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NAME: Mr. Weerasak Kongrithi

THIS THESIS HAS BEEN ACCEPTED BY

________________________________ **THESIS ADVISOR**
(Associate Professor Somporn Isvilanonda, M.A.)

________________________________ **THESIS CO-ADVISOR**
(Professor Sopin Tongpan, Ph.D.)

________________________________ **DEPARTMENT HEAD**
(Associate Professor Ruangrai Tokrisna, Ph.D.)

APPROVED BY THE GRADUATE SCHOOL ON ________________________________

________________________________ **DEAN**
(Associate Professor Gunjana Theeragool, D.Agr.)

THESIS

THE THAI RICE ECONOMY: COULD THAILAND MAINTAIN ITS EXPORTABLE SURPLUS?

WEERASAK KONGRITHI

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During the past few decades, Thailand's economy continuously expanded. Among other impacts, this economic growth led to intense competition in the use of production resources, especially land and labor, among the various economic sectors.. Rice production was inevitably affected by such developments although farmers have adapted their farming practices to more cost-efficient technology, which included the use of farm machinery. On the other hand, the increase in the price of petrol during the past five years had stimulated the development of bio-fuel from energy crops, the farming of which created more competition for land use between food crops and energy crops. The growth in energy crop farming and their higher price subsequently affected the allocation of production resources. This study investigated the impact of changes in price factors and non-price factors on the area and production of rice. It also estimated the tendency of rice production supply and exportable surplus for the 15-year period between 2010 to 2025.

The findings reveal that the most influential factor supporting the increase in rice production is investment in research followed, in diminishing degree, by rice price and area under irrigation. The negative factor includes the erratic weather pattern represented by rainfall variance, price of energy crops and price of chemical fertilizer. The most important factor for domestic demand is population growth. On the other hand, increases in household income and rice price induced a reduction in demand. An estimation of the trend in rice exportable surplus for the next 15 years shows that the country's exportable surplus would decrease under the worse scenario (B), but would increase steadily under the base scenario (A) and the most favorable scenario (C).

These findings suggest that for the government to maintain the competitiveness of Thai rice in the export market, a non-price policy would increase the surplus and reduce the production cost. The important non-price policies include investment in research and development of higher yielding and premium quality rice varieties. The new varieties and the new technologies should be particularly suited to rainfed environments. Such policy would generate a volume of exportable surplus that is enough to maintain the country's leading status in the international rice market.

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CHAPTER I

INTRODUCTION

Problem Statement

Rice is a dominant sub-sector of the country's crop production sector and has long been an important source of export earning. With the rapid economic growth in the non-agricultural sector over the past decades, the importance of rice has been declining along with that of the agricultural sector. Nonetheless, agriculture particularly the rice sub-sector continues to be the dominant economic activity in rural Thailand. Rural resources particularly land and labors are mainly used in rice production. Rice crop still accounts for almost one-third of the total value of crop production. It continues to be a major export crop; 10.01 million tons or 51.33% of total production of milled rice was exported in 2008. Thailand is the largest rice eexporter in the world. It accounted for around 30% of the total world rice export, which earned for the economy around 200.89 billion baht (or US$ 6.0 billion) in 2008 (Thai Rice Exporters Association, 2009).

Moreover, rice has been the staple food of the Thai people since ancient time. The people eat both glutinous and non glutinous rice prepared as meals, snacks, desserts and drink. About 50% of Thai rice production or around 10 million tons of milled rice was channeled for domestic availability, particularly household consumption and as raw material for rice agro-industry.

The rice economy of Thailand appears to be in transition. Improvements in agricultural infrastructure together with a widespread adoption of modern rice technology and higher cropping intensity in the past few decades have induced the expansion in the rice cultivated area and the increase in production. The successful adoption of modern rice technology by irrigated area farmers in these regions consequently resulted in a steady increase in rice exportable surplus. It may be argued that these developments in the Thai's rice economy had benefited farmers from the productivity increase. However, the increasing yield per rai was previously confined in irrigated areas, which comprise only about one-third of the total rice cultivated area. The main rice cultivation is in rainfed environments. Rice yields in the non-irrigated areas remained low. Investing in research to improve the productivity in this production environment has yet to yield promising results. Thailand was not alone in benefiting from the green revolution technologies. Other developing and rice (as well as wheat and maize) producing countries had also access to these technologies, which boosted national productivities and the world rice supply. But it also resulted in the gradual decline in the real price of rice in the world (except during 2008 when grains and other commodity prices suddenly spiked, which was however a market aberration). As Thailand is a major rice exporter, the decline in the world rice price also pulled down its domestic price. To shore up the price, a domestic paddy price support program was implemented, which was later transformed into the paddy pledging program. The heavy intervention in the paddy market in the subsequent periods had been criticized for the inefficiency of the policy and its long term adverse impact on the rice economy (Isvilanonda and Naivikul, 2006).

A higher wage rate in the rural areas, driven by a remarkable growth in the economy as a result of foreign direct investment in the non-agricultural sector, inflated the cost of rice cultivation. A shortage of hired labor in the rural areas also induced farmers to mechanize, thus generating progress in capital accumulation in the farm sector (Isvilanonda and Wattanutchariya, 1990). However, the rise in fuel price and chemical fertilizer price and the growing scarcity of water in recent years have accelerated the upward shift in the cost of growing rice and consequently further reduced farmers' incomes.

Recently, increasing competition from industry and commercial cash crops, particularly the coarse grain and bio-energy crops, has also affected the crop area adjustment. A growing demand for coarse grain and energy crop significantly inflated their prices. In Thailand, the price of sugar cane and cassava increased from 0.44 baht per kilogram and 1.04 baht per kilogram to 0.57 baht per kilogram and 1.37 baht per kilogram, respectively, during 2002-2007. In the same period the price of oil palm fresh fruit increased from 2.3 baht per kilogram to 3.0 baht per kilogram or 30.43% (Office of Agricultural Economics (OAE), 2007). In a competitive market economy, changes in economic factors, particularly relative output price, would induce adjustments in the crop sector. The cultivated area of the bio-energy crops (sugar cane, cassava and oil palm) increased from 14.7 million rai to 16.4 million rai during 2002-2007 (OAE, 2007). Given the limited land frontier for agriculture, a continuous increase in price trends of bio-energy crops may discourage farmers to grow rice, which would soon reduce the rice supply. The rate of decrease in rice cultivated area depends largely on relative prices and other non-price factors such as rice research budget, irrigated area improvement and weather condition.

On the other side, as a staple food of Thai people and a major source of income for farmers, rice plays a vital role in the economy. Twenty-five percent of the entire labor force is employed in rice farming (National Statistics Office, 2008).

The rising trend in the price of energy crops and cost of rice production may discourage farmers to grow the rice crop and would soon reduce the production supply. Sustaining the country's rice production and status as the world's leading rice exporter would require among others assesing the growth in rice supply and demand in Thailand. The information would be useful for predicting the future export surplus of Thai rice.

The aim of this research was to investigate the effect of changes in rice price, the prices of other crops especially bio-energy crops, and non-price factors on the rice supplies, analyze the trends in rice production and consumption, and to estimate the exportable surplus in the next two decades (Figure 1.1). The paper is organized into six sections. After the introduction, Chapter II examines recent developments in the Thai rice economy, Chapter III presents a methodology for estimating factors affecting the rice supply, Chapter IV discusses rice utilization and the estimation of the demand for domestic rice consumption, and Chapter V assesses the growth in rice supply and demand and estimates the exportable surplus. The last section contains the conclusions and policy suggestions

Research Objectives

A general objective of this research is to assess the capacity of the Thai rice industry through an analysis of supply and demand. The specific objectives are:

1. To assess sources of changes in Thailand's rice economy and the factors affecting production.

2. To analyze the changing pattern of household rice consumption and factors contributing to changes in rice demand.

3. To evaluate the trend of Thailand's rice supply, demand, and exportable surplus.

The Hypotheses of this Study

The hypotheses are constituted corresponding to the first and second objectives, as follows:

Hypothesis I: the changes of price and non-price factors affect the adjustment in Thailand rice area and production.

Hypothesis II: the pattern of household rice consumption varies by household income, communities, and regions.

Hypothesis III: the changes of rice price, price of competitive crops, and household income affect the adjustment in domestic rice demand.

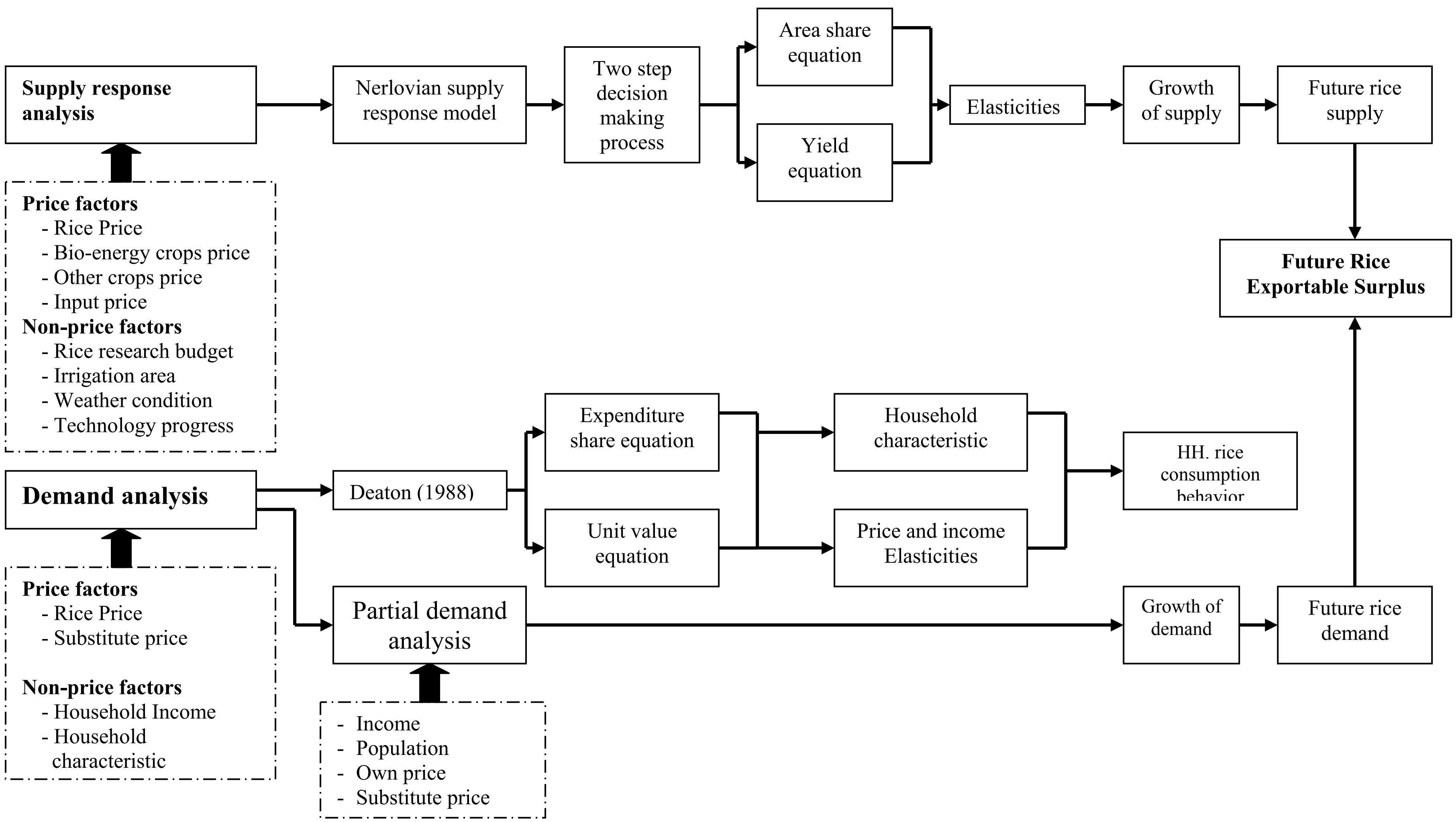

Figure 1.1 Framework of this Study

Scope of the Study

The analysis of supply side was done by employing secondary data from Office of Agricultural Economics during 1990-2007. In this estimation, rice supplies were divided into three parts consisting of the analysis base on wet season crop, dry season crop, and the two crops combined. In terms of non-glutinous and glutinous rice demands, the analysis was carried out by using cross section data collected by the Office of National Statistics in 2002 and time series data collected by FAO and the Office of Agricultural Economics during 1961-2007

Data Collection

Data for the analyses were collected from government offices and some international institutes, as follows:

1. To analysis rice supply response we used the data collected by Office of Agricultural Economics such as the provincial data concerning crops planting area, crop production and prices of crops.

2. To analyze household rice consumption behavior and demand analysis we used the data from the Socio-Economic survey Project collected in 2002 by the National Statistical Office. The data collected during that time was also used to calculate the quantity of rice and glutinous rice consumption per capita.

3. Domestic rice consumption data from 1961-2007 collected by FAO were used to estimate rice aggregate demand model.

4. Information both in the form of research reports and statistical data, from other organizations such as the Royal Irrigation Department, Rice Department, Department of Agriculture Library, National Statistical Office and Thai Meteorological Department were also used in the analysis.

CHAPTER II

THAILAND RICE PRODUCTION SITUATION: PAST OVERVIEW

Since the implementation of the 1st National Economic and Social Development Plan almost half a century ago, the development of the basic infrastructure of the national economy has accelerated growth and catalysed many changes in the country's economic structure. In the agricultural sector; the development of essential infrastructure facilitated changes in the structure of crop production, which resulted in a variety of commodities that were produced. In the rice sub-sector investments in the development of the basic infrastructure as well as the development of modern varieties (MVs) (also called high yielding varieties or HYVs) led to numerous changes in the national rice industry. This chapter reviews and describes the changes in the national rice production sector during the past fifty years.

National Economic Expansion and Agricultural Recession

More than a century ago Thailand opened its door to foreign trade. The Kingdom signed the Bowring Treaty with the United Kingdom, a significant first step for Thailand's agricultural evolution. The trade agreement provided the opportunity for rice, as well as other agricultural products, to become important traded commodities. Trade during that era subsequently provided the stimulus for expanding agricultural production, especially rice, which was grown mainly in the central plain. The aim of rice production changed from domestic consumption to commercial trading. This contributed to the expansion of agricultural lands particularly rice fields, which were constructed extensively in the central plain region (Ingram, 1955). More canals were also built to link with the network of major rivers in order to facilitate the transport of agricultural goods between the rural areas and the urban centers. The marketing system for agricultural products was established as well, which subsequently facilitated the development and expansion of communities located along the river transport network. The economy of the country at that time depended heavily on the agricultural sector; the primary source of national revenue was agricultural products (Zimmerman, 1931). However, agricuture production then did not benefit from new technology so that crop yields and thus agricultural productivity were low. Increases in production were achieved mainly by area expansion. Low yields provided farmers with low incomes. Low productivity, high production risk owing to the instability of climatic conditions, and high markets risks because of unstable crop prices combined to sink farmers to indebtedness (Narksawad, 1958).

The implementation of the 1st National Plan in 1961 and the subsequent revisions of policy every five years[1] (at present the nation is on its 10th National Plan) had created favorable conditions for economic expansion[2]. Initially the policy was focused on the development of the agricultural infrastructure. The priority was later shifted to the development of an industrial sector and a service sector that subsequently led to the decline in the relative importance of the agricultural sector. The contribution of agriculture to the national revenue during 1961-1965 was 30.2% of the gross domestic products; it has since been decreasing to less than 20% during the 5th National Plan (1982-1986) and 10% during the 7th National Plan (1992-1996). The country's economic development during the 1st to 9th National Plans affected significantly the growth of the national per capita income (based on 2002 price); the income per person of Baht 17,871 during 1961-1965 rose to Baht 94,118 during 2001-2007 (Table 2.1). Although the relative significance of the agricultural sector to the whole economy continued to decline, its importance as a source of labor remained. Moreover, the domestic agricultural sector was the major source of food for the Thai people.

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1 Except the development policy, Plan 1 lasted for 6 years. The country is currently complying to Plan 10 (2007-2011)

2 Except during 1982 and in 1997, when the country was facing a critical shortage of international reserve fund, the Thai Baht was revalued against the US dollar.

Table 2.1 Share of Thailand's Gross Domestic Product (GDP) at 2002 price and growth rate by sector and per capita income, 1961-2007

Years	Agricultural	Industrial	Construction	Other 1/	Total	Per capita income (Bht.)
			Share(%)			
1961-65	30.2	17.3	3.9	48.6	100.0	17,871
1966-70	27.1	18.8	4.8	49.3	100.0	22,672
1971-75	26.4	20.2	3.5	50.0	100.0	26,353
1976-80	24.4	22.5	4.1	49.0	100.0	32,472
1981-85	18.5	24.0	5.0	52.5	100.0	35,752
1986-90	14.8	27.6	5.4	52.3	100.0	49,955
1991-95	10.9	29.8	7.0	52.2	100.0	77,614
1996-00	9.6	33.3	4.7	52.4	100.0	73,337
2001-07	10.1	37.3	3.0	49.6	100.0	94,118

Note: "1/" including the service sector

Source: Office of the National Economic and Social Development Board (2008)

Drivers of Change in the Agricultural Structure during the Past Half Century

The numerous changes in the production structure of the agricultural sector during different periods were driven mainly by investments in agricultural infrastructure in accordance with the national economic and social development policy. The investments led to changes in the national trade structure for agricultural and food products. Investments in the construction of large- and medium-sized dams to improve the irrigation system in the different regions, particularly during the implementation of the pilot scheme of the 1st - 4th National Plans (1961-1981), contributed significantly to the expansion of irrigated areas in the central plain and the lower north. Irrigated area increased from 9.74 million rai during the 1st National Plan to 19.41 million rai by the time the 4th National Plan (1977-1981) was in force. Expansion in the irrigated area continued through the 9th National Plan (2002-2006) when the investment priority shifted from large projects to medium and smaller projects. This strategy further expanded the irrigated area to 24.25 million rai during the 5th National Plan (1982-1986) and 29.46 million rai during 7th National Plan (1992-1996). But for some reason that remains unclear, the area under irrigation slightly decreased during the 8th and 9th National Plans (Table 2.2).

Table 2.2 Irrigated areas by region from 1961 to 2007

Region	1st Plan	2nd Plan	3rd Plan	4th Plan	5th Plan	6th Plan	7th Plan	8th Plan	9th Plan
					Irrigated area (million rai)				
Northeast	0.98	1.07	1.5	2.45	3.75	4.37	5.11	6.05	6.16
North	0.8	1.67	2.34	3.85	6.1	7.08	7.81	5.45	5.06
Central	7.64	7.65	10.19	11.45	12.25	13.01	13.52	13.51	13.49
South	0.32	0.37	0.94	1.66	2.34	2.71	3.03	3.11	3.28
Total	**9.74**	**10.77**	**14.97**	**19.41**	**24.45**	**27.18**	**29.46**	**28.12**	**27.99**
					Share of irrigated area (%)				
Northeast	10.1	9.9	10.0	12.6	15.3	16.1	17.3	21.5	22.0
North	8.2	15.5	15.6	19.8	24.9	26.0	26.5	19.4	18.1
Central	78.4	71.0	68.1	59.0	50.1	47.9	45.9	48.0	48.2
South	3.3	3.4	6.3	8.6	9.6	10.0	10.3	11.1	11.7
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Office of Agricultural Economics, various issues

Initially, the development of the irrigation system was to support the adoption of modern rice varieties (MVs). The MVs gave higher yields and matured faster which allowed farmers to cultivate two or more crops per year. Adoption of the MVs[3] was widespread especially in the irrigated areas of the central plain resulting in various changes in the rice farming system, the major one being a two-crop-per-year pattern. Rice fields subsequently expanded with the improvement in rice yields (Isvilanonda and Wattanutchariya, 1990).

The development of a road network during the launching of the earlier Plan periods opened up more land for crop production, particularly rice, in other regions. At the same time, a larger tractor was widely adopted, which made it easier to break and plow the soil. This piece of machinery largely facilitated the invasion by farmers of forested areas, converting forest lands to agricultural lands and essentially extending their farmlands (Siamwalla, 1987). Using tractors to invade forest reserves turned vast areas of forests into farmlands, which lowered the price of agricultural

[3] Modern rice varieties called IR varieties (the earliest MV was IR8) were developed by the International Rice Research Institute (IRRI) located in the Philippines. IR8 was released in 1965 and became very popular. Thailand acquired the variety and cross-bred it with local varieties to suit the local agro-climatic conditions and improve grain consistency and taste. The resulting strains were released in 1969 to farmers as breeding rice named Gor.Kor 1 and Gor. Kor 3 (Jackson *et al.*, 1969)

land. The above two factors created large crop fields but not the rice field. The expansion of agricultural land faster than the expansion of labor resulted in a higher ratio of land per labor. The land expansion provided some advantages to agricultural production as well as market competition in the export market despite low production technology (Siamwalla *et al*., 1989). And the expansion of the transport network induced the expansion in the agricultural marketing structure, not only within local communities but also across regions. This subsequently facilitated the development of agricultural products for export.

Before the 1st National Plan period, most farmers were not only earning low incomes, they were in debt. They obtained loans mostly from informal sources that charged onerous interest rates. To add to their burden, they were exploited by middlemen and the local well-to-do (Narksawasdi, 1958). The objective of the Development Plan in regard to the development of local markets was to give farmers better access to capital at reasonable rates. This was accomplished by the formation of cooperatives and the establishment of the Bank of Agriculture and Agricultural Cooperatives (BAAC). The Bank provided capital at a subsidized interest rate to farmers. The financial institutions initially were unable to meet the capital needs of farmers (Thisayamontol *et al*., 1965; Onchan, 1980). The major national reform on the credit system for farmers was made during the 3rd National Plan (1972-1976) when the Bank of Thailand issued the directive that all commercial banks allocate 5% of their loans for agricultural purposes (the interest rate was lower than the normal rate of that time) (Siamwalla, 1990). The result was the availability of a greater amount of loan, which facilitated farmers' adoption of modern technologies and led to the improvement of infrastructure for agricultural production especially in the irrigated areas. Loans for agricultural purposes offered by commercial banks were expanded into rural loans not for agricultural activities only but for all rural-based production activities. The Bank of Agriculture and Cooperatives is the major lender.

Government investment in agricultural research and extension was another factor that stimulated the changes in the national agricultural structure. Investment in research for technological development was small initially but the magnitude continuously increased, which reflected the government's policy on agricultural development. The Department of Agriculture was the lead agency for agricultural research and development of new technology while the Department of Agricultural Extension had the main responsibility of promoting the adoption of new technology and providing training and information support to agricultural development program. During the plan periods 1968-1972 and 1988-1993, funding for research by the Department of Agriculture grew from Baht 541.68 million to Baht 1,260.97 million, while the budget for the Department of Agricultural Extension increased from Baht 376.37 million to Baht 2,034.85 million (Applied Economic Research Center, 1996).

Table 2.3 Average share of rice area in total crop production, 1961-2007

Periods	Rice	Upland crops: Energy crops	Upland crops: Other crops	Upland crops: Total	Veg.	Tree crops: Rubber	Tree crops: Oil Palm	Tree crops: Other tree	Tree crops: Total	Total Agri. land
Share (%)										
1961-65	72.79	8.02	5.62	13.65	0.44	10.57	0.0000	2.55	13.12	100.00
1966-70	67.44	10.23	7.91	18.15	0.58	11.16	0.0045	2.67	13.83	100.00
1971-75	63.21	15.14	7.49	22.63	0.81	10.61	0.0288	2.72	13.35	100.00
1976-80	60.41	19.16	7.11	26.27	0.68	9.75	0.1230	2.76	12.64	100.00
1981-85	57.15	22.35	7.58	29.93	0.56	9.39	0.3593	2.62	12.37	100.00
1986-90	56.19	24.42	6.11	30.54	0.42	9.21	0.69	2.96	12.86	100.00
1991-95	55.60	23.86	5.15	29.01	0.43	11.01	0.91	3.05	14.97	100.00
1996-00	58.40	21.13	3.50	24.63	0.45	12.08	1.45	2.99	16.52	100.00
2001-07	59.53	18.54	2.30	20.84	0.32	12.95	3.38	2.97	19.31	100.00

Source: Office of Agricultural Economics, various issues

The above internal and external activities motivated changes in the country's agricultural commodity mix from a few to several export items along with an expansion of crop fields from 60 million rai in 1961 to 130.27 million rai in 2007 (Office of Agricultural Economics, 2008)[4]. During 1961-1965 the total area of agricultural lands consisted of 72.79% rice fields, 13.65% crop fields, 13.12% tree crop areas and 0.44% vegetable fields. This proportion changed dramatically during 2001-2007 to 59.53% rice fields, 20.84% crop fields, 19.31% tree crop areas and 0.32% vegetable fields (Table 2.3). The area of energy crops such as cassava,

4 It was estimated that 25% of the area was with irrigation system and mostly in the central and the lower north of the country.

sugarcane and corn, as well as of oil palm, rubber and other crops had also expanded during the last three decades.

Changes in the Structure of Rice Production in the Second Half of the Century of the 1900s

The structure and technologies for rice production was undergoing many changes as the economy moved into the last decade of the previous century. As reviewed above some changes were the result of investments in agricultural infrastructure development especially irrigation. The investment for agricultural research and extension was in line with the development and adoption of modern rice varieties or the IR series of rice varieties (starting with the IR8[5]) from IRRI. The MVs from IRRI could be cultivated any time of the year, were of short-duration, of short stature and therefore lodging-resistant, and produced plenty of tillers. The varieties responded well to chemical fertilizers, thus produced high yields. The first variety released was named IR8 but soon acquired the label "miracle rice" and rapidly spread to different parts of the world. Many national rice breeders including Thailand's did not simply adopt and promote the variety. They bred in or bio-engineered some characteristics to improve the plant's adaptability to local agro-climatic conditions and make the cooking consistency, quality and taste of its grain appeal to the people's preferences.

In Thailand, the miracle rice, or "Gor Kor[6]" in Thai, was the first variety that was modified from the package of technology of the Green Revolution. Its development was carried out by the now Department of Rice, basically by crossing the IR8 with the local Luang Tong rice variety. The progeny was named "Gor Kor 1[7]". More new rice varieties were introduced to the public in 1969. After that, further

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5 IRRI developed this new rice variety and released it for mass propagation to national systems in 1966(Jackson et al, 1969)

6 Abbreviated from Department of Rice

7 An IRRI report (1983) revealed that IR8 was taken from IRRI to be crossed with the local Luang Tong rice variety in dry season rice field in 1964 at Bangkhaen Rice Testing Station. The resulting

improvements were made on the foundation variety which came up with new "Gor Kors" such as Gor Kor 7, Gor Kor 11. Later, the new rices were named after the particular research center in which each variety was developed. Thus, Pathumthani 1, Supanburi 60, Chainat 1, etc. Initially, the new varieties were unable to compete with the traditional rice in terms of quality and taste. The new rice was not popular in the domestic market and was indeed graded as low quality. However, its higher yield became the main factor that induced farmers in irrigated areas to adopt it. Eventually the quality became acceptable[8]. This led to a higher cropping intensity. Their short duration characteristic enabled farmers in the irrigated areas to plant two or more crops a year. The success achieved by farmers also prompted them to expand to new farm lands. Overtall, these boosted national rice prodcution

1. The significance of crop areas and rice production in different regions

Geographically, Thailand is divided into four regions, namely, northeast, north, central plain and south. Each region has unique landscape and climate. The northeast is largely of upland farming areas with low fertility and low water supply. Rainfall is unstable and the soil is mostly parched. There are many irrigation projects in the region including the Nampong project in Khon Kaen Province, Nam Moon Project in Ubon Ratchathani Province, Lampao project in Kalasin Province, and others. However, the proportion of irrigated area to total crop area remained low. Rice cultivation this region depends on rainwater and only one rice crop a year could be grown. The farmers in this region prefer cultivating local rice particularly Khaow Doak Mali (KDML) 105. During the last century, the rice farming area of the northeast increased from 16.20 million rai during 1961-1965 to 29.58 million rai during 1986-1990 and to 33.52 million rai during 2001-2007, which is 50.21% of the national rice area (Table 2.4). As most rice farms are rainfed, production is rather low. In 2001-2007, despite having more than half of the national rice area, the region's

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cross was called BKN56-1-2. This new rice was approved by the rice committee and was authorized for distribution to farmers on 15 December 1969. It was named Gor.Kor 1.

[8] Subsequent improvements in grain quality made its taste better as with Pathumthani 1, which was developed to have a level of amylose close to white jasmine rice

output was only a little over one third (9.58 million tons or 34.68%) of the national production.

The north, especially the upper north, is mountainous and a major water source of the country. The cultivated areas in the upper north are spread throughout the highlands while those in the lower north are mostly in the lowlands, which are linked to the central plain by many main rivers i.e. Ping, Wang and Yom, which flow south and form into the Chao Phraya River. The areas have highly fertile soil. The major irrigation projects include Phumiphol Dam, Sirikit Dam, Naresuan Dam, and others. The region's rice area increased from 8.09 million rai during 1961-1965 to 15.82 million rai during 2001-207 (Table 2.4), which was 23.70% of the national rice farming area. Its annual production also increased from 2.98 million tons during 1961-1965 to 8.29 million tons during 2001-2007, or 30.02% of the national production.

The central plain is the major commercial rice producing area of the country. Most of the farm lands in this region are lowlands served by efficient irrigation systems. The proportion of irrigated area to total agriculture area in this region is higher than in the other regions. The main irrigation projects in the central plain include the Chainat Dam, Sri Nakarin Dam, Pa Sak Dam, and other smaller ones. At present, the farmers of this region prefer to cultivate modern rice varieties and usually plant more than two rice crops a year or five crops in two years. The rice farming area in this region was only 15.12 million rai during 2001-2007 or 22.65% of the national rice area. However, its production was 8.89 million tons or 32.17% of the national production (Table 2.4).

The region with the least rice farming area is the south. Its topography and agro-climatic conditions are more suitable for plantation tree crops especially rubber and oil palm. Rice cultivation is mostly carried out in the remaining small areas of low land. The major irrigation projects are Rachaprapa Dam, Banglang Dam, and Pak Panang Basin Project. The region's farming area was 3.19 million rai during 1961-1965, which decreased to 2.29 million rai during 2001-2007 or 3.44% of the national rice area. The region produced 0.87 million tons during 2001-2007 or 3.14% of the national production (Table 2.4).

Table 2.4 Average rice area, production, and yield by region, 1961-2007

Periods	Regions				Total	Growth rate per annaum (%)
	Northeast	North	Central Plain	South		
Area (million rai)						
1961-65	16.20	8.09	13.21	3.19	40.69	1.51
1966-70	18.85	9.70	13.91	3.55	46.01	3.44
1971-75	21.95	10.56	14.86	3.53	50.90	3.36
1976-80	26.94	12.27	15.02	4.01	58.24	1.19
1981-85	28.84	13.54	15.17	4.00	61.54	1.57
1986-90	29.58	14.18	15.05	3.62	62.43	0.06
1991-95	31.07	13.27	12.75	3.07	60.16	-0.23
1996-00	32.46	15.08	13.74	2.86	64.14	1.05
2001-07	33.52	15.82	15.12	2.29	66.76	0.39
Area share (%)						
2001-07	**50.21**	**23.70**	**22.65**	**3.44**	**100.00**	**-**
Production (million ton)						
1961-65	3.21	2.98	3.45	0.75	10.39	3.34
1966-70	4.30	3.76	3.88	0.93	12.87	6.22
1971-75	4.72	3.73	4.83	0.94	14.22	2.71
1976-80	5.13	4.43	5.37	1.16	16.08	2.84
1981-85	6.51	5.24	6.05	1.07	18.87	3.35
1986-90	6.87	5.48	5.81	0.95	19.11	-2.66
1991-95	8.01	5.26	6.15	0.96	20.38	5.53
1996-00	8.74	6.82	7.25	0.96	23.78	3.31
2001-07	9.58	8.29	8.89	0.87	27.62	2.50
Production share (%)						
2001-07	**34.68**	**30.02**	**32.17**	**3.14**	**100.00**	**-**
Yield (kg/rai)						
1961-65	198	367	261	235	255	1.94
1966-70	227	387	279	263	279	2.22
1971-75	216	353	325	266	280	-0.82
1976-80	190	361	358	289	276	1.58
1981-85	225	388	399	268	306	1.69
1986-90	232	385	384	262	306	-2.88
1991-95	258	396	482	314	339	6.32
1996-00	269	452	528	337	371	2.23
2001-07	286	524	587	378	414	2.09

Source: Office of Agricultural Economics, various issues

Overall, the country's farming area increased from 40.69 million rai during 1961-1965 to 62.43 million rai during 1986-1990. During 1990-1995 the area declined because of the limited availability of more arable lands as certain parts of the areas were designated as forest land[9]. This limited production from extensive farming. Moreover, the expansion of an industrial sector and urbanization slowed down or even halted the expansion of rice farming areas. Nevertheless, during 1996-2000 and 2001-2007, there was a slight increase in the number of cultivated lands as a result of the national economic and financial crisis during the early period of the 8th National Plan. The labor force was brought back to the agricultural sector and idle rice fields were put back into cultivation as dry season paddy field (Isvilanonda, 2002).

