proportion of the variation in the dependent variable is explained by the independent variables. Because the changes in these independent variables, time (which stands for technology progress), fertilizer consumption and deflated gross returns of previous time, will explain 87.032% variation in the average yield per hectare.

(2) Significance of the Coefficients.--In order to check the significance for each coefficient, t value is used as the indicator. $t = \frac{\hat{b}}{\hat{\sigma}}$, $\hat{b}$ is the estimated coefficient in the estimated equation, and $\hat{\sigma}$ is the corresponding estimated standard error, which is stated in the parentheses under each coefficient. According to the rule of thumb in Kelejian and Oates's "Introduction to Econometrics Principles and Applications," if the ratio $\frac{\hat{b}}{\hat{\sigma}}$ exceeds two in absolute value, we reject the null hypotheses that $b = 0$ against the two-tailed alternative at a

five percent level of significance. In the first equation for area,
all the t values are below two except the constant. It means that
these coefficients are not very significant. In the second equation
for area, the t values improve, but they are still not very significant.
For the equation of per hectare yield, the t value of the coefficient
of time trend is 4.409, it indicates time trend is a significantly in-
fluential variable to the variation of yield per hectare. The con-
sumption amount of fertilizer is not so significant and the deflated
gross return of rice in previous year is not quite significant either.

(3) Durbin-Watson Test.--This test is used for checking whether
there is autocorrelation in the estimated equation. From the table of
Durbin-Watson test and the d statistics of the three equations, the
equation of area with deflated prices as the independent variables, and
the equation of per hectare yield are inconclusive of autocorrelation,
but there is no autocorrelation in the equation with deflated gross
returns as the independent variables.

(4) Multicollinearity.--Multicollinearity is against the basic
assumption that none of the explanatory variables be perfectly cor-
related with any other explanatory variable or with any combination of
other explanatory variables. It is a question of degree and not of
kind, and it is a feature of the sample and not of the population.[20]
As to the measures of multicollinearity, some people use the value
of determinant of (X'X), it is low when the degree of multicollinearity
is high, and it is zero when multicollinearity is perfect.[21] Some

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[20] Jan Kmenta, "Elements of Econometrics," Macmillan Publishing
Co., Inc., New York, 1971, p. 380.

[21] Jan Kmenta, op. cit., p. 389.

people regress each of the explanatory variables and checking their R^2's. If any one of these R^2's is close to unity, the degree of multi-collinearity is high. A high degree of multicollinearity is a feature of the sample that makes insignificant estimated coefficients. The t values of the estimated coefficients in the above three equations show that they are not quite significant except time trend in the yield equation. This result may be caused by multicollinearity, but it is not saying that because of multicollinearity then unreliable coefficients exist. The insignificance may be caused by large variances. Therefore it is hard to state conclusively whether it is multicol-linearity or not. It is a problem of degree, not of kind.

From the above statistical properties, only the equation of per hectare yield has a high R^2, the others are not quite significant. The methods of handling such kinds of problem are beyond the scope of this paper. Because of the available data and the selected variables, only the statements of problem are presented.

(II) Economic Theories

The signs and values of the estimated coefficients are indi-cators to tell the economic characteristics of the variables. They are examined separately as follows.

(1) In the First Equation.--The area of rice production is in-fluenced by the area of previous year, deflated price of rice of pre-vious year. There is a positive relationship between the area of present time and previous year. There is also a positive relationship between the deflated rice price of previous year and the area of rice

production. Which means when the price of rice goes up, farmers will increase the area of rice production. Because increasing price is an indicator to tell the producers to produce more.

(2) In the Second Equation.--Deflated gross returns of rice is used instead of the deflated price. The result indicates a positive relationship between the area and the deflated gross return of rice of previous year. The area of rice production should increase if the gross return of rice goes up, which means the profitability increases.

(3) In the Third Equation.--There are positive relationships between per hectare yield and time trend, fertilizer consumption, and deflated gross return of rice in previous year. These coincide with economic theories. The coefficient of time variable is expected to be positive because of progress in production technology. The amount of fertilizer consumption increases then the per hectare yield increases too. And deflated gross return is an indicator for the farmers to increase the per hectare yield.

III. Precipitation and Per Hectare Yield of Rice

For lack of information, precipitation cannot be included in the yield equation as an independent variable. There are only four years with annual data available of weather from 1972 to 1975. Rainfall in June and July is important for rice production. Therefore the weighted annual precipitation of June and July is calculated as to tell the approximate relationship between the variation of yearly precipitation and the variation of annual per hectare yield. The weights are the percentage of total rice production in each district,

and the annual precipitation is obtained through the total sum of

multiplication of rainfall and the weight of each district. The data

is shown in Table 10, and there is a figure showing the variation on

page 53.

This figure indicates per hectare yield and precipitation change

in the same direction during these four years. Because they have the

same direction of variation, precipitation could be a relevant variable

that has the influential ability in per hectare yield of rice production.

