THE ECONOMICS OF RICE THRESHING MACHINES IN THAILAND: A CASE STUDY OF CHACHOENGSAO AND SUPANBURI PROVINCES

RENU PATHNOPAS

MASTER OF ECONOMICS

(ENGLISH - LANGUAGE PROGRAM)

FACULTY OF ECONOMICS, THAMMASAT UNIVERSITY

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by

Renu Pathnopas

A Thesis submitted in partial fulfilment of the requirements for the degree of

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Is Hereby Approved by:

Chairman, Thesis Committee :	Chesada Loohawenchit	June 4, 1980
	(Dr. Chesada Loohawenchit)	Date
Member, Thesis Committee :	George E. DeLehanty	4 June 1980
	(Dr. George E. Delehanty)	Date
Member, Thesis Committee :	Chak Chakkapak	June 4, 80
	(Khun Chak Chakkapak)	Date
Dean, Faculty of Economics :	Medhi Krongkaew	4/6/1980
	(Dr. Medhi Krongkaew)	Date

ABSTRACT

The use of threshing machines in substitution for traditional methods of rice threshing has been widely adopted since 1975. Despite the high degree of machine diffusion, little attention has yet been paid on such matters as how and why the process of adoption is generated and accepted.

This study is undertaken as an attempt to investigate and identify some possible factors that might affect or be related to the adoption of the IRRI designed thresher. The benefit-cost approach was employed as the framework to explain the process of technology diffusion. The study could be considered the first of its kind in Thailand.

Information obtained for analysis was collected directly from farmers, local dealers and manufacturers of the machine in Chachoengsao and Supanburi provinces in the central plain of Thailand.

In our findings, the total gains realized from the utilization of the machine consist of the direct cost savings and the indirect time savings. These favorable advantages became stimulants in motivating farmers to gradually switch from other methods of rice threshing to a rice threshing machine. This, in effect, contributes to the total demand for thresher's service.

However, the investment in a rice thresher seemed costly to farmers. Only a few who have access to funds could own the machine and for those who could not afford one they may employ a rice thresher through renting it. Thresher owners can obtain benefits from owning a thresher from two sources. One is through rendering services to others who needed them. The other is through own use. The thresher also generates two kinds of benefits. One is the internal benefits that would accrue to the owner and the other is the external benefits that a thresher would contribute to the customer through time savings and cost savings.

The cost-benefit analysis proved that the investment in a thresher during the period of 1975 to 1979 yielded a considerably high rate of return to the owner. This was the main factor causing a high degree of thresher adoption.

Considering all the net benefits realized from the adoption of a modern thresher, promotion of its use may be a good government policy for the development of the country's agricultural sector. However, promotion efforts should take into consideration certain constraint concerning irrigation, cropping intensity, employment changes, etc. The provision of loan facilities with low interest rates and simplified loaning procedures is one way which may be used to help promote the utilization of threshers.

To

My Big Family,

Dr. Lochawenchit,

and

"Ott Noi"

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I would like to dedicate all the merits of this study, if there may be any, to my parents to whom I owe everything. Any possible errors or omissions that may arise from the work shall be my sole responsibility.

Thammasat University — Renu Pathnopas

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NOTE:	20 Baht	=	$1 (U.S.)
	1 Baht	=	5 cents (U.S.)
	1 Hectare	=	6.25 Rai
	1 Rai	=	0.16 Hectares
	1 Kwien	=	1,000 Kilograms
	1 Manday	=	8 Hour/man
	Changwad	=	Province
	Amphur	=	District
	Tambol	=	Group of villages
	Muban	=	Village

CHAPTER I

INTRODUCTION

A. Problem Defined

Rice production in Thailand has recently developed from subsistence production to commercial production.[1] This phenomenon was accompanied by the increasing use of farm machinery such as water pumps, power tillers, tractors, etc. A new machine recently introduced and showing a promising future is the rice thresher. It first appeared in 1975 and now about 5,000 machines are in use.[2]

Its importance may not only be on agricultural production but also on industrial production as well. This is because almost all of the rice threshers used in the country are now locally produced. It is, therefore, quite interesting to see how and why such a machine has come to be adopted by Thai farmers. This may provide us with a better understanding of Thai agriculture itself and be useful in analysing the demand for rice threshers and other farm machines in the future.

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[1] Ammar Siamwalla, "Rice in the Thai Economy," unpublished paper, Faculty of Economics, Thammasat University, June 1978 (in Thai).

[2] Rice Machinery Division and Mechanization Research, IRRI, (Los Baños, Philippines) Semi Annual Report, No. 21-27, July 1, 1975 - December 1978.

B. Objectives and Hypothesis

The study was undertaken in the hope of answering the questions of why and how rice threshing machines have come to be widely adopted. The hypothesis to be tested is that the positive net benefits from rice thresher investment induced the rapid rate of adoption. The study will also investigate the effects of thresher adoption and use on labor utilization, turnaround time, cropping intensity and cost saving. In addition, the rapid adoption of rice threshers has induced the growth of a rice thresher industry which may lead to important changes in the employment structure. But this will not be included as it is beyond the scope of the study.

C. Methodology of Study

The adoption and use of rice threshers may be approached in two ways. One is through the contractor service or utilization without actually investing in a machine. Analysis of farmers in this group may be subdivided into :

1. Those who own buffaloes and/or machines other than rice threshers which can be used for threshing.

2. Those who do not own any buffalo and/or machines other than rice threshers which can be used for threshing.

Analysis of the first group must take into consideration the operating cost of threshing with the available machine or buffalo including the rice thresher in comparison to renting whatever threshing services are available in the market. The most economical package will then be chosen.

The second group involves only comparing the rental rate (including operating cost) of the various alternative threshing services (including a rice thresher) available in the market and choosing the cheapest or most economical service.

The second approach in studying the adoption of rice threshers is to look at the net benefits of such an investment. The capital cost of investing in the machine must be compared to the benefits it is able to generate over the presently employed method of threshing.

In the present study, the main focus will be on the second approach. Only one alternative method of threshing was chosen for comparison to investing in the rice thresher and that is the renting of a small tractor (power tiller) through a contractor service. This is because the use of small tractors seems to be the only available alternative in the survey areas chosen.

D. Source of Data and Area of Study

Since the adoption of threshers in the last 2-4 years is

particularly evident in areas with good irrigation, the sites selected for the study are Chachoengsao and Supanburi provinces. The reasons for choosing these provinces are :

1. They are areas where two-wheel walking tractors and rice threshing machines are intensively used. According to the Division of Agricultural Economics,[3] it was recorded in 1975 that there were 10,147 units of two-wheel walking tractors and 1,589 units of rice threshing machines in Chachoengsao. Compared with other provinces in the country, Chachoengsao has the largest utilization percentage of the two-wheel walking tractors and rice threshing machines (about 12.30 and 40.20 percent, respectively). Supanburi has 3.8 percent of the two-wheel walking tractors but the statistics on rice threshing machines are unavailable.

2. They are important areas producing farm machinery. There are 9 firms producing two-wheel walking tractors and 4 firms producing both two-wheel walking tractors and four-wheel tractors in Chachoengsao. This is also the province with the highest concentration of rice thresher producers.[4] For Supanburi, there are 5 firms producing two-wheel walking tractors and four-wheel tractors and one firm producing rice threshing machines only.

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[3]Division of Agricultural Economics, Ministry of Agriculture and Cooperatives, Agricultural Statistics of Thailand Crop Year 1975/76 No. 54, Section XIII, Bangkok, Thailand.

[4]There are 9 firms located here.

3. Chachoengsao firms were among the earliest two-wheel walking tractor and rice thresher producers in the country. These firms could, therefore, provide relevant information regarding the development of the farm machinery industry. In contrast, Supanburi firms are relatively new and their sizes are smaller than Chachoengsao's which may indicate the direction the farm machinery industry is heading.

Within Chachoengsao, four districts were chosen while two were chosen from Supanburi. The basis in selecting these six districts is that they are areas with a relatively high density of thresher population. Within the six selected districts, a separation was made of tambol where rice threshers are widely adopted and tambol where rice threshers are not important or nonexistent. Information concerning the existence and importance of rice threshers in each tambol were obtained flow talking to district agricultural officers.

After having identified the tambol where rice threshers are widely utilized, one tambol was selected from each district for the survey. The selection was based on the consideration of travelling distance and convenience, safety, and cooperation from local government officers.

The selected tambol in Chachoengsao are as follows:

1. Tambol Bang Khanarg and Tambol Mon Thong (Bang Nam Prieo District),[5]
2. Tambol Nakorn Neung Khade (Muang District),
3. Tambol Nong Jork (Bang Pa Kong District) and
4. Tambol Ban Po (Ban Po District).

In Supanburi, the selected tambol are :

1. Tombol Rai-rot (Donchedi District) and
2. Tambol Bang-ngarm and Tambol Wang Wa (Sriprachan District).[6]

At the tambol level, help was sought from the Kamnan (head of the tambol) in classifying farmers according to the methods in threshing rice and the ownership of machines. Finally, the selection of the households to be included in the survey was carried out with the help of the Kamnan. They are based on the following sample cells :

1. Thresher owners,
2. Thresher non-owners who use threshers, and
3. Farmers who employ traditional methods of threshing : buffalo or tractor treading.

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[5]Two tambol were selected in this district due to insufficient information in Tambol Bang Khanarg.

[6]Two tambol were selected in this district due to insufficient information in Tambol Bang-ngarm.

Thirty samples are assigned in each catagory cells by province. However, during the time the field surveys were conducted (in February 1979 for Chachoengsao and April 1979 for Supanburi) farmers were busy preparing land for the dry season crop, making them unable to cooperate fully with the study. This unfortunate incidence resulted in the deviation of the expected or intended sample structure as can be seen in Table I-1.

The total sample collected is 268 households. The questionnaire employed was modified from a questionnaire in the Philippines so that cross country comparisons may be made.

E. Organization of the Study

This study is organized into six chapters. Following this introductory chapter will be a chapter summarizing some background of the provinces studied, alternative methods and costs of rice threshing in Thailand, and the threshing technology, types of rice threshers and the rice thresher industry in Thailand.

In Chapter III, a review of the literature concerning rice threshers and a discussion of some of the possible factors affecting the adoption and use of rice threshers are studied. It includes both noneconomic and economic factors.

In Chapter IV, a brief review on the discounted cash flow approach will be given and adapted for measuring the project worth

of investing in a rice thresher. The methods of identifying costs and benefits and of valuing them will be discussed here.

The empirical results of the study will be presented in Chapter V. It will be separated into two parts: past and future investment projects. Past investments are included to see whether they might provide some useful information.

Finally, some conclusions and tentative policy implications will be discussed in the last Chapter.

TABLE I-1

PERCENT DISTRIBUTION OF SAMPLE BY PROVINCE, DISTRICT, AND TYPE OF FARMERS
1978

District and province	Group of respondents sampled			
	Thresher owners	Thresher non-owners who use threshers	Farmers who employ traditional methods	
			buffalo treading	tractor treading
CHACHOENGSAO PROVINCE (N = 118)	N = 40	N = 71	N = 0	N = 7
Bang Nam Prieo	27.00	23.70	0	0
Muang	12.70	7.10	0	0
Ban Po	15.90	6.40	0	4.10
Bang Pa Kong	7.90	8.30	0	10.20
SUPANBURI PROVINCE (N = 150)	N = 23	N = 85	N = 8	N = 34
Don Chedi	19.00	31.40	16.30	26.50
Sri Prachan	17.50	23.10	0	42.90
TOTAL OBSERVATIONS (N = 268)	N = 63 (100.00)	N = 156 (100.00)	N = 49 (100.00)	

N = Number of observations.

CHAPTER II

BACKGROUND OF RICE THRESHING IN THAILAND

In this chapter, some general information on the two areas under study (Chachoengsao and Supanburi) are presented along with the alternative methods and costs of rice threshing in these two provinces. A review is also made of the different models of rice threshers available in Thailand since its introduction.

A. Characteristics of Provinces Studied

1. Chachoengsao Province

Chachoengsao,[1] one of the provinces in the heart of the commercial rice growing area of Central Thailand, is situated about 80 kilometers eastof Bangkok. It covers a total area of 5,432 square kilometers with 32.8 percent being suitable for rice production. About 80 percent of the total households are involved in agricultural activities. This province is divided into 7 amphur (districts), 80 tambol (group of villages), and 740 muban (villages). (See Table II-1).

Almost all the farmers in Chachoengsao plant rice by broadcasting. Farm mechanization is mainly employed in paddy production. The rice threshing machine has been widely adopted just recently

[1]The weather is not extremely hot in summer nor is it extremely cold in winter. The highest temperature is 35°C and the lowest one is 12.30°C.