Rice production grew from 10.39 million tons during 1961-1965 to 27.62 million tons during 2001-2007. It could be noted that during 1961-1990 the growth was from an expansion of the rice areas and the farming of modern rice varieties in irrigated lands. Hence, during 1991-2007, the expansion was partly from cultivating idle fields. The national average yield increased from 306 kg per rai during 1986-1990 to 414 kg per rai during 2001-2007.

2. Changes in areas of wet and dry season crops as well as their cultivation

With the adoption of modern short-duration rice varieties in 1967 the cropping pattern changed from one wet season crop a year to two crops, one wet and one dry-season. The dry season crop was initially sown after the wet crop farming or around February to July, particularly among farmers in the irrigated areas. The farmers in the irrigated area, especially those in the central, continuously cultivated the modern rice varieties that it became difficult to separate the wet season crop fields from the dry season crop fields. In this paper the separation of the wet season crop from dry season crop was based on the classification obtained from information of the Office of Agricultural Economics which explained that during 1966-1970 the area of dry season crop was 0.48 million rai with 0.18 million tons production. This increased to 9.31 million rai during 2001-2007 and a production of 6.26 million tons (Table 2.5). In other words, the growth in production was higher than the growth in area (Table 2.5).

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[9] The country abolished bidding for wood in the preserved areas in 1989 therefore the management of most natural forest areas is presently focused on forest conservation.

This was because during 1981-2007 much of the increase in rice farming yields was from an expansion of dry season fields. A dry season crop normally has a higher yield per rai (almost double) than a wet season crop.

Table 2.5 Average rice production, area, yield and their growth, classified by wet and dry season crops, 1966-2007

Periods	Number		Growth rate per annum	
	Wet season	Dry season	Wet season	Dry season
	Area (million rai)		**%**	
1966-70	45.53	0.48	3.25	37.80
1971-75	48.92	1.98	2.55	37.80
1976-80	55.28	2.96	1.48	-3.18
1981-85	57.61	3.93	0.86	17.34
1986-90	57.88	4.55	-0.25	4.44
1991-95	55.88	4.28	-0.59	10.18
1996-00	56.80	7.34	0.19	8.50
2001-07	57.44	9.31	0.12	2.29
	Production (million ton)		**%**	
1966-70	12.69	0.18	5.90	46.60
1971-75	13.20	1.02	1.22	41.15
1976-80	14.31	1.77	2.31	10.86
1981-85	16.54	2.34	3.29	4.12
1986-90	16.59	2.52	-2.96	3.17
1991-95	17.44	2.94	3.88	17.42
1996-00	18.80	4.98	2.25	7.66
2001-07	21.37	6.26	2.91	2.00
	Yield (kg/rai)		**%**	
1966-70	278	369	2.09	8.46
1971-75	270	513	-1.53	3.28
1976-80	259	621	0.78	16.73
1981-85	287	597	2.35	-9.55
1986-90	286	571	-2.97	1.22
1991-95	312	701	4.78	22.26
1996-00	331	678	2.07	-0.66
2001-07	372	672	2.76	-0.38

Source: Office of Agricultural Economics, various issues

The country's irrigated rice area was approximately 14.44 million rai during 2001-2007, a slight increase from the 14.32 million rai during 1989-1990 (Table 2.6). The increase was mainly in the central plain. The production from the irrigated area was 5.26 million tons during 1989-90 and 7.72 million tons during 2001-2007. It is clear that the growth in production in the irrigated area is higher than the expansion in area.

Table 2.6 Average wet season rice area and production in irrigated areas by region, 1989-2007

Periods	North	Northeast	Central	South	Total
			Area (million rai)		
1989-90	2.92	2.29	8.01	1.10	14.32
1991-95	3.31	2.65	6.94	0.82	13.72
1996-00	3.69	2.94	6.57	0.78	13.98
2001-07	3.77	3.15	6.74	0.78	14.44
			Production (million ton)		
1989-90	1.36	0.76	2.80	0.35	5.26
1991-95	1.43	0.85	3.26	0.29	5.82
1996-00	1.78	0.97	3.44	0.30	6.49
2001-07	2.14	1.06	4.19	0.33	7.72

Source: Office of Agricultural Economics (2008)

Rice yield per rai in the irrigated areas was higher, almost double, than in the non-irrigated areas; during 2001-2007 the average yield in the irrigated areas was 535 kg per rai while that in the non-irrigated areas was 350 kg per rai (Table 2.7). This difference is the result of farmers in the irrigated areas using modern rice varieties that responded highly to chemical fertilizer. With sufficient water the farmers in the irrigated areas could sow more than one crop of MVs a year compared to farmers in the non-irrigated areas who were cultivating mainly the local rice. Farming in the non-irrigated areas depended on rainwater, which allowed only one crop a year, and only a small amount of chemical fertilizer could be applied because traditional varieties do not respond to fertilization as well as the MVs; the traditional rices would grow taller with heavy fertilization and, when heavy with panicle, their tall and slender stalks would bend. This behavior is called lodging. It results in poor yield because the grains are spoiled when the panicles drop to the soil.

Table 2.7 Average rice yields in irrigated areas and non-irrigated areas by region, 1989-2007

Periods	North	Northeast	Central	South	Total
Rice yield in irrigated area (kg/rai)					
1989-90	466	330	349	318	367
1991-95	432	319	470	353	425
1996-00	481	331	524	389	465
2001-07	567	336	621	427	535
Rice yield in non-irrigated area (kg/rai)					
1989-90	333	237	235	214	258
1991-95	346	247	287	294	273
1996-00	371	258	305	300	286
2001-07	483	305	393	350	350

Source: Office of Agricultural Economics (2008)

3. Changes in farming areas and the productivity of glutinous and non-glutinous rice varieties

Rice farming can be further categorized based on the type of rice grain i.e. glutinous and non-glutinous. Glutinous rice farming is mostly carried out in the upper north and the upper northeast. The people in these areas prefer glutinous rice, which is produced mostly for household consumption, with any surplus sold in the local market. The area farmed for glutinous rice during 2001-2007 was about 26.54% of the national rice cultivated area in the wet season. Since this rice is mainly a wet season crop, the data for this paper was determined mainly from the yearly area planted to glutinous rice. Farming of glutinous rice during the dry season is rares and done only in the upper north.

The area farmed for glutinous rice farming has been decreasing. During 1989-1990 it was approximately 15.55 million rai or 26.32% of the total area of the wet season crop fields. This shrank to 15.19 million rai or 26.54% during 2001-2007. Production of glutinous rice during 1989-1990 was 4.26 million tons or 25.85% of the total wet season crop production (including non-glutinous rice). It increased to 4.99 million tons during 2001-2007. Its production level did not correlate with the decrease in area because the traditional varieties were replaced by modern varieties in many areas. Subsequently, average yield per rai grew from 273 kg during 1989-1990 to 328 kg during 2001-2007 (Table 2.8).

Table 2.8 Average wet season area, production, and yield of glutinous rice by region, 1989-2007

Periods	North		Northeast		Central Plain	South	Total	Share of glutinous rice (%)
	upper	Lower	Upper	lower				
				Area (million rai)				
1989-90	1.78	0.15	9.59	3.98	0.06	0.001	15.55	26.32
1991-95	1.88	0.26	8.96	3.66	0.04	0.001	14.80	26.48
1996-00	1.96	0.29	9.54	3.93	0.05	0.006	15.77	27.76
2001-07	2.08	0.21	9.54	3.33	0.03	0.001	15.19	26.54
				Production (million ton)				
1989-90	0.91	0.06	2.40	0.88	0.01	0.0002	4.26	25.85
1991-95	0.83	0.10	2.27	0.88	0.01	0.0002	4.09	23.45
1996-00	0.94	0.11	2.44	1.00	0.02	0.002	4.51	24.03
2001-07	1.06	0.10	2.84	0.97	0.01	0.000	4.99	23.45
				Yield (kg/rai)				
1989-90	511	380	250	222	188	265	274	-
1991-95	439	388	253	240	259	304	276	-
1996-00	480	388	256	254	303	359	286	-
2001-07	510	485	298	293	362	341	328	-

Source: Office of Agricultural Economics (2008)

The area planted to non-glutinous rice in the wet season was of course more than the area of glutinous rice: 43.54 million rai or 73.68% of the total wet season rice area during 1989-1990. This went down to 42.06 million rai (or 73.03%) during 2001-2007 while production increased from 12.22 million tons during 1989-1990 to 16.28 million tons during 2001-2007. The share of non-glutinous rice was two thirds of total rice production (Table 2.9). Its yield per rai grew from 280 kg during 1989-1990 to 387 kg during 2001-2007. During these two periods, the major non-glutinous rice farming areas were the lower north, lower northeast, central plain. While the area planted to glutinous rice in the north and the northeast decreased, the area of non-glutinous rice in the same regions increased. This was owed to the fact that several farmers allocated part of their fields to produce enough glutinous rice for the family and planted the remaining area to jasmine rice or Kaow Dok Mali 105, which is a popular premium variety with a high price.

Table 2.9 Average non-glutinous rice area, production, and yield in wet season by region, 1989-2007

Periods	North		Northeast		Central Plain	South	Total	Share of non-glutinous rice (%)
	Upper	lower	upper	Lower				
Area (million rai)								
1989-90	1.71	9.76	5.43	12.21	11.25	3.19	43.54	73.68
1991-95	1.33	8.75	5.19	12.85	10.02	2.94	41.09	73.52
1996-00	1.25	8.86	5.06	13.36	9.81	2.64	40.98	72.16
2001-07	1.30	9.14	6.01	13.62	9.89	2.11	42.06	73.46
Production (million ton)								
1989-90	0.75	3.03	1.28	2.86	3.48	0.81	12.22	74.15
1991-95	0.48	3.06	1.32	3.38	4.18	0.91	13.35	76.56
1996-00	0.35	3.54	1.48	3.53	4.47	0.87	14.25	75.97
2001-07	0.47	4.09	1.68	4.04	5.18	0.81	16.28	76.55
Yield (kg/rai)								
1989-90	447	309	236	235	304	253	280	-
1991-95	361	350	255	264	417	311	325	-
1996-00	281	399	293	264	456	331	348	-
2001-07	353	448	279	296	524	386	387	-

Source: Office of Agricultural Economics (2008)

As information was limited on the area allocation as well as respective production volumes of normal paddy rice, Kaow Dok Mali 105, and glutinous rice, this paper will only present the information on farming areas and production in 2007, which was as follows: of the total 67.46 million rai of rice area, 51.83 million rai was for non-glutinous rice and 15.63 million rai was for glutinous rice (Table 2.10).

The area for non-glutinous rice was further divided into 32.45 million rai for normal rice and 19.38 million rai for Kaow Dok Mali (KDML) 105. The total rice yield in 2007 was 30.11 million tons, of which 5.45 million tons was glutinous rice and 24.66 million tons was non-glutinous rice. This production volume of non-glutinous rice was further categorized into 18.13 million tons of ordinary rice and 6.53 million tons of KDML 105 plus Gor.Kor 15[10].

[10] Gor Kor. 15 is considered as jasmine rice 105. It was created by gamma irradiation of the jasmine rice that newly produced the varieties KDML 105'65G1 U-45. Gor.Kor 15 is preferred in the upper north and some areas in the northeast. This rice can strongly survive an attack of vultures. Moreover, it has shorter stalk than KDML 105 rice and therefore is resistant to lodging (The International Rice Research Institute, 1985)

The central plain was a major area for ordinary rice while the northeast and the north were for KDML 105. Glutinous rice was produced mainly in the north and the northeast.

Table 2.10 Non-glutinous and Glutinous rice (paddy rice) production by regions in 2007

Regions	Non-Glutinous Rice			Glutinous Rice	Total Rice
	Normal Rice	KDML 105 Rice	Total Non-Glutinous rice		
Area (million rai)					
North	11.69	2.18	**13.86**	**2.39**	**16.26**
Northeast	4.52	15.97	**20.49**	**13.19**	**33.67**
Central	14.03	1.22	**15.25**	**0.05**	**15.30**
South	2.22	0.01	**2.23**	**0.00**	**2.23**
Total	**32.45**	**19.38**	**51.83**	**15.63**	**67.46**
Area share (%)					
North	36.02	11.23	**26.75**	**15.31**	**24.10**
Northeast	13.92	82.39	**39.52**	**84.39**	**49.92**
Central	43.24	6.32	**29.43**	**0.29**	**22.68**
South	6.83	0.07	**4.30**	**0.00**	**3.31**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Production (million ton)					
North	6.66	1.00	**7.65**	**1.27**	**8.92**
Northeast	1.57	5.12	**6.68**	**4.17**	**10.86**
Central	9.00	0.41	**9.41**	**0.01**	**9.42**
South	0.90	0.01	**0.91**	**0.00**	**0.91**
Total	**18.13**	**6.53**	**24.66**	**5.45**	**30.11**
Production share (%)					
North	36.71	15.29	**31.04**	**23.23**	**29.63**
Northeast	8.65	78.38	**27.11**	**76.53**	**36.05**
Central	49.66	6.25	**38.17**	**0.24**	**31.30**
South	4.98	0.08	**3.68**	**0.00**	**3.02**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: Office of Agricultural Economics (2008)

4. The declining investment in rice research

During 1971-1975, the government provided Baht 146.48 million annually for rice research (the amount included the research management cost) and raised this to Baht 394.38 million yearly during 1996-2000. After that, the amount was reduced; it was Baht 207.34 million during 2001-2007. The trend could be seen more clearly if the research investment was divided into two periods, 1971-1990 and 1991-2007. The first period saw a growth rate in research investment of 4.97% per year, while the second experienced a decline of 6.04% per year (Table 2.11). A look into the past 10 years shows that the real rice research budget declined to 0.21% per year during 1996-2000. The percentage further declined to 20.55% during 2001-2007.

From the perspective of research funding per unit area, the figures show a research budget per rai per year of Baht 3.12 during 1971-90, which increased to Baht 5.19 during 1991-2007. However, the growth as well as the magnitude of research funding was disproportionately small in relation to the total cultivated area and the importance of rice to the farming households and to the rural and national economies. While there was some growth in the rice research budget, the total budget for all development activities related to rice shrank to 6.04% per year during 1991-2007 although it had been expanding by 4.97% per year during 1971-1990 (Table 2.11). The small amount of research investment along with its subsequent reduction may not show any severe impact in the short term as the benefits from the previous research investments would still be felt. Over the long term however, a shrinking research budget could create a shortage of rice researchers. The negative outcomes would include the deterioration in production efficiency and the risk of losing the competitiveness of the national rice industry in the world market.

Documentation is lacking that shows the proportion of rice research investment in irrigated and non-irrigated farming but the available information was enough to show that the research investment in the irrigated rice areas provided clearer research benefits than the ones in rainfed areas. Subsequently research was focused mostly on the irrigated areas. This meant that the contribution of the research investment was disproportionately small relative to the 70% share of the rainfed area to the country's total rice area. The lack of effective production technology for most rice cultivating areas led to a low average yield. The low yield was compounded by high production cost especially for farmers in the rainfed areas, which meant that their income was lower than those in the irrigated areas.

Table 2.11 The real budget allocation for rice research and institution (at 2002 price)

Periods	Rice research budget	Rice research budget per wet season rice area (baht/rai)	Annaul growth rate (%)
1971-75	146.48	2.98	11.60
1976-80	174.72	3.17	-2.53
1981-85	197.95	3.43	4.63
1986-90	190.12	3.29	6.18
1991-95	316.09	5.65	8.01
1996-00	394.38	6.94	0.21
2001-07	207.34	3.61	-20.55
The real budget in 2 periods			
1971-90	**177.32**	**3.22**	**4.97**
1991-07	**294.34**	**5.19**	**-6.04**

Source: Rice research budget figure was obtained from the Rice Research Institute formerly under the Department of Agriculture. In 2007, the Department of Rice was established by separating its function from the Department of Agriculture.

5. Changes in the number of labor force for rice cultivation

At the start of the Development Plan, the relative importance of the industrial sector to the national economy was small. Most of the workers were in the agricultural sector. The subsequent urbanization of the country and the rapid growth of the non-agricultural sector drew the labor force from the agricultural sector to the other economic sectors, which generally offered higher wages. The proportion of the agricultural labor force to the total national labor force decreased (Onchan *et al*., 1992); it was 72.34% during 1961-1965 (with 18.18 million laborers) and 62.76% during 1986-1990. The country's total labor force increased but the labor force engaged in the agricultural sector declined to 43.19% during 2001-2007 (Table 2.12). In addition, the labor movement from the agricultural sector had led to a smaller size of agricultural households from 4.75 persons per household in 1999 to 3.95 persons in 2007. In the same period, the labor size of an agricultural household decreased from 3.42 to 2.75 persons per household (OAE, 2008).

Table 2.12 Proportion of the rice labor force to the agricultural labor force, and of both to the national labor force, 1961-2007

Period	Total labor force (million)	Agr.labor force		Rice labor force[1/]	
		Number (million)	Share of Agr. labor to Total labor (%)	Number (million)	Share of rice labor to Agr. labor (%)
1961-65	14.74	10.66	72.34	7.86	53.31
1966-70	16.23	11.35	69.91	8.41	51.80
1971-75	20.13	14.55	72.29	10.49	52.12
1976-80	22.17	16.02	72.26	11.38	51.35
1981-85	24.51	16.65	67.96	12.05	49.17
1986-90	28.97	18.18	62.76	11.87	40.98
1991-95	32.07	17.88	55.75	12.10	37.72
1996-00	32.52	16.05	49.35	10.94	33.63
2001-07	35.60	15.37	43.19	9.94	27.94

Note: [1/] Calculate by multiplying provincial agricultural labor force by province ratios of ricr farm to farm household

Source: Office of Agricultural Economics, various issues

The labor force in rice farming was 53.31% of the total agricultural labor force during 1961-1965. This proportion gradually declined to 27.94% during 2001-2007 (Table 2.12). The labor movement from the agricultural sector also led to a higher average age of rice farmers. Isvilanonda *et.al.*, (2000) reported that the age of a household head doing mainly rice farming increased from 53 to 58 years old, as revealed by surveys in 1987 and in 1998. This was owing to the higher educational attainment of farmers' offsprings, which they needed to have to be able to find a good paying job in the non-farm sectors. Farm outmigration included most of the young people who moved to work in the non-agricultural sector and never returned to a farming career. All these factors contributed to a higher average age of rice farmers.

The decrease in the agricultural labor force pushed agricultural wage rates higher (Figure 2.1). One outcome of the increase in the agricultural wage rate and demand on labor for rice farming was pressure on the farmer to adopt farm machinery to replace manual labor. For a positive impact, the labor shortage spurred the development of other labor saving techniques which included the use of pre-germinated seed to eliminate the transplanting process.

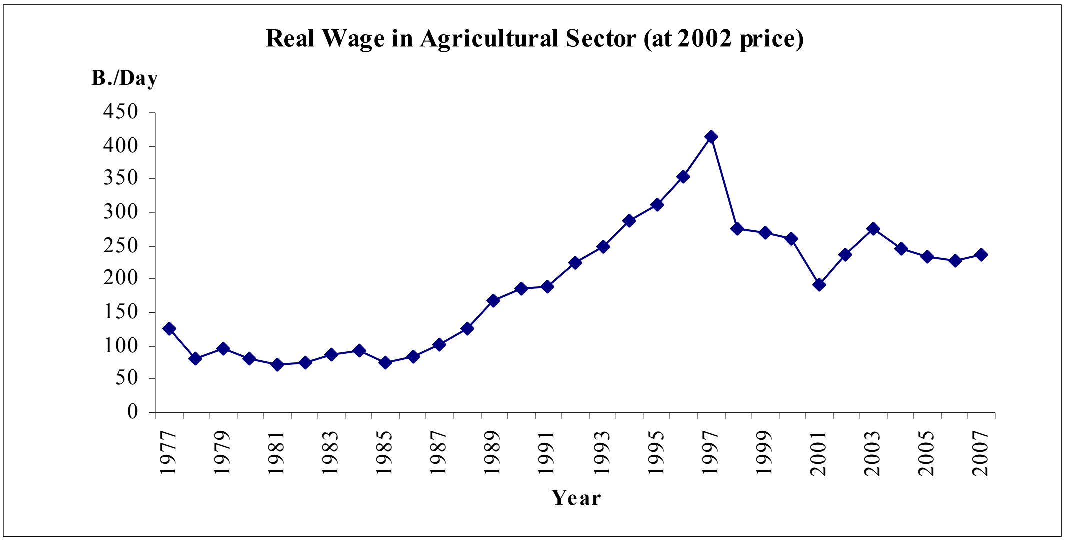

Figure 2.1 Real wage rate in agricultural sector (at 2002 price)

Source: Labor Force Survey, various issues

The declining labor force for rice production and the adoption of farm machinery raised labor productivity and reduced production cost especially of irrigated rice farming.

6. The move towards farm mechanization

Farm machinery was introduced in Thailand more than four decades ago. It started with the use of a big tractor, which facilitated the clearing of forest areas for crop cultivation especially corn and cassava. The price of the tractor made it initially attractive to farmers. Subsequently, the use of farm machinery became widespread, particularly for land preparation of wet season rice in the central region. It spread to some rainfed rice areas in other regions. A contract service was initiated and kept on increasing (Wattanutchariya, 1983). Farming of modern rice varieties in the central plain became popular and the farmers soon realized that using the water buffalo in soil preparation, because of the slow pace of work, would delay the planting of the second crop of rice. In general, the farmers also felt they were incurring a higher cost in maintaining a water buffalo as there was often a shortage of grass. Eventually, the use of draft animal for field preparation became less. The power tiller was introduced in the beginning of 1969 (Rijk, 1989) and became popular since 1980. Siamwalla

(1987) had pointed out that production efficiency was higher and cost was lower by using farm machinery instead of manual or animal labor. Today, almost every farming household owns a power tiller.

In the irrigated areas of the central plain, the shortage of labor force as well as the rising labor wage had led to the adoption of rice threshers and, eventually, rice combines[11]. These machines have become popular among farmers in the north and the northeast. Although, a harvesting machine can speed up work the harvested grains have a higher moisture content, which increases the cost and time of drying. Farmers also have little space for drying a large volume of harvest so that they would have to sell immediately to a rice mill or a buyer after harvesting. In doing so, they get a price lower than the prevailing market price. The number of units of farm machinery including big tractors, power tillers, water pumps and threshing equipment are shown in Table 2.13.

To reiterate, the expansion in the use of farm machinery during the past three decades was to compensate for the shortage of farm labor. Mechanization of land preparation and harvesting shortened these processes, and with the short maturing MVs, enabled the farmers to plant more than two crops a year or in many cases five crops over two years. In short, land and labor use became more effective..

Table 2.13 Machinery and equipment used in agricultural, 1976-2006

Period	Tractor	Power tiller	Water pump	Threshing Equipment
		Units		
1976-80	28,364	200,072	393,202	7,879
1981-85	47,933	347,094	684,507	28,559
1986-90	45,967	591,818	866,802	37,298
1991-95	102,518	1,160,334	1,603,348	55,908
1996-00	294,862	2,444,131	3,071,420	97,105
2001-06	766,456	4,504,729	4,885,618	152,120

Source: Office of Agricultural Economics, various issues

[11] There was no information on harvesting machine in the database of the Office of Agricultural Economics. However, the rice thresher that is being used for contract service has harvesting and threshing functions.

7. Utilization of chemical fertilizer

Chemical fertilizer was used more in the dry season rice farming than in the wet season farming because the dry season crop was mainly modern rice varieties, which responded better to chemical fertilizer than the traditional varieties cultivated in rainfed fields in the wet season. However, the average utilization of chemical fertilizer per rai in wet season rice planting also increased, from 3.7 kg for the wet season crops during 1971-1975 to 10.7 kg during 1986-1990 and to 28.03 kg during 2001-2006. The increases were in accord with the wider adoption of MVs for the wet season crop. The rate of application of fertilizer in the dry season crop farming likewise increased, from 27.1 kg per rai during 1971-1975 to 52.9 kg per rai during 2001-2006 (Table 2.14).

Table 2.14 Average application rate of chemical fertilizer for rice, 1971-2006

Period	Wet season	Dry season	Average
	Kg/rai		
1971-75	3.7	27.1	4.4
1976-80	5.2	37.8	7.0
1981-85	7.1	47.2	9.6
1986-90	10.7	47.5	13.4
1991-95	18.1	54.5	20.8
1996-00	25.2	52.1	28.1
2001-06	28.03	52.93	39.19

Source: By calculating from data of Office of Agricultural Economics, various issues

Overall, the average application of chemical fertilizer per rai increased from 4.4 kg during 1971-1975 to 39.19 kg during 2001-2007. Three factors could explain this higher rate: (i) farmers have replaced the local varieties with MVs, (ii) the fertility of rice lands was declining and, for a broader reason, (iii) the government policy to alleviate poverty among farmers by increasing farm productivity and economic returns stimulated the increased usage of fertilizers.

The cost of chemical fertilizer however has increased as a result of the generally rising price of petrol since 2008. The price of chemical fertilizer has doubled during the past ix years. Urea fertilizer increased from Baht 7,593 per ton in 2003 to Baht 12,538 per ton in 2007 and Baht 15,000 per ton in the beginning of 2008 while 15-15-15 increased from Baht 12,704 per ton in 2007 to Baht 19,500 per ton during the beginning of 2008 (Table 2.15). The rapid increase in price has also pushed rice production cost higher. Lowering the production cost through nutrient management to maintain or enhance soil fertility at a level that is suitable for rice cultivation is an option for farmers to decrease rates of fertilizer application without reducing yield.

Table 2.15 Local wholesale price of urea and NPK fertilizers, 2003-2008

Fertilizers	2003	2004	2005	2006	2007	2008[1/]	% Price change between 2007 and 2008
46-0-0	7,593	9,563	12,349	12,383	12,538	26,503	114.30
15-15-15	9,203	10,393	11,912	12,954	12,704	26,349	107.41
16-20-0	7,121	8,419	9,485	10,024	10,252	22,644	120.87

Note: [1/] is fertilizer price in September 2008

Source: Office of Agricultural Economics (2008)

Labor Productivity and Factors Affecting Labor Productivity

The impacts of the country's economic development on the agricultural sector were many. These included higher competition in the allocation of input factors for different crops. Moreover, the declining availability of new arable land and shortage of labor had created the current upward pressure on prices of inputs, which further increased the cost of land and farm labor. The higher wage rates in the non-agricultural sector drew the labor force away from the agricultural sector. But notwithstanding the decrease in the number of rice farm workers, rice production increased as a result of farmers' adopting farm machineries and modern technology, which minimized the use of labor force and raised production efficiency. Some examples include the use of pre-germinated seed to do away with the transplanting process, the replacement of manual weeding with herbicides, the use of synthetic insecticides, the use of combines to replace labor for harvesting and other innovations. These changes increased the efficiency of labor in rice production; labor productivity steadily rose during the last four decades from an average of 1.32 tons per worker during 1961-1965 to 2.78 tons per worker during 2001-2007 (Table 2.16). By region, labor productivity was highest in the central plain, followed by the north.

Table 2.16 Labor productivity (ton/worker) in rice production by region, 1961-2007

Period	Northeast	North	Central Plain	South	Average
1961-65	0.80	1.58	2.72	0.99	1.32
1966-70	0.99	1.85	3.09	1.19	1.53
1971-75	0.91	1.42	2.95	0.91	1.35
1976-80	0.90	1.51	3.31	1.03	1.41
1981-85	1.07	1.67	3.79	0.89	1.57
1986-90	1.14	1.81	3.69	0.78	1.61
1991-95	1.74	1.59	3.42	0.71	1.70
1996-00	1.49	2.50	5.37	1.01	2.18
2001-07	1.72	3.38	7.52	1.20	2.78

Source: By calculating from data of Office of Agricultural Economics, various issues

Factors affecting labor productivity were tested by using the General Least Square (GLS) and Weighted Least Square (WLS) techniques using the rice production per worker (PRODL) as the dependent variable. The independent variables consisted of the area of rice cultivated per labor (AREAL; rai per worker), irrigated area per labor (IRRGL; rai per worker), rice research expense per labor (RESSL; baht per worker), the weather condition represented by the variance of provincial rainfall (RAIN). The regions i.e. the north, the central and the northeast were a dummy to differentiate the production environment by having the south as a base for comparison. Since the significance of rice production in each province was different depending on the characteristics and levels of provincial resources and agro-ecological conditions, the econometric calculation was weighted with a proportion of the rice production value to the total value of all crops of the province.

The results, which appear in Table 2.17, show that the variables area grown to rice, local irrigation development, rice research investment, capital accumulation of agricultural households, and the differences in the regional environment have a strong positive impact on labor productivity, except the variable unusual weather, which shows a negative impact.

Table 2.17 Estimated results of production function, 1970-2007

Variables	PRODL	
	GLS	WLS
Constant	-0.430**	-0.396**
AREAL	0.330**	0.351**
IRGGL	0.040**	0.090**
RESSL	$(5*10^{-7})$**	$(4*10^{-6})$**
POWL	1.928**	3.917**
RAIN STD.	$(-1*10^{-5})$	-0.001**
CENTRAL	0.720**	0.200
NORTH	0.295*	-0.157
NORTHEAST	-0.041	-0.383**
Adjust R^2	0.970	0.920
F-ratio	7932.4	2745.0

Note: GLS is general least squares and WLS is weigthed least squares
*, and ** are significant at 95%, and 99%, respectively

It can be concluded that the increasing tendency in productivity per unit labor was the result of the developments on the agricultural infrastructure, investments in agricultural research, as well as the labor migration from the agricultural sector.

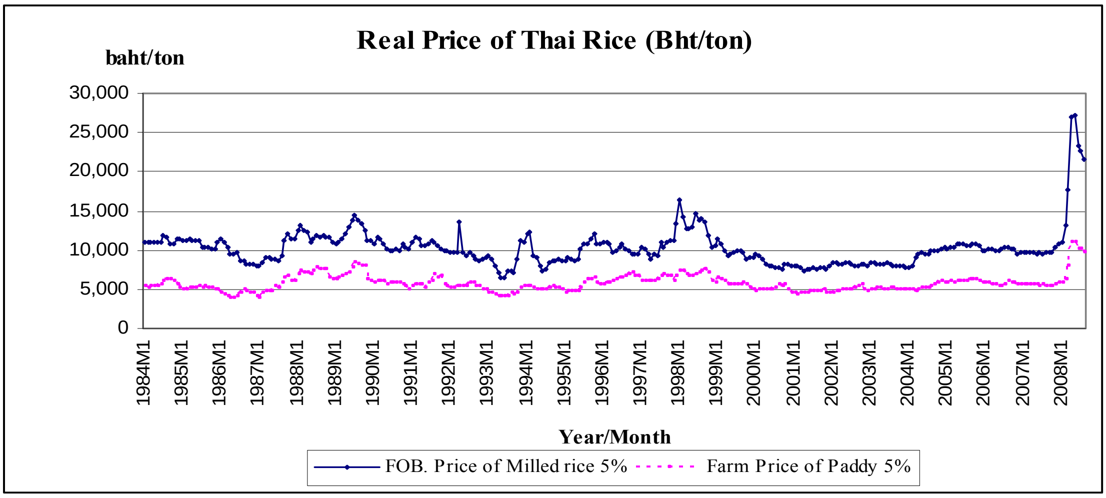

Figure 2.2 Monthly demonstration of the rice price movement for white rice 5% (F.O.B) in the export market and an average price of paddy rice at farm, from January 1984 to August 1998.