From the above evaluation, even though the selected variables

are reasonable, the estimated equation for area is a little beyond

satisfaction. In making price projection, total production is obtained

through per hectare yield multiplied by area of rice production. The

area equation with deflated price of rice as the independent variable

is used because the sign of the coefficient is reasonable according to

the economic theory, and it has a higher coefficient of determination

than that in the second equation with gross return as the independent

variable.

TABLE 10.--Annual Precipitation of June and July in Individual Food District from 1972 to 1975 (Unit: mm.)

Time		Taipei	Hsinchu	Taichung	Tainan	Kaohsiung	Eastern	Total
1972	June	240.3	180.7	1039.7	633.4	388.3	267.9	1092.48
	July	438.5	283.7	408.1	504.8	752.4	759.8	
1973	June	300.0	287.1	567.5	396.9	400.3	183.8	756.68
	July	143.8	91.9	386.1	365.9	545.7	258.5	
1974	June	417.9	700.3	905.4	511.6	546.6	344.9	840.94
	July	191.3	200.9	175.8	248.8	192.3	32.1	
1975	June	353.6	381.3	782.5	815.5	569.6	136.4	879.27
	July	239.4	31.0	386.1	235.8	221.35	26.6	

Note: Tainan Food District: average of the precipitation of Taiana and Chiayi.

Kaohsiung Food District: average of the precipitation of Kaohsiung and Hengchun

Eastern Food District: average of the precipitation of Taitung and Hwalien

Weights: Taipei: 7%   Tainan: 26%
          Hsinchu: 15%   Kaohsiung: 18%
          Taichung: 29%   Eastern: 5%

Date Source: 1. Annual Report of Central Weather Bureau 1972 to 1975, Central Weather Bureau, Taipei, Taiwan.
              2. Rice Review, No. 59, July 1975-Dec. 1975, JCRR, April, 1976.

FIGURE 4.