TABLE II-1

POPULATION, PROPORTION INVOLVED IN FARMING, AND AREA PLANTED TO RICE, BY AMPHUR, CHANGWAD CHACHOENGSAO, 1974-1975

Amphur	Number of Tambol	Number of Muban	Population	Proportion involved in farming 1974	Area Planted to Rice			
					Wet season 1974-5	Dry season 1975	% Dry season of wet season	% Dry season of total dry season in province
	no.	no.	persons	%	rai	rai	%	%
1. Muang	19	187	77,199	80.00	184,139	56,180	30.5	32.7
2. Bang Khla	17	114	68,050	83.65	168,123	772	0.5	0.5
3. Bang Pa Kong	8	106	59,138	40.90	82.899	3,904	4.7	2.3
4. Ban Po	17	72	42,547	88.20	112,475	10,147	9.0	5.9
5. Pha Nom Sara Kham	11	87	78,636	70.00	191,027	166	0.01	0.1
6. Bang Nam Prieo*	9	145	61,100	93.60	318,836	100,550	31.5	58.55
7. Sanam Chai Khet	4	29	19,564	90.90	22,124	-	-	-
Total	85	740	406,234		1,079,623	171,719	15.9	100.00

*There are 10 tambols in Amphur Bang Nam Prieo in 1978.

Source: Changwad Chachoengsao Office, "General Description of Chachoengsao," Muang District, Chachoengsao, 1974. Tables 1 and 2 (in Thai).

(within the last 3-4 years).

In the study, four of the seven districts in this province are selected, because these are the areas where rice threshers are extensively used. They are Bang Nam Prieo, Muang, Ban Po and Bang Pa Kong districts.

Among these four districts, rice threshers are most extensively used in Bang Nam Prieo. Most of the rice threshers in use are owned by farmers.[2]

The proportion of households involved in farming in 1974 were approximately 94, 88, 80 and 41 percent in Bang Nam Prieo, Ban Po, Muang and Bang Pa Kong districts, respectively.[3] Bang Pa Kong have the lowest percentage which may be because of water control problems. Eventhough the cultivated areas in this district are irrigated, most of the farm land may be damaged by salt water during the period of November to March or up to May (within the range of 5-7 months). This factor also affects the cropping intensity in Bang Pa Kong, that is, some farmers in the district can plant only one crop a year. Only 5 percent of the area planted to the wet season crop could be applied for dry season cropping

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[2]The exceptions are a rice mill and a small repair shop in Bang Nam Prieo and a small repair shop owner in Ban Po.

[3]Changwad Chachoengsao Office, "General Description of Chachoengsao," Muang District, Chachoengsao, 1974. (in Thai).

whereas it is around 9 percent in Ban Po District, the neighboring area of Bang Pa Kong. This condition has resulted in a relatively lower degree of rice thresher adoption in both districts whereas the traditional method of threshing such as tractor treading are still widely used.

2. Supanburi Province

In Supanburi, [4] there are eight amphur, 88 tambol and 620 muban with a total cultivated area of 5,339 square kilometers. About 84 percent of the total agricultural holding area is planted to rice. The province is well supplied with rain water for about six months of the year or between May and October. In the past few years, as a result of the newly completed irrigation facilities, double cropping has become common. This has been followed up closely by the widespread use of two-wheel tractors and more recently (1977) by the adoption of rice threshing machines. For areas outside the irrigation system, farming is still done with traditional methods such as buffalo plowing and threshing although tractors have become popular for land preparation.

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[4]The average annual temperature was 28°C for the period of 1970-1977. The highest average monthly temperature is in April being around 31°C and the lowest in December around 25°C. The average annual rainfall for Supanburi province measured at Supanburi Synoptic Station was 1,326 mm for the period of 1970-1977. The highest average monthly rainfall is in September (304 mm) and the lowest in February (0.6 mm).

Two of the nine districts in Supanburi have been selected for the study since they are relatively well irrigated and double-cropped areas similar to the districts chosen in Chachoengsao. They are Don Chedi and Sri Prachan districts.

Transportation in these districts are mostly done by road (in contrast to Chachoengsao where water transport still dominates). Usually on one or both banks of an irrigation canal is a small road which is passable even in the rainy season.

3. Other General Characteristics

Farm credit is provided by a number of institutions: the Bank for Agriculture and Agricultural Cooperatives, the Farmers' Association, the People's Irrigation Association, the Agricultural Cooperative Association, and the Land Cooperative Association. Interest rates for these institutes' loans averages 12-15 percent a year. However, they provide only a portion of the credit needed for the purchase of inputs. Fertilizer dealers are a major source of credit, charging about 20-30 percent interest a year. This private source is very important to farmers, particularly when they urgently need credit for production.

Besides credit facilities, extension services are also provided by the government. Government agencies under the Ministry of Agriculture and Agriculatural Cooperatives have set up demonstration plots in some villages and carried out pest and disease control projects.

The marketing of farm products is generally performed by local merchants. Farmers usually sell their paddy immediately after harvest to these merchants.

The attitude survey on the demand or need for machines used in rice production found a high interest at the land preparation and threshing stages (Table II-2).

TABLE II-2

FARMERS' PREFERENCE OF MECHANIZATION, 1978

What operation of rice production do you think should be mechanized ?	Percent*
Land preparation	60.10
Planting	19.40
Harvesting	15.30
Threshing	46.60
Hauling	5.60
Caring (pesticide & water supply)	14.50
Every stage of production	3.70
No comment	12.30
	(N = 128)

Note: *More than one choice is allowed.

B. Alternative Methods and Costs of Rice Threshing

Before the adoption of rice threshers, farmers have to pay to haul paddy bundles from the fields to their houses because they cannot thresh paddy in the fields. But when rice threshers were adopted, farmers were able to thresh their paddy in the fields instead.

The threshing of rice involves separating the grain from the panicle but not removing the husk.[5] Various methods of rice threshing are practiced in Thailand but this chapter will focus on three methods: buffalo treading, tractor treading and rice threshing machines.

The cost of rice threshing in this study will include all costs incurred in the threshing process excluding the cost of threshing floor preparation, the hauling cost of rice bundles from the fields to the threshing areas, and the hauling cost of threshed rice to the storage area. This is because of the unavailability of these data.

1. Buffalo treading

This traditional method is usually performed on the threshing ground near the farmer's house. A mixture of mud and animal manure

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[5] C.R. Karunaratne and H.L.B. Ellegala, Threshing with Tractor at Hingurakgoda Farm, Tropical Agriculture, Ceylon, (1954) 110(1):8-11.

is applied to the surface and allowed to dry before threshing. In Thailand, bundles weighing 13 to 16 kilograms are tied with long ropes made from rice stalks.[6] These bundles are placed in a circle with the heads of the bundles upward. Usually 200 to 300 bundles are placed on the threshing floor at one time but the number varies considerably. The buffaloes are driven around over the rice. Sometimes, one driver is used for a pair of buffaloes; and at other times, larger groups of buffaloes may be controlled by a man with a rope. After one hour of trampling, the buffaloes are led off. Meanwhile men using long wooden forks rake the straws off the pile. The buffaloes are brought back and the process is repeated several times, until all the grain is threshed with all the straw removed. At this stage, the threshed rice is not clean. It must be winnowed with man-power or a winnowing machine. This last step will help clean the threshed rice.[7]

From the field survey conducted in Supanburi, the average amount of rice threshed per man-day with buffalo treading is about 206 kilograms. (See Table II-3). The buffalo treading method is highly time consuming. As presented in Table II-4, threshing time for 1,000 kilograms of rice with this method is about 22 hours

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[6] W.J. Chancellor, "Survey of Indigenous Farm Implements," paper submitted to the Rice Department, Ministry of Agriculture, Bangkok, Thailand (1961).

[7] The steps in rice threshing by various methods is shown in Appendix Chart B.

compared to only 2.63 and 0.68 hours for a tractor and a thresher, respectively.

TABLE II-3

RICE THRESHED BY DIFFERENT METHODS, 1978

Unit:kilograms per man-day

Method	CHACHOENGSAO				SUPANBURI		Weighted average
	Bang Nam Prieo	Muang	Ban Po	Bang Pa Kong	Don-chedi	Sri-prachan	
Buffalo Treading	-	-	-	-	206.2 (n=8)	-	206.2 (n=8)
Tractor Treading	-	-	429.7 (n=2)	477.6 (n=5)	365.9 (n=12)	362.2 (n=18)	414.6 (n=37)
Thresher	790.5 (n=17)	879.5 (n=8)	759.9 (n=10)	740.7 (n=5)	715.82 (n=12)	537.34 (n=11)	751.8 (n=63)

Note: n = number of observations

TABLE II-4

TIME CONSUMED IN RICE THRESHING OF DIFFERENT METHODS

Unit: hours per 1000 kilogram

Method	CHACHOENGSAO				SUPANBURI		Weighted average
	Bang Nam Prieo	Muang	Ban Po	Bang Pa Kong	Don-chedi	Sri-prachan	
Buffalo Treading	-	-	-	-	22	-	22
Tractor Treading	-	-	2.48	2.24	2.74	2.94	2.63
Thresher	0.61	0.65	0.58	0.60	0.70	0.86	0.68

The threshing cost of buffalo treading is available only in Donchedi District, because buffalo and other draft animals are not employed for rice threshing purposes in other study areas. The area where buffalo treading is practiced is rather dry with only single cropping. Farmers here were also found not to own other types of farm machinery. The total threshing cost for this method averages 193 baht per kwien in 1978 (See Table II-5) and are composed of labor and buffalo costs.

The labor cost component is larger comprising 92 percent of the total cost. About three workers (all of whom were found to be household members) are required. They help one another both during the treading and cleaning. It takes around 4.85 man-days to get 1,000 kilograms of threshed rice. This cost item is to the farmers a non-cash expenditure which they exclude from the total threshing cost and thus underevaluate the buffalo treading cost. To calculate such labor costs, the physical units of labor utilized was, therefore, multiplied with the existing market wage rate of 37.10 baht per man-day in Donchedi.

The buffalo cost in treading is calculated from the market rental rate of a buffalo at 5 baht per day together with the 22 hours of required time in treading 1,000 kilograms of rice. This comes to 13 baht per kwien.

TABLE II-5

COST OF RICE THRESHING BY BUFFALO TREADING
1978

Cost Item	Unit	Donchedi* (n = 7)
I. Buffalo		
Time consumed	hour per kwien	22.00
Price	baht per hour	0.60
Buffalo cost	baht per kwien	13.20 (6.83%)
II. Labor Cost		
Time consumed	man-day per kwien	4.85
Wage Rate	baht per man-day	37.10
Labor Cost	baht per kwien	179.94 (93.17%)
Total Cost	baht per kwien	193.14 (100.00%)

* Buffalo treading data is available only in Donchedi.

2. Tractor treading

One of the simplest means of threshing is through the use of tractors for treading.[8] Similar to buffalo treading, the threshing floor must be prepared. The crop is then spread out on

[8] W.J. Chancellor, op.cit.

the threshing floor large enough to allow the tractor to be driven over the rice bundles. A hard clean floor is necessary but a concrete floor should not be used. At least 45 cm of straws should be maintained. If the same precautions are taken as with animal threshing, there will be less cracking and husking.

The steps in tractor treading are shown in Chart II-1 of the Appendix. The average amount of clean rice threshed by this method is 415 kilograms per man-day.

The total cost of threshing with a tractor is about 140 and 152 baht per kwien in Chachoengsao and Supanburi provinces, respectively. This consists of labor cost, tractor charge and material costs.

Similar to buffalo treading, labor cost in tractor treading is also the largest component (See Table II-6). For all stages of threshing, 2.22 and 2.74 man-days are required for 1,000 kilograms of threshed rice in Chachoengsao and Supanburi, respectively. In calculating the labor cost, the market wage rate at the farm level in each district was applied (See Table IV-8).

The cost of hiring a tractor for rice threshing is about 100-150 baht per day.[9] Since some farmers employ their own tractors,

[9]Information from the survey found that in hiring out tractors for rice threshing, tractor owners do not provide any material costs and tractor operators. Farmers who rent tractors have to pay for these costs themselves. Thus, the average of 100-150 baht/day reflect a net charge rate although this rate may still include a slight transportation cost.

TABLE II-6

COST OF RICE THRESHING BY TRACTOR TREADING, 1978

Cost Item	CHACHOENGSAO		SUPANBURI	
	Baht/Kw	% of total cost	Baht/Kw	% of total cost
Fuel cost (diesel)	8.85	6.30	8.00	5.30
Engine oil	7.50	5.35	7.65	5.05
Grease	-	-	1.10	0.70
Labor cost	82.10	58.55	93.00	61.35
Tractor charge	41.75	29.80	41.85	27.60
TOTAL VARIABLE COST	140.20	100.00	151.60	100.00

Note: Labor cost = (no. of man-days used per kwien) x (wages in baht per man-day)

Chachoengsao: Labor cost = 2.22 man-days x 37.00 baht/man-day
= 82.10 baht/kwien

Supanburi: Labor cost = 2.74 man-days x 34.00 baht/man-day
= 93.00 baht/kwien

this study will evaluate tractor cost at the market rental rate to reflect its opportunity cost.[10] This cost is the second largest item in the total cost of threshing with values of 29.8 and 27.6 percent in Chachoengsao and Supanburi, respectively.