Source: Farm price of paddy was from the Office of Agricultural Economics; export price was from IMF Online (12/2008)

Movement of the Rice Price during the Last Two Decades

In a free trade regime, prices are the main factors that influence the producer's decision to allocate resources for the production of a mix of goods. Price movement depends on supply of and demand for a particular good. The rapid increase in rice supply during the height of the green revolution, in Thailand and the other rice producing countries, coupled by the declining rice consumption per capita were the results of the expansion of national economies. World rice demand grew sluggishly owing to a slightly increasing population. The low volume of international rice trade relative to the world rice production[12] dampened its price in the world market. The movement of rice price in the international markets had a direct influence on the movement of rice price in Thailand (TDRI 1988). Figure 2.2 shows the movement of the price of white rice 5% (F.O.B) in the export market and the average farm price of paddy rice from January 1984 to August 2008. The figure indicates that the movements of rice price in the export market and at the farmgate were mostly in the same direction. In early 2008 when the export price was high, the farmgate price adjusted accordingly.

The relation between export milled rice (5%) price and wholesale milled rice (5%) price in the Bangkok market, and the paddy rice price at the central market and paddy rice price at farm are shown in Table 2.18. The results indicate that the movement of export milled rice (5%) price and domestic wholesale price of the same milled rice were correlated significantly (at 99%). The paddy rice price at the central market and milled rice (5%) price at the export market also showed significant correlation at 99% level. The relation between paddy rice price at the farm and milled rice price 5% at the export market was statistically significant at 99% level. The analysis clearly shows that domestic price was strongly correlated with export price.

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[12] In 2007 global rice production was 430 million tons of paddy rice, while only 28 million tons were traded in the world market

Table 2.18 Analytical result of the relation between export milled rice price (5%) and wholesale milled rice price (5%) in Bangkok market; paddy rice price at the central market and farmgate paddy price on monthly basis during 2004-2007.

Items		Estimated results
1. Wholesale and FOB. Price for 5% milled rice	Whpr =	40.894 + 0.930 expr
	t-statistics	(0.181) (45.485)
	S.E.	(225.64) (0.020)
	R-square	0.982 ; Adjusted R-square = 0.981
	F-statistics	2068.90
2 Paddy price at central market and FOB. price for 5% milled rice	Central =	-335.671 + 0.604 expr
	t-statistics	(-1.031) (20.473)
	S.E.	(325.643) (0.030)
	R-square	0.917 ; Adjusted R-square = 0.915
	F-statistics	419.13
3 Farm price (paddy) and FOB. Price for 5% milled rice	Farmpr =	944.067 + 0.487 expr
	t-statistics	(2.593) (14.754)
	S.E.	(364.08) (0.033)
	R-square	0.851 ; Adjusted R-square = 0.847
	F-statistics	217.68

Source: By calculating

An examination of the movement of rice price in the export market and the domestic market during the last 50 years reveals that the price in the export market decreased from an average price of Baht 20,135 per ton during 1961-1965 to Baht 9,144 per ton during 2001-2007. The farm price, on the other hand, increased from Baht 6,129 per ton during 1961-1965 to Baht 7,074 per ton during 1976-1980. However, the farm price went down to Baht 5,730 per ton during 2001-2007 (Table 2.19).

Since 2002 petrol price began increasing steeply and by the end of 2007 the price had reached such a high level that many countries, particularly the Unites States, issued a policy supporting the production of bio-energy from food crops such as corn and soybean as a raw material. Food crop production was focused to produce ethanol in Brazil, USA, some European countries as well as Thailand. This increased the demand for food crops as sources of bio-fuel, which further increased the price of many food crops. Rice is not used as a raw material to produce bio-energy directly but its price also increases in line with other food crops as rice was used as a substitute to them. In addition, rice fields were also used for cultivating other food crops, which subsequently reduced rice output.

Table 2.19 Average real farm price of paddy and real FOB. price of milled rice (at 2002 price), 1961-2007

Period	Farm price (paddy)[1/]	FOB. price (5% milled rice)[2/]
	Price (TBH/ton)	
1961-65	6,129	20,135
1966-70	6,164	23,870
1971-75	7,002	24,087
1976-80	7,074	18,402
1981-85	5,314	13,031
1986-90	6,202	10,741
1991-95	5,377	9,559
1996-00	5,941	10,385
2001-07	5,763	9,144
	Average Price	
1961-80	6,592	21,624
1981-07	5,723	10,466
	Growth rate (%)	
1961-80	1.95	1.29
1981-07	1.31	-2.10

Source : [1/] from Office of Agricultural Economics (2008)
[2/] from IMF (2008)

Moreover, the decreasing rice stocks during late 2007 of the two countires with the largest populations, China and India, prompted their governments to take measures to ensure national food security, which included stopping rice exportation (Isvilanonda, 2008). This contributed to the rapid increase in the rice price in the world market during the beginning of 2008. The price of Thai rice exports subsequently increased and so did the farm price. Figure 2.3 supports this statement; it shows that the export price of milled rice (F.O.B) and its wholesale price in Bangkok market, as well as average farm price, were moving in the same direction.

Although during the later period of 2008, the price of a food crop planted for bio-fuel seemed to decrease, the policy to promote energy crops remained in effect, which resulted in farmers having to choose which crop would be most profitable to produce. It was expected that instability of price would continue for a while. It was also predicted that price of food crops would rise to a higher level than their original price in 2007 because of higher production cost.

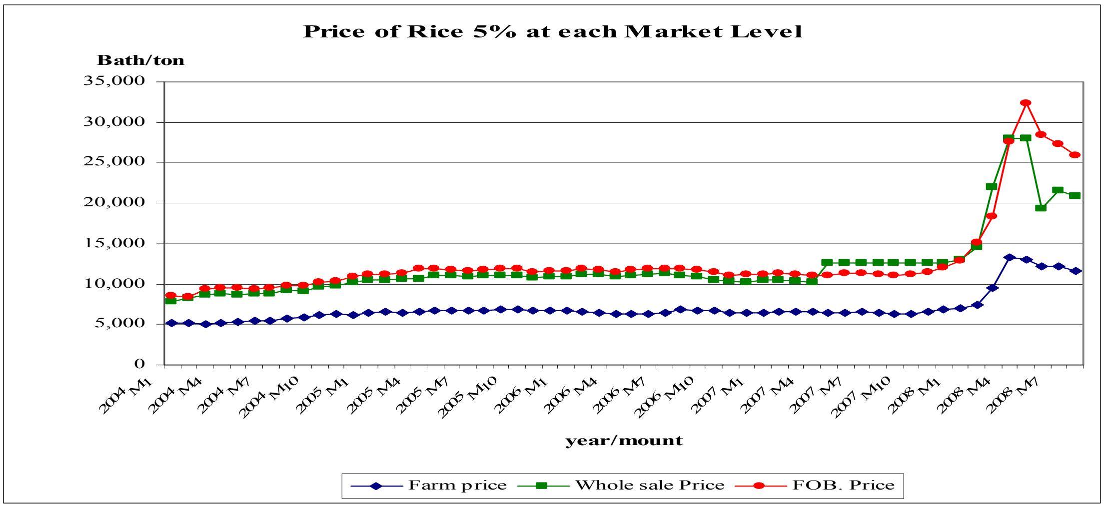

Figure 2.3 Monthly rice price movement, export price for milled rice 5% (F.O.B) and its wholesale price in Bangkok markets as well as farm price of paddy rice during 2004-2007

Source: Office of Agricultural Economics, various issues

The Impact of State Interference in Paddy Rice Markets

The use in 1955 of a price method to improve farm price level of paddy rice is considered as the beginning of state interference. The government initiated the intervention with the establishment of the Public Warehouse Organization (PWO), which was given the responsibility of buying and collecting paddy rice from farmers after the harvesting season. It did not have much success in raising paddy price ex farm so that the government in 1960 decided to set up the Rice Reserve Committee. The committee was put in charge of buying paddy rice from farmers especially in provinces where farmers were complaining that their paddy rice price was too low. Unfortunately, its operation was limited to certain areas due to the small amount of budget provided for this purpose.

A serious attempt to improve paddy price was launched in 1973, in an era when the government began to pay more attention to farmers' complaints. An announcement was made of a guarantee price for paddy of Baht 2,500 per ton and the price of milled rice was set at Baht 7,500 per ton (Siamwalla and Na Ranong, 1990). In 1974, the Farmers' Aid Fund Act[13] was established. In the same year the Market Organization for Farmers (MOF) was established and assigned the responsibility of buying paddy directly from the farmers and milling it. Some milled rice from this program was exported according to a quota set by the Department of Foreign Trade. The greater portion of the milled rice was sold to the Public Warehouse Organization (PWO) which in turn sold it in the domestic market in line with the policy to stabilize the domestic market price of rice (Itharattana, 1999).

During 1976-1980, the government authorized MOF to buy paddy with the aim of supporting its price. The strategy was for the MOF office in each region to buy rice at a price in line with the local market price but that the buying price must not exceed the highest level of guarantee price that the government had set. This highest level of price was standard for the whole country. However, the scheme was not successful; problems arose when the guarantee price was lower than the market price as well as when it was higher than the market price. The former situation made farmers unhappy, the latter caused heavy government losses. Later, facing a problem of fund shortage, the MOF discontinued this operation.

The price support program operations declined during 1979-1981 when demand for rice from the export market increased, which served to increase paddy price. The government took this opportunity to replace the price support program with the Rice Buffer Stock policy. The new policy was operationalized by arranging a loan on subsidized interest rate to a rice mill owner who would then buy paddy from farmers, mill it, and sold the milled rice to PWO. This organization would keep the rice in reserve for sale to the domestic market at a reasonable price (Agribusiness Research Unit, 1996). PWO's operation incurred losses shortly after it was launched because its price was almost always higher than the market price in some areas. The

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[13] An operational fund was from the rice premium fee.

government realized that it could not sustain this policy (Siamwalla and Na Ranong, 1990).

In 1981 the government began setting up a central market for paddy in various major locations where many rice farms operated. The purpose was to encourage farmers to sell their paddy directly to a local rice mill. The following year the government exerted much effort to organize the Paddy Pledging Program.[14] The program, which was another price intervention scheme, was launched in 1984. It is similar to the US loan rate program. It was not originally designed to support price, but to provide short-term liquidity through low interest rate loans to farmers. The loan would allow farmers to delay selling their rice harvest until prices rose later in the season. The farmers pledge their paddy with the BAAC at a price that is 90-95 percent of the target price (which is the predicted market price at harvest time) against the evidence of on-farm storage. Farmers who are not BAAC's client can pledge their paddy with two other government agencies, namely, the Farmers Market Organization and the Public Warehouse Organization (PWO). But they have to bring their paddy for storage in the designated warehouses. The farmers receive the loan for their pledged paddy at the net interest cost of three percent per annum. With the government's five-percent-interest subsidy to BAAC, the total loan rate is eight percent per annum. Farmers are given five to seven months to redeem their pledged paddy, otherwise ownership of the pledged rice goes to the government. The government hires the PWO to stock the paddy until it can sell the rice in the domestic market and/or the world market. The government also bears the costs of storage, handling, milling and any loss from rice sale.

Since 2001, the paddy pledging program had changed format from paddy pledging to paddy price support, which was organized by increasing the target price of pledging to a level that is higher than the market price. At the same time the target quantity for pledging was increased. The result was a large quantity of pledged rice,

[14] The paddy pledging program was a small pilot scheme arranged by the Bank of Agriculture and Agricultural Cooperation in response to political pressure. The bank had to postpone paying back the loan for farmers. It was also for farmers to keep their rice to sell at the best time. Rice was kept stored in tthe warehouses of PWO

which was 1.62 million tons valued at Baht 8,205.03 million during 2000-2001. The volume rose to 8.65 million tons valued at Baht 39,209.06 million during 2004-2005 and although the quantity was down to 5.30 million tons during 2005-2006, its value was Baht 45,157.23 million. All these were a result of a higher pledging price. The downside of a higher pledging price than market price was that few farmers took back their pledged rice. During 2005-2006 the government found itself with 4.39 million tons leftover stock valued at Baht 38,358.92 million (Isvilanonda and Naivikul, 2006)

Impact of the Intervention Measure on the Paddy Market

The intent of the various government market intervention policies and measures described in the previous section was to help farmers earn more and obtain reasonable returns from their work. However, the policies had negative impact on the country's rice market system, which Isvilanonda and Naivikul (2006) had described as follows.

> "Firstly, since the pledged paddy accounted for a large percentage of total paddy production, e.g., one third of the production in 2005/06, the volume of paddy turnover in the central paddy markets declined proportionately. The number and activities of middlemen involved in paddy purchase at harvest time also declined. Meanwhile the government operation, i.e., storage, transport, milling, selling, etc., is not as efficient as that of the private operators.

> "Secondly, there is widespread corruption in the operation of the paddy pledging programs. According to its Board of Directors, the PWO sued more than 200 rice millers breach of contract with the PWO. In addition, there was serious adulteration of the high quality Khaow Dok Mali 105 or KDML rice among 57 rice mills in 2006. The adulteration can seriously affect the price of KDML rice in the world market.

"Finally, the paddy pledging program has seriously affected the volume of rice trading in the Thai Futures Market, according to the Agricultural Futures Trading Commission."

In conclusion, if the paddy pledging program is to continue, the Thai rice market will soon be seriously damaged, resulting in the loss of Thailand's competitiveness in rice export."

Petrol Crisis and Its Impact on Thai Rice Production System

The energy crisis has impacted directly on the country‘s energy security and its economic and social development. The government has invested much effort and funds in the development of alternative sources of energy to reduce dependence on fossil fuel. Thailand's alternative energy development plan, Phase 3 which covers the period 2005-2011 states that *"An operation based on energy development plan is set to use more alternative energy. It is forecasted that by 2011 the usage of alternative energy should be up to 9.2% of the final step of energy utilization or equivalent to the commercial utilization of approximately 7,530 thousand tons of crude oil"*. The government focused on ethanol and bio-diesel. The meeting of three ministers from the Ministry of Energy, the Ministry of Agriculture and Cooperatives and the Ministry of Industry determined the target and strategy of alternative energy development by having a development and production support as well as utilizing bio-diesel from palm oil and ethanol from sugar cane and cassava (Department of Alternative Energy Development and Efficiency, 2007).

The support and incentives given for the production of alternative energy attracted many private enterprises to invest in producing ethanol and bio-diesel. Unfortunately, ethanol factories can produce at present only 43.3% of the total production efficiency whereas bio-diesel output was less than its market demand (Department of Alternative Energy Development and Efficiency, 2007). One major reason could be an insufficient amount of the production factors as they were needed in the food industry as well as production of animal feed. Therefore, bringing sugarcane, cassava and oil palm into producing bio-energy served to raise the demand that further pushed their prices higher.

The rapid increase in the cultivation of energy crops made impacts on the industrial sector and the agricultural production structure. This was because agricultural land was limited. Comparative profitability of the various crops played a major part in the changes in production structure of energy crops, food crops, industrial crops and animal feed crops. It is obvious that the high price of energy crops motivated farmers to allocate increasing areas of their farms for energy crops; the country's energy crop area increased from 18.6 million rai in 2002 to 22.3 million rai in 2007 (Table 2.20). As expected, a decreasing area was planted to other crops.

Table 2.20 Average energy crops area, 2002-2007

Year	Maize	Sugar cane	Soybean	Cassava	Oil Palm	Total energy crops	Total Agri. Land
				Area (Million rai)			
2002	7.32	2.88	0.11	6.22	2.10	18.63	130.89
2003	6.50	2.47	0.10	6.31	2.26	17.65	130.68
2004	6.11	2.33	0.10	6.10	2.38	17.02	130.48
2005	6.63	2.37	0.07	6.52	5.50	21.09	130.28
2006	6.04	2.26	0.07	6.93	5.91	21.21	130.28
2007	5.96	2.26	0.07	7.62	6.40	22.31	130.30

Source: Office of Agricultural Economics (2008)

The result of an average regression equation to look for relationships between petrol price, food crop price and energy crop price through a method of general least square (see Table 2.21 below) confirms the impact of increasing petrol price on energy crops. The higher coefficient of energy crops compared to the coefficient of the food crop (rice) shows that the price of energy crops tends to be higher than the price of food crops. This suggests that if the price of petroleum in the world market continues to rise there will be more opportunity for various energy crops to be used as a raw material to produce ethanol and bio-diesel. If so, demand for and price of energy crops will continue to increase, which no doubt will impact on the competitiveness between energy crops and other crops. This would lead to further changes in the production structure of energy crops, food crops, industrial crops and animal food crops. This suggests the need for research to aid the prediction of future production adjustments. A reliable predictive tool would be useful for policy and programs that enable all concerned sectors to prepare adequately for the possible changes and to adopt measures to mitigate the adverse impacts of such changes.

Table 2.21 Analytical result on the relation between petrol price, food crops price and rubber price

Variables	Rice	Cassava	Maize	Oil Palm	Rubber
Constant	1.575**	1.161**	1.609**	0.885*	0.807**
	(13.01)	*(3.235)*	*(7.036)*	*(1.555)*	*(3.097)*
Petrol	0.213**	0.418*	0.195*	0.555**	0.678**
	(3.515)	*(2.333)*	*(1.705)*	*(1.950)*	*(3.705)*
Adjusted R^2	**0.602**	**0.682**	**0.610**	**0.611**	**0.954**

Note: ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Source: by calculating

The increase in price of fuel oil and energy crops might not have an impact on rice production in the short term. The estimation of the relationship between the price of rice and energy crop (in table 2.22) indicates that an increase in price of the energy crops leads to an increase in rice price. In addition, the increase in price of rice does not cause any significant difference in the profitability of rice farming compared to energy crop production. This is crucial to a policy or measure meant to slow down the conversion of rice lands to energy crop production areas.

The rise in petrol price did not only affect the crop production structure but also the adjustment of various input factors especially the price increase in chemical fertilizer, which in turn raised the cost to rice production to almost 60% of the total rice production cost (Isvilanonda, 2008)[15]. This higher price is not expected to go

[15] The cost of wet rice field production increased from approximately Baht 5,000 per ton in 2003 to Baht 7,000 perton in 2008 and the increase was expected to be more for rainfed rice fields. Farmers will be able to create suitable innovation that can reduce their production cost which further reduces

down to the previous level. In such case, should rice price go down, the farmers will face even more difficulties. On the other hand, the possibility is strong that the rice price is going to increase due to the government rice pledging policy, which as mentioned earlier, sets the price higher than market price. This would send the wrong signal to farmers, giving them the illusion that it is desirable to expand their land for rice cultivation and, consequently, producing an excessive quantity of rice. If the large excess can not be absorbed by the international market, the rice price will surely drop. In such case, government will be forced to intervene, but if the intervention still includes a higher paddy pledging price than market price, the measure would only solve the immediate problem. On the other hand, if the government abolishes this paddy pledging program, the problem of low paddy price will come back. In summary, state intervention in the market inevitably impacts, in the long term, on the efficiency of the entire national rice industry.

Table 2.22 Analytical result on the relation between rice price and energy crop price

Variables	Cassava	Maize	Oil Palm	Rubber
Constant	530.41	-0.014	-7.240	3.859
	(0.004)	*(-0.082)*	*(-0.180)*	*(1.388)*
Rice	1.026**	1.285**	0.629**	0.051**
	(3.178)	*(21.96)*	*(4.297)*	*(2.337)*
Adjusted R^2	0.93	0.96	0.94	0.92

Note: ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Source: by calculating

unnecessary impact from both a lower rice price and an increasing price of production factors. The current situation where the rice price is bound to decrease while the factor production price is bound to increase is when the government should support a research and develop essential knowledge for farmers that they are able to reduce their operational cost. This will be beneficial to national rice industry in the long term and it is better than trying to interfere in the rice market through the paddy pledging policy, which seems to have turned into a policy of guarantee price through offering a pledging price higher than the market price.

Domestic Rice Usage and Exportable Surplus

Annual rice production carried over from the previous year is utilized in three ways (i) domestic consumption (ii) export and (iii) ending stock. During 2001-2007, domestic use of rice was 12.25 million tons per year or 43.78 % of the annual rice production. The uses can be categorized into direct domestic consumption, animal feed, seed, raw material for related industries i.e. flour, glutinous flour, yellow noodle, noodle and alcohol.

Table 2.23 Thailand paddy rice production, export, domestic demand, and carry stock, 1961-2007

Period	Total Supply	Annual Domestic Rice Used					Exports	Excess Supply
		Seed	Feed	Food Manufacture	Food Consumption	Total		
				Quantity (million ton)				
1961-65	**11.27**	*0.56*	*0.41*	*0.30*	*6.27*	7.53	2.43	1.30
1966-70	**12.87**	*0.64*	*0.44*	*0.34*	*7.55*	8.97	1.87	2.04
1971-75	**13.95**	*0.70*	*0.49*	*0.37*	*8.97*	10.54	1.99	1.42
1976-80	**15.92**	*0.80*	*0.57*	*0.44*	*9.74*	11.55	3.71	0.65
1981-85	**18.87**	*0.94*	*0.60*	*0.46*	*10.11*	12.12	5.81	0.95
1986-90	**19.27**	*0.96*	*0.59*	*0.33*	*9.70*	11.58	7.54	0.15
1991-95	**20.38**	*1.02*	*0.59*	*0.30*	*9.00*	10.91	7.89	1.58
1996-00	**23.88**	*1.19*	*0.63*	*0.32*	*9.45*	11.59	9.36	2.93
2001-07	**27.97**	*1.37*	*0.65*	*0.31*	*9.93*	12.25	12.18	3.55
				Share (%)				
1961-65	**100.00**	*7.44*	*5.44*	*3.98*	*83.27*	66.88	21.57	11.55
1966-70	**100.00**	*7.13*	*4.91*	*3.79*	*84.17*	69.64	14.50	15.86
1971-75	**100.00**	*6.64*	*4.65*	*3.51*	*85.10*	75.54	14.29	10.17
1976-80	**100.00**	*6.93*	*4.94*	*3.81*	*84.33*	72.56	23.34	4.10
1981-85	**100.00**	*7.76*	*4.95*	*3.80*	*83.42*	64.20	30.77	5.03
1986-90	**100.00**	*8.29*	*5.09*	*2.85*	*83.77*	60.09	39.13	0.77
1991-95	**100.00**	*9.35*	*5.41*	*2.75*	*82.49*	53.52	38.71	7.77
1996-00	**100.00**	*10.27*	*5.44*	*2.76*	*81.54*	48.54	39.20	12.26
2001-07	**100.00**	*11.18*	*5.31*	*2.53*	*81.06*	43.78	43.53	12.68

Source: FAO. Statistic (2008)

A breakdown of the uses of rice in the domestic market during 2001-2007 gives the following information: more than 81 % of the rice is for direct consumption, 5.31 % for raw material of animal feed, 11.18 % for seed and 2.53 % for related industries (Table 2.23). Direct food consumption is the highest owing to the fact that rice is the major staple food of Thai people. During the last 20 years, per capita rice consumption declined from 119 kg per year in 1990 to 101 kg per year in 2002 (Isvilanonda and Kongrithi, 2007). This is due to the changes in households' consumption patterns. Urban residents and households with higher income, for example, consume more meat, fruits and bread and less rice. Nonetheless, the country's rice consumption has continuously increased mainly from an increasing population. Consumption grew from 7.53 million tons during 1961-1965 to 9.93 million tons during 2001-2007.

Moreover, it was found that during the past four decades, the rice requirement of the country's food manufacturers showed a very small change compared to the rice requirement for animal feed and seed (Table 2.23). Although rice requirement of other activities slighly increased, it has been population increase that drove the increase in domestic rice consumption. Overall, the demand for domestic rice also increased.

The excess of the domestic rice requirement is exported. Over the past four decades paddy rice export has increased from 2.43 million tons during 1961-1965 to 12.18 million tons during 2001-2007 or respectively 21.57% and 43.53% of the annual rice production (Table 2.23).

Thai Rice Export

The green revolution had provided the technological impetus for the steady rise in world rice production. Milled rice output grew from 263.35 million tons during 1979-1980 to 439.77 million tons during 2006-2008, with an average growth rate of 1.90% per year. With an increasing world population, the demand for milled rice increased from 264.40 million tons during 1979-1980 to 427.77 million tons during 2006-2008 or an average growth rate of 1.83% per year (Table 2.24).

During some periods, production was less than the demand but during the last 30 years, production for the most part has been slightly greater than consumption requirement by an average of one million tons per year. However, every year during 2001-2005, world rice production was less than the demand. The result was a lower world stock of milled rice, from 134.36 million tons during 1996-2000 to 79.67 million tons during 2006-2008 (Table 2.24). This led to the rise in world market price of rice especially in 2008 when it went up by almost 90% compared to the same period in 2007. This had a strong impact on rice trade.

Table 2.24 World milled rice production (million t), 1979-2008

	Production	Domestic Consumption	Export	Ending Stocks
		Quantity (million tons)		
1979-80	263.35	264.40	11.95	53.30
1981-85	300.92	291.88	11.44	72.40
1986-90	331.94	326.16	12.46	113.52
1991-95	358.96	360.60	17.28	121.08
1996-00	394.18	388.50	23.72	134.36
2001-05	398.12	412.32	28.28	93.26
2006-08	430.77	427.77	30.43	79.67
		Average annum growth rate (%)		
1979-80	5.10	5.28	-2.59	-0.83
1981-85	3.36	2.59	0.01	13.69
1986-90	2.03	2.32	1.84	5.35
1991-95	0.99	1.30	10.39	-1.33
1996-00	1.62	1.46	6.24	4.40
2001-05	1.01	1.04	3.95	-11.90
2006-08	1.66	1.43	0.22	3.82
1979-08	1.90	1.83	2.07	3.86

Source : USDA. Statistic (2008)

Table 2.25 The rice market share of some exporting countries in world rice market, 1961-2007

Year	China	India	Myanmar	Pakistan	Thailand	Vietnam	World
				Share (%)			
1961-65	11.65	0.03	19.53	1.98	21.27	1.33	100.00
1966-70	16.91	0.16	7.55	1.74	15.86	0.12	100.00
1971-75	21.60	0.32	4.77	7.28	16.38	0.02	100.00
1976-80	9.27	3.33	5.41	9.06	21.06	0.09	100.00
1981-85	6.78	2.40	5.75	9.20	33.13	0.74	100.00
1986-90	5.35	3.83	2.70	8.25	37.63	6.99	100.00
1991-95	4.84	11.37	2.20	8.06	28.06	12.88	100.00
1996-00	10.27	10.87	0.84	8.48	25.44	15.66	100.00
2001-07	4.76	16.10	1.09	8.82	27.44	15.07	100.00

Source: USDA. Statistic (2008)

The volume of rice traded in the world was only about 5% of the global production. The important rice exporting countries are Thailand, Vietnam, China, India and the United States. During the past 20 years, Thailand has been the top exporter. During 1961-1965, the market share of Thai rice exports was 21.27% of the the total world rice trade, increasing to 37.63% during 1986-90 (Table 2.25). After 1990, the country continued to export in larger quantity but its market share decreased; during 2001-2007 the market share declined to 27.44%. Thailand lost its share mainly to India and Vietnam, particularly Vietnam, which increased its share during the past 20 years from 1.33% during 1961-1965 to 15.07% during 2001-2007. India's share rose from 0.03% to 16.07% during the same period (Table 2.25).

Table 2.26 Thai rice export by rice quality, 1971-2007

Years	High quality (100% + 5% + jasmine)	Mediume quality (10% + 15%)	Glutinous (100% + 15%)	Parboiled rice	Low quality	Total
1971-75	0.20	0.19	0.05	0.25	0.61	1.31
1976-80	0.53	0.38	0.07	0.46	0.89	2.34
1981-85	1.25	0.35	0.15	0.71	1.32	3.79
1986-90	1.71	0.51	0.12	0.78	1.56	4.69
1991-95	2.24	0.53	0.17	0.83	1.08	4.85
1996-00	2.65	0.47	0.23	1.16	1.52	6.03
2001-07	3.52	0.75	0.23	1.91	1.52	7.93
Growth (%)	**12.25**	**23.56**	**16.70**	**13.27**	**10.92**	**7.59**
			% share			
1971-75	15.30	14.91	3.97	18.80	47.02	100.00
1976-80	22.59	16.27	3.16	19.73	38.26	100.00
1981-85	33.05	9.19	4.06	18.73	34.97	100.00
1986-90	36.41	10.84	2.65	16.72	33.39	100.00
1991-95	46.11	10.91	3.59	17.18	22.21	100.00
1996-00	44.03	7.74	3.74	19.24	25.26	100.00
2001-07	44.38	9.52	2.88	24.10	19.13	100.00

Source: Board of Trade of Thailand (2008)

Thailand is the only country that exports the various types of rice, which include the high quality or premium rice, medium quality rice, low quality rice, glutinous rice, and parboiled rice. During the past 30 years, Thailand's rice export industry continuously developed on both quantity and quality. During 1971-1975 47.02% of the total export of milled rice was of low quality and only 15.30% was of high quality. However, during 2001-2007, the proportion of low quality rice was down to 19.13% while that of high quality rice rose to 44.38%, followed by parboiled rice with 24.10%. During the same period, export of medium quality rice registered the highest growth rate at 23.56% per year followed, respectively, by glutinous rice, parboiled rice and high quality rice at 16.70%, 13.27% and 12.25% per year (Table 2.26).

The major markets for Thai rice are countries in Africa continent, Asia, the Middle East, the American continent, Europe and Oceania (Table 2.27).

Africa Market

This is an important market for low quality Thai rice. The annual requirement is quite high but the fact that most African countries are rather poor and having difficulties with foreign currency makes theur governments prefer to buy rice with either low price or at a long term credit. The important buyers of this market are South Africa, Senegal, Benin, Madagascar, Cameroon, and Cote d΄lvoire. Thailand's export to Africa was about 2.56 million ton of milled rice or 38.77% of the annual country rice export in 2000 and increased to 4.64 million ton or 46.35% of annual country rice export in 2008 Table 2.27).

Asia Market (except the Middle East)

The important buyers of this region are Hong Kong, Singapore, Malaysia, Brunei, Indonesia, China, The Philippines and Bangladesh. This market imports Thai rice amounting to 2.47 million tons of milled rice or 24.71% of the country's rice export in 2008

The Middle East Market

This is an important market for Thai high quality rice. There was an ongoing expansion of Thai rice export to this market. However, during the past ten years, export volume had slightly slowed down, probably because of the regional political problems. Consumers in this region are wealthy and pay more attention to quality than price. The average rice export to this region is 1.31 million tons per year or 16.04% of yearly rice export. The important buyers are Iran, United Arab Emirates (Dubai), and Saudi Arabia.

American Continent Market

The countries in this region import only a small quantity of Thai rice. The average rice export to this region is 0.48 million ton per year or 5.83% of Thailand's rice export. The important countries in the Americas that are purchasing Thai rice are the United States, Canada, Cuba, Brazil and Mexico.