PER HECTARE YIELD OF RICE AND PRECIPITATION OF 1972 TO 1975
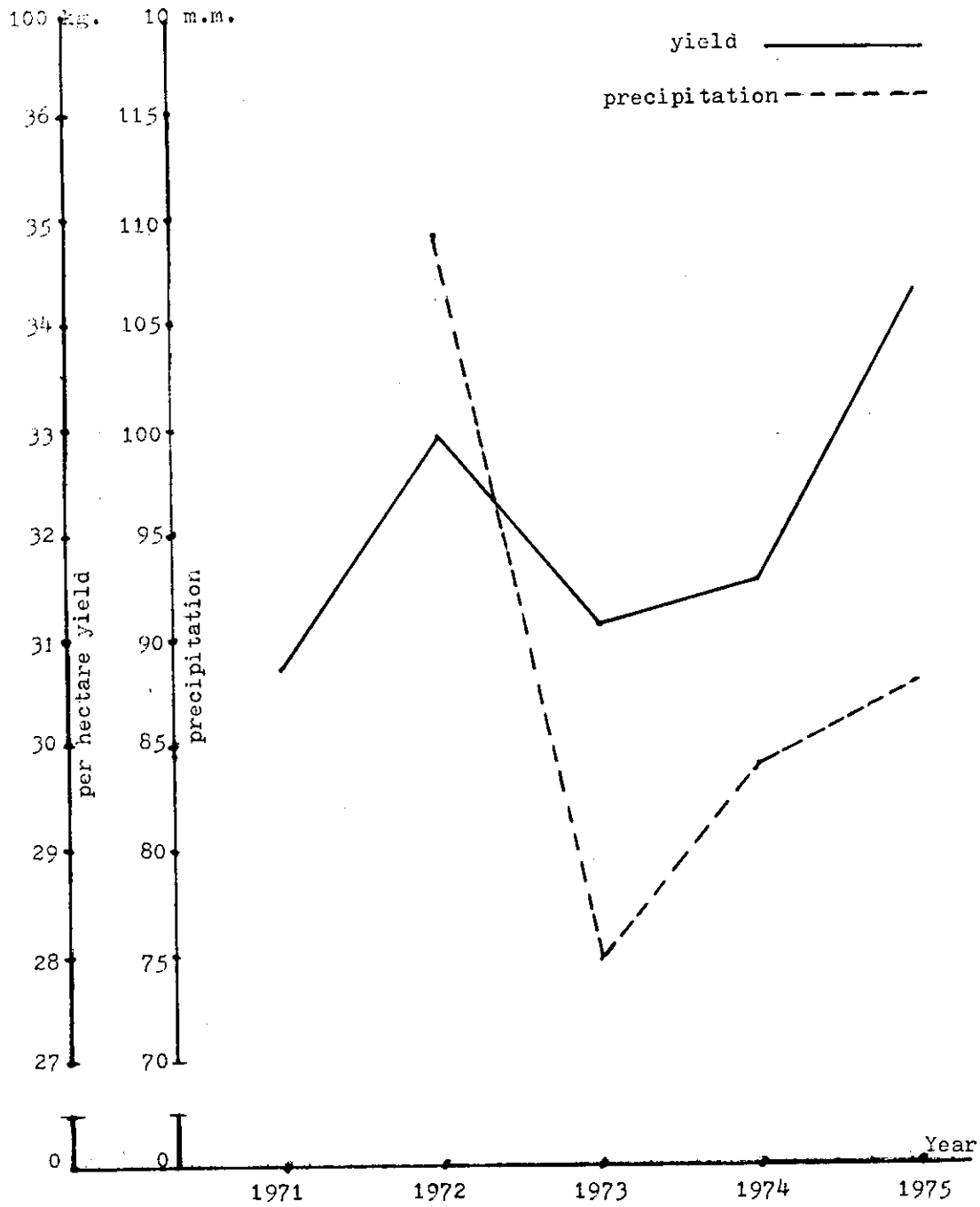
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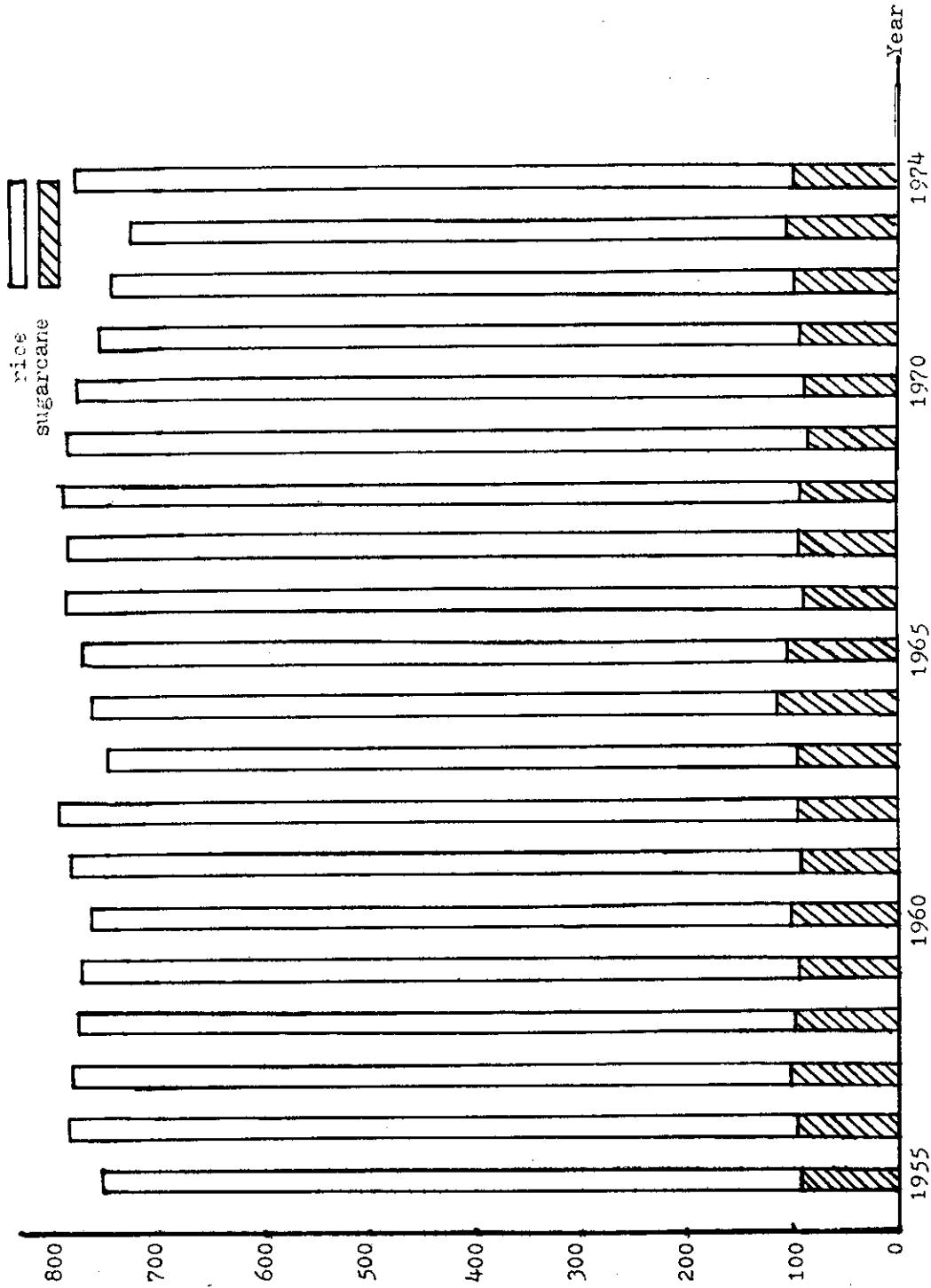FIGURE 5. ANNUAL ACREAGE OF RICE AND SUGARCANE (unit: 1000 Ha.)

FIGURE 6.