The smallest cost component is material costs which include fuel, engine oil and grease and is around 17 baht per kwien in both Chachoengsao and Supanburi. These intermediate inputs are applied mostly during the tractor treading and rice cleaning (if winnowing machines are used) stages.

3. Rice Thresher

3.1 Method of Rice Threshing By a Thresher

Sometimes this method of threshing is called "straight through type" because rice plants in bundles or as a loose mass are fed through the machine with the resulting output being the threshed rice.[11] The grain is threshed from the straw as it passes between a moving cylinder and a steel grate called "the concave" through which the grain falls. Straws are separated and cleaned. The straw is broken as it passes through the machine. The capacity of a machine

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[10] J. Price Gittinger, Economic Analysis of Agricultural Projects (The John Hopkins University Press, Baltimore and London, 1972), pp. 17-18.

[11] B.A. Stout, Equipment for Rice Production, (Rome: Food and Agriculture Organization of the United Nations, 1966), p. 130.

of about 7-10 h.p. is approximately 1,000-2,000 kilograms per hour depending on the number of workers employed. (See Figures II-1 to II-6)

3.2 Threshing Cost

The total operating cost of a rice thresher is shown in Table II-7. It consists of material costs -- fuel cost, engine oil cost and grease -- and wages paid for a semi-skilled labor in operating a thresher. These costs are usually incorporated in the contract charge rate (baht/kwien of rice threshed) which is 50.00 and 70.00 baht per kwien in Chachoengsao and Supanburi, respectively.

Thresher users also pay for labor costs which is the largest cost item in the total variable threshing cost. Table II-7 shows the total threshing cost by province which is approximately 76.00 and 98.00 baht per kwien of threshed rice in Chachoengsao and Supanburi, respectively.

The differences between the contractor charge rates and the operating costs (excluding labor costs) are terms as "the net return to capital" or the rice thresher service charge for the thresher owners. This item can be broken down into capital consumption allowances or depreciation, interests on capital and the net profit to thresher owners. The imputed service charge is about 41.70 and 60.95 baht per kwien in Chachoengsao and Supanburi, respectively. These will be applied in the evaluation of the net income stream of a rice thresher investment in Chapter 5.

FIGURE II-1

FEEDING AN AXIAL FLOW THRESHER

FIGURE II-2

A THRESHER IN OPERATION

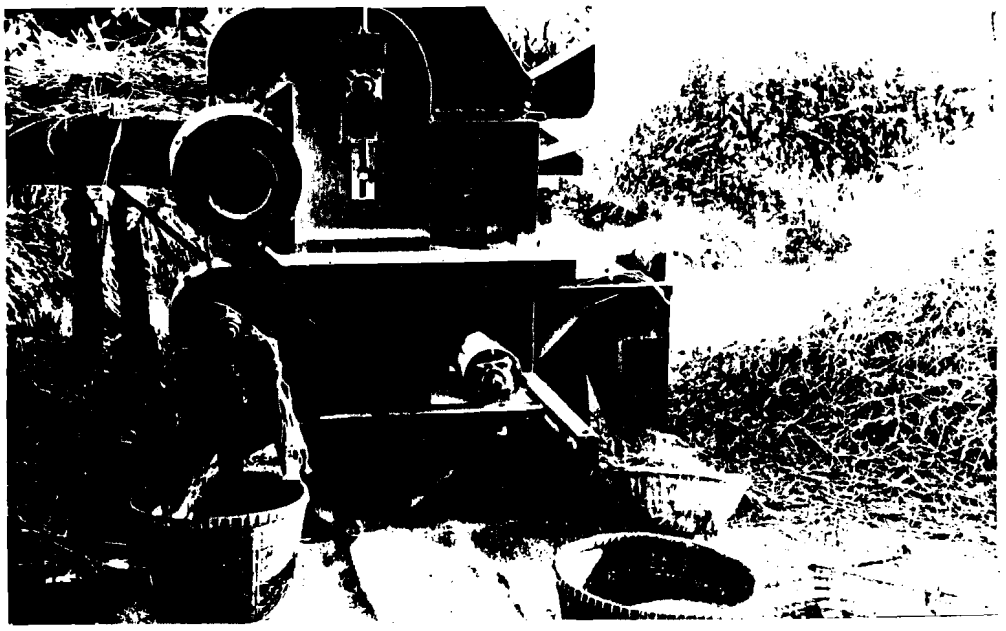


FIGURE II-3

THRESHED RICE IS READY FOR SALE IMMEDIATELY

FIGURE II-4

TWO MEN ARE REQUIRED TO CONTROL CHAFF

FIGURE II-5

TRANSPORTING A THRESHER ON LAND

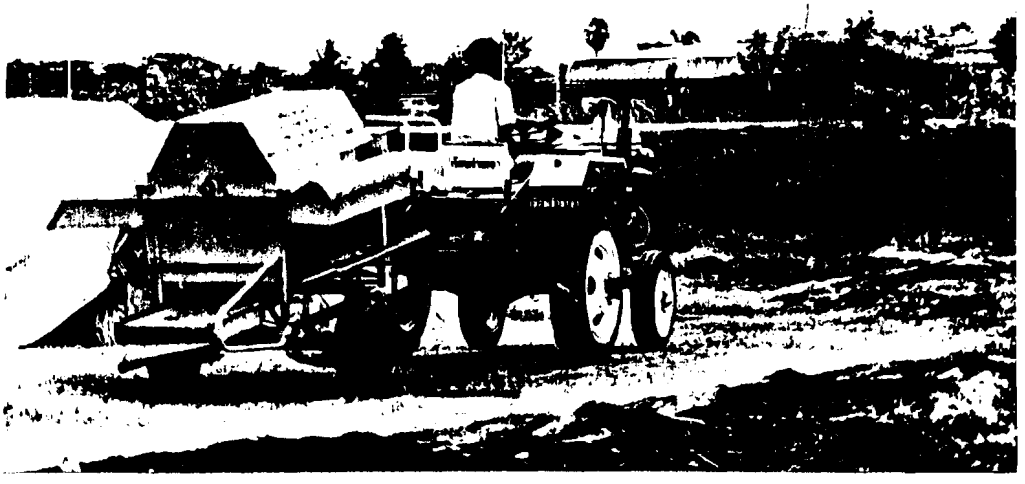


FIGURE II-6

TRANSPORTING A THRESHER ON WATER

TABLE II-7

OPERATING COST OF A RICE THRESHER BY PROVINCE, 1978
(51 Thresher Owners)

Cost Item		Unit	Chachoengsao	Supanburi
1. FUEL	quantity	litre/kw	0.825	0.93
	price (diesel)	baht/litre	3.03	3.33
	fuel cost	baht/kw	2.50	3.10
2. ENGINE OIL	quantity	litre/kw	0.055	0.08
	price	baht/litre	17.85	17.85
	cost	baht/kw	1.00	1.45
3. GREASE COST	quantity	kg/kw	0.006	0.006
	price	baht/kg	17.00	17.00
	cost	baht/kw	0.10	0.10
4. THRESHER OPERATOR COST	rate of operation	m-hr/kw	0.61	0.8
	wage	baht/m-hr	7.70	5.5
	operator cost	baht/kw	4.70	4.4
5. LABOR COST	#labor used	m-day/kw	0.67	0.88
	wage	baht/m-day	38.75	31.85
	labor cost	baht/kw	26.10	28.00
6. SERVICE CHARGE[2] (OPPORTUNITY COST ON FARM USE)		baht/kw	41.70	60.95
7. TOTAL VARIABLE THRESHING COST ON FARM (1+2+3+4+5+6)		baht/kw	76.10	98.00

Source: Appendix Table C-2.

Note: [1]Esso motor oil 10w, 30, 40, 50.
[2]From Table IV-7.

C. Technology, Types of Rice Threshers and the Rice Threshing Industry [12]

Interviews were carried out with rice thresher manufacturers in order to understand the following points :

1. the nature and history of technology transfer, and
2. the nature of production and marketing of threshers.

The flow chart in Figure II-7 shows how the IRRI axial flow thresher came into existence in Thai agriculture. There are four models of rice threshers sent to the Thai IRRI office. They are:

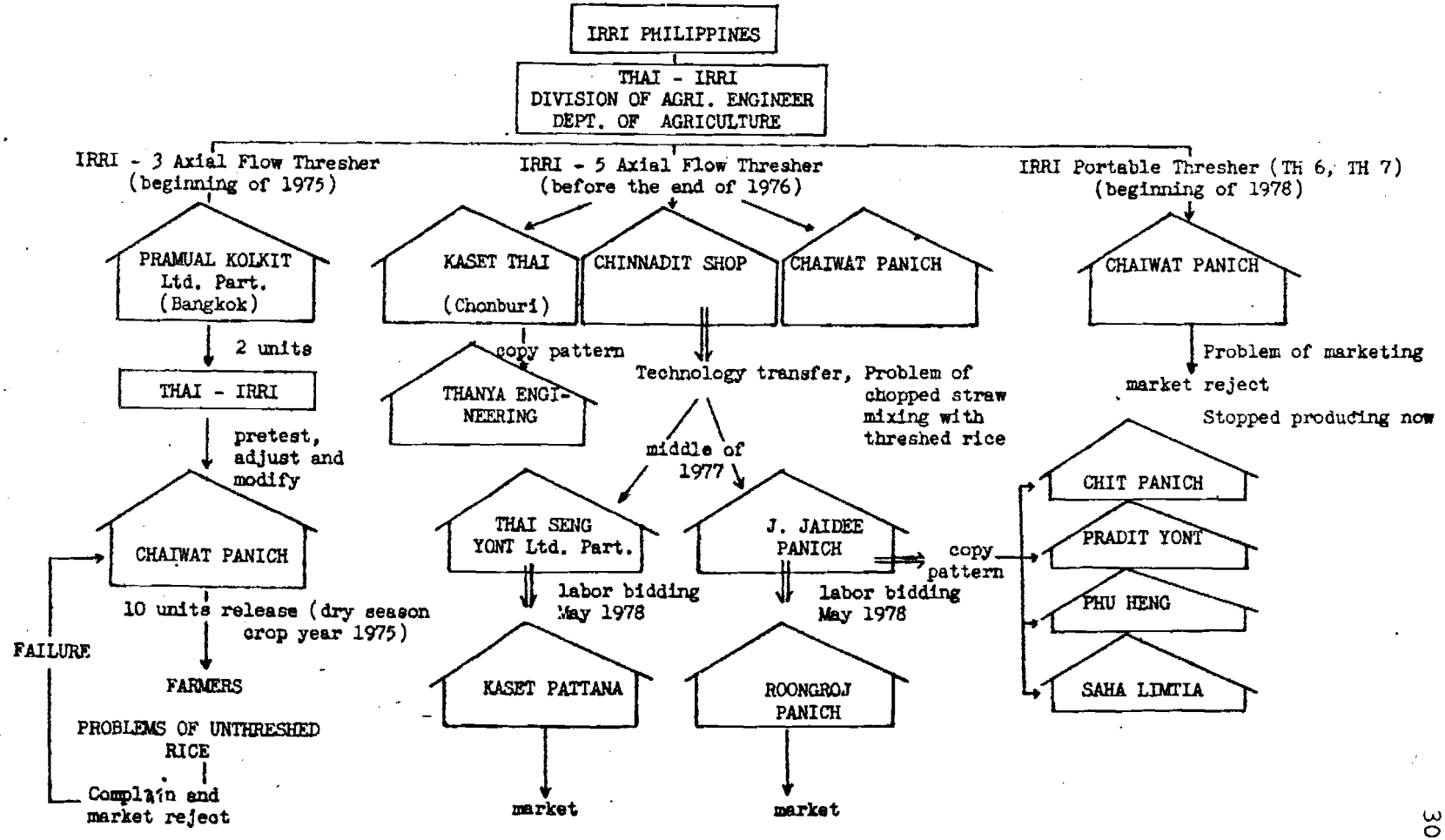
1. IRRI - 3 Axial Flow Thresher
2. IRRI - 5 Axial Flow Thresher
3. IRRI - Portable Thresher (TH6, TH7)
4. IRRI - TH8 Thresher

---

[12] Information in this section comes from two sources: 1.A survey of rice thresher manufacturers during the period of May-June, 1979; and 2. the Thai - IRRI office at the Agricultural Engineering Division, Department of Agriculture, Ministry of Agriculture and Cooperatives.