Table 2.27 Thai milled rice export by destination, 2000-08

Years	Asia	Middle Asia	Europe	Africa	America	Oceania	Total
			Quantity (million)				
2000	1.95	1.39	0.33	2.56	0.30	0.08	6.60
2001	2.04	1.08	0.41	3.56	0.38	0.08	7.55
2002	2.36	1.22	0.34	2.86	0.37	0.08	7.25
2003	2.68	1.17	0.34	2.62	0.70	0.09	7.60
2004	2.58	1.61	0.44	4.76	0.61	0.13	10.14
2005	2.06	0.91	0.33	3.45	0.41	0.14	7.30
2006	2.07	1.58	0.40	2.74	0.48	0.15	7.42
2007	2.89	1.47	0.65	3.92	0.48	0.16	9.56
2008	2.47	1.35	0.79	4.64	0.55	0.20	10.01
Average	**2.34**	**1.31**	**0.45**	**3.46**	**0.48**	**0.12**	**8.16**
			Share (%)				
2000	29.54	21.06	4.93	38.77	4.53	1.16	100.00
2001	26.98	14.32	5.44	47.16	5.08	1.02	100.00
2002	32.64	16.85	4.75	39.52	5.15	1.10	100.00
2003	35.29	15.37	4.51	34.43	9.21	1.20	100.00
2004	25.49	15.89	4.35	46.91	6.05	1.31	100.00
2005	28.17	12.41	4.55	47.24	5.67	1.96	100.00
2006	27.89	21.26	5.45	36.87	6.51	2.02	100.00
2007	30.25	15.33	6.77	41.04	4.99	1.63	100.00
2008	24.71	13.53	7.91	46.35	5.52	1.98	100.00
Average	**28.73**	**16.04**	**5.49**	**42.37**	**5.83**	**1.51**	**100.00**

Source: Board of Trade of Thailand, 2008

European Market

Europe is a market for good quality rice, although it imports only a small quantity from Thailand. The reason is most Europeans prefer long grain rice, especially the US rice. The average yearly export to this region is 0.45 million tons or

5.49% of the country's total rice export. The important buyers in this market are Russia and other Eastern European countries.

Oceania Market

The major importing countries of this group are Australia, New Zealand, Papua New Guinea and Fiji. Countries of this group actually buy only a small quantity of Thai rice. This is because Australia also produces and exports white rice. Imports from Thailand of this region was only 0.12 million ton per year or 1.51% of the country's annual rice export.

CHAPTER III

THE RICE SUPPLY ANALYSIS

In the previous chapter, the importance of rice in the Thai economy and the country's resources used in rice production were outlined, this chapter, a relation between rice production as well as price and non-price factors, including public research investment on rice will be quantified.

Theoretical Concepts

The study of supply response can be carried out in two ways: direct or one-step analysis and indirect or two-step analysis. Direct analysis can be done by using total rice production as a proxy of planned production. The indirect analysis involves two steps which consist of the analysis of area equation and yield equation (Behrman, 1968; Sadoulet and Janvry, 1995). This concept is based on the fact that farmers have two procedures in their decision making. First, they have to make a decision for an allocation of the cultivating areas. If farmers would like to increase their production, they need to allocate more areas. After they allocate the planting areas, the second step is to increase their production through yield improvement (Behrman, 1968).

Previous study of Thai rice supply responses were found in Behrman (1968), Prakongtanapan (1976), Triratvorakul (1984), and Isvilanonda and Poapongsakorn (1993). However, those studies reported the plus sign of price elasticity that varied from 0.101 to 0.360 in a short term and 0.310 to 0.814 in a long term. Tanapornpan (1986) suggested that the variation of price elasticities of rice supply may create from these reasons:

1) By using the differences of econometric models and econometric methods in the analysis, it could be seen that the models used in these studies consisted of different equations. In additions, the determination of variables time lag was varied according to each equation, creating different values of estimated coefficient.

2) The influencing of different time periods in the study showed that the results of each research using different period of data for analyze was different. The difference became more important when farmers' response behaviors to price and non price factors changed according to time, as shown in Prakongtanapan (1976).

The reason behind an assumption of rice supply responding differently depending on a period of studying is the fact that, as time goes by, important factors influencing farmers' decision i.e. factors of economic condition, society condition, and environment condition, can affect their production behaviors. This results in different sizes of the response on rice production supply within each period of the study. Considering solely on a study of Thai rice production supply, it reveals that after 1990 there has been non availability of the study on this topic although during 1990-2007 many situations on economic, society and natural factors have changed dramatically, especially currently when there is a maximum requirement on energy crops. There are lots of concerns that the change will impact the country rice production as well as the future country food security. Subsequently, the national rice policy makers turn their attention to the problem. However, since the existing information on factors affecting the country rice production supply is not update, it becomes essential to update this information. Therefore, this chapter will contain a study on a response of rice production supply toward an economic factor along with a certain environment factor during 1990-2007 for the benefit of those policy makers.

In the analysis, the rice supply response is estimated by following the two steps supply response, which is an indirect analysis.

Indirect Analysis

The indirect analysis is based on the fact that how much rice production changes depend on planted area and yield. Farmers choose to allocate their area by, first, observing price and non-price factors including the production environment. After that, they select necessary factors to improve their yield per unit area.

To formulate the theoretical model, farmers' decision-making behaviors are simply proposed in order to maximize their profits in crop production, subject to the production technology which can be shown as equation (3.1)

$$h(Q,X,Z) \qquad (3.1)$$

where Q is the vector of output quantities

X is the vector of variable input quantities and

Z is a vector of quasi fixed factor quantities

Variable inputs involved in this estimation model comprise of labor, fertilizer, water, pesticides, seeds, hours of rental utilized machine, and other inputs which can be purchased in the desired quantities. Quasi-fixed factors, the factors that cannot be changed within a short term are considered a short term fixed factor**.** However, they may be changed in a long term such as public factors (infrastructure and extension services), exogenous factor (such as weather and distance to market) (Sadoulet and Janvry, 1995).

If P and W are the price of outputs and inputs, the farmers' decision-making behavior will maximize profits by choosing the combination of variable inputs and outputs to provide the maximize profit, subject to the technology constraint:

$$\underset{X,Q}{\text{Max}}(PQ - WX), \quad \text{s.t.} \quad h(Q,X,Z) = 0 \qquad (3.2)$$

The solution to this maximization problem is a set of output supply function:

$$Q = f(P, W, Z) \qquad (3.3)$$

Equation (3.3) shows that the output supply (Q) is a function of its own price (P), price of variable inputs (W), and fixed factor (Z).

The production of an agricultural crop is generated by the area harvested and the average yield per unit area. Thus, rice production can be expressed as:

$$Q = A * Y \tag{3.4}$$

where Q is the total output, A is the area harvested, and Y is the yield per unit area.

A yield per unit area function (3.5) can be derived from (3.3) and (3.4)

$$Y = \frac{Q}{A} = y(P, W, Z, A) \tag{3.5}$$

The relation between Y and A is expected since increasing in rice area involves bringing marginal land into production. A decrease in rice area will lead to a higher average yield because marginal land is moved out of rice production (Evans and Bell, 1978).

Following Evans, S. and T.M. Bell (1978), supply elasticities can be estimated by using a system of two behavioral equations (equations (3.6) and (3.7)) and an identity (3.8):

$$A = a(P, W, Z) \tag{3.6}$$

$$Y = y(P, W, Z, A) \tag{3.7}$$

$$Q = A * Y \tag{3.8}$$

The total differentials of equations (3.6), (3.7), and (3.8) (ignoring the Z's, for simplicity) obtain equations (3.9), and (3.10), and (3.11), respectively.

$$dA = a_P dP \tag{3.9}$$

$$dY = y_P dP + y_A dA \tag{3.10}$$

and

$$dQ = Y * dA + A * dY \tag{3.11}$$

Using Cramer's rule, the relation between dQ and dP can be written as equation (3.12).

$$\frac{dQ}{dP} = A * y_P + A * y_A * a_p + Y * a_P \qquad (3.12)$$

Multiplying equation (3.12) by P/Q, the owned price elasticity of the supply can be derived as equation (3.13).

$$\begin{aligned} E_{Q/P} &= E_{Y/P} + E_{Y/A} * E_{A/P} + E_{A/P} \\ &= E_{Y/P} + E_{A/P}(1 + E_{Y/A}) \end{aligned} \qquad (3.13)$$

where $E_{Q/P}$, $E_{Y/P}$ and $E_{A/P}$ are respectively the elasticity of production, yield and acreage with respect to that output price. $E_{Y/A}$ is the elasticity of yield with respect to acreage.

From equation (3.13), the owned price elasticity of the supply depends on the elasticity of yield and planting areas with respect to price including the effecting of marginal land on productivity. Obviously, $E_{Y/P}$ and $E_{A/P}$ are positive and $E_{Y/A}$ is Negative. If $E_{Y/P}$ equals 0, $E_{Q/P}$ will always be less than $E_{A/P}$. If $E_{Y/P}$ exceeds 0, $E_{Q/P}$ may be greater or lesser than $E_{A/P}$

This procedure (equation (3.13)) can be used to calculate the elasticity of rice supply with respect to other independent variables.

The implication is that policy makers, to achieve desired production increasing or decreasing, must be aware of the related responses contained in expression (3.13).

Estimation Model

For empirical estimation for rice supply, the estimation model used in this study is formulated in the form of a system crop analysis for area response equations. In this system, wet season and dry season rice crops are separated into different commodities. After the estimation of area responses, the equation of yield response is estimated based only on the rice production.

Rice and Other Crops Areas Response Equation

An economic theory states that farmers base their planting decisions on an expected price of their output, an expected price of competitive crops, cost of inputs, their own production capacity and risks involved.

The partial adjustment hypothesis provides a logical basis for the inclusion of lagged planted area as an explanatory force which captures the influence of a number of fixed production factors. Such factors include specialized equipment for a particular crop, technical expertise and other facilities. The sum effect of such forces may induce farmers to plant a level of an area that is related to the area being planted in the previous year. The analysis of an area response equation was carried out by using provincial cross section-time series data of 22 crops during 1990-2007. The 22 crops were divided into seven groups consisting of wet season rice crop, dry season rice crop, energy crop (maize, sugar cane and cassava), oil palm crop, rubber tree, other crops and tree crop.

According to equation (3.6), because of the total crop production area is limited changes in related commodity prices would affect the allocation of cultivating areas. Here, the system crop analysis for an area response equation is introduced. This technique was applied by TDRI (1988) in estimation of crop supply in Thailand. Isvilanonda and Paopongsakorn (1994) also used this technique for estimation of rice area response.

It is summarized that, the response of each crop area share can be written in the functional form as equation (3.14).

$$s_{jt} = f(P, W, Z), \qquad j = 1 - n \qquad (3.14)$$

In formulating the behavioral equation of the area share (which represents a planted area), the partial adjustment model is employed. It is hypothesized that the planned area crop share (s*) is dependent on the set of related output prices as well as related input prices, and other supply shifters, particularly public investment in irrigation, research and extension. That is:

$$s^*_{jt} = a_j + \sum_i \beta_{ij} \ln P_{it} + \sum_k \gamma_{kj} \ln W_{kt} + \sum_m \omega_{mj} \ln Z_{mt} + u_{jt}, \qquad i, j = 1 - n \quad (3.15)$$

where

s^*_{jt} is the planned area crop share in year *t*

P_{it} is the output price variables (rice price and competition crop price)

W_{kt} is the input price variables (fertilizer price, wage rate and quantity of power tiller per household)

Z_{mt} is the quasi-fixed factors (public investment in irrigation, research budget and rainfall quantity)

$\beta_{ij}, \gamma_{kj}, \omega_{mj}$ are the coefficient of independent variables

u_{jt} is the error term

It is further assumed that the process of area adjustment is taken as equation (3.16)

$$s_{jt} - s_{jt-1} = \phi(s^*_{jt} - s_{jt-1}) \text{ and } 0 < \phi < 1 \qquad (3.16)$$

where j = 1-7 and t = year.

Intuitively, the equation (3.16) explains that farmers are able to change a share of the crop (s_{jt}) in any year only in a fraction of ϕ of the difference between the planned area share and the actual planted area share in the preceding year. By solving the equation (3.15) and (3.16) we obtained the dynamic supply model, it can be written as equation (3.17).

$$S_{jt} = \alpha_j + \sum_{i=1}^{6} \beta_{ij} \ln P_{t-1} + \sum_{k=1}^{3} \gamma_{kj} \ln W_{kt} + \sum_{m=1}^{3} \omega_{mj} \ln Z_{mt} + \delta_j S_{jt-1} + \eta_{jt} \qquad (3.17)$$

where

j = an index of rice crop and other competing crops area share equations in the system equations (j = 1 for wet season rice crop, 2 for dry season rice crop, 3 for energy crop, 4 for other crops, 5 for tree crop, 6 for oil palm, and 7 for rubber tree).

i = an index of rice crop price and other competing crops price (i = 1 for wet season rice crop price, 2. for dry season rice crop price, 3 for energy crop price, 4 for other crops price, 5 for tree crop price, 6 for oil palm fresh fruit price, and 7 for rubber price).

k = an index of variable input prices such as price of fertilizer, labor and number of power tillers (k = 1 for fertilizer price, 2 for wage rate, and 3 for quantity of farm machineries).

m = an index of fixed inputs such as an irrigated area, rainfall quantity and an rice research budget (m = 1 for irrigated area, 2 for rainfall, and 3 for rice research budget).

$\alpha, \beta, \gamma, \omega, \delta$, are parameters in the model

η_{jt} = error term

To get the estimated coefficient of the rice area share equation response, systems of area share equations are jointly estimated by using the seemingly unrelated regression technique. Restrictions on some coefficients are needed to maintain the property of output supply as equation (3.18).

$$\begin{aligned} \sum \alpha_j &= 1 \\ \sum \beta_{ij} + \sum \gamma_{kj} &= 0, \text{ both i and k} \\ \sum \omega_{mj} &= 0 \\ \sum \beta_{ij} &= \sum \beta_{ji} \text{ all i and j} \end{aligned} \tag{3.18}$$

The first three restrictions are to ensure that the shares (S_j) always sum up to one. The last restriction is a symmetry requirement.

From equation (3.17) we can calculate the elasticity of rice area by dividing the coefficient value with mean of rice share area, a calculation of the price elasticities of rice area as equation (3.19) is an example.

$$E_{A/P} = \frac{\beta_j}{S_{rice}} \tag{3.19}$$

The elasticities of rice area with respect to other independent variables can be calculated in the same procedure.

Rice Yield Response Equation

To estimate the elasticity of rice supply response, the rice yield equation is estimated. A number of factors may be hypothesized to affect rice yields. The principal ones among them are: 1) economic factors, such as the output price which farmers expect to receive and the cost of inputs that farmers pay, 2) technological factors, such as the production technology for farmers, and 3) physical factors, such as weather condition, amount of rainfall, and soil quality. The logical basis for inclusion of lagged yield variable can be assumed as factors which include the variety of seed used, soil fertility and others.

The specification of this model is given by equation (3.20).

$$\log Y_t = \alpha_0 + \alpha_1 \log P_{t-1} + \alpha_2 \log A_t + \alpha_3 \log F_t + \\ + \alpha_5 \log I_t + \alpha_6 \log R_t + \alpha_7 \log RES_t \quad (3.20)$$

where

P_{t-1} = a one year lag of paddy price;

A_t = planted area on season *t*,

F_t = fertilizer price during planting season *t*;

I_t =share of irrigated area to total rice area in year *t*;

R_t = the variance of rainwater quantity

RES_t = the current state of technical knowledge

The determination of research budget variable will be considered according to the principles proposed by Pochanukul (1992; cited in Oungsawat, 1995). Pochanukul utilized a direct search method for the measure of technical knowledge (RES). Ultimately, it is determined by the government expenditure on rice research in real term. Let RES_t be the variable of the current state of technical knowledge the formula can be expressed as follows:

$$RES_t = 0.2RES_{t-1} + 0.4RES_{t-2} + 0.6RES_{t-3} + 0.8RES_{t-4} + 1.0RES_{t-5} + 0.9RES_{t-6} \\ + 0.8RES_{t-7} + 0.7RES_{t-8} + ... + 0.1RES_{t-14} \quad (3.21)$$

Estimated Results

The results of this study will be divided into three parts: (1) the result of rice area response, (2) the result of rice yield response, (3) the result of output elasticity of total rice supply. The explanation of the response in each part will be formulated into a short-term and a long-term.

Estimated Results of Rice Area Response Equation

The analysis of rice area response equation was jointly estimated with other crop area response equation by using provincial cross section-time series data of 22 crops during 1990-2007. The 22 crops were divided into seven groups consisting of wet season rice crop, dry season rice crop, energy crop (combining with maize, sugar cane and cassava), tree crop, oil palm crop, rubber tree, and other crops. The Divisia price index is used to generate the provincial crop price index, taking into account the provincial crop mixture. The crop price index is weighted by the consumer price index at 2002 price to reflect a related crop value.

In seven equations of the crop system, dependent variables include a share of wet season rice area (SHRW), a share of dry season rice area (SHRD), a share of energy crop area (SHENG), a share of tree crop area (SHTRE), a share of oil palm area (SHPO), a share of rubber tree area (SHRUB), and a share of other crops area (SHOTH). Each of these seven equations has the same independent variables which include a lag of wet season rice price index (PRW_{t-1}), a lag of dry season rice price index (PRD_{t-1}), a lag of energy crop Divisia price index (PE_{t-1}), a lag of palm fresh fruit Divisia price index (PPO_{t-1}), a lag of rubber Divisia price index ($PRUB_{t-1}$), a lag of tree crop Divisia price index ($PTRE_{t-1}$), and a lag of other crops Divisia price index (PC_{t-1}). The variables used as a representative of input price consist of the average price of chemical fertilizer (PF_t), a minimum provincial wage rate (W_t), and the quantity of power tillers per household (POW_t). In terms of quasi fixed factors such as weather and public policies, variance of provincial rainfall quantity ($RAIN_t$) is used to represent weather condition. The ratio of an irrigated area to the total rice area (IRR_t) and a rice research budget (RES_t) are used to represent the public policies, and the last variable is a share of rice cultivated areas in the previous year (S_{t-1}).

By using the Seemingly Unrelated technique (SUR) to estimate the crop system equations, the results of rice area share equation are shown in Table 3.1. The results show that the rice price variable has significant positive signs in the total rice area equation, the wet season rice area equation, and the dry season rice area equation. This implies that if the rice price increases, rice cultivated areas both in wet and dry season will increase. On the other hand, the energy crop price has a significant negative sign in total rice and wet season rice equations. It implies that the energy crop price has negative impact on rice cultivated areas only in wet season. The coefficient of oil palm fresh fruit price variable has a significant negative sign for the dry season rice cultivated areas only.

Table 3.1 Estimated results of rice area share equations

	SUR		
	Wet Season	**Dry Season**	**Total**
Constant	-4.160	-0.271	-2.731
	*(-4.421)****	*(-1.048)*	*(-3.514)****
$LnPRT_{t-1}$	-	-	0.093
	-	-	*(-1.619)**
$LnPRW_{t-1}$	0.016	0.017	-
	*(1.903)**	*(2.577)***	-
$LnPRD_{t-1}$	0.005	0.011	-
	(0.129)	*(1.622)**	
$LnPOTH_{t-1}$	-0.131	-0.026	-0.143
	(-0.349)	*(-2.557)***	*(-1.409)*
$LnPTRE_{t-1}$	-0.003	-0.0001	-0.004
	(-0.452)	*(-0.128)*	*(-0.545)*
$LnPE_{t-1}$	-0.093	-0.026	-0.052
	*(-3.386)****	*(-1.240)*	*(-1.939)**
$LnPPO_{t-1}$	-0.034	-0.025	-0.001
	(-0.934)	*(-2.502)***	*(-0.027)*
$LnPRUB_{t-1}$	-0.035	-0.028	-0.037
	(-0.543)	*(-1.586)*	*(-0.617)*
$LnPF_t$	-0.049	-0.019	-0.092
	(-1.628)	*(-1.619)**	*(-1.751)**
LnW_t	-0.060	-0.054	-0.138
	(-0.294)	(-1.332)	(-1.384)
$LnPOW_t$	0.078	0.006	0.067
	(22.01)***	(6.119)***	(19.345)***
$LnIRR_t$	0.085	0.002	0.077
	*(7.588)****	*(1.695)**	*(8.218)****
$LnRES_{t-n}$	0.041	0.017	0.085
	*(3.607)****	*(0.420)*	*(2.127)***
$LnRAIN_t$	-0.049	-0.007	-0.066
	*(-2.219)***	*(-1.178)*	*(-3.029)****
S_{t-1}	0.341	0.103	0.262
	*(36.82)****	*(85.15)****	*(41.83)****
Sample	**1,190**	**1,190**	**1,190**
R^2	**0.78**	**0.92**	**0.82**
Chi-square	**1,455**	**1,430**	**1,445**

Note: * is significant at 90 %

** is significant at 95 %

*** is significant at 99 %

(…) is t-value

Source: calculated from OAE. Data

The result from the analysis of the relation between input price and rice area shows that the chemical fertilizer price has a negative impact on the rice area change. The coefficients of the fertilizer price variables calculated from the three equations of a rice share area are significant. The wage rate variable has a negative but statistically insignificant impact on rice cultivated areas in all equations. The coefficient of the quantity of power tillers per household variable, used to represent the number of farm machineries, has significant positive impact on rice share area in three equations (total rice, wet season rice, and dry season rice share area equation).

Table 3.2 Estimated results of yield response equations

Variables	**WLS**		
	Wet Season	**Dry Season**	**Total**
Constant	1.853	2.046	1.888
	*(8.375)****	*(7.623)****	*(17.601)****
LNPR	0.111	0.284	0.090
	*(1.854)**	*(5.073***)*	*(1.742)**
LNFER	-0.202	-0.036	-0.106
	*(-2.783)***	*(-0.280)*	*(-1.762)**
LNIRR	0.119	0.042	0.043
	*(7.419)****	*(2.496)***	*(3.056)****
LNRAIN	0.003	-0.032	-0.017
	(0.245)	*(-1.391)*	*(-1.765)**
LNRES	0.183	0.181	0.121
	*(8.572)****	*(2.522)***	*(7.849)****
LNWAGE	-0.097	-	-
	*(-1.615)**	-	-
LNPOW	-	0.055	-
	-	*(2.986)***	-
LNA	-0.013	-0.084	-0.022
	(-0.941)	*(-3.456)****	*(-1.850)**
DUM_C	0.075	0.204	0.094
	*(2.156**)*	*(2.910)***	*(3.155)****
DUM_N	0.082	0.164	0.082
	*(2.324)***	*(2.305)***	*(2.690)***
DUM_NE	0.004	0.030	-0.036
	(0.103)	*(0.402)*	*(-1.191)*
Sample	**1,190**	**1,079**	**1,190**
R^2	**0.99**	**0.98**	**0.99**
F test	**224.54**	**63.34**	**376.83**

Source: calculated from OAE. Data

The weather condition which is represented by a variance of rainfall quantity has significant negative coefficient in the total rice area and the wet season rice area equations. This indicates that the more the rainfall quantity deviating from the mean, the greater the decreasing in `rice cultivated areas. The coefficient of irrigated areas and a research budget variable in the total equation of rice cultivated area share and the equation of wet season rice area share has significant positive impact on changes in rice cultivated areas.

Estimated Results of Rice Yield Response Equation

The assumption of rice yield response equation is that rice yield depends on a rice price, an irrigated area, a research budget, a cultivated area, a climatic condition and an input price and the equation is determined in the form of logarithm (equation 3.20). The weighted least squares method was used for the analysis which reveals that rice price has a significant positive impact on rice yield changes in all rice yield response equations. On the other hand, a rice cultivated area has significant negative impact on a rice yield.

In terms of variance of the rainfall variable, only the two crops combine yield equation reveals significant coefficient value and it has negative impact on rice yield. The coefficient of the research budget variable has significant positive impact on a rice yield most in the wet season, the dry season and the two crops combine yield equation (table 3.2).

Estimated Result of Rice Supply Elasticity

The output elasticity of supply rice was calculated by using equation (3.13). The results are shown in Table 3.3. The owned price elasticity in the short-term is 0.147 0.371 and 0.259 in the wet season, the dry season and the total rice productions, respectively. The elasticity in the long-term is 0.165 0.382, and 0.319, respectively. When comparing rice production response to rice price of wet and dry seasons, it is found that both in the short-term and long-term, rice supply responds more to its price in the dry season than in the wet season.

The analysis of input price elasticity of rice supply reveals that the response of rice supply to the price of chemical fertilizer is in the opposite direction. The short-term rice supply elasticity with respect to chemical fertilizer price is respectively -0.317, -0.154 and -0.274 for the wet season, the dry season and the two crops combining and -0.376, -0.171 and -0.334 in a long-term. This indicates that the increasing in the price of chemical fertilizer results in the declining of rice production both in a short-term and a long-term. The analysis of rice supply response to the change of power tillers quantity per household shows that the rice production will increase if the quantity of power tillers per household increases. The more the wage rate increases, the more the farmers substitute man with farm machineries. This results in greater efficient farming leads to an increasing in rice production.

Table 3.3 The short-run and long-run output elasticities of rice supply

Elasticities	**Short-run**				**Long-run**			
	Wet season	**Dry season**	**Two crops combine**		**Wet season**	**Dry season**	**Two crops combine**	
			(1)	**(2)**			**(1)**	**(2)**
Rice price	0.147	0.371	0.199	**0.259**	0.165	0.382	0.215	**0.319**
Other crops price	Ns	-0.207	-0.048	**Ns**	Ns	-0.231	-0.053	**Ns**
Energy crop price	-0.214	Ns	-0.165	**-0.097**	-0.325	Ns	-0.250	**-0.131**
Fresh palm fruit price	Ns	-0.197	-0.045	**Ns**	Ns	-0.219	-0.050	**Ns**
Irrigated area	0.317	0.058	0.257	**0.182**	0.419	0.060	0.336	**0.232**
Rain STD.	-0.114	Ns	-0.088	**-0.138**	-0.173	Ns	-0.133	**-0.181**
Research budget	0.277	-0.181	0.216	**0.276**	0.326	0.181	0.293	**0.331**
Fertilizer price	-0.317	-0.154	-0.280	**-0.274**	-0.376	-0.171	-0.329	**-0.334**
Agricultural wage rate	-0.097	Ns	-0.075	**Ns**	-0.097	Ns	-0.075	**Ns**
Quantity of power tiller	0.181	0.107	0.164	**0.122**	0.276	0.113	0.239	**0.165**

Note: See the estimation of rice production elasticities in Table A 8

Ns is non-significant parameters

(1) is the weighted elasticities (the weights used are 0.77 for wet season and 0.23 for dry season)

(2) is the elasticities calculated from the coefficients of total rice area and yield equations in Tables 3.1.and 3.2

Source: calculated from data in Tables 3.1 and 3.2

It is found in a factor of a government investment that the investment in a development of an irrigation system together with a research and technology affects the response to rice supply in a positive direction as the rice supply elasticity with respect to proportion of irrigated areas in a long term for wet season, dry season and the total productions of both crops is 0.419, 0.060, and 0.232 respectively. Meanwhile, the rice supply elasticity with respect to the investment of a rice research in a long term for wet season, dry season and the total of both crops is respectively 0.326, 0.181 and 0.331.

The response of rice production to the change in energy crop price, tree crop price, oil palm fresh fruit price, rubber and other crops prices were calculated to obtain the coefficient of the variables ($LnPE_{t-1}$), ($LnPTRE_{t-1}$), ($LnPPO_{t-1}$) and ($LnPRUB_{t-1}$). However, these competitive crop variables are not available in the equation of rice yield response, it is hypothesized that farmers respond to competitive crop price only in a process of selecting areas for rice cultivation. Once the cultivation has been carried out, the change in competitive crop price will have no effect on the maintenance of rice production in the field. Only the rice price will cause a response from farmers in this step.

An analytical outcome of rice supply elasticity with respect to energy crop price indicates that rice production supply negatively responds to energy crop price as in a short term its elasticity is -0.097 for the two crops combine rice supply, -0.214 for wet season rice supply and in a long term it increases to -0.131 and -0.235. On the contrary, there is no response to energy crop price for dry season rice supply as all energy crops showing in the equations are those that grow in the rainfed areas where there is not suitable for dry season rice farming. So, when the price of energy crops rises, farmers will use their wet season farmlands to cultivate energy crops in order to gain a profit margin, yet, it has impact to neither dry season farmlands nor its productions.

Rice supply elasticity with respect to oil palm fresh fruit price reveals that the price has a negative impact to the dry season rice supply as the elasticity in a short term is -0.197 and -0.219 in a long term. On the other hand, rice supply of wet season farming shows no response to oil palm fresh fruit price. Nevertheless, an impact of oil palm fresh fruit price toward dry season rice supply is insufficient to change the total rice supply as neither the two crops combining rice supply nor wet season rice supply responds to the price of oil palm fresh fruit.

Comparison of Rice Supply Elasticities in 1970-1990 and 1990-2007

During the last 4 decades, Thai rice production sector had continuously changed mainly through a driven force of the green revolution technology during late 1960s to early 1970s decade. Rice farming productions had changed from a traditional production to a commercial production. Such alteration made farmers depend more on input factors outside their farms. Subsequently, the country rice production supply responded more to changes of various factors i.e. price and non-price. In order to confirm this perspective, conceivable information is presented to compare and show the differences of a responding size of rice production supply to a change on economic factor during the first 20 years of the green revolution (1970-1990) and the last 17 years (1990-2007).

The comparison of rice supply elasticity with respect to an economic factor and a certain environment condition during 1970-1990 and 1990-2007 as showing in table 3.4 reveals that a size of the response of rice production supply to rice price, energy crop price, chemical fertilizer price, irrigated areas, rice research budgets, variance of rainfall and the number of power tiller per household during 1970-1990 is lower. A factor of labor wages also shows less response as during 1970-1990 rice production supply elasticity with respect to labor wage in a long term is -0.124 while it is 0.000 during 1990-2007. This can be affected from the increase of an agricultural wage rate since 1980. Farmers were unable to adjust their production technologies at the beginning causing the increasing in the labor wage that reduced the rice production supply. However, they later replaced human labor with farm machineries that during late 1990 the labor growing rate had no impact to the rice production supply, instead, it responded to the number of farm machineries. This can be seen from the response of rice production supply with respect to the number of power tillers during 1990-2007.

The reason that makes rice production supply responds higher to rice price and other competitive crop price during 1990-2007 can possibly be from many causes i.e. the modern rice varieties adoption that gives higher yield, the rapid increasing of energy crop price and farmers' adoption of new technology enabling them to have quick adjustment, etc. All in all, it can be concluded that the response of rice production supply to a rice price factor keeps on increasing which shows that rice production of Thai farmers change from a consuming purpose to a commercial one and a system of decision making contains more of an economic reason.

Table 3.4 Compare the two periods of rice supply elasticities

Variable	1970-1990		1990-2007	
	Short-run	**Long-run**	**Short-run**	**Long-run**
Rice price	0.018	0.057	0.259	0.319
Energy crop price	-0.015	-0.025	-0.097	-0.131
Fertilizer price	0.000	0.000	-0.274	-0.334
Irrigated area	0.032	0.015	0.182	0.232
Rain	0.013	0.013	-0.138	-0.181
Rice research investment	0.164	0.273	0.276	0.331
Wage	-0.109	-0.124	Ns	Ns
No. of power tiller	0.013	0.013	0.122	0.165

Source: calculated from OAE. Data

A higher response of rice production supply to chemical fertilizer price may cause from the fact that, during a later period, the modern rice varieties adoption. These modern varieties require more fertilizer than those of the local rice varieties, making chemical fertilizer an important factor in rice farming. The rising in chemical fertilizer price therefore impacts the declining of rice production supply during 1990-2007. This is the same as an irrigated area and a rice research budget.