ACTUAL AND ESTIMATED PRODUCTION AREA OF RICE FOR THE FIRST EQUATION (unit; 1000 ha.)
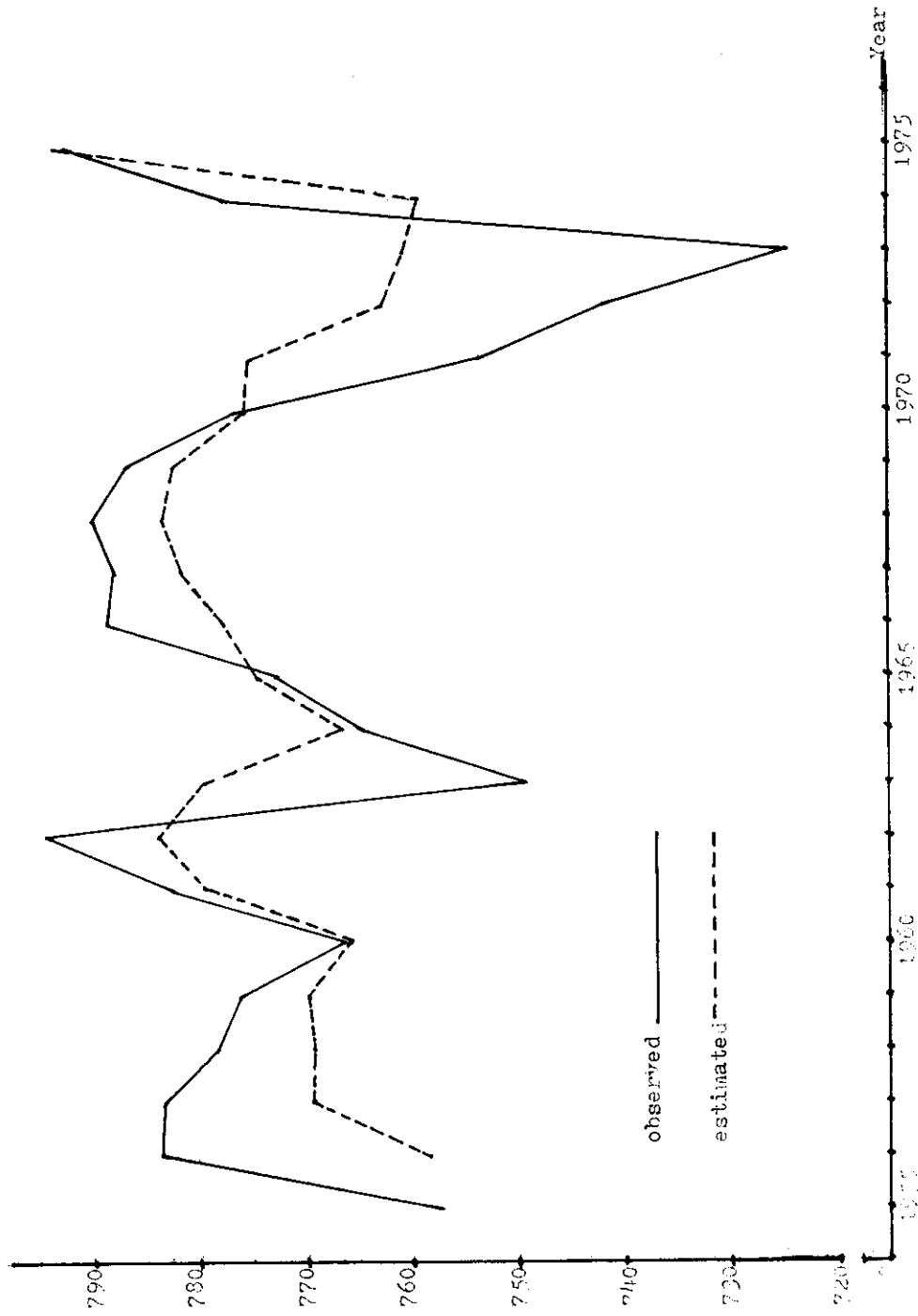
FIGURE 7.
ACTUAL AND ESTIMATED PRODUCTION AREA OF RICE FOR THE SECOND ADAPTION (UNIT: 1000 ha.)