FIGURE II-7

FLOW CHART OF THE DEVELOPMENT OF TECHNOLOGY TRANSFER
(A HISTORICAL BACKGROUND)



1. IRRI - 3 Axial Flow Thresher (Figure II-8)

The blue-print of this model was first introduced to the Thai-IRRI office from the IRRI head office in the Philippines at the beginning of 1975. Pramual Kolkit, a manufacturer in Bangkok, used the blue-print to produce 2 units of IRRI - 3 axial flow thresher for the Thai - IRRI office. The Thai - IRRI staff tested and modified the machines to suit local conditions before releasing it to the commercial sector.[13] The Chaiwat Panich Shop in Chachoengsao Province obtained the modified blue-print and produced 10 units of the thresher. The total cost of the thresher was about 7,000 baht per unit. The selling price charged by the factory was 12,000 baht each. Its capacity of threshing rice was about 1,000 kilograms per hour. The modified IRRI - 3 axial flow thresher was first provided to farmers during the dry season of crop year 1975/76. Some problems, however, were discovered but unsolved. Most farmers who bought the machines complained about the shaking screen and/or the high separation loss. Khun Trakulchai Chaiwat Panich Shop and Khun Suwit Bunyawanichkul, a Thai - IRRI employee at the time, unsuccessfully tried to solve the problems together.

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[13] Some modifications in the shaking screen was made.

FIGURE II-8

IRRI-3 AXIAL FLOW THRESHER

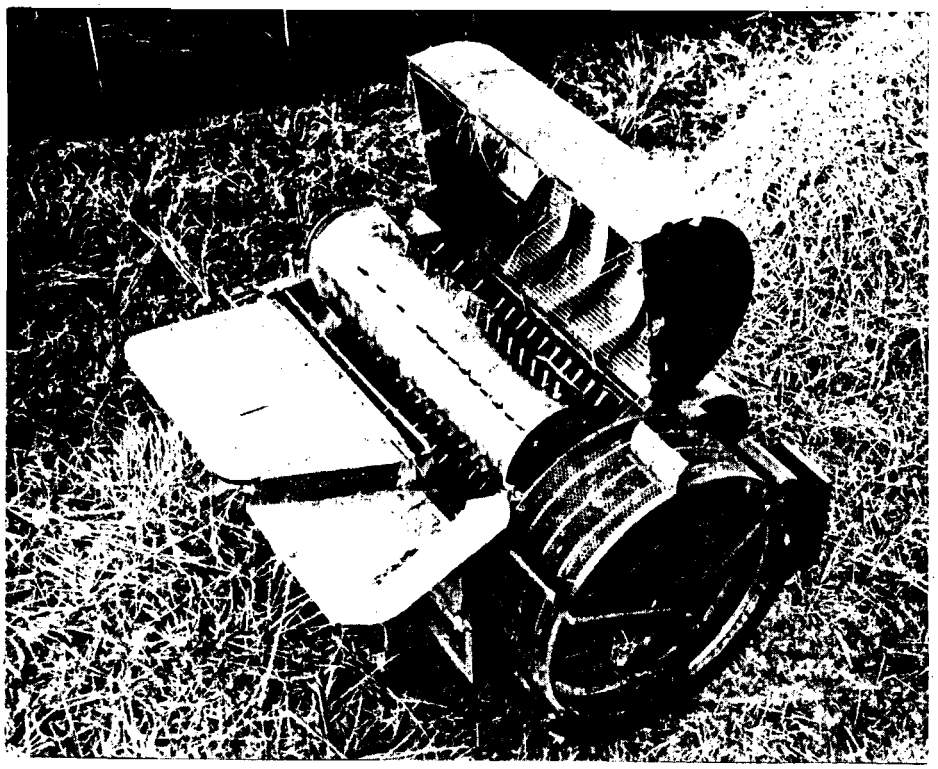
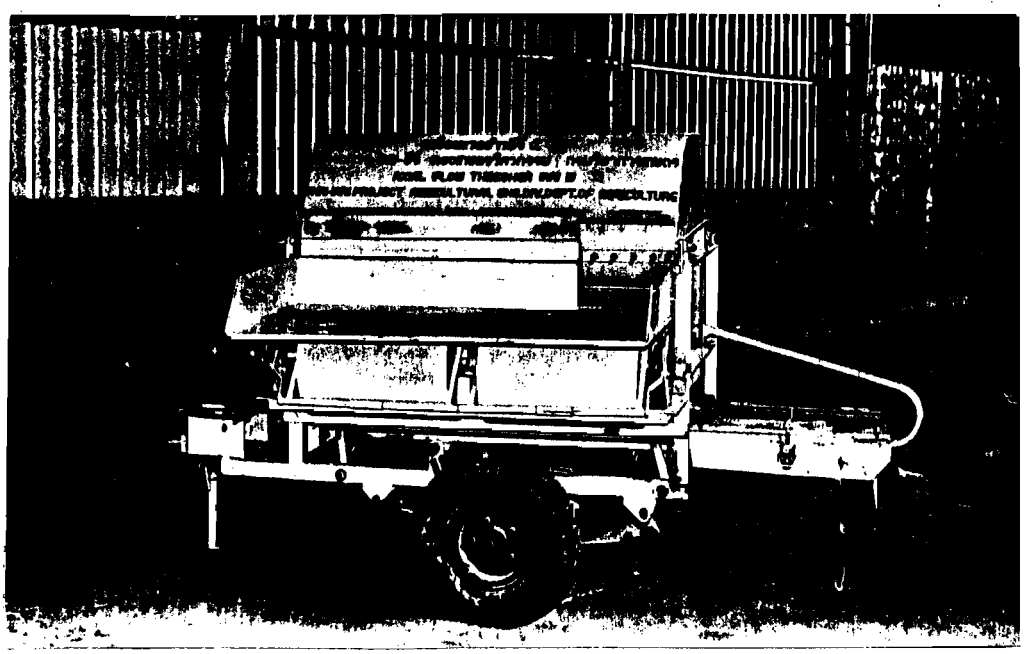


FIGURE II-9

IRRI-5 AXIAL FLOW THRESHER



2. IRRI - 5 Axial Flow Thresher (Figure II-9)

At the end of 1976, while the problems of the IRRI - 3 axial flow thresher were under investigations, the IRRI office in the Philippines sent a new model, the IRRI - 5 axial flow thresher, to the Thai - IRRI office. Chinnadit Shop, a manufacturer located at Muang District of Chachoengsao, was the first to produce and market this machine at the beginning of 1977. The Chaiwat Panich Shop also began, in late 1977 to produce the IRRI - 5 axial flow thresher. About 30 units were produced with a total cost of 9,000 baht each. The selling price was 14,500 baht per unit.

Around the middle of 1977, the technology required to produce the IRRI - 5 axial flow threshers spread to other firms. Some of Chinnadit's skilled laborers shifted to the J. Jaidee Panich Shop (in Chachoengsao) and the Thai Seng Yont Limited Partnership (in Bangkok), both rapidly expanding firms. While the Thai Seng Yont Limited Partnership was expanding thresher production, some laborers moved from this shop around May 1978 to the Kaset Pattana Shop, located at Muang District opposite to the Chaiwat Panich Shop. Furthermore, the manager of the J. Jaidee Panich Shop allowed Khun Sombat Watchara, the manager of Roong Roj Panich Shop, to borrow some skilled laborers from the firm to help demonstrate how to produce threshers. The Roong Roj Panich Shop began producing rice threshers in October 1978. In addition, the four new manufacturers in Chachoengsao Province - Chit Panich, Pradit Yont, Phu Heng and

Saha Limtia - bought J. Jaidee Panich Shop's product and copied the model with some modifications.

The IRRI - 5 thresher blue-print was also sent from the Thai - IRRI office to Mr. Jaroy Booriboon's firm which is located in Panutnikom District, Chonburi Province, at the end of 1976. The Thanya Engineering Shop bought a thresher of this model for copying.

It was found that the IRRI - 5 axial flow thresher had some weak points and was not suitable for threshing some varieties of rice in Supanburi. The resulting semi-threshed paddy received a lower price.

3. IRRI - Portable Thresher (Figures II-10 and II-11)

The TH6 Portable Thresher was designed to solve the problem of transporting the machine over distances and help reduce labor requirements. It is a small portable thresher without an oscillating screen. Before being distributed to manufacturers, the Thai - IRRI staff and especially Khun Suwit Bunyawanichkul tested its performance and modified it by including an oscillating screen. It was called the TH7 portable thresher.

The IRRI - Portable thresher was first introduced to the Chaiwat Panich Shop in November 1977 with some additional parts such as a blower, a shaking screen and a screw conveyor. The modified machine's performance has been tested by Khun Suwit Bunyawanichkul

FIGURE II-10

IRRI TH7 - PORTABLE THRESHER

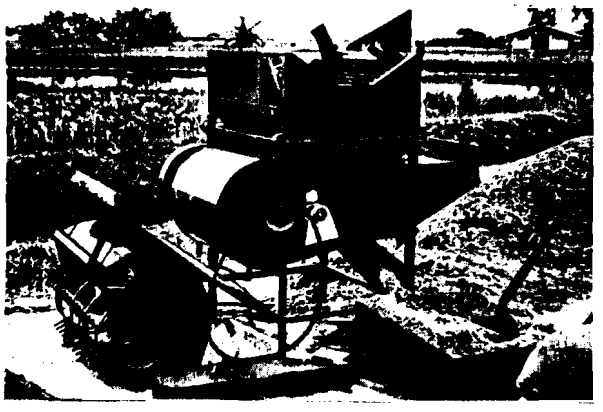


FIGURE II-11

TRANSPORTING AN IRRI TH7 - PORTABLE THRESHER

and the firm's manager. Up to now, nine units of the portable thresher have been produced. The machine price is 8,500 baht without an engine. The average capacity of rice threshing is about 600 kilograms per hour with a labor requirement of three persons.

However, the small thresher has not been well accepted. Most farmers reject the portable thresher because of its lower threshing capacity. The Chaiwat Panich Shop has now stopped production of this machine.

4. IRRI - TH8 Thresher (Figure II-12)

Most versions of the axial flow thresher, produced by manufacturers in cooperation with IRRI, use one oscillating screen for cleaning. A new version of the axial flow thresher with two oscillating screens under the full-length of the concave is under development. This model was recently sent to the Thai - IRRI Office. It is being studied and has not yet been produced.

5. Marketing and Production

The Thai - IRRI office has recorded all names of manufacturers producing both axial flow and portable threshers. About 30 firms are now producing rice threshers in Thailand, of which 10 firms are located in Chachoengsao Province and only 1 firm in Supanburi Province. Although a large number of thresher dealers are located in Supanburi, only three were found in the study area of the province. Their