The variance of rainwater quantity variable shows a positive coefficient at the beginning period but later changes to a negative one which is not quite easy to explain the background reason. One possible reason is, during 1970-1990, most farmers were cultivating mainly the local rice varieties as this rice was strong enough to resist the dryness and flood. Luckily an instable climate condition was lesser than nowadays that a loss of rice production causing from the instability of climate was also less. In the later period (1990-2007) the local varieties were replaced by modern rice varieties and they are less resistance to dryness or flood. Meanwhile the climate conditions were more instable that the chance of rice production destruction from such instability was also high. All these cause a negative response of rice production supply.

Analysis on the Glutinous Rice Supply Response

Information obtaining from the Office of Agricultural Economics (2008) indicates that during the past of more than 10 years glutinous rice cultivated area and its production were rather stable[16]. Although there is no clear information about the quantity of glutinous rice consumption, a report of Kasikorn Research Center (2006) reports that glutinous rice is widely popular in Thailand and is the staple food of the northeastern and northern people. Aside from direct consumption, glutinous rice is also a raw material used in liquor production, as well as glutinous rice flour being used in the food and snack industries. However, a point to note is that there has been growth in the number of factories that now use glutinous rice flour as a primary ingredient, particularly Japanese frozen food factories, in producing such delicacies as *Moji*, dumplings, etc. These factories focus on exports to Japan. Due to the fact that the elderly in Japan are rising in number as a proportion of the populace, demand for soft and instant foods that are easy to prepare is increasing accordingly. The expansion in Japanese frozen foods for export has increased demand for glutinous rice as a primary ingredient. In addition, glutinous rice strains are being developed that have higher quality to meet the demand. Demand for glutinous rice keeps increasing, both domestic and abroad market, thus raising the price. The increasing of glutinous rice price will subsequently impact low income consumers.

There has never been a study on the response of glutinous rice to an economic factor that can be clearly demonstrated in this study. Therefore, the statement here on

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[16] Details regarding glutinous product and its cultivating areas can be found in chapter 2

the response of glutinous rice toward a price and non-price factor is an attempt to present conceivable information in regard to a factor affecting a change in the national glutinous rice production supply that it will be beneficial in a policy determination on the national glutinous rice production to be enough to serve the future demand.

Estimated Result of the Glutinous Rice Supply Equation

An analysis on the response of glutinous rice supply to a change of both price and non-price factors conducted by using provincial time series and cross-section data (panel data) which collected by Office of Agricultural Economics during 1990-2007. The cross-section data is divided into 6 group data based on the difference of region i.e. the upper north, lower north, upper northeast, lower northeast, central and south.

Variables using in the analysis consisted of a price variable of glutinous rice in the previous years (PG_{t-1}), a price variable of wet season paddy rice of the previous years (PRW_{t-1}), a price variable of KDML 105 rice in the previous years (PRH_{t-1}), a price variable on cassava in the previous year (PCV_{t-1}), a price variable of corn in the previous year (PCN_{t-1}), a price variable of chemical fertilizer (PF_t), a variance of rainwater quantity variable ($RAIN_t$), a labor wage rate variable ($WAGE_t$), a variable of a rice research budget ($BUDG_t$) and a proportion of irrigated area to total rice area variable ($IRRI_t$).

An analytical experiment on the response of glutinous rice supply using Nerlovean supply response of indirect analysis, the same method as the aforementioned overall analysis, shows that the coefficient is not in accordance with the assumption and the economic theory. Yet, upon trying on the data direct analysis through using a panel regression model to look for the coefficient, the finding is more reliable. This reveals that a direct analysis through a panel regression model is more suitable than the indirect analysis in explaining the response of glutinous rice supply.

Panel data analysis using a panel regression model to estimate the coefficients can be done through various methods, but the most important ones are the fixed effect methods and the random effect methods. A choice of methods to be used is based on an assumption of intercept, slope coefficient and error term (uit)[17].

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The analysis on an equation of the above response uses a method of fixed effect model by assuming that intercept and slope coefficients are different in each region. This is because it is the best testing method when comparing the estimated coefficients with other methods. The equation can written is as followed.

$$\begin{aligned}PRO_{it} &= \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \alpha_5 D_{5i} + \alpha_6 D_{6i} + \beta_1 PG_{it} + \beta_2 PRW_{it} \\ &+ \beta_3 PRH_{it} + \beta_4 RAIN_{it} + \beta_5 WAGE_{it} + \beta_6 BUDG_{it} \\ &+ \beta_7 IRRI_{it} + \gamma_1 (D_2 PG_{it}) + \gamma_2 (D_2 PRW_{it}) + \gamma_3 (D_2 PRH_{it}) + \gamma_4 (D_2 RAIN_{it}) \\ &+ \gamma_5 (D_2 WAGE_{it}) + \gamma_6 (D_2 BUDG_{it}) + \gamma_7 (D_2 IRRI_{it}) + \gamma_8 (D_3 PG_{it}) + \gamma_9 (D_3 PRW_{it}) \\ &+ \gamma_{10} (D_3 PRH_{it}) + \gamma_{11} (D_3 RAIN_{it}) + \gamma_{12} (D_3 WAGE_{it}) + \gamma_{13} (D_3 BUDG_{it}) \\ &+ \gamma_{14} (D_3 IRRI_{it}) + ... + \gamma_{36} (D_6 IRRI_{it}) + u_{it}\end{aligned} \quad (3.22)$$

An analytical outcome of the equation 3.22, as shown in table 3.5 reveals that glutinous production supply of each region responds to a change in the price and non-price factors differently as the coefficient of glutinous price variable of the previous year (PG_{t-1}) shows a positive response in all regions. Yet, only in the upper northeast, the coefficient is showing a statistical significant at a reliability level of more than 90% (Table 3.5).

It is found on a response of glutinous rice production to a change of wet season non-glutinous rice price that only in the upper northeast shows statistical significance in a negative direction which reveals that if wet season paddy rice price increases, the glutinous rice production of this region will decrease. Meanwhile, the coefficient of KDML 105 rice price in all regions shows statistical insignificance. However, the response of glutinous rice toward a change of KDML 105 rice price is opposite direction.

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[17] See in Greene. W.H. 2003. Econometric Analysis (International Edition)

An important factor in glutinous rice production is chemical fertilizer. The analytical finding in an equation 3.22 shows that only the coefficient of the chemical fertilizer variable (PF_t) in the upper northeast has statistical significance, yet, the relating direction is opposite the change of glutinous rice production. That is, if chemical fertilizer price rises, the glutinous rice production of this region will decrease. On the other hand, the coefficient of a labor wage rate is insignificant in all regions.

Table 3.5 Analytical findings from equations on the response of glutinous rice production through a method of panel regression model with Fixed effect model

Dependent variable	NU	NL	NEU	NEL	C	S
	PRO					
Fixed effect Intercept	0.522	-0.041	**1.620**	-1.897	0.012	-0.007
Glutinous rice price(+)	0.145	0.007	**0.313**	0.066	0.017	0.001
	(0.177)	*(0.935)*	***(0.006)****	*(0.554)*	*(0.873)*	*(0.994)*
Non-glutinous rice price (-)	-0.061	-0.031	**-0.120**	0.034	0.007	-0.001
	(0.377)	*(0.688)*	***(0.096)**	*(0.757)*	*(0.936)*	*(0.991)*
KDML 105 rice price(-)	-0.060	-0.007	**-0.059**	-0.114	-0.026	-0.001
	(0.311)	*(0.331)*	***(0.466)***	*(0.265)*	*(0.712)*	*(0.991)*
Fertilizer price (-)	0.053	0.037	**-0.267**	0.215	0.018	0.001
	(0.344)	*(0.666)*	***(0.100)**	*(0.186)*	*(0.835)*	*(0.993)*
Wage rate (-)	0.000	0.000	**0.013**	0.003	0.000	0.000
	(0.368)	*(0.956)*	***(0.120)***	*(0.509)*	*(0.923)*	*(0.999)*
Rice research investment (+/-)	-0.0006	-0.00009	**-0.00021**	-0.00011	-0.00005	-0.00001
	(0.697)	*(0.715)*	***(0.309)***	*(0.627)*	*(0.708)*	*(0.984)*
Irrigated area	-0.047	0.017	**-0.342**	-0.463	0.006	0.001
	(0.450)	*(0.770)*	***(0.002)****	*(0.001)*	*(0.920)*	*(0.990)*
Rain std.	0.000	0.000	**0.005**	-0.011	0.001	0.000
	(0.994)	*(0.836)*	***(0.093)**	*(0.028)***	*(0.730)*	*(0.982)*

Critical Value			
Adjusted R-squared	0.99	S.D. dependent var.	0.97
S.E. of regression	0.08	Sum squared residual	0.27
Log likelihood	169.99	F-statistic	238.42
Durbin-Watson stat	2.13	Prob(F-statistic)	0.00

Note: (..) is P-value

Source: calculated from OAE. Data

A research budget is an important factor that helps in a growth of the country rice production. But, the analytical equation on the response of glutinous rice production shows that the coefficient of a research budget variable ($BUDG_t$) is minus. It means that if the rice research budget is increase, the glutinous rice production will be decrease. This is because the previous rice researches focused mainly on the development of non-glutinous rice that during the past 3 decades the production of this non-glutinous rice had continuously increased that farmers replaced the glutinous rice farming with non-glutinous one in order to gain their profit. This information is consistent with the response of glutinous rice production toward a change of irrigated areas in both the upper and the lower northeast.

Conclusions

Findings from the study on a response of rice supply to a price factor reveals that the supply responds in a positive direction toward the rice price but in a negative direction toward energy crop price, oil palm fresh fruit price and other crops price. Although the total rice production supply is response to the rice price factor higher than energy crops price, but the energy crop price is still one of the main factor affecting the declining of rice production supply, especially in a long term when farmers have time enough to adjust their production system, then the increasing of energy crop price will show more impact on a change of the rice production. As for a response of rice supply to a input factor, it shows that an increasing of chemical fertilizer price impact the reduction of rice supply. Meanwhile, a labor wage rate discloses no influence toward a change of the rice supply. It is because during this study, farmers replace human force with farm machineries.

A response of rice supply to a non-price factor shows that the expansion of an irrigated area and a research budget on a development of rice production technology plays an important role in supporting the increase of rice production supply in a long term. Moreover, it is found that the country rice production has to depend significantly on a weather condition as it shows in this study that the variance of the quantity of rainwater or the climate conditions has an impact on the declining of the country rice production supply.

The glutinous rice production, the rice that is cultivated mainly in the upper northeast and upper north, illustrates that its production tends to decline as farmers replace their fields with non-glutinous rice farming since it gives them better profit. All previous researches focused on the improvement of non-glutinous rice to make the higher yield that its profit margin was higher than the farming of glutinous rice and the result was sufficient motivation for farmers to change their farmlands to non-glutinous rice. Subsequently, farming of glutinous rice has been only for a purpose of household consumption. Another supporting factor for rising production would be continued support provided by both the public and private sectors concerned in promoting exports of both glutinous rice and derivative products. They are focusing on measures to improve varieties of glutinous rice yielding higher-quality rice to meet demand by consumers and processing plants, which will enhance the promise of future Thai glutinous rice exports.

In order to increase the rice supply under the current pressing condition of a high production cost and increasing of competitive crops price, the government should accelerate its support on a research and a development of the new rice production technology enabling farmers to increase their productions, yet, reduce the production cost. This will be more beneficial to the national rice industrial system in a long term than the intervention in the market price.

CHAPTER IV

HOUSEHOLD FOOD EXPENDITURE AND RICE CONSUMPTION DEMAND

Introduction

Economic growth and urbanization have inevitably affected household food consumption patterns, particularly for rice, which is a staple food in almost all Asian countries. Indonesia's per capita rice consumption in the last two decades in urban and rural areas had been decreasing. The share of rice in household expenditure has been decreasing as well because of a higher per capita income (Sudaryanto *et al*., 2002). Huang and Bouis (1996) found that the per capita rice consumption in Taiwan declined; while that of meat, fish, and fruits increased. In Thailand, the growing economy has stimulated the consumers to adjust their consumption behavior towards an increasing demand for luxury food items, particularly meat and horticulture products with less rice (Patamasiriwat and Poldee, 1990; Agribusiness Research Unit, 1996).

The rice consumption patterns can be assessed by using information on price and income elasticities of demand. The demand elasticities are normally measured from a single-equation demand function with price and income variables using time-series data. Wong (1978) found the price and income elasticities for the short run of rice consumption in Thailand to be -0.42 and 0.09, respectively, and for the long run to be -0.47 and 0.10, respectively. By allowing the estimation of income elasticities to vary with level of income, Ito *et al*. (1989) found a negative income elasticity of rice consumption in Thailand. An alternative approach for the estimation of food demand is to employ the theory of demand as a guideline for mathematically specified models of consumer choice under the imposition of constraints on demand parameters (Deaton and Muellbauer, 1980). A separability concept is assumed for this technique in order to partition the choice of food group from other goods in household budget constraint. The household food budget share analysis under the basic model framework of an almost ideal demand system (AIDS) can provide the expenditure and price elasticities. Huang and Bouis (1996) employed this technique in analysing the parameters of food consumption in Taiwan. They found the expenditure and price elasticities of rice consumption in Taiwan to be 0.17 and -0.61, respectively.

In Thailand, the estimation of demand elasticity for rice consumption has been limited to the estimation of the Engel curve or expenditure elasticity using cross-sectional data of the households' expenses on food products; see Jansai (1996) and Prasertsung (2004) for instance. In this paper, a more updated data set of the cross-sectional data from the socio-economic survey (SES) of Thai households in 2002 allows for the estimation of both expenditure and price elasticities of rice demand for Thai household consumption. The analysis is based on the model framework introduced by Deaton (1988). The availability of data also allows exploration of the consumption patterns in response to the differentiation of rice quality, subject to different income levels.

This chapter has three objectives (1) to present the consumption patterns of non-glutinous and glutinous rice in a Thai household (2) to analyze household price and income elasticities of non-glutinous and glutinous rice. By analyzing, the impact of rice quality is separated from rice price through using the technique developed by Deaton in 1988 (Quality, Quantity, and Spatial Variation of Price). The socio-economic data collected by Thai National Statistics Organization in 2002 (34,785 household samples) was used to analyze in this study.(3) to analyze the effects of domestic rice consumption demand to the change of price and non price factors by using time series data were collected by OAE. during 1970-2007

Previous Studies on Rice Demand

Demand is related to the quantities of goods that consumers are willing to purchase at a range of price of the goods while holding other fixed factors (Tomek and Robinson, 1990). If a price declines the quantity purchased should typically increase as dictated by law of demand. Consumers' reaction to income and price changes can be examined in terms of income and substitution effects. The income effect can be expressed as a change in the amount purchased goods, for example goods "i", as income changes, given that fixed relative prices of goods "i", the substitution effect is the amount that a consumer substitutes goods "j" for "i" as the price of goods "j" changes, given the fixed level of utility. (Henderson and Quander, 1980).

Generally, the demand level for given goods is determined by four major factors (Tomek and Robinson, 1990). First, changes in preferences and tastes can impact demand for any goods and the changes can be from several reasons such as age, advertising, education, and experience with the product. Second, the distribution of income can effect consumers' tastes and generally there are positive relation between income and demand for most goods. Distributions of incomes among the rich and poor should impact demand but most likely in different ways (Girapuntong, 2002). Third, the rate of population growth, age distribution, and regional distribution of the population has an impact on the total demand as well as demand for different products. Lastly, changes in price of one goods will cause changes in demand for other goods.

Many methods are used to study household demand and consumption pattern. One of them is partial demand analysis which is used to study individual goods, not concerning about the impact of other goods on household expenditure. In fact it is found that an expenditure of one goods is related to the expenditure of other goods because of a limited budget that a consumer has. So, if he/she spends more on one goods there will be less money left for other goods. This leads to the need to study consumers' behavior by using demand system analysis techniques. In Thailand, Triratvorakul (1983), Pattamasiriwat (1990), and Isvilanonda (1993) employed the system analysis technique in studying the rice demand.

Previous estimation of rice demand elasticities was reviewed by Tanapornpan (1987) and it was found that the estimated results of the short term elasticities were less than 1. Only Kerdpibule (1970) reported this value that equaled to -1.251.

However, in the group that found the elasticity less than 1 the obtained values were largely varied from zero (Behrman, 1968) to -0.9316 (Wattanutchariya, 1978). According to Tanapornpan (1987), the differences of elasticity were a result of employing the varieties of techniques, estimation methods, as well as models and estimation durations.

Moreover, Blaskeslee *et.al*. (1982) presented rice consumption demand elasticity in the country as positive which indicated that rice is giffen goods for a Thai household. Researchers explained that the elasticity showed a plus sign because the rising of rice price had led to the increasing in price of other kinds of food. So, farmers' households turned to consume more rice while non-farmers' households consumed less. As farmers' rice consumption was higher, rice consumption demand increased along with its price. Blaskeslee *et al.* (1982) proposed that the study should be done by separating the estimation of households in urban from rural as they believed that these two groups of households distinguished different rice consumption patterns.

Many estimations of rice income elasticity were from using both cross-section and time series data. Almost all studies which used time series data reported income elasticity with a plus sign. This indicated that rice was superior goods for Thai households. However, Ito *et al*. (1989) reported income elasticity with a minus sign which showed that rice was regarded as inferior goods for Thai households. The income elasticity found by these latter groups was lower that it was consistent with Engel's Law. However, Wattanutchariya (1978) reported higher income elasticity while Behrman (1968) and Kerdpibule (1970) showed the income elasticity estimation that equaled to zero. This implied that rice consumption demand of the Thai households did not respond to the change of consumers' income.

Triratvorakul (1984) and Isvilanonda (1994) used cross-section data to analyze rice consumption demand of Thai households and it was done by using the relation in terms of Engel curve. The analysis of the income elasticity of rice demand in both studies was done by differentiating the elasticity according to the layers of household's income i.e. 25 percent of high income households, 50 percent of medium income household and 25 percent of low income household. The elasticity of the analysis was between zero and one. The demand response of the high income households to the change of income was lower than the low income households.

Household Consumption Expense and Food Expenditure Shares

Household income has crucial effects on household consumption expenditure. If the household income increases, the household food expenditure trends to increase. However, the increasing of food expenditure share is diminishing, which is consistent with Engel curve's law. Besides, the expenditure share on non-glutinous and glutinous rice in low income household is higher than other households.

Table 4.1 Household total income, total expenditure, and food expenditure separated by income classes in 2002

Expenditure (TBH/M)	Income classes			
	Bottom 25%	**Middle 50%**	**Top 25%**	**Average**
Sample	8,698	17,392	8,695	34,785
Household income	3,548	9,717	34,467	14,361
Household Expenditure	4,723	9,128	23,020	11,499
Household Food expenditure	2,222	3,635	6,124	3,904
- Share of food exp. by total exp.	47.0	39.8	26.6	33.9
% share of food exp. Per total food exp.				
Rice and grains	16.8	11.6	7.6	10.8
Meats and Fish	25.3	20.7	16.9	19.9
Milk and oils	8.3	8.2	7.9	8.1
Fresh vegetables and Fresh Fruits	14.2	13.2	12.3	13.0
Food away from home	11.3	18.8	28.1	21.4
Food prepare form home	12.5	14.7	15.4	14.7
Other	11.7	12.8	11.8	12.2
Total expenditure	**100.0**	**100.0**	**100.0**	**100.0**

Source: Calculate form socio economic survey data (2002)

Table 4.1 shows different patterns of household food expenditure in according to income classes. The budget for expenses on food of poor households is Baht 2,222 per month while the budget is Baht 3,635 and Baht 6,124 per month for that of middle and rich households. However, the larger proportion or 47.0 percent of household expenditure of the poor goes to food. It decreased from 97.28% in 1990 (Isvilanonda and Poapongsakorn, 1994). The ratio is smaller for that of middle and rich households (or 39.8% and 26.6% in 2002).

The patterns of household food expenses decompose by the different of household occupations. Monthly income of a professional or technical household is Baht 30,543 per month which is higher than other occupations while a farmer household has the lowest income (Baht 9,566 per month) (Table 4.2). However, a proportion of food expenditure per total expenditure of a farmer household is higher than those of other occupations. In terms of the item of food expenditure, it is showed that the expenses on rice and cereal are lower than the expenses on meat (including meat and fish), fresh vegetables and fresh fruits for all occupations.

Table 4.2 Household total income, total expenditure, and food expenditure decompose by household occupation in 2002

Expenditure (TBH/M)	**Farmer**	**Entrepre-neurs**	**Professional**	**Laborers**	**Service**	**Other**	**Average**
Sample	5,671	7,857	4,004	2,394	9,351	5,508	34,785
Household income	9,566	17,811	30,543	6,018	12,449	9,484	14,361
Household Expenditure	7,870	13,503	22,469	5,978	10,648	8,247	11,499
Household Food expenditure	3,168	4,472	5,534	2,877	4,076	2,819	3,904
- Share of food exp. by total exp.	40.3	33.1	24.6	48.1	38.3	34.2	33.9
% share of food exp. Per total food exp.							
Rice and grains	16.5	9.7	7.3	15.1	9.8	12.2	10.8
Meats and Fish	28.1	18.8	16.0	25.5	17.4	21.7	19.9
Milk and oils	8.3	7.7	8.1	8.4	7.9	8.8	8.1
Fresh vegetables and Fresh Fruits	15.1	12.9	12.2	13.7	11.8	14.3	13.0
Food away from home	10.8	20.0	30.9	13.9	25.7	16.0	21.4
Food prepare form home	8.3	18.2	14.7	10.2	14.7	15.9	14.7
Other	12.9	12.6	10.9	13.1	12.7	11.1	12.2
Total food expenditure	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Calculate form socio economic survey data (2002)

Table 4.3 shows the different patterns of household food expenditure in according to household head educations. The expenses budget for food of the lowest education is Baht 2,911 per month while the budget is Baht 5,580 per month for those of the highest education. However, the larger proportion or 42.4 percent of household expenditure of the lowest education goes to food. The ratio is smaller for people of the higher educations.

Table 4.3 Household total income, total expenditure, and food expenditure separated by household head education in 2002

Expenditure (TBH/M)	Lower elementary	Elementary	Secondary	Vocational	Bachelor or upper	Average
Sample	2,364	21,831	4,875	2,580	3,135	34,785
Household income	7,825	10,782	17,529	22,016	32,983	14,361
Household Expenditure	6,864	9,169	13,400	16,919	23,804	11,499
Household Food expenditure	2,911	3,545	4,396	4,880	5,580	3,904
- Share of food exp. by total exp.	42.4	38.7	32.8	28.8	23.4	33.9
% share of food exp. Per total food exp.						
Rice and grains	13.7	12.6	8.8	7.3	6.4	10.8
Meats and Fish	22.4	22.5	17.2	14.8	14.3	19.9
Milk and oils	8.0	8.1	7.8	8.1	8.1	8.1
Fresh vegetables and Fresh Fruits	14.5	13.6	12.1	11.5	11.8	13.0
Food away from home	15.2	17.1	25.1	28.8	32.8	21.4
Food prepare form home	14.1	13.4	16.7	17.3	16.0	14.7
Other	12.0	12.7	12.3	12.2	10.6	12.2
Total food expenditure	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Calculate form socio economic survey data (2002)

By dividing household location into urban and rural households, it is found that the pattern of food expenditure consumption of urban households is different from rural ones as the pattern of the urban households is higher than those of the rural However, if we compare the share of food expenditure with total household income, we found that food expenditure share of rural households is higher than that of urban households (Table 4.4).

Considering household food expenditure on six groups of food (rice and grains, meat and fish, milk and oil, fresh vegetables and fresh fruits, take away food, and other foods), it is found that the expenditure on meat and fish is higher than fresh vegetables and respectively followed by fresh fruits, milk and oil, and rice and grains. Rural households have higher food expenditure share on rice and grains than urban households.

Table 4.4 Household total income, total expenditure, and food expenditure separated by community types in 2002

Expenditure (TBH/M)	Community Types		
	Urban	**Rural**	**Total**
Sample	21,565	13,220	34,785
Household income	16,970	10,105	14,361
Household Expenditure	13,307	8,550	11,499
Household Food expenditure	4,250	3,339	3,904
- Share of food exp. by total exp.	31.9	39.1	33.9
% share of food exp. per total food exp.			
Rice and grains	9.4	13.6	10.8
Meats and Fish	17.8	24.2	19.9
Milk and oils	7.8	8.7	8.1
Fresh vegetables and Fresh Fruits	12.5	13.9	13.0
Food away from home	23.9	16.2	21.4
Food prepare form home	16.7	10.4	14.7
Other	11.9	13.1	12.2
Total expenditure	**100.0**	**100.0**	**100.0**

Source: Calculate form socio economic survey data (2002)

The patterns of household food expense differ across regions. The budget spending on food of households in Bangkok is baht 6,247 per month while it is baht 4,249, 3,045, 3,522 and 4,298 per month for the central, north, northeast and south households (Table 4.5). However, a proportion of food expenditure per total expenditure of the households in Bangkok is lower than other regions. In terms of the items of food expenditure, it is showed that the expenses on rice and cereal are lower than the expenses on meat (including meat and fish), fresh vegetables and fresh fruits for all regions. Comparing the major shares of food in 1990 and 2002, we found that the major share of food budget of Thai households was for rice and cereal in 1990 while this major shares was given to meat, fresh vegetables and fresh fruits in 2002

Rice Consumption per Household and Capita

Socio-economic data of the Thai households surveyed in 2002 showed that the quantity of non-glutinous and glutinous rice consumption of the households was 66 kilograms per capita per year and 35 kilograms per capita per year, respectively. The quantity of both non-glutinous and glutinous rice of urban households is lower than rural households. The unit value per kilogram of rice (both non-glutinous and glutinous rice) of urban households is higher than rural households (Table 4.6).

Table 4.5 Household total income, total expenditure, and food expenditure by region in 2002

Items	Region					
	Bangkok	**Central**	**North**	**Northeast**	**South**	**Total**
Sample	1,946	10,367	7,971	9,043	5,458	34,785
Household income(TBH/M)	30,261	15,730	11,176	12,313	14,135	14,361
Household Expenditure (TBH/M)	22,332	12,570	8,991	9,866	11,971	11,499
Household Food expenditure (TBH/M)	6,247	4,249	3,045	3,522	4,298	3,904
- Share of food exp. by total exp.	28.0	33.8	33.9	35.7	35.9	33.9
% share of food exp. Per total exp.						
Rice and grains	5.0	8.5	13.1	15.2	9.6	10.8
Meats and Fish	11.2	17.5	20.8	25.5	20.3	19.9
Milk and oils	5.8	7.9	8.9	8.0	8.8	8.1
Fresh vegetables and Fresh Fruits	12.0	12.7	15.3	11.8	13.2	13.0
Food away from home	38.7	23.7	16.6	15.3	21.4	21.4
Food prepare form home	18.8	15.2	12.6	14.2	14.3	14.7
Other	8.6	14.6	12.9	9.9	12.3	12.2
Total expenditure	**100**	**100**	**100**	**100**	**100**	**100**

Source: Calculate form socio economic survey data (2002)

The quantity of rice consumption is varied according to regions, communities, and income classes. Table 4.6 shows the quantity and value of rice consumption both per household and per capita. Considering the amount of rice consumption among regions, it is found that the average of rice consumption per household in Bangkok is 46 kilograms (in terms of milled rice) per annum. This includes both glutinous rice (2 kgs per annum) and non-glutinous (44 kgs per annum). The average annual rice consumption in the North, Northeast, Central plain and South, is 2.4, 3.1, 1.7, and 1.8 times higher than those in Bangkok. Furthermore, cultural differences among regions are also reflected through a type of rice preferences. Northeastern and Northern households normally prefer glutinous than non-glutinous rice. Shares of glutinous rice for the total rice consumption of households in Northeast and North are 60.6% and 46.8%, respectively. Glutinous rice consumption of the households in other regions has an insignificant share. Households in central plain, south, and bangkok prefer non-glutinous rice to glutinous rice.

The different household income brings about different patterns of rice consumption of the households. That is, high income household consumes less rice than low income households. Moreover, the unit value per kilogram of rice (both non-glutinous and glutinous rice) which is consumed by the high income households is higher than the low income households (Table 4.6). This result indicates that continuous growth of Thai economic, the low growth of Thai population and the increasing of household income lead to the diminishing of domestic rice consumption demand.

Considering on a household rice consumption pattern by categorizing on the differences of the main occupations (the family main earning), it was found that agricultural households consumed the highest quantity of rice per capita per year as it was 130 kilograms/person/year. This figure could further be categorized into 72 kilograms/person/year for non-glutinous rice and 58 kilograms/person/year for glutinous rice On the other hand, families of professional and technical career consumed the least as it was only 79 kilograms per capita per year (59Kilograms for non-glutinous rice and 20 kilograms fro glutinous rice). Hence, upon considering on rice price per unit, it showed that agricultural households consumed the lowest rice price per unit which was Baht 11.50 per one kilogram for non-glutinous rice and Baht 11.00 per one kilogram of glutinous rice while households of professional and technical career consumed the highest rice price per unit of Baht 13.20 and Baht 11.70 per one kilogram for non-glutinous and glutinous rice respectively. This information disclosed that family requirement of professional and technical households was for better quality rice which was because these people were with higher income and varied in educational levels.

Table 4.6 Sample household, quantity and value of household rice consumption per capita consumption and rice unit value in 2002

Item	Sample	Household Size	White rice		Glutinous rice		Total rice Consumption (kg./capita/ year)
			kg./capita /year	Baht/kg.	Kg./capita /year	Baht/kg.	
Kingdom	34,785	3.4	66	12.2	35	11.4	101
3rd Income classes							
Bottom 25%	8,698	2.9	68	11.5	57	11.1	125
Middle 50%	17,392	3.4	67	12.2	33	11.5	100
Top 25%	8,695	3.9	63	13.2	18	11.8	80
5th Income class							
20% Lowest	6,958	2.8	68	11.4	59	11.1	127
20% Low	6,956	3.3	67	11.8	46	11.2	113
20% Middle	6,956	3.4	67	12.2	32	11.5	99
20% High	6,957	3.6	66	12.6	23	11.8	89
20% Highest	6,958	4	62	13.3	17	11.8	78
Occupations							
Farmer	5,671	3.9	72	11.5	58	11.0	130
Entrepreneurs	7,857	3.6	67	12.7	27	11.8	94
Professional,	4,004	3.3	59	13.2	20	11.7	79
Laborers	2,394	3.6	69	11.8	43	11.4	113
Service	9,351	3.5	61	12.4	27	11.5	88
Other	5,508	2.6	69	12.1	44	11.2	113
Education							
Lower elementary 4	2,364	3.5	71	12.1	34	11.4	105
Elementary 6	21,831	3.6	68	11.9	43	11.3	112
Secondary	4,875	3.2	62	12.8	24	11.6	87
Vocational	2,580	3	58	13.5	15	12.4	72
University	3,135	2.9	57	13.7	15	11.8	72
Community							
Urban	21,565	3.3	63	12.7	30	11.5	93
Rural	13,220	3.6	71	11.7	43	11.2	114
Region							
North	7,971	3.2	58	12.2	51	11.5	109
Northeast	9,043	3.6	56	11.6	86	11.2	142
Central	10,367	3.4	77	12.6	3	12.4	80
South	5,458	3.6	81	12.6	2	12.7	83
Bangkok	1,946	3.3	44	15.2	2	13.6	46

Source: Calculate form socio economic survey data (2002)

Based on an educational level of a family leader, households are categorized into 5 groups (1) a leader with an educational level of elementary school (M.S. 4) or lower (2) a leader with and educational level of primary school (M.S. 6) (3) a leader with high school diploma (4) a leader with vocational school diploma (5) a leader with bachelor degree or higher. It was found that a household leader of a higher degree consumed lower quantity of rice per person yet rice value per consuming unit tended to be higher (Table 4.6).

From the information of rice consumption for households and rice value per consuming unit, as shown in table 4.6, it can be concluded that households of higher income or higher education or urban residents consumes lesser quantity of rice per person than other groups but their rice value per household is higher which means that family members of these households prefer rice of better quality than other group members.

Comparing the annual quantity of rice consumption per capita in 1990 to the one in 2002, it was found that it declined from 119 kilograms per capita in 1990 (Isvilanonda, 1993) to 101 kilogram per capita in 2002.