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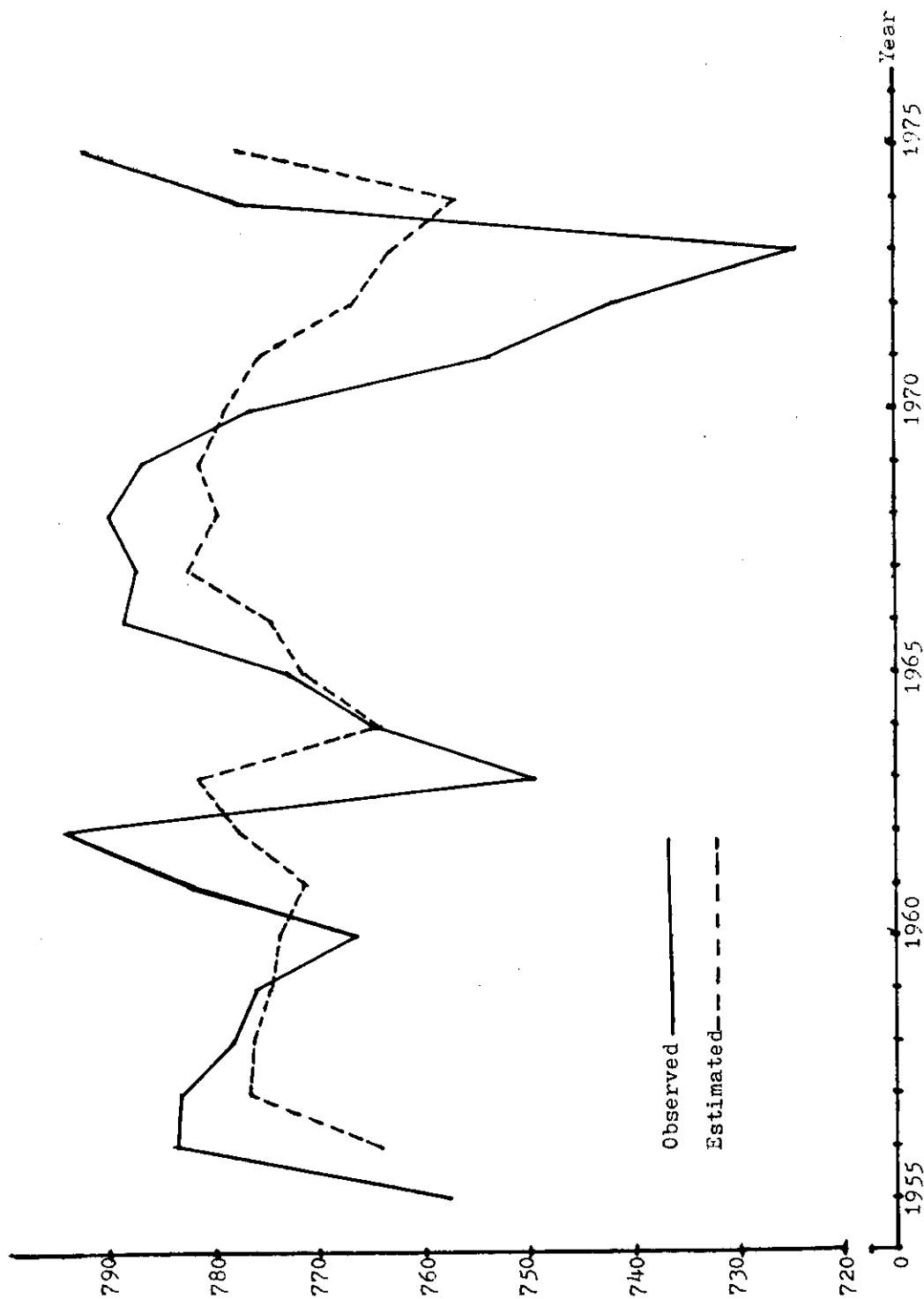
FIGURE 8.
ACTUAL AND ESTIMATED PER HECTARE YIELD OF RICE (unit: 100 kg.)
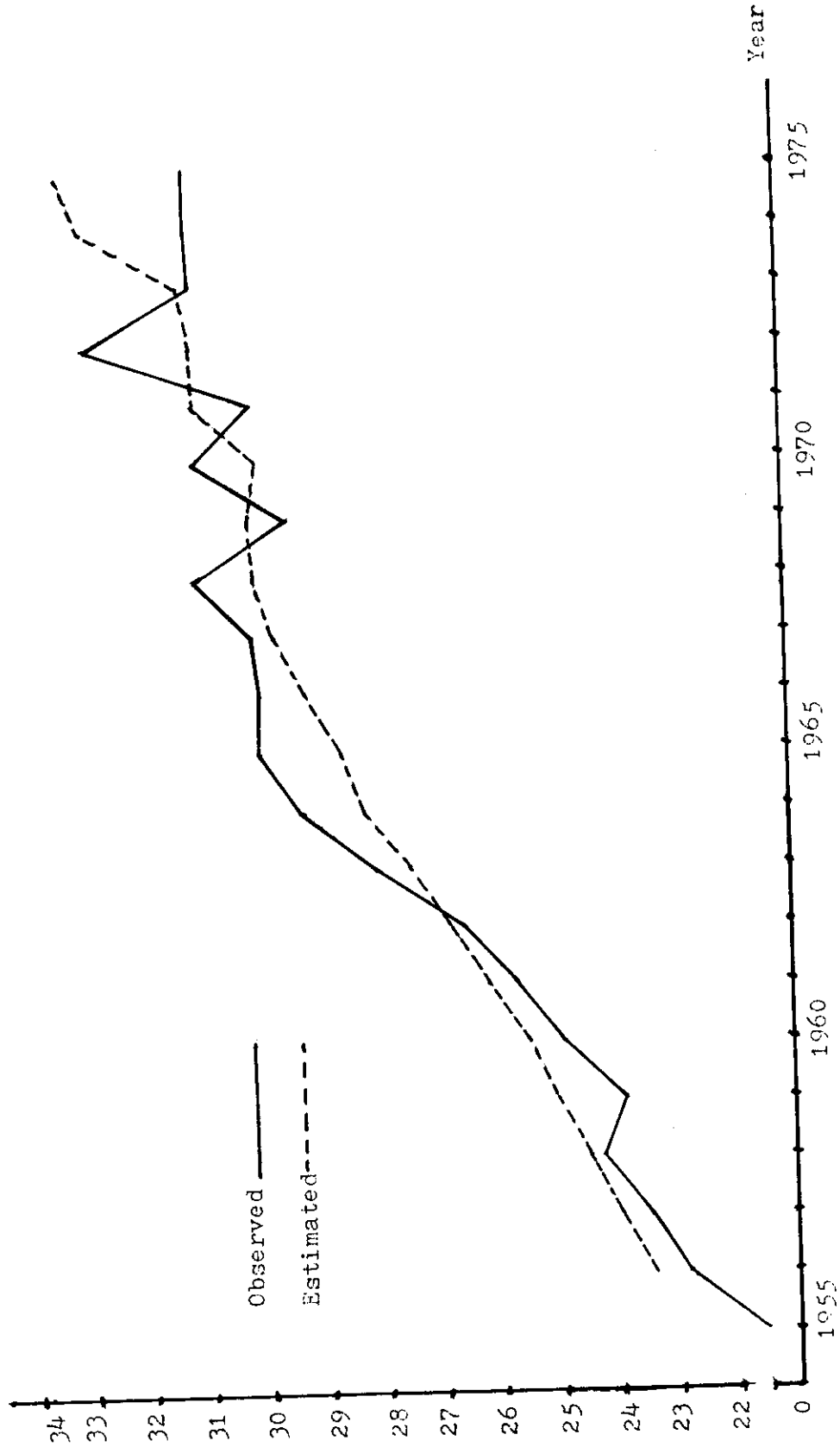
CHAPTER V