FIGURE II-12

COMPONENTS OF AN IRRI - TH 8 THRESHER

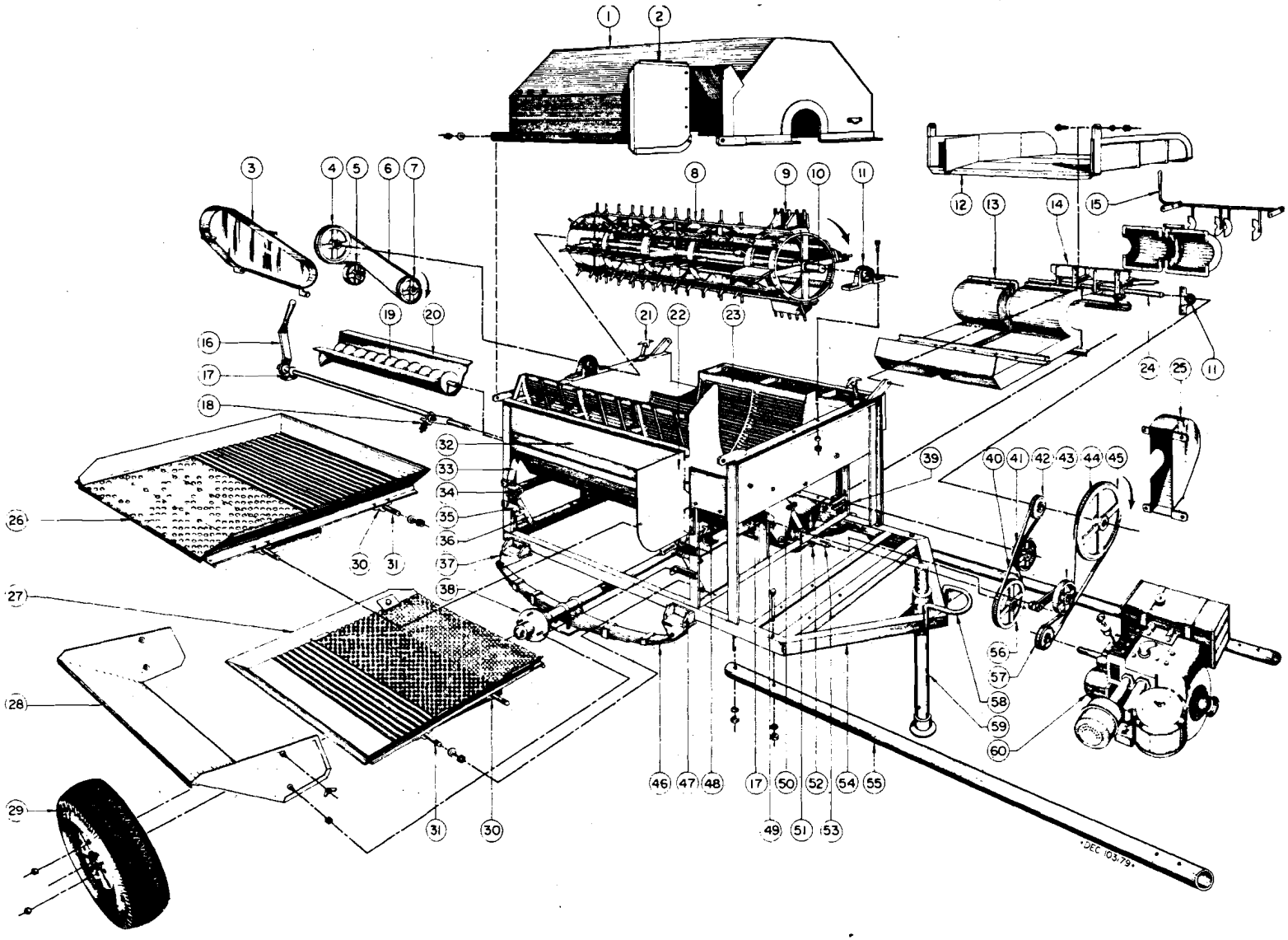


FIGURE II-12 --Continued

COMPONENT PARTS LIST

REF.	REQ'D	DESCRIPTION
1	1 SET	COVER ASSEMBLY
2	1 PC.	UPPER STRAW DISCHARGE GUIDE ASSY.
3	1 PC.	BLOWER/CYLINDER BELT GUARD ASSY.
4	1 PC.	8"Ø V-PULLEY, SECTION 'B'
5	1 PC.	IDLER ASSEMBLY
6	1 PC.	V-BELT, SECTION 'B', B-70
7	1 PC.	6" Ø V-PULLEY, SECTION 'B'
8	1 SET	THRESHING CYLINDER ASSEMBLY
9	4 PCS	PEG-TYPE STRAW PADDLE ASSEMBLY
10	1 PC.	THRESHING CYLINDER SHAFT
11	4 SETS	1¼' DIA. PILLOW BLOCK BEARING
12	1 PC.	FEED TRAY ASSEMBLY
13	2 SETS	BLOWER HOUSING ASSEMBLY
14	2 PCS	BLOWER BLADE ASSEMBLY
15	1 PC.	BLOWER SHUTTER ASSEMBLY
16	1 PC.	CLUTCH CONTROL ASSEMBLY
17	2 PCS	PIVOT BRACKET
18	1 SET	SPRING LOADED-CLUTCH CONTROL ASSY.
19	1 PC.	AUGER ASSEMBLY
20	1 PC.	AUGER HOUSING ASSEMBLY
21	2 SETS	STD. JEEP HOOD CATCH
22	1 PC.	LOWER STRAW DISCHARGE QUIDE ASSY.
23	1 SET	CONCAVE ASSEMBLY
24	1 PC.	BLOWER SHAFT
25	1 PC.	BLOWER/IDLER BELT GUARD ASSY.
26	1 SET	UPPER SCREEN ASSEMBLY
27	1 SET	LOWER SCREEN ASSEMBLY
28	1 PC.	ADJUSTABLE WINDBOARD ASSEMBLY
29	2 SETS	TIRE, SIZE: 5.60 t x 13.4 PLY
30	8 PCS	CLAMP
31	4 PCS.	SCREEN SHAFT
32	1 SET	GRAIN CHUTE ASSEMBLY
33	2 PCS.	UPPER SCREEN HANGER
34	2 PCS.	SLOTTED BRACKET, L & R
35	2 PCS.	PIVOT BRACKET
36	2 PCS.	LOWER SCREEN HANGER
37	2 PCS.	SPRING SHACKLE ASSEMBLY
38	1 SET	WHEEL AXLE ASSEMBLY
39	1 SET	BLOWER/AUGER ASSEMBLY
40	1 PC.	V-BELT, SECTION 'A', A-53
41	1 PC.	6" Ø V-PULLEY, SECTION 'B'
42	1 PC.	3½" Ø V-PULLEY, SECTION 'A'
43	1 PC.	IDLER ASSEMBLY
44	1 PC.	V-BELT, SECTION 'A', A-75
45	1 PC.	14" Ø V-PULLEY, SECTION 'A'
46	2 SETS	STD. JEEP FRONT LEAF SPRING
47	2 PCS	SPRING HANGER ASSEMBLY
48	2 PCS	CLUTCH CONTROL BRACKET
49	2 PCS.	PIVOT BRACKET
50	1 SET	BELL CRANK ASSEMBLY
51	1 SET	ECCENTRIC CRANK ASSEMBLY
52	1 SET	1" DIA. PILLOW BLOCK BEARING
53	1 PC.	AUGER SHAFT
54	1 SET	MAIN FRAME ASSEMBLY
55	2 PCS.	TOWING BAR
56	1 PC.	8" Ø V-PULLEY, SECTION 'A'
57	1 PC.	3½" Ø V-PULLEY, SECTION 'A'
58	1 PC.	HITCH ASSEMBLY
59	1 PC.	STAND ASSEMBLY
60	1 PC.	10 HP. GASOLINE ENGINE. 3200 RPM AIR-COOLED

threshers come from the Kaset Pattana Shop and the Saha Limtia Limited in Chachoengsao.

Since the rice thresher industry has just developed during the last 3 years, most manufacturers are quite small compared to producer of other kinds of farm machineries in Thailand, for example, power tillers and tractors. Nine firms listed in Table II-8 could be classified as "small firms" by the number of laborers employed.[14] They are characterized by a lack of management specialization. Management functions are performed by one person, the owner-manger, who normally has no specialist staff assistance. They have very little organized division of labor. Only a relatively small number have access to organized marketing facilities and bank credit.

In our findings, the laborers are mostly unskilled with only primary school education. Not more than 10 percent are skilled laborers and/or technicians.

These firms originally produced other types of farm machinery. Some of them still produce both rice threshers and other machines whereas others have since concentrated only on threshers. Two peak periods of production are around April to June and October to December.

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[14] A small manufacturer is defined as an establishment employing 50 or less workers and an investment in total assets of up to 2 million baht (US$100,000). See Industrial Projects Department, Industrial Development in Thailand, (Bangkok: Ministry of Industry, 1975), p. 49.

TABLE II-8

PROFILE OF RICE THRESHER MANUFACTURERS May-June, 1979

Name	Year operations started & initial machinery produced	Commencement of thresher production	labor employed (persons)	Capacity of thresher production (unit/month)	Capacity of rice thresking (ton/hour)	Price of thresher without engine 1978/79 (baht)	Market (Province)
1. J. Jaidee Panich	end of 1964 2-wheel tractor	1976	40	45	Large:3 Small:1-1.5	16,000 12,000	Rachburi, Lopburi Chainat, Khon Kaen, Udon, Chantaburi, Pitsanulok, Sukothai, Nakorn Sawan, Chachoengsao
2. Saha Limtia	n.a. tractor water pipe puddler	1978	6	10	1	16,500	Supanburi, Chachoengsao
3. Kaset Pattana	May 1978 tractor water pipe	May 1978	30	50	Large:3 Small:1	15,500 12,000	Supanburi, Chainat, Nakorn Rachsima, Chachoengsao
4. Mitre Kasikorn	1967 2-wheel tractor water pipe	1976	15	9	2	15,000	Nakornpathom, Chainat, Pichit, Supanburi, Chachoengsao
5. Roongroj Panich	1974 tractor water pipe	June 1978	13	6	1.25	15,500	Burirum, Chachoengsac

TABLE II-8 --Continued

Name	Year operations started & initial machinery produced	Commencement of thresher production	labor employed (persons)	Capacity of thresher production (unit/month)	Capacity of rice threshing (ton/hour)	Price of thresher without engine 1978/79 (baht)	Market (Province)
6. Thanya Engineering	end of 1976	end of 1976	12	5	1.65	16,500	Supanburi, Payao
7. Thai Seng Yong	n.a. tractor	mid 1977	30	50	3	16,500	Chainat, Supanburi, Nonburi, Pathumthani, Nakorn Rachsima, Phrae, Phitsanulok, Sukothai, Kamphaengpet, Pichit
8. Chakpet Tractor	Oct. 1976 tractor	Aug. 1978	43	50-60	3	16,000	Pitsanulok, Nakornrachsima, Petchaboon, Pichit, Saraburi, Nakornpatom, Rachburi, Patumtani
9. Chaiwat Panich	1970 puddler 2-wheel tractor	1976	5	5	0.6	8,500	Sungai-Ko-Lok, Trad, Prachinburi, Chachoengsao

n.a. = not available.

The average market price of a local rice thresher without an engine (Figure II-13) is 15,500 baht in 1978 and the machine is usually sold in cash without any discount. Firms need not advertise given the supply shortage that exists due to the rapid increase in demand. Some firms such as Kaset Pattana and Chakpet plan to expand their firm sizes and increase their production capacities up to 50 units per month. Kaset Pattana plans to build a new warehouse for spare parts, raw material inputs and the produced rice threshers.

To summarize briefly, the axial flow thresher production seems to have progressed rapidly with a minimum of problems. Compared with other countries, Thailand ranks second to the Philippines in the number of rice threshers produced. Almost 1600 threshers were produced in 1978 (Table II-12 and Figure II-14) by manufacturers with links to IRRI and it is reasonable to assume that several hundred additional machines were produced by firms not directly involved with the IRRI program. From information gathered from a survey of manufacturers, it is estimated that 5,000 threshers have been produced in Thailand. Thresher sales in the Central Region are expected to level off, but sales in the Northeast and Southern Regions are expected to increase because these are still relatively new market areas. One manufacturer in the North has started manufacturing the portable thresher and other manufacturers expect farmers to shift to the smaller machines in the future. An increase in production of the small portable threshers may be expected as