Theoretical Framework for Per capita Rice Demand Analysis

From the assumption of consumers' behavior theory stating "a household will reasonably purchase goods through considering the utility and budget availability for each kind of goods" it shows that consumers' decision on purchasing any kind of goods is correlated. That is, the higher the households purchase a certain kind of goods, the lower they can purchase other goods because of their set budget. Accordingly, the study of the households' consumption patterns should be done systematically rather than using partial analysis (Pattamasiriwat and Pattamakijsakul, 1990)

An empirical research concerning demand system analysis which is considered an influential pioneering study was a Linear Expenditure System (LES) originally proposed by Sir Richard Stone. This model was further developed by a group of World Banks economists and rename it as Extended Linear Expenditure System (ELES) (more details are available at Lluch, Powel and Williams (1977)). Apart from these two models, there are other models used to analyze demand systematically such as Almost Ideal Demand System (AIDS), Central Bureau of Statistics (CBS), and Generalized Adding Demand System (GADS). Each of these models has different strengths and weaknesses (Girapunthong, 2002). This study will apply the concept of AIDS model to create equations for analyzing. AIDS model was based on duality theorem and consumer's behavior theorem. The model indicates the relation between expenditure share of goods being interested and its own price, including set of price of other goods (more details are available at Deaton and Muellbaure (1990)

A framework of this demand analysis is based on a model of consumer behavior developed by Deaton (1988) in which households choose how much of rice to buy and in what quality or grade. Rice is considered as a collection of heterogeneous goods within which consumers can choose more or less expensive items, so that the unit value of rice is a matter of choice. Both quantity and quality choices are functions of household income, price, and household character. Household income affects consumer choice because better-off households will tend to consume not only the better and more expensive quality rice, but also the different proportions. It is expected that there will be a positive relation between a unit value of rice purchased and household income. On the other hand, the richer households will spend fewer shares on rice, implying a negative correlation between higher household income and its rice expenditure share. In this model, the market price is treated as unobservable variable. The quantity purchased is determined through the unit value[18].

[18] using unit value as a dependent variable in the model encounters with measurement errors as a result of interviewing process, generating a spurious correlation between quantity and unit value. This spurious correlation needs to be corrected in the elasticity estimation process.

The Model of Rice Consumption Behavior

In estimating equations, it is assumed that common households in each village or cluster will purchase rice which equals in it quality and price. This assumption is necessary because it implies that each household in the same village is facing the same transportation cost and market price. However, due to unequal in quality purchase between villages, the market prices will differ over areas or locations. Since the market price is unobservable but it will be reflected in quantity purchased and in its unit value which, on the other hand, are directly observed. Denoting the household by "i" and cluster by "c", the two basic equations are:

$$W_{ic} = \alpha_1 + \beta_1 \ln X_{ic} + \gamma_1 Z_{ic} + \theta_1 \ln P_c + f_c + U_{1ic} \quad (4.1)$$

$$\ln V_{ic} = \alpha_2 + \beta_2 \ln X_{ic} + \gamma_2 Z_{ic} + \theta_2 \ln P_c + U_{2ic} \quad (4.2)$$

where

W_{ic} is the share of rice expenditure (including both actual purchases and imputed expenditures);

X_{ic} is the per capita household food expenditure (Baht) and is in logarithmic form;

V_{ic} is the calculated unit rice value (Baht/ kg.) in each household and is also in logarithmic form;

Z_{ic} is a household character variable and is represented by family size;

P_c is a village price of rice which is unobservable and is in the logarithmic form;

f_c is a set of cluster fixed effects which represents unobservable taste variation from village to village;

U_{1ic} and U_{2ic} are error terms of equations (5.1) and (5.2), respectively; and

$\alpha_i, \beta_i, \gamma_i, and \theta_i$ are coefficients in estimating equations.

The equation (4.1) demonstrates a dependent relation of the budget share variable condition on the right-hand side variables. Because the budget share included both purchasers and non-purchasers, the equation is a standard Engel curve specification. It relates rice expenditure to total food spending, price and household character. The unit value equation (4.2) which can be observed only for households that recorded positive market purchases represents the quality choice analysis. It relates unit value of rice to the food budget, household character, and the market price of rice purchased.

The share equation (4.1) contains a set of cluster fixed effects f_c that represented unobservable taste variation from cluster to cluster. They can be thought of as "residuals" in a cross-cluster explanation of purchased (Deaton 1988).

As the socio-economic survey data collected by National Statistic Office did not cover the commodity price, an estimation of equation (4.1) and (4.2) has to be carried out by assuming that common households in each village or cluster will purchase rice which equal price. This implies that the price variable in equation (4.1) and (4.2) is constant. The new equations under this assumption are shown in equation (4.3) and (4.4).

$$W_{ic} = \alpha_1 + \beta_1 \ln X_{ic} + \gamma_1 Z_{ic} + f_c + u_{1ic} \qquad (4.3)$$

$$\ln V_{ic} = \alpha_2 + \beta_2 \ln X_{ic} + \gamma_2 Z_{ic} + u_{2ic} \qquad (4.4)$$

Therefore, to derive the food expenditure elasticity of quantity rice demand, we follow a technique developed by Deaton (Deaton 1988) by firstly use the information of rice budget share which is equivalent to unit rice value (V), multiply by quantity of rice purchased (Q), and divide by the total food budget (X) which can be written in logarithmic form as equation (4.5).

$$\ln W = \ln V + \ln Q - \ln X \qquad (4.5)$$

a differentiation of both equations (4.5) with respect to lnX obtains (4.6)

$$\frac{d \ln W}{d \ln X} = e_{VX} + e_{QX} - 1 \text{; or} \qquad (4.6)$$

$$\frac{X.dW}{W.dX} = e_{VX} + e_{QX} - 1 \qquad (4.6.1)$$

Where

e_{VX} is a food expenditure elasticity of unit rice value; and

e_{QX} is a food expenditure elasticity of quantity rice demand.

By taking differentiation of equation (4.1) with respect to X, we obtain food expenditure elasticity of rice budget share as equation (4.7)

$$\frac{X.dW}{W.dX} = \frac{\beta_1}{W}; \qquad (4.7)$$

Also a differentiation of equation (4.2) with respect to X, food expenditure of unit rice value as equation (4.8) is obtained.

$$\frac{d \ln V}{d \ln X} = \beta_2 \text{; or} \quad e_{VX} = \beta_2; \qquad (4.8)$$

By substitution of $e_{VX} = \beta_2$ into equation (4.6.1) and equates it equals to equation (4.7), it yields as equation (4.9)

$$e_{QX} = 1 + \frac{\beta_1}{W} - \beta_2 \qquad (4.9)$$

Equation (4.9) represents a food expenditure elasticity of quantity rice demand which can be estimated by using the estimated parameters of $\beta_1 and\ \beta_2$.

The fact that the socio-economic survey of the Thai households in 2002 by National Statistic Office did not collected data on commodity price purchased (P) by households, thus, a calculation of rice price elasticity of quantity demand cannot directly be estimated from equations (4.1) and (4.2). Nonetheless, Deaton (1988) suggested that given no collected price data of commodity purchased, the price elasticity of quantity demand for particular commodity can be indirectly estimated by differentiation of equation (4.5) with respect to lnP and rearranging in elasticity terms as equation (4.10).

$$\left(\frac{P}{W}\right)\left(\frac{dW}{dP}\right) = e_{VP} + e_{QP} \tag{4.10}$$

Where

e_{QP} is a price elasticity of quantity rice demand; and

e_{VP} is a price elasticity of unit rice value.

By taking a partial differentiation of equation (4.1) with respect to lnP and rearranging in the form of price elasticity of rice expenditure share as demonstrates in equation (4.11)

$$\left(\frac{P}{W}\right)\left(\frac{dW}{dP}\right) = \frac{\theta_1}{W} . \tag{4.11}$$

Also, a differentiation of (4.2) with respect to lnP and rearranging in elasticity term (e_{VP}) obtained equation is (4.12)

$$\frac{d \ln V}{d \ln P} = \theta_2 \text{ ; or } \quad e_{VP} = \theta_2 . \tag{4.12}$$

a substitution of equations (4.11) and (4.12) into equation (4.10) can be written as equation (4.13)

$$e_{QP} = \frac{\theta_1}{W} - \theta_2 \tag{4.13}$$

Deaton (1988) showed that in this case a price elasticity of unit value (e_{VP}) is related to a price elasticity of quantity demand and food expenditure elasticity of quantity demand as equation (4.14)

$$e_{VP} = 1 + \frac{\beta_2 e_{QP}}{e_{QX}} = \theta_2 \text{; or} \qquad (4.14)$$

$$\theta_2 = 1 + \beta_2 e_{QP} \big/ (1 + \beta_1 \big/ W - \beta_2) \qquad (4.14.1)$$

Parameters θ_1 and θ_2 cannot be directly calculated from equation (4.1) and (4.2), respectively. Nonetheless, the indirect estimation of price and income elasticities of quantity demand can be done as follows:

Step I, by regressing equation (4.3) and using the estimated coefficients to calculate the predicted share value of equation (4.4). By subtracting the predicted share value with the actual share value, we get the estimated residual term of the share value ($\hat{y}_{1ic}$) as equation (4.15). By the same token, the estimated residual term ($\hat{y}_{2ic}$) is as equation (4.16).

$$\hat{y}_{1ic} = W_{ic} - \hat{\beta}_1 \ln X_{ic} - \hat{\gamma}_1 Z_{ic} ; \qquad (4.15)$$

$$\hat{y}_{2ic} = \ln V_{ic} - \hat{\beta}_2 \ln X_{ic} - \hat{\gamma}_2 Z_{ic} \qquad (4.16)$$

By taking average the estimated residual terms $\hat{y}_{1ic}$ and $\hat{y}_{2ic}$ for each cluster or village, we obtain $\hat{Y}_{1c}$ and $\hat{Y}_{2c}$, respectively, which represent the estimated residual terms at the cluster level. These estimated residual terms can be simply written as equations (4.17) and (4.18), respectively.

$$\hat{Y}_{1c} = \alpha_1 + \theta_1 \ln P_c + f_c + u_{1c} \qquad (4.17)$$

$$\hat{Y}_{2c} = \alpha_2 + \theta_2 \ln P_c + u_{2c} \tag{4.18}$$

Terms $\hat{Y}_{1c}$ and $\hat{Y}_{2c}$ in equation (4.17) and (4.18), respectively reflect price differences between cluster levels of average households. Deaton (1988) indicated that the variance of $\hat{Y}_{2c}$ and covariance between $\hat{Y}_{1c}$ and $\hat{Y}_{2c}$ are equal to equation (4.19) and (4.20)

$$\mathrm{var}(\hat{Y}_{2c}) = \theta_2^2 m_p + \sigma_{22}/n_c^+ \tag{4.19}$$

$$\mathrm{cov}(\hat{Y}_{1c}, \hat{Y}_{2c}) = \theta_1\theta_2 m_p + \sigma_{12}/n_c \tag{4.20}$$

where

m_p	represents variation of $\ln P_c$ among clusters or villages,
σ_{12}	is covariance of error terms u_{1c} and u_{2c} of equations (4.3) and (4.4), respectively,
σ_{22}	is variance of error term u_{2c} of equation (4.4),
n_c	represents number of households by clusters,
n_c^+	represents number of households by clusters which have positive expenditure on rice.

Step II, A spurious correlation between food expenditure and unit value variables may create a bias of the estimated coefficients θ_1 and θ_2. Thus, we adjust θ_1 and θ_2 by ϕ to reduce the estimation bias. The ϕ can be obtained by dividing equation (4.20) by equation (4.19), we obtain equation (4.21)[19].

$$\phi = \frac{\mathrm{cov}(\tilde{y}_1\tilde{y}_2) - \sigma_{12}/t}{\mathrm{var}(\tilde{y}_2) - \sigma_2/t^*}, \mathit{when} \left[\hat{Y}_{1c}/t = \tilde{y}_1\right] \mathit{and} \left[\hat{Y}_{2c}/t^* = \tilde{y}_2\right] \tag{4.21}$$

19 a symbol "t" is represented an average cluster size and a symbol "t*" is represented an average household in cluster which has a positive expenditure of the rice commodity.

Thus, $\phi = \theta_1 / \theta_2$. here, a value t is $(C/\sum n_c^{-1})$ and t* is $(C/\sum n_c^{*-1})$ which are the appropriate measures of average cluster size. By substituting $\theta_2 = \frac{\theta_1}{\phi}$, $e_{QP} = \frac{\theta_1}{W} - \theta_2$, and $e_{QX} = 1 + \frac{\beta_1}{W} - \beta_2$ into equation (4.14) and by rearranging term for solving θ_1 , we obtain equation (4.22):

$$\theta_1 = \frac{\phi[\beta_1 + W(1-\beta_2)]}{\beta_1 + W - \phi\beta_2} \qquad (4.22)$$

When the estimated θ_1 is obtained, θ_2 can be derived from the relation of $\theta_2 = \theta_1 / \phi$ The estimated θ_1 and θ_2 are information for further calculation of the price elasticity of quantity demand for rice as in equation (4.13)

Results of Estimation

From the variable specification in equation (4.1) and (4.2), the total household expenditure (X_1) is used as the approximation of household income and the share of the budget for purchasing rice (W_1) (including both actual purchases and impute expenditures). Household size is used to represent the variable (Z), and the amount of years in school is represented by the variable (EDU) in the models. These variables are also in logarithm form. Moreover, we also add the dummy variable on the household head's occupation (OCC; it equals to zero for agricultural households) in both share and unit value equations. The ordinary least squares (OLS) method is used to estimate the parameters of the rice expenditure function as defined in equation (4.1) and (4.2).

The estimations of non-glutinous, glutinous, and aggregated rice expenditure and unit value in the entire kingdom are shown in appendix table (1). The estimation of glutinous rice expenditure and unit value is confined to northeastern and northeast regions. It is found that the variable lnX yields show negative relation with all share expenditures (W1, W2, and W3) at a significant level of 1%, implying that the higher expense the household has, the smaller rice expenditure the household shares. Furthermore, the expenditure variable (X) has a positive relation with all unit value equations (LnV1, LnV2, and LnV3). This suggests that the higher the expenditure is, the higher the quantity of rice demand becomes. The household size has a negative relation with all the share equations at a significant level. This implies that when family size is bigger, the share of rice expenditure declines. Occupation variable (OCC) has a positive significant relation with all share equations, suggesting that farm households share has greater rice expenditure than non-farm households. On the other hand, the OCC variable has a negative significant relation with all unit value equations, implying that farm households spend less unit value of rice than non-farm households. The EDU variable has a negative significant relation with all share equations, suggesting that the higher education households spend less than lower education households. On the other hand, EDU variable has a positive relation with all unit value equations, implying that higher education households focus on rice quality more than lower education households.

For the estimation of share and unit value equation of non-glutinous and glutinous rice by considering community types (appendix table 2, 4), the results show that the variable (lnX) has a positive relation with all share equations of non-glutinous and glutinous rice. This result shows that the higher expense the household has, the smaller rice expenditure the households both in urban and rural share. In contrast, the growing in expenditure (X) tends to increase the quality demand of both urban and rural households. This can be seen from positive significant effects of this variable on unit value equations. In both urban and rural communities, household size has a negative significant relation with the share equations, suggesting that households with bigger member tend to have a smaller expenditure share on non-glutinous and glutinous rice. In contrast, household size has a positive significant relation with the unit value equation both in urban and rural communities, implying that when the family size is bigger, the household will pay more attention on rice quality. The dummy variable of household head's occupation is significant in all equations. It implies that farm households have greater rice expenditure share both on non-glutinous and glutinous but they have lower unit value of rice. The level of educations (lnEDU) of household members has negative effect on non-glutinous and glutinous rice expenditure share in all equations. In contrast, the variable lnEDU has a positive significant relation with unit value of non-glutinous both in urban and rural household, but it has insignificant relation with glutinous unit value equations.

By dividing households into three different income groups (bottom 30%, middle 40%, and top 30%) and five different income groups (lowest 20%, low 20%, middle 20%, high 20%, and highest 20%), the estimation of share and unit value equations of non-glutinous and glutinous rice by income classes is shown in appendix table (3, 5). The result reveals that the expenditure variable has a negative significant relation with all share equations, suggesting the negative effect of expenditure on rice share. For the unit value equation, a positive significance of expenditure variable demonstrates positive effects of expenditure on quality demand. The family size variable has positive significant effects on all share equations, implying that the larger size the household has, the smaller expenditure on rice the household shares. For the effect of household size on unit value by income classes, it has insignificant effects on unit value equations of non-glutinous rice of poor and middle household equations, but it has positive significant effects on the unit value equation of rich households. The unit value equation of glutinous rice has insignificant effects on poor household equation, but it has positive significant in middle and rich households. For other variables, OCC variable has positive effects on the non-glutinous share equation of poor household, but this variable has negative significant effects on the share equation of middle and rich household. This implies that poor farm households have greater expenditure share on rice than the household with other occupations, but the middle and rich farm households have smaller expenditure share on rice than on others. For the glutinous rice, OCC variable, both in share and unit value equations has insignificant effects on rich households, but it has positive significant effects on share equation of poor household and negative effect on middle household. In both non-glutinous and glutinous rice, the EDU variable yield has negative effects on the share in all equations. Moreover, both middle and rich households reveal positive significant effects on unit value equation of non-glutinous rice, but they have insignificant effects on glutinous equation.

The estimations of non-glutinous, glutinous, and aggregated rice expenditure shares and unit values equations by regions are shown in appendix table 7. The results indicate that the variable lnX causes negative significant effect at 0.01% on the share equations of the northern, northeastern, central plain, southern, and Bangkok regions (W1, W2, W3, W4, and W5), implying that the higher expenditure or income the households of all regions have, the smaller the expense on rice they will have. Furthermore, the positive significant effects of expenditure variable (X) on all unit value equations (LnV1, LnV2, LnV3, LnV4, and LnV5), suggest that the increasing in expenditure or household income (X) tends to further increase the quality demand of Thai household of all regions. The household size, in all regions, causes negative significant effects on the share equations. This suggests that the household with bigger member tends to have smaller share of rice expenditure. However, household size has insignificant effect on the unit value equations of the northern, central plain, and Bangkok. The household head's education variable has positive significant effects on the share equation of the northern and northeastern household, implying that the higher education the household heads of the northern and northeastern obtain, the higher expense on rice they will have. In contrast, this variable has a negative significant effect on the share equation of the central plain and southern households. The variable lnX causes positive significant effects on the share equations of the northeastern, central plain, southern, and Bangkok region (W2, W3, W4, and W5), suggesting that the higher age of household heads (Age) tends to increase the expense on rice of Thai household in these regions. However, the coefficient magnitude of this variable is nearly zero both in share and unit value equations. The dummy variable of community is significant in all equations. It implies that the rural households have greater share on rice expenditure but they have lower unit value of rice.

The parameter β_1 and β_2 from the share and unit value equations are used to compute the expenditure elasticity, price elasticity, and the expenditure elasticity of quantity demand (Deaton, 1988) (Table 4.7 and 4.8).

Estimations of Rice Elasticities

Table (4.7, 4.8) shows the parameters employed for the estimation of the demand elasticities. The parameter β_2 directly demonstrates the expenditure elasticity of quantity demand. For the calculation of income elasticity of quantity demand, the parameters β_1, β_2 and W_1 are involved. On the other hand, the calculation of price elasticity of quality demand needs all parameters in table 4.7 of glutinous rice and table 4.8 of non-glutinous.

Estimations of income elasticities

The estimation results of non-glutinous and glutinous rice demand of the Thai households are equal to 0.045 and 0.038. This result shows that the consumption quantity of non-glutinous and glutinous rice has small response to the change of the household income.

Table 4.7 Estimated parameters for glutinous rice elasticity calculation

	β_1	B_2	Φ	θ_1	θ_2	w
Glutinous rice	-0.129	0.050	-0.040	-0.015	0.371	0.141
Community type						
Urban	-0.097	0.089	-0.041	-0.012	0.291	0.113
Rural	-0.150	0.062	-0.029	-0.012	0.423	0.170
Income classes						
Bottom 30%	-0.149	0.076	-0.012	-0.006	0.467	0.174
Middle 40%	-0.114	0.072	-0.024	-0.009	0.386	0.131
Top 30%	-0.082	0.039	-0.005	0.000	0.003	0.085

Source: Calculated form socio economic survey data (2002)

Moreover, the estimation of rice income elasticity which is separated by community types shows that the income elasticity of non-glutinous and glutinous rice of urban households equals to 0.05 and 0.027, respectively. For rural households, these elasticities are greater than those of rural households, whose income elasticities equal to 0.054 and 0.032, respectively. In addition, the different income among the households causes different expenditure elasticity between high income and low income households. The expenditure elasticity of non-glutinous and glutinous rice of high income households is lower than middle income and low income households. The elasticity is close to zero (Table

4.9). This result shows that non-glutinous and glutinous rice are normal goods for most of the Thai households.

Table 4.8 Estimated parameters for non-glutinous rice elasticity calculation

	β_1	B_2	Φ	θ_1	θ_2	W
Non-glutinous rice	-0.047	0.108	-0.040	-0.008	0.196	0.056
Community type						
Urban	-0.040	0.099	-0.041	-0.005	0.128	0.046
Rural	-0.058	0.089	-0.029	-0.006	0.200	0.066
3rd Income classes						
Bottom 30%	-0.058	0.082	-0.013	-0.004	0.333	0.067
Middle 40%	-0.050	0.084	-0.024	-0.005	0.225	0.057
Top 30%	-0.040	0.097	-0.005	-0.001	0.198	0.045
5th Income class						
20% Lowest	-0.628	0.065	0.166	0.084	0.504	0.710
20% Low	-0.704	0.067	0.427	0.261	0.611	0.796
20% Middle	-0.711	0.069	0.107	0.027	0.248	0.780
20% High	-0.721	0.072	0.157	0.034	0.218	0.791
20% Highest	-0.661	0.076	0.184	0.007	0.039	0.717
Region						
North	-0.821	0.075	0.759	0.641	0.845	0.989
Northeast	-0.439	0.086	0.199	0.076	0.381	0.498
Central	-0.858	0.093	-0.019	-0.005	0.262	0.983
South	-0.869	0.088	0.015	0.004	0.280	0.989
Bangkok	-0.892	0.095	0.066	0.001	0.019	0.988

Source: Calculated form socio economic survey data (2002)

The estimation of rice demand elasticity by region revealed that almost all of the rice demand elasticity is inelastic. The quality elasticity of rice demand in Bangkok is higher than other regions. The implication of this is the fact that the households in Bangkok place more emphasis on rice quality than the household in other regions. On the other hand, the income or expenditure elasticity of rice demand in Bangkok is 0.002 which is the lowest. This implies that the Thai households in this city are less responsive to the change of their income than in other regions. Furthermore, the income or expenditure elasticity demand of rice is less than 1. This indicates that rice is normal goods for the Thai household.

The income elasticity of glutinous rice of high income households is closed to zero. This result indicates that the increasing of higher household income has insignificant effects on the increasing of their glutinous rice consumption. This is because glutinous consumption of the rich households, at present, has reached the maximum. Thus, the increasing of their income will not lead to the growing number of glutinous rice consumption.

Table 4.9 Elasticity of rice quality, expenditure elasticity and price elasticity of white rice and glutinous rice

Item	Quality Elasticity of rice expenditure		Expenditure elasticity		Price Elasticity	
	White rice	Glutinous rice	White rice	Glutinous rice	White rice	Glutinous rice
Kingdom	0.108	0.050	0.045	0.038	-0.337	-0.476
Community type						
Urban	0.099	0.089	0.027	0.050	-0.242	-0.397
Rural	0.089	0.062	0.032	0.054	-0.288	-0.496
3^{rd} Income classes						
Bottom 30%	0.089	0.076	0.042	0.071	-0.396	-0.499
Middle 40%	0.084	0.072	0.035	0.054	-0.321	-0.458
Top 30%	0.097	0.039	0.026	0.000	-0.218	-0.003
5^{th} Income class						
20% Lowest	0.065	-	0.050	-	-0.386	-
20% Low	0.067	-	0.049	-	-0.283	-
20% Middle	0.069	-	0.020	-	-0.214	-
20% High	0.072	-	0.016	-	-0.175	-
20% Highest	0.076	-	0.002	-	-0.029	-
Region						
North	0.075	-	0.095	-	-0.197	-
Northeast	0.086	-	0.032	-	-0.229	-
Central	0.093	-	0.034	-	-0.268	-
South	0.088	-	0.034	-	-0.276	-
Bangkok	0.095	-	0.002	-	-0.018	-

Source: Calculated form socio economic survey data (2002)

The estimation results of quality elasticity of rice expenditure suggest that this elasticity has a positive sign both in non-glutinous and glutinous rice. It implies that when household income increases, the household tend to pay more consideration for rice quality. This elasticity of urban households is higher than rural households. Besides, the quality elasticity of rice expenditure of high income household is higher than other groups of income households. These results show that both urban and high income households have more response to rice quality than rural and low income households (Table 4.9).

Estimation of price elasticities

Most of rice price elasticities have a negative sign. Moreover, non-glutinous and glutinous rice consumers have different price elasticities of quantity demand. The price elasticity of non-glutinous is -0.476 which is greater in absolute value than glutinous rice consumers (-0.337). The urban households' price elasticity of non-glutinous and glutinous is lower than the rural households. This result implies that the rural households' rice consumption has more response to the change of rice price than the urban households (table 4.9). It is noticed that price elasticity of low income classes (-0.396 and -0.386) is greater in absolute value than high income classes both in the 3rd and the 5th income classes

The price elasticity of rice demand in Bangkok is -0.180, which is the lowest. This implies that Thai households in this city have less response to the change of rice price than those in other regions. The negative sign the price elasticity obtained is consistent with the economic principle which points out that the increasing in rice price leads to the decreasing in rice demand. This result also indicates that rice is necessary goods for the Thai households.

Moreover, the price elasticity of glutinous rice of rich households is near to zero which indicates that the change in glutinous price causes the small change in their glutinous rice consumption.

The Analysis of Domestic Rice Consumption Demand

The per capita estimation of household rice consumption demand elasticity by using cross section data as previously carried out reveals individual household rice consumption behavior, yet, it cannot explain the effects of aggregate demand to the change of price and non price factors. In order to investigate aggregate demand behavior, we have to estimate rice demand by using time series data. The time series data used for estimating aggregate demand in this section derives from OAE. during 1970-2007.

The model for estimating per capita domestic rice consumption is as follow:

$$\ln(Q/C)_t = \alpha_1 + \lambda_1 \ln PR_t + \lambda_2 \ln PW_t + \lambda_3 \ln(GDP/C)_t + u_t \quad (4.23)$$

where, ($\ln(Q/C)_t$) is the three year moving average of per capita domestic rice consumption in year t (calculated from, production – total export – feed - seed) in logarithm form, ($\ln PR_t$) is the wholesale rice price in Bangkok market in year t in logarithm form, ($\ln PW_t$) is the price of substitute goods which is represented by wheat import price in logarithm from, ($\ln(GDP/C)_t$) is national per capita income in logarithm form, and variable (D2) is dummy variable by determining that the economic crisis in period 1997-2004 equal 1 and ohers are 0.

The results obtained by using the Generalize Least Square technique to estimate the coefficient parameters in equation (4.23) are shown in Table 4.10. From the estimation result, it is found that the rice price variable has negative significant effects on per capita domestic rice consumption. The absolute value of rice price elasticity is less than 1. This indicates that rice price elasticity is inelastic.

Table 4.10 Estimation results of per capita domestic rice consumption

Variables	**Coefficients**
Constant	**2.099**
	(6.080)***
$\ln PR_t$	**-0.042**
	(-1.892)*
$\ln PW_t$	**0.022**
	(2.049)**
$Ln(GDP/C)_t$	**-0.190**
	(1.784)*
D2	**0.007**
	(1.658)*
N	37
R2 adj.	0.98
F-statistic	249.92***
D.W.	2.02

Source: calculate from Office of Agricultural Economis data, various issues

Moreover, the results obtained from the estimation of coefficient of $\ln(GDP/C)_t$ is -0.190 this indicates a negative effect of income elasticity on per capita domestic rice consumption. This result implies that the increasing of the consumer s' income leads to the decreasing of the per capita domestic rice consumption. In contrast, the wheat price variable ($lnPW_t$) shows positive significant effects on per capita domestic rice consumption, suggesting that if wheat price increases, the domestic rice consumption will also increase.

Conclusions

The consumption patterns of non-glutinous and glutinous rice in the Thai households depend upon the location of the household (urban or rural) and their income. Both non-glutinous and glutinous rice are consumed more by rural and low income household than urban and high income household.

The income elasticities of non-glutinous and glutinous rice have a positive sign and are close to zero. Moreover, the magnitude of price elasticity declines if household income decreases or the community becomes urbanized. This study found that most Thai households respond to rice quality. However, urban households with high income will consider more on rice quality than rural households with low income.

Besides, the extension of a city has changed household consumption behaviors. City households have turned to consume more meat and bread instead of rice. For this reason, the more urbanization can bring about the decreasing in per capita rice consumption demand. However, if the population of the country increases, rice consumption demand in the country has a tendency to increase.

The price elasticity of non-glutinous of Thai households is lower than glutinous rice. Because of this, glutinous rice will be more responsive to the change in price than non-glutinous rice. This implies that non-glutinous is more necessary goods for the Thai household than glutinous rice.

The estimation of the elasticities of per capita domestic demand for rice availability indicate that the growth of per capita income and rice price cause decreasing of domestic rice availability demand.

CHAPTER V

THE FUTURE OUTLOOK OF RICE SUPPLY, DEMAND AND EXPORTABLE SURPLUS

Characters and components of factors affecting an expansion or shrinking of rice production supply and demand were explained in chapter 3 and 4 which reveal that in an aspect of supply the expansion or shrinking includes not only the price factor but also other factors i.e. an expansion of irrigated areas, an investment for rice research as well as prices of other related crops. While an aspect of demand, apart from rice price, a factor of consumers' income, occupation, and education is important to the changing in consumption behaviors of a household. In order to oversee a tendency of the future production, consumption and export, this chapter will use a principle of growth accounting model to forecast in various assumptions regarding different changes of factors influencing on rice supply and demand that occur at the time of this study until 2025.

Future Rice Supply

Rice supply projection is determined by simultaneous system of acreage and yield response equation. Since rice is nested in the crop system, the rice acreage response is jointly estimated with other crop share, implying an interaction effect of production resources and crops as well as input price in a mix crop system. In contrast, a rice yield response function is independently estimated from other crop yield.

Growth Accounting Model and Policy Variables

Base on significant affects of independent variables on rice yield and acreage, the growth model of rice supply in this study can be demonstrated as the following equation (5.1)[20]

$$\frac{\hat{Q}}{Q} = e_{QPR}\frac{P\hat{R}T}{PRT} + e_{QPE}\frac{P\hat{E}}{PE} + e_{QPF}\frac{P\hat{F}}{PF} + e_{QPOWT}\frac{POW\hat{T}}{POWT} + e_{QRAIN}\frac{R\hat{A}IN}{RAIN} + e_{QIRR}\frac{I\hat{R}R}{IRR} + e_{QRES}\frac{R\hat{E}S}{RES} \quad (5.1)$$

Where

$\hat{Q}/Q$	=	growth of quantity rice supply,
$P\hat{R}T/PRT$	=	growth of real paddy price index,
$P\hat{E}/PE$	=	growth of real energy crops price index,
$P\hat{F}/PF$	=	growth of real fertilizer price index
$POW\hat{T}/POWT$	=	growth of number of power tiller per household
$I\hat{R}R/IRR$	=	growth of irrigated area per cultivate area,
$R\hat{E}S/RES$	=	growth of real agricultural research budget

E_{QPR}	=	elasticity of rice supply for its owned price,
E_{QPE}	=	elasticity of rice supply for energy crop price,
E_{QPF}	=	elasticity of rice supply for fertilizer price,
E_{QPOWT}	=	elasticity of rice supply for number of power tiller per household,
E_{QRAIN}	=	elasticity of rice supply for rainfall condition,
E_{QIRR}	=	elasticity of rice supply for irrigated area,
E_{QRES}	=	elasticity of rice supply for agricultural research budget

[20] Isvilanonda, S. and N. Poapongsakorn. 1994. "Rice supply and Demand in Thailand: The Future Outlook".