PROJECTION OF DEMAND AND SUPPLY OF RICE

(1976 TO 1985)

The estimated equations of demand and supply should be the basic framework to make the projection. Future price of rice could be established through the demand and supply equations.

But because of the insignificant estimated equation of demand, the simultaneous equation system cannot be established satisfactorily. It seems that deflated retail price of rice, per capita real income and price of substitute cannot give an adequate explanation of the variation of per capita consumption. Per capita consumption of rice does not vary much because rice is necessary to life. Therefore in making the projection of rice demand, the estimated demand equation is not going to be used in this study.

The projections for demand and supply are made with the basic assumptions that the government retains the present agricultural programs and does not change them, and there is no other exogeneous variables such as weather, insect disease or the attractive profitability of other industries to influence rice production and consumers do not change their consumption behavior etc.

Demand Projection

Even though the estimated equation of demand is not quite proper

for price prediction, it was used to attempt a demand projection for

the consideration of trend. Because these reasonably considered inde-

pendent variables cannot strongly explain the variations of rice con-

sumption, there may exist some shadow factors beyond economic considera-

tions that influence the level of per capita consumption of rice.

While in making demand projections, trend is the variable that

is involved in the procedure of making projections. This is a straight

way to find the projection without considering those insignificant

variables. This trend is

$$PCC = 134.75 - 0.02\ T$$

$$(1.4755) \quad (0.1175)$$

$$R^2 = 0.117\%, \text{ Durbin-Watson } d = 0.94453$$

T starts from one for 1955, then two, three, four . . . for 1956,

1957, 1958 . . . and so forth. From statistical point of view this

equation is neither significant nor reliable for the independent

variable to explain the variation of dependent variable. This phenomenum

indicates again that there is no significant trend in the per capita

consumption of rice for the Taiwanese people in the long term. The

standard error of estimate means that there is only minor variation

around this trend. Therefore in making projections of future demand

of rice is by the method of multiplying a constant level of per capita

consumption of rice by the projected population of the future.

The choice of this constant level of per capita consumption is

made by taking an average of the latest five years. The reason for

not using trend as a basis for projecting total demand is because it would assume that the rate of growth of population in the past twenty one years would continue the same in the future. Growth rate of population is projected to be decreasing according to the report of Conference on Population and Economic Development in Taiwan in 1976. The projected growth rate of population is stated in Table 11. The projected population from 1976 to 1985 in this study is shown in Table 12, which is calculated by the equation:

$$POP_{1975 + n} = POP_{1975} (1 + r)^n$$

r is the growth rate. Its value is 1.85% for 1975 to 1980, and 1.75% for 1981 to 1985. Projected total demand for rice from 1976 to 1985 are also stated in Table 12. The five year average is 132.44 kg.