FIGURE II-13

A RICE THRESHER PRODUCED
BY A LOCAL MANUFACTURER

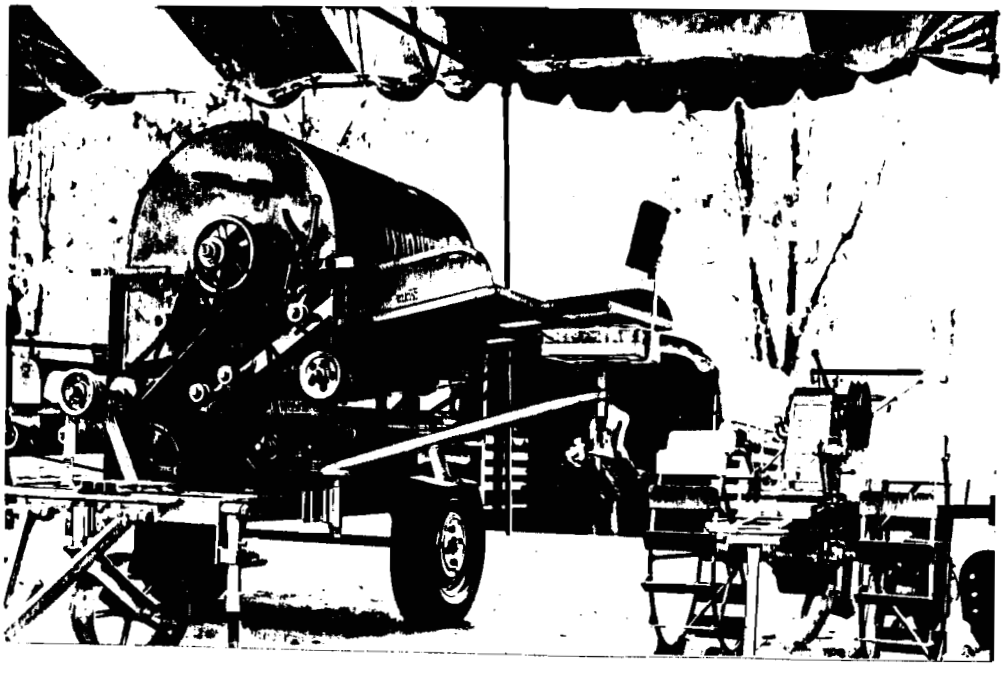


TABLE II-9

NUMBER OF RICE THRESHERS PRODUCED, 1974-1978

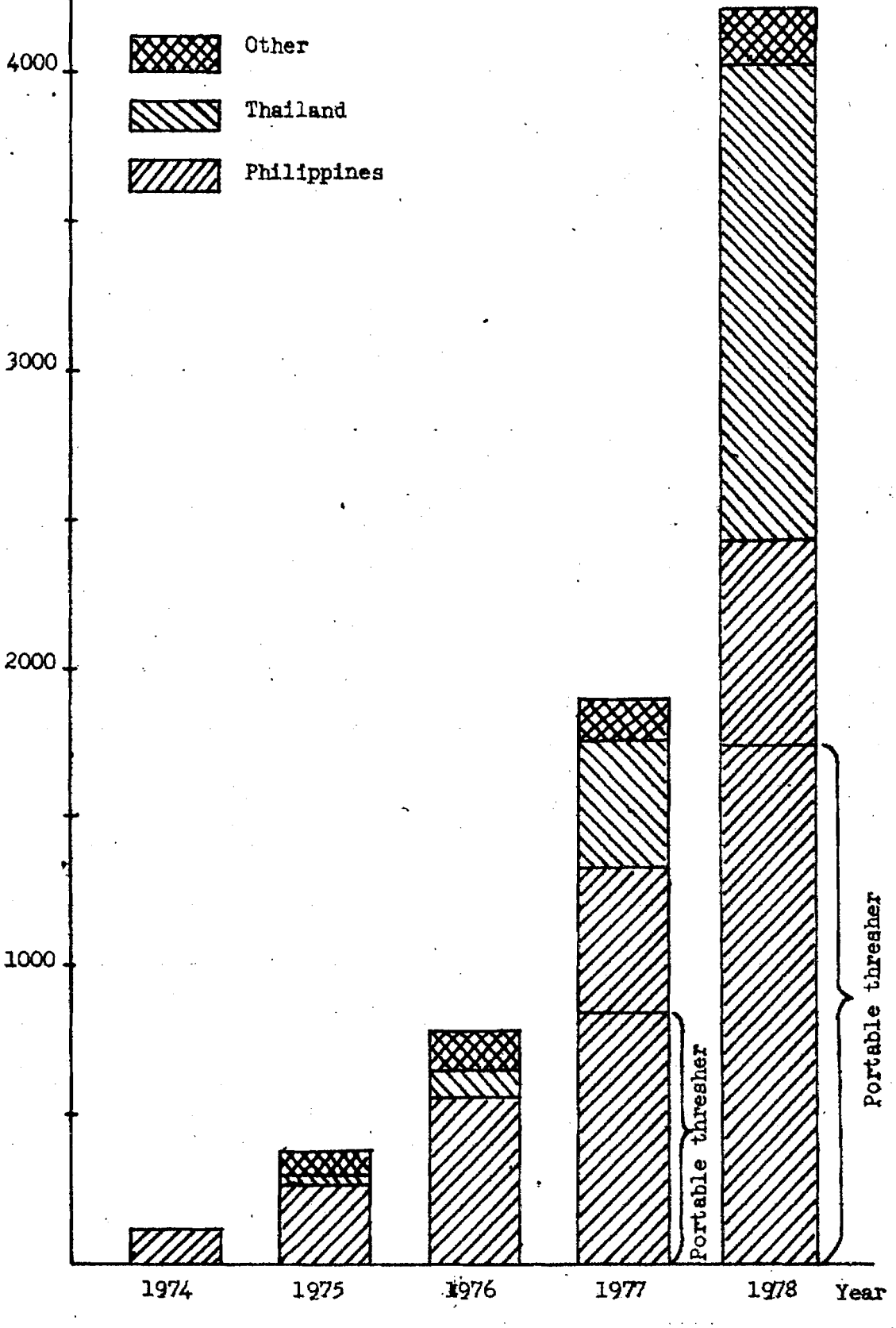
Country	1974	1975	1976	1977	1978	Total
India	0	60	103	68	45	276
Indonesia	0	0	43	0	8	51
Philippines	120[e]	275	552	1,321	2,435	4,583
Pakistan	0	2	0	26	26	54
Sri Lanka	0	0	3	11	28	42
Thailand	0	10	97	444	1,590	2,141
Egypt	0	0	0	10	96	106
Columbia	0	0	0	3	0	3
Total	120	347	798	1,883	4,228	7,256

Source: Rice Machinery Division and Mechanization Research, IRRI, Semi Annual Report, No. 21-27, Los Baños, Philippines, July 1, 1975-December 1978.

Note: [e]Estimated value.

FIGURE II-14

IRRI Axial-flow thresher production



individual farmers show interest in owning their own machines.[15]

D. Rice Thresher Adoption and Diffusion

Rice threshers were first introduced to Thai farmers during crop year 1975/76. However, the rapid spread of threshers did not occur until 1977 and 1978 in Chachoengsao and 1978 in Supanburi.

Farmers' first encounter and knowledge of the machines were through information from salesmen and demonstration by manufacturers. Information was later also spread by farmers themselves. Most farmers adopted the thresher because it is easier to operate and more effective as compared to pre-existing methods of threshing. It saves time which is especially valuable in allowing farmers to plant their crop on time. Some commented that the threshed paddy is cleaner with the new machine as compared to traditional methods of threshing.

Some farmers, however, prefer to thresh rice with tractors because they already own a tractor. Others were not faced with labor shortage problems and thus they employ tractor treading methods, especially in Ban Po and Bang Pa Kong Districts.

Almost 50 percent of the farmer respondents consider its performance quite satisfactory. Moreover, almost 15 percent reported that rice straw accumulating in a heap 1-2 meters from the machine

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[15]Rice Machinery Division and Mechanization Research, IRRI Semi-Annual Report, No. 27, Philippines, July 1, 1978 (mimeographed).

would fall into the threshing area and the clean threshed rice would be mixed with rice straw again. Farmers, therefore, want threshers that can blow the straw further away from the machine.

From the field survey, it appears that most farmers using thresher contractor services and traditional methods of threshing are interested in purchasing rice threshers. However, they do not have enough money and some of them are chronically in debt. According to the study's survey of the demand for farm machinery, the demand for power tillers is the greatest with rice threshers coming a close second (See Table II-10).

TABLE II-10

POTENTIAL DEMAND FOR FARM MACHINES

	Number of respondents*	Percent
What type of farm machines do you want to own ?		
Power tiller	58	21.6
Transplanter	34	12.7
Sprayer	45	16.8
Water pump	39	14.5
Combiner	15	5.6
Rice thresher	52	19.4
Winnower	2	0.7
Power engine	17	6.3
Trailer	3	1.1
Grass cutter	3	1.1
All machines	1	0.4
None	67	25.0

* More than one choice is allowed.

CHAPTER III

REVIEW OF LITERATURE AND SOME FACTORS AFFECTING RICE THRESHER ADOPTION

This chapter will review some of the literature concerning rice threshing activities. It will also present some of the possible factors affecting the adoption and use of rice threshers. Both economic and noneconomic factors will be included.

A. Review of Literature

The rice threshing method chosen may not only depend on the output of threshed rice but also on the possible uses of its by product from threshing. Stout[1] in 1966, for instance, has pointed out that if the rice straw were to be used as input materials for the production of rope, mats and other industrial purposes, a threshing method that would produce broken or chopped straw such as the use of a rice thresher would not be used.

Locational consideration is another factor affecting the choice of the threshing method chosen. Suitable gathering and placement of the unthreshed rice at a particular threshing point in the field would help decrease the work load considerably. According to a detailed analysis made by Chancellor[2] in 1963, the over all rate

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[1] B.A. Stout, op.cit., p. 124.

[2] W.J. Chancellor, "Transport Distances for Gathering and Distribution Materials on an Open Rectangular Field," unpublished paper, University of Malaya, 1963.

of threshing was highly affected by the gathering and the transporting operations. He found that in concentrating the threshing activity at the center of a field would reduce the transporting task by half as compared to threshing at one particular corner of a field. Thus good locational planning can indirectly increase the threshing efficiency and thus should be worthy of careful consideration especially when the shape of the field is rather elongated.

Toquero and others[3] (1976) revealed in their study how improvement in technology would help decrease production losses. The longer the interval of time between harvesting and threshing, the larger would be the grain loss. The use of threshers could help reduce such losses by speeding up the threshing activity.

Although mechanization has been accepted as a possible major factor in the improvement of farming efficiency, there are still many constraints hindering the adoption of machines for harvesting and threshing. Khan's[4] survey conducted in 1971 pointed out that some farmers were reluctant to accept modern methods because of

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[3]S. Toquero, C. Moranas, L. Ebron and E. Duff, "Empirical Assessment of Alternative Field Level Rice Post Production System in Nueva Ecija, Philippines," The IRRI, Department of Agricultural Engineering, 1976.

[4]Amir U. Khan, "Harvesting and Threshing of Paddy." a paper presented at the International Rice Research Conference at the IRRI, Los Baños, Laguna, Philippines, 1971.

their poor mechanical aptitude and/or inability to raise capital to finance the purchase of a machine. The latter point is especially important when the equipment or machine involved is imported at a high cost while local methods using labor and local equipment are relatively cheaper.

Another study on modern threshing methods was conducted by Sriaroon Rasanond and others.[5] In their study, the acceptance of the IRRI axial flow thresher was found to be largely due to its better efficiency in terms of cost saving as compared to other threshing methods. In addition, in areas where double cropping are widely practised, the shorter time period available for threshing and the scarcity of labor were major factors encouraging the adoption of modern threshing methods.

Although there have been studies on the benefits and costs of a rice thresher, there have been no systematic studies. One of the most comprehensive study of thresher was done by Sison and others[6]

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[5]Sriaroon Rasanond et. al., "A Survey of the IRRI Axial Flow Thresher Efficiency Compared with the Traditional Methods of Threshing," (Unpublished Report, Faculty of Economics and Business Administration, Agrobusiness Management Program, Kasetsart University, 1977).

[6]W.M. Sison, B.C. Sarmiento and C.C. Dacumos, "Comparative Study and Test Evaluation of Village Type Rice Threshers," (Unpublished paper of Post-Harvest Rice Technology, National Grains Authority, Philippines, 1977).

in 1977. The study tried to measure the costs, benefits and return on investment of different rice threshers in different areas of the Philippines. The results were mixed. But again as in other studies, the thresher was not treated as a piece of capital which cannot be subdivided into small units. Such a static framework may therefore be unsuitable in analysing investments in rice threshers. This, perhaps, is one reason justifying the present study.

B. Some Factors Affecting Rice Thresher Adoption

1. Noneconomic Factors

1.1 Farmer's Background

Age of household heads in the study ranges from 43-45 years (Table III-1). About 85 percent of the household heads of our sampled families had four years or less of elementary education while another 11 percent had no formal education at all. Only 4 percent had studies more than four years.

According to the field survey information, age does not seem to affect the adoption and use of threshers (Table III-1). In terms of the level of education and experience, they also seem to show the same tendency. This is supported by Supan's study[7] using a chi-square test which did not show any significant relation

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[7]Supan Suwanpimolkul, "Socio-Economic Constraints on Rice Yield in Parts of Supanburi Province, Thailand, Wet Season, 1974," unpublished M.A. Thesis, University of Philippines, 1975. P 39.

between farmer's educational attainment and technology adoption. The explanation may be found in the Thai educational system which is mainly academic and not technical. Most farmers gained their experience in farming from their parents or friends.

TABLE III-1

AVERAGE AGE OF HOUSEHOLD HEAD, 1978

(Years)

District and Province	Thresher owners	Thresher renters	Farmers who employ tradional methods
CHACHOENGSAO	(N = 40)	(N = 71)	(N = 7)
Bang Nam Prieo	45.0	44.0	-
Muang	50.0	44.0	-
Ban Po	48.0	51.0	46.0
Bang Pa Kong	50.0	53.0	45.0
SUPANBURI	(N = 23)	(N = 85)	(N = 42)
Don Chedi	44.0	49.0	52.0
Sri Prachan	48.0	45.0	43.0
Age range in two provinces	44-50	44-53	43-52

N = Sample size.

1.2 Farm Characteristics

Looking at Table III-2, farmers in Chachoengsao with their own land are more prevalent among those who own threshers than among those who do not own but use threshers and farmers who employ traditional methods of threshing. The figures are 55, 40 and 29 percent, respectively. In the case of Supanburi, there is not much difference between thresher owners and farmers who employ traditional methods. But for thresher non-owners but users, the proportion of land owners is somewhat smaller than the other two groups.

TABLE III-2

LAND OWNERSHIP STATUS BY TYPE OF FARMERS, 1978

	Type of farmers		
	(1)	(2)	(3)
Chachoengsao			
Land owner	55	40	29
Landless	45	60	71
Supanburi			
Land owner	95	86	98
Landless	5	14	2

Note: (1) = Thresher owners.
(2) = Thresher non-owners who use threshers.
(3) = Farmers who employ traditional methods.