The long-run elasticities of rice production supply are shown in Table 5.1 were used to calculate the future of rice production supply.

Table 5.1 Estimated price and non-price elasticities for projected rice supply

Elasticities	Long-run
Rice price	0.319
Irrigated area	0.232
Research budget	0.331
Rainfall condition.	-0.181
Energy crop price	-0.131
Fertilizer price	-0.334
Quantity of power tiller	0.165

Source: calculate from OAE. Data, various years

The elasticity showing in Table 5.1 demonstrates a direction of impact on both price and non-price factors toward the total rice production supply. Such elasticity indicates that factors toward a positive impact are paddy price, irrigated areas, a government rice research budget and a proportion of a power tiller per household while factors toward a negative impact are variables of variance of annual rainwater quantity, energy crop price and chemical fertilizer price.

Table 5.2 Growth assumptions used for projected rice supply

Factors	Scenarios		
	A	B	C
Rice price (+)	4.5	5.0	7.0
Irrigated area (+)	1.0	-1.0	2.0
Research budget (+)	1.0	0.5	2.0
Rain STD.(-)	2.0	4.0	4.0
Energy crop price (-)	4.3	6.3	6.3
Fertilizer price (-)	5.3	7.3	7.3
Quantity of power tiller(+)	4.9	6.9	6.9
Growth of rice supply (%)	**0.11**	**-1.32**	**0.51**

In estimating a growth rate of rice production supply, from the time of this study until 2025, three scenarios are determined. The determination on scenario A, a base case, is by having the changes of related factors being the average of an annual growth rate of each factor during the past 7 years (2000-2007). The result shows an increasing of 0.11% of an annual growth rate of the rice production (Table 5.2).

Scenario B, a worse case, is determined for a case that does not support an increasing of rice production supply. The determination is (1) the annual growth rate of real rice price setting equal 5.0% which is a result from an abolishment of the paddy pledging program. Therefore, the domestic rice price will have a growth rate lower than the rates of other crops. (2) energy crop price is determined to be 6.3% higher than the one in scenario A due to an increasing of a bio-energy demand to substitute an ongoing higher price of petroleum (3) chemical fertilizer price is determined to be higher than the one of scenario A since its cost has to be in line with the petrol price which is annually growth 7.3% higher (4) the annual growth rate of the variance of annual rainwater quantity is determined to be 4% higher owing to the instable conditions of climate as well as a problem of global warming (5) the government intention in rice research investment is determined to be very low with an annual growth rate is only 0.5% (6) an opportunity in a new improvement of an irrigation project is determined to be minimized due to a limitation of a landscape along with a water supply and at the same time existing irrigated areas are substituted by the cultivation of other crops as well as habitats of an urbanization resulting in 1% declining of irrigated areas for rice farming (7) farmers are determined to use higher number of farm machineries than that in scenario A. where an growth rate of utilization is 6.9% annually. Scenario B shows that a growth rate of rice production reduces 1.32% annually (Table 5.2).

Scenario C is a case determining for a continuously declining of rice supply in the world market as a result of the decreasing of the world rice production which causes from an impact of global warming. Moreover, a rice area is substituted by energy crop farming. (1) rice price is determined to increase 7% yearly (2) annual energy crop price is determined to be 6.3% higher, the same as scenario B (3) an annual growth rate of chemical fertilizer is determined to be 7.3% higher, the same as scenario B (4) the variable of variance of annual rainwater quantity is determined to be 4% higher, again, the same as scenario B (5) the rice research investment is determined to be at a high level with an annual growth of 2% (6) irrigated areas used for rice farming is determined to have 2% growth rate, (7) farmers are determined to use more farm machineries by having an annual growth rate of 6.9% which is a result from an increasing of agricultural labor wages rate. Scenario C shows that an expansion rate of rice production growth 0.51% yearly (Table 5.2).

Trends of the Total Rice Production Supply in 2025

This is to illustrate the tendency of the total rice production for the year 2025 based on Thailand agricultural statistic 2007 of 29.5 million tons for paddy rice production. Utilizing this information as a base for a tendency assumption, it is found in scenario A, a base case where the changing behaviors of all related variables are normal, that rice production in 2010,2015,2020,2025 is estimated to be 29.69, 29.86, 30.02 and 30.19 million tons respectively (Table 5.3)

Table 5.3 Projection of paddy rice production under different growth assumptions

Years	Quantity of Milled Rice Production		
	A	B	C
2007	29,592,379	29,592,379	29,592,379
2010	29,691,476	28,435,489	30,047,455
2015	29,857,375	26,606,969	30,821,521
2020	30,024,202	24,896,030	31,615,527
2025	30,191,961	23,295,112	32,429,988

Source: by calculating

Scenario B, a worse case where rice price declines while other crops price as well as fertilizer price increases but an irrigated area and a government rice research budget decrease, shows the rice production in 2010,2015,2020 and 2025 at 28.44, 26.61, 24.90 and 23.29 million tons respectively (Table 5.3).

Scenario C, a case when the growth rate of rice price, irrigated areas and a government rice research budget more than scenario B whereas a growth rate of energy crop price, variance of rainwater quantity and chemical fertilizer price is the same as scenario B, shows that the rice production in 2010, 2015, 2020 and 2025 as 30.05, 30.82, 31.62 and 32.43 million tons respectively (Table 5.3).

It can be concluded that the country rice supply tends to decrease in the worse case (scenario B) while in a base case (scenario A) and in the most favorable case (scenario C), it is bound to continuously increase.

Future Domestic Rice Consumption Demand

The process on the rice consumption demand projection is somewhat different, particularly when it depends on the nature and pace of economics, population, price growth and the changing pattern of household rice consumption demand. In forecasting the consumption growth, the past information on rice consumption demand, rice price, population, and GDP are used in fitting the rice aggregate demand equations. The estimated coefficients from the consumption demand analysis are employed in a calculation of the consumption growth.

Domestic Demand Growth

The growth in domestic rice demand is considered to be driven primarily by various growths of population, income, and commodity prices which can be demonstrated as follow:

$$D_g = \varepsilon_{qi}(INC_g - POP_g) + (\varepsilon_{qpr} * PR_g) + (\varepsilon_{qpw} * PW_g) + POP_g \qquad (5.2)$$

where

D_g	=	growth of domestic rice demand,
INC_g	=	growth of real income,
PR_g	=	growth of consumer purchased price for milled rice,
PW_g	=	growth of consumer purchased price for wheat
POP_g	=	growth of population growth,

E_{qi} = income elasticity of domestic rice demand,

E_{qpr} = price elasticity of domestic rice demand

E_{qpw} = price elasticity of domestic wheat demand

The determination on a growth rate of variables using in the tendency forecast of domestic rice demand is the growth rate of the national population, income and milled rice price. The tendency on a growth rate of population is obtained from information of the population forecast calculated by the Office of National Economic and Social Development Board (2007). The tendency on a growth of rice price is determined into 3 scenarios, the same as the growth of paddy rice price in the assumption of rice production supply showing in the previous topic.

The tendency of a growth rate for income is by using the growth of the national GDP. However, a forecast on the tendency of the future GDP of 10-15 years cannot be accurate due to an involvement of various risk factors i.e. economic, social, political, and other conditions. Therefore, the determination on the trend of a growth rate for income is within 3 choices of normal, low and high rates.

Table 5.4 Estimated price and non-price elasticities for projected rice consumption in Thailand

	Per capita Rice Consumption Elasticities
Rice price	-0.042
Income	-0.190
Wheat price	0.022

Source: by calculating

A calculation of the tendency of domestic rice consumption demand is by using information of elasticity obtaining from a calculation of the per capita rice consumption demand showing in table 5.4. Since information of the overall quantity of rice consumption demand is limited as it is unable to distinguish the demand based on community character or regional consumption, an analysis on the tendency is therefore limited only on the overall quantity of rice consumption demand.

The determination of the tendency of a population growth is conducted by using information on the forecast of the population trend of the Office of National Economic and Social Development Board (2007) which showing an expansion of 0.82% during 2007-2015 and 0.55% during 2016-2025. On the other hand, the tendency of a growth rate of rice price along with a growth of income is determined into 3 choices, the same as the determination on a growth rate of paddy rice using in the forecast of a rice production supply. That is, in scenario A, the determining of a normal growth leads to a price growth rate of 4.5% and a growth rate of 5% for GDP during 2007-2015 which reduces to 4.0% during 2016-2025. Scenario B is determined with a situation of economic shrinking resulting in 5% increasing of a price growth rate and a small growth rate of 3.00% for GDP during 2007-2015 which further reduces to 2.5% during 2016-2025. Meanwhile, scenario C is determined to a situation of a growing economic growth rate resulting in the tendency of 7% up for rice price and 7% for a growth rate of GDP during 2007-2015, but, reduces to 6% during 2016-2025. As for a growth of imported wheat price in each scenario, it is determined to move to the same direction and the same size of a growth rate of rice price (Table 5.5). The aforesaid scenarios of all determinations are utilized for a calculation along with the consumption demand elasticity with respect to income and price showing in Table 5.4, the result is the growth of rice consumption of the entire national population.

A growth rate of milled rice consumption of the national household is illustrated in table 5.11. It shows that an expansion rate under scenario A, B, and C is -1.03%, -0.364% and -1.73% during 2007-2015 and -0.98%, -0.41% and -1.68% during 2016-2025 (Table 5.5). This rate will be used for the next estimation on the trend of rice consumption.

Trends of the Domestic Rice Consumption in 2025

Upon calculating the elasticity in Table 5.4 together with an growth rate of rice consumption demand, the result is a quantity trend of domestic rice consumption demand, as shown in Table 5.6. It shows that in scenario A the domestic milled rice demand decline from 7.98 million tons in 2007 to 7.72, 7.32, 6.97 and 6.63 million tons in 2010, 2015, 2020 and 2025 respectively. Scenario B is a slightly declining number of the domestic milled rice demand from 7.98 million tons in 2007 to 7.89, 7.74, 7.55, and 7.36 million tons in 2010.2015,2020 and 2025 respectively. On the other hand, scenario C is a declining number of the domestic milled rice demand from 7.98 million tons in 2007 to 7.54, 6.88, 6.29 and 5.76 million tons in 2010, 2015, 2020 and 2025 respectively (Table 5.6).

Table 5.5 Growth assumptions used for projected rice consumption demand

Items	**SCENARIOS**		
	A	**B**	**C**
	2007-2015		
Rice price	4.5	5.0	7.0
Income	5.0	3.0	7.0
Wheat price	4.5	3.0	7.0
Population	0.82	0.82	0.8
Growth of Rice Demand per annum	**-1.03**	**-0.364**	**-1.734**
	2016-2025		
Rice price	4.5	5.0	7.0
Income	4.0	2.5	6.0
Wheat price	4.5	3.0	7.0
Population	0.55	0.55	0.55
Growth of Rice Demand per annum	**-0.98**	**-0.494**	**-1.684**

Source: by calculating

Table 5.6 Projection of domestic milled rice consumption under different growth assumptions

Year	**Scenarios**		
	A	**B**	**C**
2010	7,723,367	7,885,387	7,544,428
2015	7,318,915	7,735,534	6,875,417
2020	6,967,249	7,546,345	6,294,509
2025	6,632,480	7,361,783	5,762,682

Source: by calculating

The Projection of Rice Exportable Surplus

Knowledge of future rice supply and demand will be held to predict the domestic rice balance for policy implication. Given a small amount of seed (5% of total rice production) and feed industrial uses (3.15% of total rice production), the balance will mostly be for an export. In this projection the rice supply (in term of paddy) is converted to be milled[21] calculation of the exportable surplus.

Table 5.7 Projection rice supply-demand balances (in term of milled rice) under different growth assumptions

Year	Scenarios		
	A	B	C
2010	10,003,186	9,091,311	10,394,654
2015	10,506,684	8,149,491	11,525,801
2020	10,957,950	7,317,207	12,580,751
2025	11,392,875	6,545,981	13,598,832

Source: by calculating

In a normal situation (scenario A of both supply and demand), it is found that, in 2010, the quantity of rice production in a form of milled rice is 10.0 million tons more than the quantity of the national requirement. The number increases respectively to 10.51, 10.96, and 11.39 million tons in 2015, 2020 and 2025 (Table 5.7).

In the worse case, that is, when a level of rice price supply shows a low growth rate but the rate of energy crop price as well as chemical fertilizer price is high. Also, the government intention in a rice research investment and a development of irrigation projects are very low (scenario B on supply) whereas demand is assumed to have a low growth rate of rice price to be in line with a change of the supply price and the national economy is low growth rate resulting in the same rate of people's income (scenario B on demand). It illustrates from these situations that the quantity of milled rice production in 2010 is 9.09 million tons more than a domestic demand. Yet,

[21] Using 1 ton of paddy equivalents to 0.65 tons of milled rice.

the number reduces to 8.15, 7.32 million tons in 2015, 2020 and in 2025 the number of exportable milled rice production will be down to 6.55 million tons

The determination on conditions of factors for demand and supply under the worse case (scenario B) indicates that although the quantity of rice production is still higher than a domestic requirement but it is tend to a declining path. This is because in this scenario rice price is set to be low while competitive crop price and input factor are high. Also, when adding an increasing number of the population; economic recession; lower tendency of household revenue; a higher rice proportion of a household consumption and a reducing proportion of other food consumption, the surplus of rice production quantity in scenario B is lesser than other scenarios.

As for a favorable situation, that is when rice price continuously increases and the government simultaneously pays a lot of attention to an investment in rice research while irrigated areas are accordingly expanding (scenario C on supply) whereas demand is assumed to have better growth on rice price as well as the same growth of supply (scenario C on demand). It is found in these situations that the quantity of milled rice production in 2010 is 10.39 million tons higher than a domestic requirement. The number goes up to 11.26, 12.58 million tons in 2015, 2020 while the surplus of the domestic milled rice production in 2025 will be as high as 13.59 million tons (Table 5.7).

The determination on conditions of factors for demand and supply under the baseline and the most favorable situation (scenario A and C) reveals that although the quantity of rice production exceeds a domestic requirement and leading toward a rising direction but the increasing is because of higher rice price and the government policy in supporting more activities on rice farming. There are the increasing in a rice research budget and the development on an irrigation system while a domestic requirement for rice consumption tends to decline due to a high growth of economic situations making a household gain higher income that they substitute rice with bread, vegetables, fruits and meat and subsequently a proportion of rice consumption per household decreases. The result is a declining tendency of the quantity of domestic rice consumption.

A question of what direction a change of the future surplus rice supply will lead to depends on a price situation of the rice and related goods as well as an input price which in this study is chemical fertilizer price. Moreover, there is non price factor which includes the government rice research investment and a development on an irrigation system which are important parts of the rice supply increase or decrease.

It can be concluded that Thailand rice production supply in 2025 bounds to decline in scenario B, the worse case, while the base case (scenario A) and the favorable case (scenario C) tend to continuously increase. On the other hand, its demand reveals that the quantity of a domestic rice requirement in 2025 tends to decline in all scenarios it is due to an ongoing growth of the national economy making people's income higher that their consumption turns to rice substitution. The tendency of the quantity of national milled rice consumption demand in 2025 is between 5.76-7.36 million tons. Of course, the number in reality will mainly depend on a changing situation of price, household's income and the number of population.

Upon gathering the situations of both demand and supply, it is found that in the base case (scenario A), the number of exportable milled rice supply in 2025 increases approximately 11.39 million tons. Hence, if the government slows down its investment on rice research as well as an irrigation system whereas energy crop price keeps on increasing, the quantity of exportable rice supply is sharply down as shown in scenario B (the surplus quantity is only 6.55 million ton of milled rice).

Obviously, the changing in a production method from a conditional to a commercial production, farmers increase their response toward changes on an economic condition. The compared profit margin in a form of cash plays an important role in the household decision for more production investment. Of course, this is not only because rice is a major source of income for most farmers but it is also a main dish of the country. Maintaining a level of rice production by assuring sufficient quantity for the domestic consumption is the concern of the government. Establishing a suitable agricultural policy must therefore correlate with the changing trend both in price and non-price factors determining the future supply.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The green revolution that began in the 1960s has driven the growth of Thai rice production. It contributed to the country's becoming the biggest rice exporter in the world for more than 20 years. The major technological impetus from the green revolution came from the development of modern high yielding varieties (HYVs) with shorter maturity than the traditional rice varieties.. The modern rice varieties however required more water and fertilizer so that the government had to modernize the country's irrigation system. However, geographical constraints and low water supply put a limit to the expansion in irrigated area. Today, irrigated rice lands make up only about 20 % of the total rice farming area. This also limited the expansion in the area planted to modern rice varieties. Since 2000, rice output has been shrinking at approximately 1% per year, driven among others by the shift from rice to more profitable crops. The trend in cultivating other crops in rice areas is expected to accelerate. This is now compounded by urbanization, which means more rice lands being converted to residential or commercial purposes.. To make up for the loss of production area as well as to overcome the limitation in irrigated areas, the alternative is to raise production by developing new rice varieties that yield higher than the present varieties, especially varieties that can provide higher yield in a rainfed environment. Otherwise, Thai rice production will inevitably decline with the shrinking area cultivated to rice

The driver of change from rice to other crops is profitability; farmers choose to cultivate any crop that they expect will provide the highest economic return. During the past 20 years, the price of rice has steadily declined as a result of an increasing world supply, which was one of the results of the green revolution. The declining rice price made farmers turn to other crops, particularly those that would give them higher returns than rice. A consequence was the reduction in the area grown to rice.

The decreasing availability of arable land will intensify competition in land use between rice and other crops. At present, even if the price of rice is increasing, that of competitive crops especially energy crops, is also rising because of an increasing demand for energy crops. Moreover, the government has increased its support for the expansion of energy crop areas under the national strategy to develop alternative energy sources.

The lack of clarity of the national rice policy has been exacerbated by the government having transformed the paddy pledging program into a price support scheme. This distortion could weaken the rice marketing system by destroying the private market mechanism. An intervention in the market mechanism through a rice guarantee price may give short term benefits to farmers by enabling to sell at a price higher than the market price. However, when this policy is abolished a strong possibility as the government has sustained the loss of billions of Baht from the paddy pledging policy the negotiating power of farmers in the rice market will be considerably weakened because of the destruction of the private market system. This will lower the efficiency of rice production as well as the entire national rice industry, further reducing the profitability of rice compared with other crops. This would also affect the production structures of rice and other crops by reducing rice cultivated area. Rice being a staple food of the people and a major export commodity of the country, its declining production will impact on the national food security as well as national income. In order to guarantee such security and maintain the country’s share in the world markets, there is need to forecast changes in the future rice production and determine the future of its surplus when there is a change on the price and non-price factors. The result would benefit to the formulation of a national rice policy so that all concerned sectors can adjust and mitigate the negative impacts.

This research examined the impact of price change and of price and non-price factors, on the changes of rice farming areas and rice production. It also estimated the tendency of rice production surplus in the next 15 years.

The following conclusions can be derived from the findings:

1. **There will be changes in the structure of Thai agricultural production** because of the limitation of agricultural lands and the fact that farmers are prohibited by law to convert forest lands to agricultural purposes. The decreasing availability of arable land will intensify the competition for land resources between agricultural and non-agricultural users. This will likely further reduce the area grown to rice. Moreover, the rising price of fossil fuel has already increased the price of input factors especially chemical fertilizer, which has been rising rapidly. As fertilizer is an important factor the cost of rice production has also increased. The increase in petrol price also gave impetus to the development of alternative energy sources. One of the more popular alternative sources are bio-fuels derived from food and energy crops i.e. corn, cassava and oil palm. Subsequently, the demand for these crops has increased rapidly along with their price. The study indicates that the increasing price of energy crops has resulted in the expansion of areas grown to these crops and the reduction in the areas devoted to other crops including rice. If this trend continues, much of the land now under rice cultivation will likely be planted to energy crops.

2. **The structure of Thai rice farming is in a period of transition.** This is a result of the green revolution; it required the development of an irrigation system, development and adoption of HYVs and the accompanying farming technology to grow them, and the increase in rice output per unit area. The new practices included cropping intensification from wet season rice crop only to two crops a year on irrigated land. The problem is, lately, irrigated rice areas are planted solely to modern rice varieties that they cannot be expanded for any additional dry season rice farming. The development of a two-crop-a-year rice farming technology in flood-prone area has become the main factor in expanding the area for dry season rice cultivation. All these changes have steadily increased national rice production. In the future, however, it will be difficult to expand the irrigated areas owing to the limitation in arable land, water supply and the limited area under irrigation. This situation is pointing to an end of the effects of the green revolution on national rice production.

The fading of the effects of the green revolution in the national rice production along with a shrinking rice area, shortage of agricultural labor force, increasing production cost particularly from higher cost of chemical fertilizer, as well as strong competition in the world rice market will have a severe impact on the Thai rice industry. Past increases in technical and economic efficiency in rice production were largely the result of the green revolution technologies and farm mechanization. For the immediate future, the national innovation system for agriculture will need to urgently develop new sets of more efficient technology to replace the aging technologies from the green revolution era

3. Any chances to increase rice supply in the country: The question as to which direction the national rice production will go can be answered by the following factors:

3.1. Output price factor: This factor includes the prices of rice, energy crops, oil palm fresh fruit, rubber and other crops. Although the total supply from rice production responding to the rice price is higher than that of other crops, the price of energy crops has an important influence on the reduction of rice production supply. In the short term, energy crop price may not show much effect on rice production supply but over the long term, as farmers gradually adjust their production system to energy crops, the increasing energy crop price will have a greater impact on the change of rice production supply.

Wet season rice production will be more adversely affected than dry season rice by the increasing price of energy crops. This is indicated by the greater response of the supply from wet season rice production to energy crop price, in both the short and long terms than that of the dry season rice. In fact the dry season rice supply showed no response. The reason is that all energy crops used in the equations were normal crops that are cultivated in rainfed environment. Therefore, if energy crop price is high, farmers will grow energy crops in the wet season instead of rice because they obtain higher returns. This conclusion is supported by a study on the response of the regional rice production supply. The results showed that only the rice production supply in the north and northeast where most rice farms are rainfed responded to energy crop price while the supply in the central plain and the south did not.

It can be concluded that wet season rice production supply will be affected more by the increasing price of energy crops (i.e maize and cassava) while dry season production supply will be affected by the increasing prices of oil palm and other crops. This situation will persist in the long term if the profitability of rice farming continues to be lower than that of other crops.

3.2. Input price factors: This factor includes the price of chemical fertilizer and wage rate for labor. It is found that the increasing price of chemical fertilizer causes a reduction in rice production supply but labor wage rate does not show any influence on supply. This can be explained by the fact that when this study was carried out, farmers had replaced manual labor with farm machinery.

The spike in the price of petrol (which occurred during the study period) caused the price of chemical fertilizer and fuel to rise, which inevitably impacted on the country's rice production because of higher production cost.

3.3. Government investment in the development of rice production technology: This factor includes the investment in irrigation and funding for research on rice variiety. It is found that investing on the improvement of irrigated areas and on research on rice variety would support an increasing rice production supply in the long term.

3.4. Irregularity of climatic conditions affecting rice production: Erratic rainfall patterns have, as would be expected, adversely affected production because about 70% of the country's rice areas are in rainfed environment. The variable used to represent weather irregularity is the variance of annual rainwater quantity; it was shown that the wider the variance the more unstable the weather is. Accordingly, production fluctuates.

It can be seen that the positive factors on rice production are an investment in rice research, the price of rice, area under irrigation, and the number of units of farm machinery per household. The factors with the greatest influence are investment in rice research, rice price, and the extent of irrigated areas. This shows that the price factor has weaker influence than the non-price factor. The negative factors are unstable climatic conditions, energy crop price and chemical fertilizer price.

4. Increasing demand from an increasing population. It is found that households of higher income and urban consumers tend to consume less rice; As a household's income rises it tends to spend more on other food items such as. meat, vegetables and fruits. This reduced the rice consumption per household of higher income and urban households to a lower level than those of lower income and rural households. Per capita income in Thailand as well as urbanization have been rising. This has also led to a decline in rice consumption from 119 kilograms/year/person in 1990 to 101 kilograms in 2002 (35% of the consumption was of glutinous rice). During the past ten years the quantity consumed of both glutinous and non-glutinous rice decreased in the same proportion.

An analysis of the response of household rice demand to its own price reveals that household consumption of glutinous rice responds higher than that of non-glutinous rice. The other response behavior is that as a household's food expenses increase, it also increases its expense on rice consumption, but in a diminishing proportion. Rice consumption of urban households respond less to the change in total food expenses than the rural households. Similarly, the household rice consumption demand of high income families shows less response to the change in the total food expenses than lower income families. As household income increases and urbanization grows, domestic rice consumption will expand slowly and more high income families will tend to consume higher quality rice.

5. The trend in exportable rice supply. The difference in the country rice production and the trend in its consumption shown that, under normal condition, the production of milled rice will increase from 19.23 million tons (or 29.59 million tons paddy rice) in 2007 to 19.62 million tons (approximately 30.19 million tons paddy rice) in 2025. But if chemical fertilizer price or energy crop price increases and irrigated areas and rice research budgets shrink, the supply of milled rice production supply will be further reduced to 15.14 million tons (or 23.29 million tons paddy rice). On the other hand, in a normal situation, the consumption of domestic milled rice will increase from 9.2 million tons (or 13.9 million tons paddy rice) in 2007 to 6.63 million tons (or 10.05 million tons paddy rice) in 2025. In such a normal situation, the surplus of milled rice supply will increase from 10.3 million tons in 2007 to 11.39 million tons in 2025. However, if chemical fertilizer and energy crop prices remained high and the irrigated area and rice research budget declined, the surplus rice supply will decline (scenario B).

Recommendations

The study clearly indicates that the country's exportable rice supply will be declining through 2025 in the least favorable situation. In the short run, exportable supply will increase if rice price increases. A long-term increase however will depend on an increase in irrigated rice area and investment in rice research.

There is a need to increase exportable rice supply and to maintain the country's presence in the export markets. Just as important is the need to ensure domestic food security. Both objectives have to be achieved under the pressure of increasing input prices. The study shows that the pathway to pursue these objectives is the intensification of government support for research and technology development that will enable farmers to reduce their production cost and the Thai rice industry to increase its competitiveness in the world market. This will be more beneficial to the national rice industry in the long term.

The expansion of the irrigated area will be constrained by the growing scarcity of arable land and diminishing water supply. Increasing production by expanding dry season rice farming area will be difficult as well. Under these constraints, the government will need to develop innovations including higher quality rice varieties that will increase the productivity of rainfed environments. Research to develop new higher yielding varieties of premium quality and develop production technology that increases efficiency would increase supply, reduce production cost and improve Thailand's competitiveness in the international rice market. Domestic consumers would benefit from the availability of higher quality rice at a lower price, farmers would obtain better economic returns from lower production cost, and the government does not have to spend (and lose) large sums of money to intervene in the market to help farmers. The other desirable result is that rice farming might regain its competitiveness over energy crop farming. This will help slow down the decline in rice production.