TABLE 11.--Projected Growth Rate of Population from 1975 to 2000

(per thousand people)

Selected Year	Crude Birth Rate			Crude Death Rate			Natural Increase		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
1975	25.5	23.7	22.6	5.2	5.2	5.1	20.3	18.5	17.4
1980	28.6	22.9	20.2	5.5	5.5	5.4	23.1	17.5	14.8
1985	28.6	21.1	19.9	5.6	5.6	5.7	23.0	15.4	14.2
1990	26.7	19.9	19.0	5.6	5.6	6.0	21.0	14.0	13.0
1995	24.2	18.2	17.3	5.6	6.1	6.3	18.5	12.1	11.0
2000	23.5	17.1	15.7	5.7	6.3	6.5	17.8	10.7	9.1

Data Source: T. H. Sun, "The Prospects for Population Growth Socio-Economic Implications for Taiwan," Conference on Population and Economic Development in Taiwan, The Institute of Economics, Academia Sinica, Taipei, Taiwan, Republic of China, December 29, 1975 to January 2, 1976, p. 61.

TABLE 12.--Projected Population and Total Demand of Rice from 1976 to 1985

Year	Population (thousand)	Total Demand (1000 kg)
1976	16,449	2,178,505.5
1977	16,753	2,218,767.3
1978	17,063	2,259,823.7
1979	17,379	2,301,674.7
1980	17,700	2,344,188.0
1981	18,010	2,385,244.0
1982	18,325	2,426,963.0
1983	18,646	2,469,476.2
1984	18,972	2,512,651.6
1985	19,304	2,556,621.7

Supply Projection

There are two equations in the supply model. One for area, the other for per hectare yield. Because of the inelasticity of price, the coefficient of price is also insignificant. The real price does not vary very much. Therefore in the supply projection, a real constant farm level price is assumed. With this constant independent variable, and the properly projected values of other independent variables such as trend, fertilizer consumption, and gross returns in the yield equation, production area of previous year in the area equation, total rice supply can be projected.

The available deflated farm level price of rice is up to 1975.
The latest five year average of it is used as this constant. The
reason for using this real price are not only because it is the latest
price but also because from the projected result, the comparison can
be made for the future and current production conditions, and there may
be some indications for the current agricultural condition. There is
another benefit if it deletes the inflation consideration. This con-
stant is 0.0146.

The procedure for supply projection is made year by year. Be-
cause with the production area, gross returns of current year, the
production area and per hectare yield of following year can be found.
For the properly projected fertilizer consumption, it is estimated
through a time function obtained by simple linear regression. The
reason for applying a time function is because the price of fertilizer
is not available and the technological improvement will affect the
amount of per hectare consumption. The estimated equation for per
hectare fertilizer consumption is

$$F = 667.4 + 5.54 \ T \qquad R^2 = 6.931\%$$

$$(4.6532817)$$

T is trend, which starts from one for 1955, and then increases as time
goes on. Following are the projected total rice supply in Taiwan for
the future up to 1985. These values are obtained by means of these
independent variables year by year into the two equations for production
area and per hectare yield. Total rice supply is found by multiplying
per hectare yield by production area.

The result of this projection shows that there is a decreasing tendency for rice production area, but per hectare yield and total quantity of supply still increase.

TABLE 13.--Projected Production Area, Per Hectare Yield, and Total Supply of Rice from 1976 to 1985 in Taiwan

Year	Production Area (ha)	Per Hectare Yield (kg/ha)	Total Supply of Rice (1000 kg)
1976	770,095.43	3,438.64	2,606,642.2
1977	763,460.83	3,438.64	2,625,266.9
1978	761,271.50	3,490.08	2,656,898.4
1979	760,549.02	3,541.18	2,693,240.9
1980	760,310.60	3,592.28	2,731,248.5
1981	760,231.92	3,643.38	2,769,813.7
1982	760,205.93	3,694.48	2,808,565.6
1983	760,197.33	3,745.58	2,847,379.9
1984	760,194.53	3,796.68	2,886,215.3
1985	760,193.53	3,847.78	2,925,057.4

CHAPTER VI

CONCLUSION AND IMPLICATIONS

IN AGRICULTURAL POLICIES

Conclusion

Rice is the major food in Taiwan. Because it is a staple food, and there is no close substitute for rice, its price elasticity and income elasticity of demand are very small, and the income elasticity even shows that rice is an inferior good. In the demand analysis, since the dependent variable, per capita consumption lacks much fluctuation, the independent variables cannot strongly explain its variability. And also because of the insignificant coefficients in the demand equation, the projection of demand was made by a constant level of per hectare consumption multiplied by the projected population without regarding those considered independent variables.

The per hectare yield equation has a high coefficient of determination. This is because the variation of yield is largely caused by the technological improvement. As a whole, the supply model is more reliable than the demand model. But the coefficient of price of rice is still not quite significant and the real price level does not change very much. Therefore in making the supply projection, a deflated constant farm level price is used. The reason for selecting the latest farm level price is to make comparison with what happens in the future

by keeping the present real price level. The projections for both
demand and supply up to 1985 shows there will be excess total rice
production over total rice consumption. This result is shown in the
following table, which indicates there is excess supply of rice in the
future but with a decreasing level.