If cultivated areas may be used as a proxy for farm sizes, it appears that thresher owners possess larger farm size than thresher renters and those who employ traditional methods of threshing except in Ban Po where the difference does not show much significance. (Table III-3)

It therefore seems that land ownership and farm size may have a certain effect on thresher adoption. This might be because ownership of land and larger farm sizes show the economic position of farmers. They tend to be farmers with higher income.

1.3 Cropping Intensity, Irrigation and Water Availability.

Cropping intensity and water availability are found to be important factors affecting rice thresher adoption. This is because irrigation and water availability promote double cropping which increases the seriousness of the seasonal labor shortage problem, particularly during threshing. Thresher adoption could solve these labor and time constraint problems in double cropping. It can be

TABLE III-3

CULTIVATED AREA AND CROPPING PATTERN BY TYPE OF FARMERS, CROP YEAR 1978/79

District and Province		Type of farmer	Cultivated area (rai)			1978 crooping pattern	
			wet season	dry season	dry season as % of wet season	double cropping	single cropping
						(as % of farmer respondents)	
CHACHOENGSAO PROVINCE							
Bang Nam Prieo.	(N_1=17)	1	60	41	68.3	100.00	-
	(N_2=37)	2	37	25	67.6	88.2	11.8
			(44)	(30)	(68.2%)		
Muang	(N_1= 8)	1	80	62	77.5	100.00	-
	(N_2=11)	2	57	45	78.9	100.00	-
			(67)	(52)	(77.60%)		
Ban Po	(N_1=10)	1	46	44	95.6	100.00	-
	(N_2=10)	2	50	36	72.0	100.00	
	(N_3= 3)	3	51	N.A.	-	20.00	80.00*
			(48)	(40)	(83.3%)		
Bang Pa Kong	(N_1= 5)	1	68	30	44.1	60.00	40.00
	(N_2=13)	2	39	17	43.6	84.60	15.40
	(N_3= 5)	3	75	N.A.	-	20.00	80.00*
			(53)	(21)	(39.6%)		
Provincial Mean	(N=118)		50	36	72.0%		

TABLE III-3 -- Continued

District and Province	Type of farmer	Cultivated area (rai)			1973 cropping pattern	
		wet season	dry season	dry season as % of wet season	double cropping	single cropping
SUPANBURI PROVINCE						
Don Chedi (N_1=12)	1	40	29	72.5	58.30	41.70
(N_2=49)	2	24	15	62.5	73.50	26.50
(N_3=21)	3	35	19	54.3	81.00	19.00
		(30)	(18)	(60.0%)		
Sri Prachan (N_1=11)	1	39	27	69.2	63.60	36.40
(N_2=36)	2	21	18	85.7	52.80	47.20
(N_3=21)	3	31	19	61.3	66.70	33.30
		(27)	(20)	(74.0%)		
Provincial Mean (N=150)		29	19	65.50%		

Note: N = Sample size.

[a]Figures in parentheses are the average district values.

*Cultivated areas were damage because of salt water; A single crop was possible only.

Type of farmer: 1 = Thresher owners,
2 = Thresher non-owners who use threshers.
3 = Farmers who employ traditional method.

noted that rice thresher adoption is widely and extensively found in double cropped areas. However, a large number of farmers who practice single cropping in some areas of Chachoengsao (Bang Pa Kong District) and Supanburi (both Donchedi and Sriprachan) have bought rice threshers even though they are unable to utilize the machine's capacity fully by themselves. The reason is that they are able to hire out their machines.

1.4 Farmers' Associations and Extension Programs

Most farmers, both thresher users and non-users, participate in farmers' associations and/or extension programmes. They gain benefits from such activities as training programmes on new farming technology and new high yielding rice variety demonstration. They may also obtain fertilizer at subsidized prices. Information from the survey seems to indicate that thresher adoption is not influenced by such activities. However, some farmers' associations plan to have members chip in to buy threshers as a common property.

1.5 Government Agencies and International Organizations

The Agricultural Engineering Division, Ministry of Agriculture and Cooperatives is directly involved in rice thresher modifications and improvements. Its main task is to make threshers adaptable to local conditions. This office, in cooperation with the IRRI, has played a significant role in the development of the rice thresher industry.[8]

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[8] As mentioned in section C, Chapter II.

1.6 Labor Shortage.

Since the labor shortage problem is made more serious through double cropping, the reduction of time pressure by mechanization, especially with rice threshers, would reduce the excess demand for labor during the period of harvesting and land preparation.

2. Economic Factors

2.1 Source of Funds

The availability and cost of funds seem to be an important factor determining investment in rice threshers. This is because the initial cost of investment is rather high for farmers (27,200 baht in Chachoengsao and 38,520 baht in Supanburi in 1978).

Since the BAAC and commercial banks usually have a limit on the amount of loanable fund (about 6,000 baht)[9] provided for farm machinery investment, the investment on a thresher could not be made without funds from other sources especially farmer's own savings.

From the survey data, the sources of funds for purchasing rice threshers come largely from the personal savings of farmers with the rest from financial institutions and/or money lenders in the area (Tables III-4 and III-5). The interest rate charged by the Bank for Agriculture and Agricultural Cooperatives (BAAC) was

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[9] Survey information.

TABLE III-4

SOURCES OF FUNDS FOR RICE THRESHER INVESTMENT
(N = 63)

Source	Percent
Own cash	69.3
Loans	6.5
Both own cash and loans	24.2
Total	100.0

TABLE III-5

SOURCES OF LOANS FOR RICE THRESHER INVESTMENT

Source	Respondents (Percent)	Interest rate (Percent/Year)
Bank for Agriculture and Agricultural Cooperatives	73.7	12
Agricultural Cooperatives	15.7	15
Money lenders	5.3	20-30
Relatives	5.3	0.00

12.0 percent whereas it was 15.0 percent for commercial banks in 1978. For other noninstitutional sources such as money lenders, they are about 20-30 percent. The profitability of investing in a rice thresher, therefore, depends on the source of finance or interest rate charged by lenders.

2.2 Contractor Service System

One very important factor affecting thresher adoption is the availability of customers. As shown in Table III-6, the quantity of rice threshed for customers is much higher than that threshed on farm.

The contractor service system is also the main way in which machines are made available to farmers who do not have the capital to buy these machines for themselves.

2.3 Net Cost Saving.

The net cost saving is defined as the difference between the total variable threshing cost of operating a thresher and the total variable cost of threshing with an alternative method. As shown in Table III-7, rice threshing by a thresher involes a lower unit cost as compared to both tractor and animal treading. The net cost saving of using a thresher averages about 64.10 baht per kwien in Chachoengsao and 53.60 baht in Supanburi in 1978 when compared to tractor treading.

TABLE III-6

AVERAGE QUANTITY OF RICE THRESHED BY A THRESHER, 1978

unit : 1,000 kilograms

Province and district	thresher owners				Thresher non-owners but users	
	own use		customer			
	1st crop	2nd crop	1st crop	2nd crop	1st crop	2nd crop
CHACHOENGSAO	30.90	22.91	211.91	205.64	21.00	14.90
Bang Nam Prieo	25.00	20.22	157.50	139.44	15.70	11.00
Muang	25.00	26.57	60.00	108.33	16.70	17.10
Ban Po	26.61	25.56	262.22	300.00	27.80	18.16
Bang Pa Kong	41.00*	16.00	200.00	160.00	19.20	8.75
SUPANBURI	28.24	49.25	203.37	167.03	8.70	8.91
Don Chedi	31.05	59.00*	232.50	191.11	8.50	8.24
Sri Prachan	24.73	19.00	160.55	132.20	8.88	9.50

*The figure also includes machine utilization by relatives of the thresher owners.

By way of comparison, adoption of a thresher machine as against buffalo treading yields a net cost saving of about 95.00 baht per kwien in Supanburi whereas no figure is available in Chachoengsao. This is because buffalo treading does not exist as an alternative threshing method within the area studied in the latter province.

TABLE III-7

NET COST SAVING OF SWITCHING FROM ALTERNATIVE METHODS OF THRESHING TO A RICE THRESHER, 1978

Unit:baht/kwien

Alternative Method : Tractor treading		
Chachoengsao	Total threshing cost employing tractor treading	140.20
minus	Total thrishing cost employing a thresher	76.10
	net cost saving	64.10
Supanburi	Total threshing cost employing tractor treading	151.60
minus	Total threshing cost employing a thresher	98.00
	Net cost saving	53.60
Alternative Method: Buffalo treading*		
Supanburi	Total threshing cost employing buffalo treading	193.00
minus	Total threshing cost employing a thresher	98.00
	Net cost saving	95.00

*Buffalo treading is not an alternative threshing method in Chachoengsao.

Source: Tables II-5 and II-6.

CHAPTER IV

CASH FLOW ANALYSIS AND THE ADOPTION AND USE OF A RICE THRESHER

The purpose of this chapter is to provide an analytical framework to study and measure the costs and benefits of investing in and operating a rice thresher. The general framework chosen is the cash flow analysis.

A. Theoretical Background

1. Definition of Cash Flow

Cash flow is the residual of the gross benefit obtained from the capital investment minus all input costs such as fuel, labor, operating materials and the like.

Because both costs and benefits occur over different periods of time, the measurement of all costs incurred in one period and benefits received in another must be carefully and logically worked out. Currently, the two widely employed approaches are through the use of either the present value concept(in which all future streams of net return are discounted) or the internal rate of return concept. The general formulas used in calculating present values and internal

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[1]J. Price Gittinger, op.cit., p. 66, and E.J. Mishan, Cost-Benefit Analysis: new and expanded edition (New York: Praeger Publisher Inc., 1976), pp. 166-7.

rates of return may be obtained from most macroeconomic textbooks.[2]

2. The Net Present Value Approach (NPV)

$$NPV = -C + \frac{R_1}{(1+i)} + \frac{R_2}{(1+i)^2} + \frac{R_3}{(1+i)^3} + \text{---} + \frac{R_n}{(1+i)^n} \quad \text{---(4.1)}$$

where C is the investment cost of the project,

$R_1 \ldots R_n$ is the stream of net income in periods 1, 2,...,n, respectively,

i is the discount rate, and

NPV is the net present value of the project's income stream.

Suppose a given amount of capital investment is undertaken in period 0, and the investor can produce net output in all the periods starting from period 0 through out its useful life. In order that the time value of money is taken into account, each of the year's cash flows must be discounted back to the base year as illustrated in Figure IV-1. The present value is represented by the shaded bars in the figure. The cash flow for year 1 and subsequent years are reduced by the discount factors which represent

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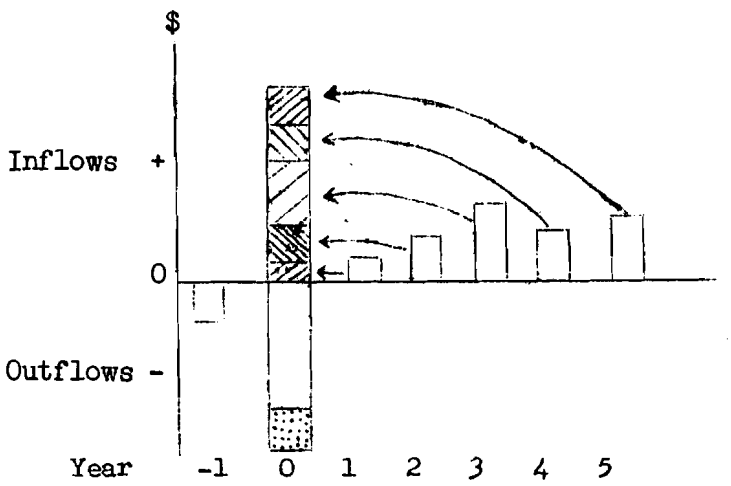
[2] William H. Branson, Macroeconomic Theory and Policy (New York : Harper and Row, Publishers, Second edition, 1975), pp. 214-24; Thomas F. Dernburg and Duncan M. McDougall, Macroeconomics (Tokyo : McGraw-Hill Inc., fifth edition, 1976), pp. 190-117; E.J. Mishan, op. cit. and Ajit K.Dasgupta and D.W. Pearce, Cost-Benefit Analysis : Theory and Practice (Bungay, Suffolk: Chancer Press Ltd., 1972), pp. 159-173. Most of them, however, point out the difficulties of the application of each approach.

the earning power or opportunity cost of the cash flows in the intervening years. Expenditure prior to year 0 is increased by the interest to bring it to base year values, so that the project bears the cost of the funds during the period they are tied up in the project and not earning a return.

FIGURE IV-1

PROCESS OF RELATING CASH FLOWS TO BASE YEAR VALUES



Source : M.G. Wright, Discounted Cash Flow (McGraw Hill Book Company Limited, London, second deition, 1973), p. 18.