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APPENDICES

Appendix A
Estimated Result Tables

Appendix Table A 1 Estimated results of share and unit value equations by rice species

Variables	Non-glutinous Rice		Glutinous Rice		Aggregated Rice	
	W1	LnV1	W2	LnV2	W3	LnV3
Constant	1.050	1.24	0.808	1.350	1.174	1.713
	(133.5)**	(34.97)**	(67.9)**	(34.17)**	(61.3)**	(26.4)**
LnX	-0.047	0.108	-0.129	0.050	-0.106	-0.075
	(120.4)**	(36.34)**	(-103.7)**	(30.7)**	(-53.2)**	(-11.2)**
LnZ	-0.024	0.031	-0.021	0.022	-0.036	-0.031
	(-33.7)**	(9.23)**	(-34.9)**	(6.01)**	(-20.8)**	(-5.21)**
EDU	-0.0005	0.002	-0.0005	0.002	-0.001	0.0006
	(-13.5)**	(10.43)**	(-14.5)**	(9.63)**	(-9.31)**	(1.83)ns
OCC	0.027	-0.059	0.012	-0.07	0.017	-0.024
	(28.4)**	(-13.97)**	(12.3)**	(-13.4)**	(10.3)**	(-4.05)**
R^2	0.41	0.08	0.36	0.07	0.34	0.02
F	6,112**	707**	4,137**	538**	1,162**	56.6**
Df	34,780	32,827	29,145	27,122	34,780	32,827
of cluster .No	3,639	3,446	3,471	3,446	3,639	3,446

Note: * is significant at 90 %, ** is significant at 95 %

*** is significant at 99 %, (..) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 2 Estimated results of share and unit value equations of non-glutinous rice by community types

Variables	Urban		Rural	
	W1	LnV1	W2	LnV2
Constant	0.593	1.541	0.921	1.152
	(62.32)**	(19.99)**	(66.80)**	(23.5)**
LnX	-0.040	0.099	-0.058	0.89
	(-56.26)**	(14.06)**	(-59.2)**	(15.09)**
LnZ	-0.011	0.019	-0.028	0.023
	(-14.07)**	(2.907)**	(-22.23)**	(3.83)**
EDU	-0.0003	0.002	-0.0007	0.0023
	(-8.26)**	(4.06)**	(-8.47)**	(6.15)**
OCC	0.012	-0.048	0.006	-0.041
	(4.92)**	(-2.55)**	(4.75)**	(-6.62)**
R^2	0.30	0.03	0.31	0.05
Df	10,167	9,029	10,369	10,056
of cluster .No	1,059	1,059	1,456	1,456

Note: * is significant at 90 %, ** is significant at 95 %

*** is significant at 99 %, (..) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 3 Estimated results of share and unit value equations of glutinous rice by community types

Variables	Urban		Rural	
	W	lnV	W	lnV
Constant	1.029	1.655	1.28	1.834
	(36.97)**	(16.06)**	(37.35)**	(17.33)**
LnX	-0.097	0.089	-0.150	0.062
	(-31.5)**	(7.58)**	(-32.5)**	(5.65)**
LnZ	-0.034	0.039	-0.034	0.019
	(-13.75)**	(4.28)**	(-11.2)**	(1.98)*
EDU	-0.001	-0.0001	-0.001	0.0003
	(-7.45)**	(-0.181)^{ns}	(-3.56)**	(0.462)^{ns}
OCC	0.015	-0.021	0.011	-0.017
	(5.85)**	(-2.17)**	(4.24)**	(-2.112)*
R^2	0.30	0.20	0.26	0.11
F	410.9**	20.1**	342.1**	11.7**
Df	3,831	3,831	3,983	3,983
No. of cluster	423	423	546	546

Note: * is significant at 90 %, ** is significant at 95 %

*** is significant at 99 %, (..) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 4 Estimated results of share and unit value equations of non-glutinous rice by income classes

Variables	Low income 30%		Middle income 40%		High income 30%	
	W	lnV	W	lnV	W	lnV
Constant	1.025	1.84	0.791	1.638	0.561	1.283
	(43.58)**	(20.43)**	(67.74)**	(23.79)**	(55.77)**	(13.57)**
LnX	-0.058	0.082	-0.050	0.084	-0.040	0.097
	(-38.94)**	(7.73)**	(-62.6)**	(14.16)**	(-50.94)**	(14.42)**
LnZ	-0.027	-0.006	-0.019	-0.01	-0.016	0.03
	(-12.89)**	(-0.72)^{ns}	(-18.62)**	(-1.64)^{ns}	(-17.79)**	(3.47)**
EDU	-0.001	-0.0005	-0.0006	0.002	-0.0003	0.001
	(-8.99)**	(-0.86)^{ns}	(-12.83)**	(6.32)**	(-8.04)**	(4.41)**
OCC	0.014	-0.052	-0.006	0.06	-0.012	0.079
	(6.62)**	(-6.62)**	(-5.02)**	(9.23)**	(-6.51)**	(4.77)**
R^2	0.28	0.03	0.33	0.05	0.29	0.04
Df	6,158	5,732	14,782	13,743	8,199	7,711
of cluster .No	2,353	2,181	3,285	3,246	2,610	2,583

Note: * is significant at 90 %, ** is significant at 95 %

*** is significant at 99 %, (..) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 5 Estimated results of share and unit value equations of glutinous rice by income classes

Variables	Low income 30%		Middle income 40%		High income 30%	
	W	lnV	W	lnV	W	lnV
Constant	1.201	2.079	1.122	1.601	0.915	1.144
	(30.04)**	(17.14)**	(34.7)**	(13.68)**	(23.87)**	(8.50)**
LnX	-0.149	0.076	-0.114	0.072	-0.082	0.039
	(-25.81)**	(3.19)**	(-31.19)**	(7.24)**	(-21.49)**	(5.58)**
LnZ	-0.032	-0.005	-0.032	0.048	-0.029	0.046
	(-9.28)**	(-0.51)ns	(-10.47)**	(4.29)**	(-7.93)**	(2.76)*
EDU	-0.002	0.0002	-0.0008	0.0009	-0.001	0.0004
	(-5.01)**	(0.248)ns	(-5.22)	(1.48)ns	(-6.51)**	(0.706)ns
OCC	0.020	-0.013	-0.013	0.026	-0.007	0.21
	(7.19)**	(-1.636)ns	(-5.18)**	(2.88)**	(-1.38)ns	(0.855)ns
R^2	0.21	0.006	0.24	0.08	0.34	0.03
F	227.4**	6.39**	351.4**	20.0**	177.3**	10.3**
Df	3,427	3,427	4,353	4,353	1,404	1,404
No. of cluster	928	928	1,101	1,101	690	690

Note: * is significant at 90 %, ** is significant at 95 %

*** is significant at 99 %, (..) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 6 Estimated results of share and unit value equations of non-glutinous rice by five income classes

Variables	20% LOWEST		20% LOW		20% MIDDLE		20% HIGH		20% HIGHEST	
	W1	LnV1	W2	LnV2	W3	LnV3	W4	LnV4	W5	LnV5
Constant	0.489	-0.049	0.525	-0.020	0.666	-0.043	0.716	-0.084	0.669	-0.057
	(14.51)	*(-4.01)*	*(15.25)*	*(-1.51)*	*(19.97)*	*(-3.12)*	*(17.60)*	*(-5.76)*	*(17.13)*	*(-3.40)*
LnX	-0.628	0.065	-0.704	0.067	-0.711	0.069	-0.721	0.072	-0.661	0.076
	(-25.70)	*(5.09)*	*(-27.16)*	*(6.02)*	*(-27.89)*	*(5.44)*	*(-23.94)*	*(6.53)*	*(-29.72)*	*(7.91)*
LnZ	-0.290	0.004	-0.292	0.011	-0.241	-0.007	-0.150	0.006	-0.128	0.000
	(-15.81)	*(0.61)*	*(-14.53)*	*(1.45)*	*(-11.74)*	*(-0.77)*	*(-6.12)*	*(0.70)*	*(-6.46)*	*(0.01)*
EDU	-0.003	0.000	-0.003	0.0002	-0.004	0.001	0.000	0.002	-0.001	0.001
	(-2.38)	*(-0.13)*	*(-2.12)*	*(0.33)*	*(-3.57)*	*(2.73)*	*(-0.46)*	*(5.34)*	*(-1.88)*	*(2.95)*
Age	0.001	0.000	0.002	0.000	0.002	0.000	0.001	0.000	0.003	0.001
	(1.98)	*(1.79)*	*(4.13)*	*(-0.88)*	*(3.88)*	*(0.07)*	*(2.03)*	*(2.03)*	*(5.49)*	*(2.76)*
DCOM	0.024	0.006	0.028	0.001	-0.027	0.002	0.005	0.036	-0.028	0.000
	(1.05)	*(1.05)*	*(1.84)*	*(0.16)*	*(-1.73)*	*(0.30)*	*(0.26)*	*(5.27)*	*(-1.51)*	*(-0.02)*
R^2	0.10	0.06	0.11	0.08	0.12	0.01	0.10	0.02	0.14	0.02
Df	6,953	6,618	6,950	6,591	6,950	6,516	6,951	6,514	6,952	6,563
No. cluster	2,439	2,324	2,912	2,793	2,997	2,912	2,886	2,834	2,504	2,473

Note: (…) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 7 Estimated results of share and unit value equations of non-glutinous rice by regions and Bangkok

Variables	North		Northeast		Central		South		Bangkok	
	W1	LnV1	W2	LnV2	W3	LnV3	W4	LnV4	W5	LnV5
Constant	0.548	-0.061	0.388	-0.031	0.717	-0.058	0.792	-0.059	0.547	-0.125
	(12.82)	*(-4.46)*	*(14.64)*	*(-3.17*	*(33.09)*	*(-5.27)*	*(27.29)*	*(-3.59)*	*(8.01)*	*(-4.21)*
LnX	-0.821	0.075	-0.439	0.086	-0.858	0.093	-0.869	0.088	-0.892	0.095
	(-17.49)	*(7.23)*	*(-15.90)*	*(6.32)*	*(-47.68)*	*(10.02)*	*(-37.72)*	*(7.39)*	*(-19.58)*	*(3.38)*
LnZ	-0.118	-0.010	-0.079	0.012	-0.148	0.008	-0.112	0.016	-0.091	0.009
	(-5.43)	*(-1.46)*	*(-5.79)*	*(2.25)*	*(-12.85)*	*(1.36)*	*(-7.43)*	*(1.84)*	*(-2.56)*	*(0.55)*
EDU	0.004	0.001	0.004	0.001	-0.004	0.001	-0.004	0.002	0.000	0.002
	(3.45)	*(4.01*	*(5.95)*	*(2.74)*	*(-6.61)*	*(2.94)*	*(-5.06)*	*(5.60)*	*(-0.23)*	*(3.14)*
Age	0.000	0.000	0.002	0.000	0.005	0.001	0.004	0.000	0.008	0.001
	(0.50)	*(1.03)*	*(3.88)*	*(0.93)*	*(14.40)*	*(2.91)*	*(7.88)*	*(0.46)*	*(6.52)*	*(2.90)*
DCOM	-0.088	0.019	-0.150	0.002	-0.014	0.003	-0.007	0.005		
	(-4.62)	*(3.19)*	*(-12.20)*	*(0.45)*	*(-1.33)*	*(0.60)*	*(-0.51)*	*(0.65)*		
R^2	0.13	0.21	0.23	0.08	0.25	0.02	0.23	0.02	0.22	0.02
F	26.8	75.2	103.3	12.3	675.8	28.2	413.7	23.7	107.5	7.2
Df	7607	7965	9037	8690	10,361	9,689	5,452	5,169	1,940	1,647
No. of cluster	796	796	892	892	1,164	1,164	596	594	191	191

Note: (…) is t-value

Source: Calculated from socio economic survey data (2002)

Appendix Table A 8 The calculation of rice supply elasticities in short-run and long-run

Variables	Short-Run			Long-Run			Supply Elasticities	
	Eai	Eyi	Eya	Eai	Eyi	Eya	Short-Run	Long Run
Two crop Combined								
Rice price	0.173	0.090	-0.022	0.235	0.090	-0.022	**0.259**	**0.319**
Other crops price	0.000	0.000	-0.022	0.000	0.000	-0.022	**0.000**	**0.000**
Energy crop price	-0.099	0.000	-0.022	-0.134	0.000	-0.022	**-0.097**	**-0.131**
Fresh palm fruit price	0.000	0.000	-0.022	0.000	0.000	-0.022	**0.000**	**0.000**
Rubber price	0.000	0.000	-0.022	0.000	0.000	-0.022	**0.000**	**0.000**
Irrigated area	0.143	0.043	-0.022	0.193	0.043	-0.022	**0.182**	**0.232**
Rain STD.	-0.124	-0.017	-0.022	-0.167	-0.017	-0.022	**-0.138**	**-0.181**
Research budget	0.159	0.121	-0.022	0.215	0.121	-0.022	**0.276**	**0.331**
Fertilizer price	-0.172	-0.106	-0.022	-0.233	-0.106	-0.022	**-0.274**	**-0.334**
Agricultural wage rate	0.000	0.000	-0.022	0.000	0.000	-0.022	**0.000**	**0.000**
Number of power tiller	0.124	0.000	-0.022	0.168	0.000	-0.022	**0.122**	**0.165**
Wet Season Rice								
Rice price	0.037	0.111	-0.023	0.056	0.111	-0.023	**0.147**	**0.165**
Other crops price	0.000	0.000		0.000	0.000		**0.000**	**0.000**
Energy crop price	-0.219	0.000	-0.023	-0.333	0.000	-0.023	**-0.214**	**-0.325**
Fresh palm fruit price	0.000	0.000		0.000	0.000		**0.000**	**0.000**
Rubber price	0.000	0.000		0.000	0.000		**0.000**	**0.000**
Irrigated area	0.202	0.119	-0.023	0.307	0.119	-0.023	**0.317**	**0.419**
Rain STD.	-0.116	0.000	-0.023	-0.177	0.000	-0.023	**-0.114**	**-0.173**
Research budget	0.096	0.183	-0.023	0.146	0.183	-0.023	**0.277**	**0.326**
Fertilizer price	-0.118	-0.202	-0.023	-0.178	-0.202	-0.023	**-0.317**	**-0.376**
Agricultural wage rate	0.000	-0.097		0.000	-0.097		**-0.097**	**-0.097**
Number of power tiller	0.186	0.000	-0.023	0.282	0.000	-0.023	**0.181**	**0.276**
Dry Season Rice								
Rice price	0.096	0.284	-0.085	0.107	0.284	-0.085	**0.371**	**0.382**
Other crops price	-0.226	0.000	-0.085	-0.252	0.000	-0.085	**-0.207**	**-0.231**
Energy crop price	0.000	0.000	-0.085	0.000	0.000	-0.085	**0.000**	**0.000**
Fresh palm fruit price	-0.215	0.000	-0.085	-0.240	0.000	-0.085	**-0.197**	**-0.219**
Rubber price	0.000	0.000	-0.085	0.000	0.000	-0.085	**0.000**	**0.000**
Irrigated area	0.019	0.041	-0.085	0.021	0.041	-0.085	**0.058**	**0.060**
Rain STD.	-0.062	0.000	-0.085	-0.069	0.000	-0.085	**-0.057**	**-0.064**
Research budget	0.000	0.181	-0.085	0.168	0.181	-0.085	**0.181**	**0.181**
Fertilizer price	-0.168	0.000	-0.085	-0.187	0.000	-0.085	**-0.154**	**-0.171**
Agricultural wage rate	0.000	0.000	-0.085	0.000	0.000	-0.085	**0.000**	**0.000**
Number of power tiller	0.057	0.055	-0.085	0.063	0.055	-0.085	**0.107**	**0.113**

Note: 1) Ns is “Not significant”

2) Eai is the rice cultivated area elasticity with respect to factor i

3) Eyi is the rice yield elasticity with respect to factor i

4) Eya is the rice yield elasticity with respect to rice cultivated area

Source: calculated from OAE. Data

Appendix Table A 9 The short-run and long-run weighted output elasticities of total rice supply

Elasticities	Short-run			Long-run		
	Wet Season	Dry Season	Two crops Combine[1/]	Wet Season	Dry Season	Two crops Combine 1/
Rice price	0.147	0.371	0.199	0.165	0.382	0.215
Other crops price	0.000	-0.207	-0.048	0.000	-0.231	-0.053
Energy crop price	-0.214	0.000	-0.165	-0.325	0.000	-0.250
Fresh palm fruit price	0.000	-0.197	-0.045	0.000	-0.219	-0.050
Irrigated area	0.317	0.058	0.257	0.419	0.060	0.336
Rain STD.	-0.114	-0.057	-0.101	-0.173	-0.064	-0.148
Research budget	0.277	0.319	0.287	0.326	0.334	0.328
Fertilizer price	-0.317	-0.154	-0.280	-0.376	-0.171	-0.329
Agricultural wage rate	-0.097	0.000	-0.075	-0.097	0.000	-0.075
Quantity of power tiller	0.181	0.107	0.164	0.276	0.113	0.239

Note : See the estimation of rice production elasticities in Appendix Table 8

Ns is non-significant parameters

[1/] is the weighted elasticities (the weights used are 0.77 for wet season and 0.23 for dry season)

Source: calculated from data in Tables 3.1 and 3.2

Appendix B

Estimated Results of Rice Supply Response Classified by Regions

Estimated Results of Rice Supply Response Classified by Regions

As the response of rice product toward many changing factors varied because of the differences of characters of landscape, climate, economy, social and culture of each region or each area, the regional necessities and abilities in adjusting product patterns are subsequently different. Nevertheless, in analyzing the national overall equations in Chapter 4, we were unable to add all conditional variables that caused different regional adjustment into one equation. Therefore, an analysis here is going to be the one on the response of rice product supply of each region that will help us explain clearly the ability in regional rice product adjustment

In the model, the independent variables appearing in acreage share response equations are acreage share of rice, energy crop, and other crops. The explanations used in the model consist of four indices crop prices, namely rice (PR_{t-1}), other crops (PC_{t-1}), tree crop ($PTRE_{t-1}$), and energy crop (PE_{t-1}) together with fertilizer price (PF_{t-1}); ratio of irrigation area by rice area (IRR_t); rice research investment (RES_{t-n}), rainfall condition (R_t); labor wage rate (W_t); quantity of power tiller per household (Mc_t); and lag acreage rice share area (Sr_{t-1}). In each share equation, the variables, particularly crop output and fertilizer prices, irrigation area, rice research budget, rainfall condition, labor wage rate, and quantity of power tiller are in logarithm form.

The yield per Rai is assumed to depend on the same set of its price and other supply shifter variables in the acreage share equation. However, the lag acreage share is excluded whereas the amount of cultivated area is included. The latter variable is employed to capture the marginal effect of acreage expansion on rice yield. The yield equation is also assumed to be linear relation with those regressions. The weighted least squares method is used for the analysis.

Appendix Table B 1 SUR Estimated results of rice area share equations by region

Variables	Northeast	North	Central	South
Constant	0.699	2.491	-1.024	-0.298
	*(4.30***)*	*(7.01)****	*(-1.54)*	*(-1.72)**
$LnPR_{t-1}$	0.149	0.261	0.031	0.002
	*(3.41)****	*(3.75)****	*(1.64)**	*(0.19)*
$LnPC_{t-1}$	-0.041	-0.154	-0.051	-0.198
	*(-3.13)****	*(-0.63)*	*(-2.41)***	*(-1.18)*
$LnPE_{t-1}$	-0.092	-0.421	-0.061	-0.121
	*(-2.16)***	*(-3.98)****	*(-0.93)*	*(-1.62)**
$LnPTRE_{t-1}$	-0.003	-0.126	-0.0003	-0.0001
	(-0.69)	*(-1.24)*	*(-1.07)*	*(-0.354)*
$LnPOP_{t-1}$	-	-	-	-0.008
	-	-	-	*(-0.44)*
$LnPRB_{t-1}$	-	-	-	-0.036*
	-	-	-	*(1.62)*
$LnPf_t$	-0.183	-0.293	-0.148	-0.019
	*(-2.69)***	*(1.80)**	*(-1.37)*	*(-1.99)***
$LnIRR_t$	0.031	-0.076	0.051	0.002
	*(1.91)**	*(-2.68)**	*(3.06)*	*(0.60)*
LnR_t	0.042	-0.064	0.012	-0.003
	*(1.67)**	*(-5.09)****	*(0.67)*	*(-0.21)*
$LnRES_{t-1}$	-	-	0.091	-0.065
	-	-	*(1.64)**	*(0.99)*
LnW_t	-0.113	-0.048	-0.014	
	(-1.23)	*(-1.67)**	*(-0.15)*	
$LnMC_t$	0.079	-	0.014	0.004
	*(3.97)****	-	*(1.49)*	*(1.14)*
Sr_{t-1}	0.618	0.148	0.504	0.682
	*(48.79***)*	*(5.03)*	*(66.09)**	*(70.54)****
Adjust R^2	0.92	0.92	0.96	0.98
DF.	255	246	398	227
Mean of Sr_{t-1}	0.758	0.592	0.582	0.174

Note: * is significant at 90 %

** is significant at 95 %

*** is significant at 99 %

(…) is t-value

Source : calculated from OAE. Data

Appendix Table B 2 Estimated results of rice yield equations by regions

Variables	Northeast	North	Central	South
Constant	-0.338	-2.612	-2.827	-1.937
	(-0.34)	*(-1.29)*	*(1.45)*	*(-1.09)*
$LnPR_{t-1}$	0.038	0.062	0.017	0.118
	*(3.38)****	*(4.38)****	*(3.54)****	*(0.96)*
$LnPf_t$	-0.105	-0.018	-0.011	-0.646
	(-0.48)	*(-0.06)*	*(-0.04)*	*(-2.15)***
$LnIRR_t$	0.002	0.046	0.124	0.016
	(0.05)	*(2.19)****	*(1.67)**	*(0.99)*
LnR_t	-0.039	-0.024	-0.105	-0.109
	(-0.89)	*(-0.38)*	*(1.64)**	*(1.86)**
$LnRES_{t-1}$	0.195	0.177	0.138	0.173
	*(3.77)****	*(2.11)***	*(2.02)***	*(2.21)***
LnW_t	-0.077	-0.249*	-0.596	0.153
	*(-3.85)****	*(1.69)*	*(-2.13)***	*(0.64)*
$LnAR_t$	-0.104	-0.019	-0.021	-0.008
	*(-8.14)****	*(-2.22)***	*(-2.24)***	*(-0.95)*
Adjust R^2	0.45	0.45	0.53	0.52
F-Test	22.5***	22.8***	38.5***	29.5***
DF.	255	249	400	230

Note: * is significant at 90 %

** is significant at 95 %

*** is significant at 99 %

(…) is t-value

Source : calculated from OAE. Data

Analysis result of output elasticity of rice supply by regions

Appendix Table B 3 shows the estimated elasticities of rice supply by regions. The long-run elasticity of rice price in the north is respectively higher than the central, the northeast and the south. Between the highest and lowest, the rice production elasticity and the values are between 0.000 and 0.570, in long-runs.

Cross-price elasticities are calculated from the acreage share equation. Increasing in energy crops price, in long-runs, will reduce the rice production in the northeast and north regions. At the same time increasing in other crops price will reduce the rice production in the northeast and central regions. Only the south responds to the changes of a para rubber price as the estimation demonstrates that increasing in the para rubber price will reduce rice production in the south region.

The long-run rice supply elasticity has positive response to the change of irrigation area in the northeast, north, and central regions but it does not show the same response in the south region where its elasticity value is zero. Research budget for supporting and developing rice production is considered a significant factor for the increasing of rice production in all regions. This result indicates that the rice research investment is important for increasing rice production in all regions.

Apendix Table B 3 The elasticities estimated by regions

Variables	Short Run				Long-Run			
	North east	North	Central	South	North-east	North	Central	South
Rice price	0.214	0.495	0.070	0.000	0.499	0.570	0.122	0.000
Other crops price	-0.049	0.000	-0.086	0.000	-0.127	0.000	-0.173	0.000
Energy crop price	-0.109	-0.366	0.000	0.000	-0.286	-0.429	0.000	0.000
Rubber price	0.000	0.000	0.000	-0.006	0.000	0.000	0.000	-0.065
Fertilizer price	-0.241	-0.495	0.000	-0.233	-0.630	-0.580	0.000	-0.462
Irrigated area	0.041	-0.083	0.212	0.000	0.107	-0.105	0.301	0.000
Rice research inv.	0.195	0.177	0.295	0.170	0.195	0.177	0.455	0.170
Rain std.	0.056	-0.108	-0.105	-0.106	0.146	-0.127	-0.105	-0.106
Wage rate	-0.277	-0.330	-0.096	0.000	-0.277	-0.344	-0.096	0.000
No. of power tiller	0.105	0.000	0.000	0.000	0.274	0.000	0.000	0.000

Source: calculated from OAE. Data, various issues.

The analysis result of input price elasticity of rice supply reveals that the response of rice supplies to the price of chemical fertilizer is in opposite directions in the northeast, north, and south but not the central. This indicates that the increasing of chemical fertilizer price results in the declining of rice supply in the northeast, north, and south. The analysis of response of rice supply to the change of power tillers quantity per household shows that only the rice product in the northeast responds positively to the change. Moreover, this result also shows that the increasing in a wage rate, in long-runs, will reduce the rice production in the northeast, north, and central regions but will not effect the change on rice production in the south region.

Tendency of Rice Product Categorizing by Regions in 2025

The non-similarity of eco-condition in each region shows different result in rice production and its product quantity therefore estimation on rice product quantity must be on both the overall and within each region.

Long term elasticity is used to calculate an expansion rate of regional rice product as shown in Appendix Table B 3 which includes factors effecting positively toward rice product supply i.e. milled rice price, irrigated areas, government rice research budget and a proportion of power tillers per household. Factors effecting negatively toward the changes of rice product supply are variables of annual rainwater quantity, palm oil price, para rubber price, other crops price, chemical fertilizer price as well as agricultural labor wages

Appendix Table B 4 Growth assumptions used for projected rice supply by region

Variables	Scenarios		
	A	B	C
Rice price (+)	4.5	3.0	7.0
Irrigated area (+)	1.0	-1.0	2.0
Research budget (+)	0.5	0.1	2.0
Rain STD.(-)	2.0	2.5	2.5
Energy crops price (-)	5.0	6.0	6.0
Rubber tree price (-)	0.5	2.0	-1.0
Other crop price (-)	0.5	2.0	-1.0
Fertilizer price (-)	5.0	7.0	7.0
Wage rate (-)	0.5	1.0	1.0
Quantity of power tiller(+)	5.0	5.0	7.0
	Growth of rice supply (%)		
Northeast	**0.03**	**-0.74**	**0.43**
North	**-0.51**	**-1.56**	**-0.03**
Central	**0.17**	**-1.36**	**1.64**
South	**-2.14**	**-3.22**	**-2.34**

Three scenarios are determined to calculate the growth assumption rate of regional rice product supply as well as the growth of total rice product supply from the time of this study to 2025. An annual expansion rate of all factors along with an expansion rate of regional rice product is demonstrated in Appendix Table B 4.

It can be summarized from Appendix Table B 5 that there seems to be slightly different in the changes of rice supply. In the northeast and the north, rice supply seems to decline in the normal situation (scenario A) while in the central, it bounds to increase in the same situation. During the least fortunate situation (scenario B), it is found that rice supply of the three regions tends to decrease. On the contrary, their supply increases in the most fortunate situation (scenario C). Nevertheless, rice supply of the south seems to decrease in all scenarios.

Appendix Table B 5 Projection of paddy production under different growth assumptions categorized by region

Years	SCENARIOS		
	A	B	C
	Northeast		
2007	10,541,149	10,239,496	10,623,288
2010	10,330,688	9,197,965	10,656,467
2015	9,989,217	7,692,137	10,711,996
2020	9,659,032	6,432,833	10,767,814
2025	9,339,762	5,379,694	10,823,923
	North		
2007	8,468,653	8,247,047	8,447,803
2010	7,747,652	6,967,977	7,671,635
2015	6,679,793	5,261,631	6,533,234
2020	5,759,117	3,973,142	5,563,761
2025	4,965,338	3,000,183	4,738,150
	Central		
2007	9,431,759	9,307,510	9,567,290
2010	9,640,687	9,142,633	10,206,880
2015	9,999,236	8,874,304	11,369,284
2020	10,371,120	8,613,850	12,664,068
2025	10,756,835	8,361,040	14,106,308
	South		
2007	871,338	861,131	865,759
2010	808,366	771,149	787,860
2015	713,363	641,583	673,290
2020	629,525	533,787	575,381
2025	555,540	444,102	491,710

Source: by calculating

The result from the growth assumptions of future rice supply reveals that the total assumptions of rice supply from wet season rice farming and dry season rice farming are unequal to the supply of overall national assumptions. This is because the assumptions categorizing by regions are varied based on producing seasons whereas, in the overall, the determination on the growth of different factors is the same rate. In reality, changes of factors determining supply are always different among regions as well as during rice farming of wet season or dry season. Therefore, using the expansion rate of overall supply factors to assume an estimation of rice supply from wet season and dry season farming or using it for an assumption of regional rice supply can be inadequate. However, the result gives enough important information to demonstrate a direction of changes in regional rice supply as well as a direction of changes in wet season or dry season rice farming that will be beneficial for future policy makers on rice production of each region.

Appendix C

Projection of Rice Supply by Crops Season

Tendency of Wet Season Rice Product in 2025

Elasticities used in a calculation of the growth rate of wet season rice product showing in Appendix Table C 1 consist of factors effecting positively toward rice product supply i.e. milled rice price, irrigated areas, government rice research budget and the quantity of power tillers per household as well as factors effecting negatively toward changes of rice product supply i.e. the variables of annual rainwater quantity, energy crop price and chemical fertilizer price.

Appendix Table C 1 Estimated price and non-price elasticities for projected rice supply in wet season

Elasticities	Long-run
	Wet season
Rice price	0.165
Irrigated area	0.419
Research budget	0.326
Rain STD.	-0.173
Energy crop price	-0.325
Fertilizer price	-0.376
Quantity of power tiller	0.276

Source: by calculating

The growth rate estimation of rice product supply from wet season farming within the duration of this study to 2025 is conducted through a determination of choices within 3 scenarios. The same performance is determined for the growth assumption of the total rice product supply in chapter 5 as showing in Appendix Table C 2.

Using information of the quantity of wet season rice product 2007 as a foundation for an assumption of the product, it reveals that scenario A, which is a normal situation where the determination of an expansion rate of different related variables is the same as an average rate of the last 5 years, shows wet season rice product in 2010, 2015, 2020 and 2025 with 22.44, 21.94, 21.26 and 20.98 million tons, respectively (Appendix Table C 3).

Appendix Table C 2 Growth assumptions used for projected rice supply in wet season

Factors	Scenarios		
	A	B	C
Rice price	4.5	5.0	7.0
Irrigated area	1.0	-1.0	2.0
Research budget	0.5	0.1	2.0
Rain STD.	2.0	4.0	4.0
Energy crop price	4.0	7.0	7.0
Fertilizer price	4.0	7.0	7.0
Quantity of power tiller	5.0	5.0	7.0
Growth of rice supply (%)	-0.45	-3.78	-1.02

Scenario B is a situation when an expansion of rice price is less than energy crop price and at the same time the price of chemical fertilizer is increased. Moreover, irrigated areas and government rice research budget are reduced. So, the wet season rice product in 2010, 2015, 2020 and 2025 is 19.57, 16.15, 13.32 and 10.98 million tons, respectively (Appendix Table C 3).

Appendix Table C 3 Projection of paddy production under different growth assumptions in wet season

Years	Quantity of Rice Production		
	A	B	C
2007	22,839,695	22,839,695	22,839,695
2010	22,435,403	19,576,926	21,920,224
2015	21,940,088	16,145,899	20,822,763
2020	21,455,707	13,316,189	19,780,248
2025	20,982,021	10,982,411	18,789,928

Source: by calculating

Scenario C is a situation when the rice price shows a positive sign and an expansion rate of energy crop price, rainwater quantity and chemical fertilizer price are in a direction of choice B where irrigated areas and government rice research budget are increased. Accordingly, the wet season rice product in 2010, 2015, 2020 and 2025 is 21.92, 20.82, 19.78, and 18.79 million tons (Appendix Table C 3).

It can be concluded that Thailand wet season rice supply tends to decline in all situations i.e. normal situation (scenario A) 0.45% annually, the least fortunate situation (scenario B) 3.78% annually, and the most fortunate situation (scenario C) 1.02% annually.

Tendency of Dry Season Rice Product in 2025

Elasticities used in a calculation for an expansion rate of dry season rice product showing in Appendix Table C 4 consist of factors effecting positively toward rice product supply i.e. milled rice price, irrigated areas, government rice research budget and a proportion of power tillers per household as well as factors effecting negatively toward changes in dry season rice product i.e. variables of annual rainwater quantity, oil palm price, other crops price and chemical fertilizer price**.**

Appendix Table C 4 Estimated price and non-price elasticities for projected rice supply in dry season

Elasticities	Dry season
Rice price	0.382
Irrigated area	0.060
Research budget	0.334
Rain STD.	-0.064
Oil palm price	-0.219
Other crop price	-0.231
Fertilizer price	-0.177
Quantity of power tiller	0.113

Source: by calculating

An assumption on the growth of dry season rice product supply from the time of this study to 2025 is conducted through choices of 3 scenarios, the same performance as the assumption of the growth of the total rice product supply as well as wet season rice product supply. Factors showing negative impact include palm oil price and other crops price yet energy crop price has no impact to changes of quantity of dry season rice product supply. An expansion rate of all factors is showing in Appendix Table C 5.

Appendix Table C 5 Growth assumptions used for projected rice supply in dry season

Factors	Scenarios		
	A	B	C
Rice price (+)	4.5	5.0	7.0
Irrigated area (+)	1.0	-1.0	2.0
Research budget (+)	0.5	0.1	2.0
Rain STD.(-)	2.0	4.0	4.0
Energy crop price (-)	4.0	7.0	7.0
Oil palm price (-)	4.0	7.0	7.0
Other crop price (-)	0.5	2.0	2.0
Fertilizer price (-)	4.0	7.0	7.0
Quantity of power tiller(+)	5.0	5.0	7.0
Growth of rice supply (%)	0.68	-1.04	0.76

Using the information on quantity of dry season rice product in 2007 as a foundation for an assumption of the product trend, it is found that scenario A which is a normal situation, the changing behavior of all related variables is in accordance with the normal trend. It is also found that dry season rice product in 2010, 2015, 2020, and 2025 is 6.99, 7.18, 7.43 and 7.69 million tons, respectively (Appendix Table C 6).

Appendix Table C 6 Projection of paddy production under different growth assumptions in dry season

Years	Quantity of Rice Production		
	A	B	C
2007	6,752,684	6,752,684	6,752,684
2010	6,939,204	6,475,705	6,961,147
2015	7,179,615	6,145,404	7,230,798
2020	7,428,356	5,831,949	7,510,895
2025	7,685,714	5,534,483	7,801,841

Source: by calculating

Scenario B is a situation when rice price declines and at the same time there are more competitive crops and higher price of chemical fertilizer while irrigated areas and government rice research budget are reduced. The result of dry season rice product in 2010, 2015, 2020 and 2025 is respectively 6.48, 6.15, 5.83 and 5.53 million tons (Appendix Table C 6)

Scenario C is a situation when rice price is in a positive direction and an expansion rate, quantity of rainwater as well as chemical fertilizer price are directing to choice B. However, irrigated areas, government rice research budget and the number of agricultural machines are assumed to be higher than scenario B. The result reveals that dry season rice product in 2010, 2015, 2020 and 2025 is respectively 6.96, 7.23, 7.51 and 7.80 million tons (Appendix Table C 6).

It can be summarized from the assumption that the country rice supply from dry season rice farming tends to increase in the normal situation (scenario A) as well as in the most fortunate situation (scenario C) while in the least fortunate situation (scenario B) the rice supply bounds to continuously decrease.

The answer to an enquiry of "What direction will the change in future rice supply lead to?" depends on the rice price along with its related goods as well as its production factor which for this study is the chemical fertilizer price. Moreover, it also depends on non-price factors i.e. government rice research investment and a development of an irrigation system which is an important component toward an expansion or shrinking of rice supply. While rice is the main earning of most farmers in the country and it is also the main dish for people throughout the country, it is imperative that proper policy making in regard to agriculture must be correlated with the tendency of future changes in factors determining the rice supply.