TABLE 14.--Projected Excess Supply of Rice from 1976 to 1985

Year	Excess Quantity	Year	Excess Quantity
1976	428,136.7	1981	384,569.7
1977	406,499.6	1982	381,602.6
1978	397,074.7	1983	377,903.7
1979	391,566.2	1984	373,563.7
1980	387,060.5	1985	368,435.7

Policy Implications

Over one third of the population in Taiwan are farmers. In
order to protect their revenue and maintain certain level of their
standard living, the government uses many policies or institutional
effects to protect farmers. Because agricultural production is an
industry with much risk and the production period is longer than that
of other industries, and also because the profitability of agriculture
is less than that of other industries in general. On the other hand,
rice is the major food crop, the level of its production is very
important in order to support the vast demand. Therefore government
plays another role as to keep certain level of production.

From the projections for both demand and supply up to 1985, the results indicate that there will be more rice supplied than demanded for domestic consumption if the current policies remain the same and real price level does not change, and if the technology of production keep improving.

The results of projection indicates that there is excess supply in the future. Exports of rice seem possible if this excess quantity is greater than the quantity that government wants to store for the purpose of precaution for lack of rice supply. The quantity of proper storage is made by the current policies which is not discussed here, but if the present policies continue, there is excess supply of rice.

Taiwan is an island with limited area for agricultural production. Projected area for rice production is decreasing yearly, but it appears there is not much of a problem to worry about with regard to the limitation of land. The results of the projections indicate there is a decreasing excess supply, therefore the government may want to give special attention to ways to increase the total quantity of rice supplied.

CHAPTER VII

SUMMARY AND SUGGESTIONS

Summary

Rice market is under careful supervision by the government in
Taiwan. Because more than one third of population are farmers and
rice is the major crop produced in this island, the government sets
the official price for rice with the purpose to protect farmers, keep
certain level of farmers revenue and to establish stability in price
level. Official price is the key that influences the market prices.
It is set to cover the cost for rice production and plus twenty percent
revenue for the farmers, and it has a function as being a method to
fulfill the current economic policies or agricultural programs. From
a twenty one yearly data time series, the official price is the basic
price level. Farm level price and retail price of rice are above the
official price level.

The purpose of this study is to make a price analysis of rice
in Taiwan. It is considered preferable to be made by way of demand
and supply equilibrium system to get the proper price level. Demand
and supply models were formulated as the basic framework in developing
this price analysis.

Multiple regression was used with time series data for the
period 1955 to 1975. The selection of variables was made according

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to the consideration of actual consumption and production situation
in Taiwan. In the demand equation, per capita consumption of rice is
the dependent variable. Deflated retail price of rice, price of sub-
stitutes, wheat, and per capita real income are the independent variables.
In the supply model, there are two equations; one for area and one for
per hectare yield. For the area equation, production area of previous
year, deflated farm level price of rice of previous year are inde-
pendent variables and the production area of current year is the
dependent variable, while trend, consumption of fertilizer per hectare
and deflated gross return of per hectare of previous year are the
independent variables.

Because of less fluctuation in the time series data of per
capita consumption of rice, the results of demand equation are not
satisfactory. The estimated demand equation is not significant.
Therefore for making demand projections, this estimated equation was
not used. In its place, a constant level of per capita consumption
multiplied by projected population was used to project the total demand
of rice.

The results of supply analysis are a little better than those
of the demand analysis. In the yield equation, with an R^2 of 0.87,
it means 87% of the variation in per hectare yield can be explained by
these independent variables in this equation. The result of the area
equation is not quite satisfactory but the signs of each independent
variable are reasonable and R^2 is 26%. The response of the variation
in rice production area cannot be strongly explained by the previous
production area and deflated farm level price. The possible reasons

are the lack of information, or the traditional concept for crop
production, and the most important is the political influence which
encourage farmers to grow more rice or other economic crops. Another
reason is that farmers may transfer their land from agricultural utili-
zation to other industry because of the profitability of other industries.

Because of price inelasticity and insignificant coefficient of
price, supply was projected by a constant deflated latest farm level
price of rice and other properly projected independent variables.
The projection of supply is made year by year by substituting the pro-
jected values of the other independent variables.

Suggestions for Further Study

Per hectare fertilizer consumption in rice production is an
exogeneous variable in the supply model. With the proper analysis of
fertilizer consumption and with a study of the cost structure of rice
production, the supply projection could be more accurate.

Rice is the staple food for Taiwanese people. Its income
elasticity and price elasticity of demand are very small. Recently,
people put emphasis on the consumption of protein food and dairy pro-
ducts gradually, an analysis of these types of food consumption is
helpful in making a comparison between it and the consumption of rice.
Because there may exist a strong relationship between rice consumption
and protein food consumption, and this relationship may indicate the
trend of food consumption and nutrition adaptation for the Taiwanese
people.

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