3. The Internal Rate of Return Approach[3] (IRR)

The internal rate of return is the average rate of discount that will reduce the present value of the sequence of cash flows to the same value as the cash invested in the project. This approach

[3] William H. Branson, op.cit., Chapter 11, and E.J. Mishan, op. cit., Chapter 25-29.

will enable management to rank investments in order of profitability. The general form of this approach is :

$$0 = -C + \frac{R_1}{(1+m)} + \frac{R_2}{(1+m)^2} + \text{---} + \frac{R_n}{(1+m)^n} \qquad \text{--- (4.2)}$$

All variables used in the equation (4.2) are the same as those in the present value approach except that 'm' is the average rate of discount which satisfies equation (4.2), i.e. it is the internal rate of return.

4. Why Both NPV and IRR ?

This study employs both the present value and the internal rate of return approaches since in some special cases, these two approaches may yield different results.[4]

The present value concept measures and compares the present value of the net returns and the investment cost in monetary terms by using the appropriate long run predetermined market interest rate. But the internal rate of return concept compares the expected rate of return with the market rate of interest.

Both NPV and IRR have their weaknesses. If the machine life lasts long as expected, then NPV will reflect an accurate evaluation of the project. However, a new investment whose life span is unknown and may be short may overstate its present value if calculation is made based on an excessive long life time. Under such circumstances, calculated NPV will fail to be an appropriate indicator of the

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[4] Ibid.

project worth. The IRR approach, on the other hand, requires that the life span of the machine is known. But such a life span differs among users. Fixing the investment's life span may also be a rather restrictive assumption.

B. Methodology

The thresher investment can be separated into two categories:

(a) past investment projects (groups 1-4), where capital investment have already been made but the machines are not yet obsolete. (The analysis is classified into 4 groups depending on the year of purchase of the thresher)

(b) future projects which are at the decision-making stage (group 5).

It should be pointed out that the historical analysis in category (a) may be useful in providing additional information which have possible bearing on current investment decisions. But the main focus of the study will be on the study of rice thresher in category (b).

The formulas used in calculating the present value for the different groups are as follows:

$$\text{Group 1, NPV 1} = -C1 + \frac{R1,\ 1978}{(1+i)} + \frac{S1,\ 1978}{(1+i)} \text{ ----------(4.3)}$$

$$\text{Group 2, NPV 2} = -C2 + \frac{R2,\ 1977}{(1+i)} + \frac{R2,\ 1978}{(1+i)^2} + \frac{S2,\ 1978}{(1+i)^2} \quad \text{---(4.4)}$$

$$\text{Group 3, NPV 3} = -C3 + \frac{R3,\ 1976}{(1+i)} + \frac{R3,\ 1977}{(1+i)^2} + \frac{R3,\ 1978}{(1+i)^3} + \frac{S3,\ 1978}{(1+i)^3} \quad \text{---(4.5)}$$

$$\text{Group 4, NPV 4} = -C4 + \frac{R4,\ 1975}{(1+i)} + \frac{R4,\ 1976}{(1+i)^2} + \frac{R4,\ 1977}{(1+i)^3} + \frac{R4,\ 1978}{(1+i)^4} + \frac{S4,\ 1978}{(1+i)^4} \quad \text{---(4.6)}$$

where NPV = the net present value of investing in a rice thresher,

C = the cost of purchasing a rice thresher and its complements,

R = the net income of a rice thresher investment,

S_{1978} = the resale value of a thresher and its complements at the end of crop year 1978/79.

$$\text{Group 5, NPV 5} = -C5 + \frac{R5,\ 1979}{(1+i)} + \frac{R5,\ 1980}{(1+i)^2} + \ldots + \frac{R5,\ n}{(1+i)^n} \quad \text{----------(4.7)}$$

The formulas used in calculating the internal rate of return for different groups are :

$$\text{Group 1, } 0 = -C1 + \frac{R1,\ 1978}{(1+m)^1} + \frac{S1,\ 1978}{(1+m)^1} \quad \text{---------- (4.8)}$$

$$\text{Group 2, } 0 = -C2 + \frac{R2,\ 1977}{(1+m)} + \frac{R2,\ 1978}{(1+m)^2} + \frac{S2,\ 1978}{(1+m)^2} \quad \text{-----(4.9)}$$

$$\text{Group 3, } 0 = -C3 + \frac{R3,\ 1976}{(1+m)} + \frac{R3,\ 1977}{(1+m)^2} + \frac{R3,\ 1978}{(1+m)^3} + \frac{S3,\ 1978}{(1+m)^3} \quad \text{----(4.10)}$$

$$\text{Group 4, } 0 = -C4 + \frac{R4,\ 1975}{(1+m)} + \frac{R4,\ 1976}{(1+m)^2} + \frac{R4,\ 1977}{(1+m)^3} + \frac{R4,\ 1978}{(1+m)^4} + \frac{S4,\ 1978}{(1+m)^4} \quad \text{---(4.11)}$$

and

$$\text{Group 5, } 0 = -C5 + \frac{R5,\ 1979}{(1+m)} + \frac{R5,\ 1980}{(1+m)^2} + \ldots + \frac{R5,\ n}{(1+m)^n} \quad \text{----------(4.12)}$$

The formulas look simple, but actual application is difficult in terms of identifying and defining the factors determining the income stream and the discount rate.

1. Project Evaluation With Risk and Uncertainty

The economics of buying and operating a rice thresher involve some risk and uncertainty. Let us consider a few of the major elements of risk and uncertainty.

(a) Technological Uncertainty

Technological change and development can substantially or drastically affect the earning power of an investment project. Technological progress has resulted in a higher capacity (in terms of kwien/hr) of rice threshing machines. These machines are competing with and will eventually substitute the original models.

(b) Price Uncertainty

There is generally some uncertainty with respect to product and input prices. The first half of 1979 saw some substantial price changes that affected production costs. An increase in the minimum wage from 28 baht to 35 baht per day took place in October 1978. Another factor which will definitely put upward pressure on petroleum product prices is the raising of the price of crude oil by OPEC on July 1, 1979 from US$14.55 per barrel to US$18-23.5 per barrel.[5] Higher oil prices will increase the cost to farmers

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[5]Since October 16, 1973, the oil crisis ignited by the Organization of Petroleum Exporting Countries (OPEC) turned critical when the posted price of Middle East crude oil shot up by about 70 percent from US$5.34 per barrel. The same action was taken on January 1, 1974 when the posted price was raised again to US$11.65 per barrel. In the first half of 1979 the crude oil price of the OPEC countries changed twice. First from US$12.70 per barrel to US$14.55 per barrel and then to US$18-23.5 per barrel. See Rungsunt Piyavongsepinyo, "Inflation in an Open Economy : A Case Study of Thailand," (Unpublished M.A. Thesis, Faculty of Economics, Thammasat University, 1979).

who use tractors and threshers.

The analysis of a rice thresher investment will be based on forecasting the expected values of a number of variables in real terms. These variables will be discussed in the remaining parts of this chapter.

2. Definition of Variables

There are two types of gains from adopting a rice thresher :

(1) .gains from ownership or rental, and

(2) gains from utilization.

In order to test the hypothesis that the net benefits of using and owning (renting) a thresher induced the rapid rate of adoption, the identification and definition of the components of net benefits are discussed below:

2.1 Capital Investment in a Rice Thresher (C)

The amount of capital invested in a thresher includes not only the purchasing price of the machine but also an engine and a boat or truck for carrying the thresher. The average purchasing price of a new rice thresher without an engine in Chachoengsao was 12,500 baht in 1975 and 17,000 baht in 1979 (see Table IV-1). The price in Supanburi was somewhat higher or 18,000 baht in 1979.

TABLE IV-1

PRICE OF A RICE THRESHER AND ITS COMPLEMENTS
BY INVESTMENT YEAR

(baht)

Investment Year	PTH*	PEN*	PBT*	C*=PTH+PEN +PBT
1975 CHACHOENGSAO (2)	12500	4500	5000	23000
1976 CHACHOENGSAO (4)	13500	5000	5000	23500
1977 CHACHOENGSAO (5)	14500	6000	6000	26500
1978 CHACHOENGSAO:				
Bang Nam Prieo (5)	15500	6000	5000	26500
Muang (3)	15000	6000	5000	26000
Ban Po (4)	15000	5500	4000	24500
Bang Pa Kong (3)	15000	3600	6500	25100
Provincial average	15200	6000	6000	27200
1979 CHACHOENGSAO[a]	17000	6000	8000	31000
1977 SUPANBURI (2)	15000	13000	-	28000
1978 SUPANBURI:				
Donchedi (11)	16000	16800	-	32800
Sriprachan (10)	16500	16800	9600	42900
Provincial average	16250	16800	N.A.	38520
1979 SUPANBURI[a]	18000	16800	10000	44800

Note: *PTH = purchasing price of a rice thresher,
PEN = purchasing price of an engine,
PBT = purchasing price of a boat or small locally made truck,
C = total investment cost of a rice thresher and its complements.

Figures in parentheses indicate the number of observations.

[a]Survey information obtained from J. Jaidee Panich and Kaset Pattana for Chachoengsao; and Thanya Engineering and Sun Radio (dealer) for Supanburi.

For a power engine, most farmers in Chachoengsao buy a second hand 4 cylinder Japanese car engine (about 6,000 baht for a 15 h.p. one) rather than a new 10-12 h.p. diesel engine (18,000 baht), whereas farmers in Supanburi prefer new ones. This explains the large difference in the total investment cost of a thresher in 1979 for Chachoengsao (31,000 baht) and Supanburi (44,800 baht).

Besides rice threshing, almost 15 percent of the thresher owners in Chachoengsao used the engines for other purposes. This was not true in Supanburi. Since these other uses are not too important and in order to keep the study's scope limited and manageable, the following analysis will assume that the engines attached to the rice thresher were used for rice threshing only.

The price of a strong iron boat with a flat bottom averages about 4,000-6,500 baht in Chachoengsao. The boat is specially designed for carrying the thresher only. It uses a diesel engine. This method of transporting threshers is mainly used in Chachoengsao.

Thresher owners in Donchedi, Supanburi, can move their machines on wheels with human power along passable paths to neighboring customers whereas thresher owners in Sriprachan District prefer to move the machine by small locally made truck whose purchasing price is about 9,600 baht in 1978.

The cash investment or the cost of investing in a rice thresher is therefore composed of three parts:

1) the purchasing price of a rice thresher (baht),

2) the purchasing price of a power engine attached to the rice thresher (baht), and

3) the purchasing price of a thresher complement (boat or truck) used for transportation (baht).

Table IV-1 shows that the investment cost of a rice thresher and its complements increases every year from 23,000 baht in 1975 to 27,200 baht in 1978 for Chachoengsao. It averages about 28,000 baht in 1977 and 30,520 baht in 1978 for Supanburi.

2.2 Resale Value of a Thresher and Its Complements at the End of Crop Year 1978/79 (S_{1978})

The resale value is the value of the machine as evaluated by its owner at the end of crop year 1978/79.

In calculating the present value of past investments in rice threshers, we are faced with the difficulty of determining the remaining machine life and the salvage value of the machine when it wears out. With perfectly competitive markets, the resale value of the machine should approximate the present value. We, therefore, use estimates of the resale value obtained from farmers in our calculations.

These resale values of a rice thresher and its complements are shown in Table IV-2. The older the machine the smaller is its resale value as would be expected.

2.3 Benefits of A Rice Thresher

2.3.1 Annual Net Income of Thresher Owners (R_t)

Thresher owners gain due to cost and time saving of switching from traditional methods of threshing to using a rice thresher on their own fields and, in order to utilize the capacity of the machine more fully, they hire out threshers through a contractor service.

In sum, estimation of the annual net income of a thresher owner or R_t can be obtained from the following equations :

$$R_t = NRF_t + NROF_t - MA_t \qquad \text{----------(4.13)}$$

$$NRF_t = CSF_t + VTSF_t \qquad \text{----------(4.14)}$$

$$NROF_t = S_{2t}\,(QOF_t) \qquad \text{----------(4.15)}$$

$$CSF_t = NCS_t\,(QF_t) \qquad \text{----------(4.16)}$$

$$VTSF_t = W_t\,(TSF_t) \qquad \text{----------(4.17)}$$

$$NCS_t = VC_{1t} - VC_{2t} \qquad \text{----------(4.18)}$$

$$VC_{1t} = M_{1t} + L_{1t} + S_{1t} \qquad \text{----------(4.19)}$$

TABLE IV-2

RESALE VALUE OF A RICE THRESHER AND ITS COMPLEMENTS BY INVESTMENT YEAR, AT THE END OF 1978

(baht)

Investment Year		STH*	SEN*	SBT*	S^*_{1978}
1975	CHACHOENGSAO (2)	9500	3400	6100	19000
1976	CHACHOENGSAO (4)	11000	5000	6500	22500
1977	CHACHOENGSAO (5)	12000	5500	6000	23500
1978	CHACHOENGSAO:				
	Bang Nam Prieo	14000	5000	3000	22000
	Muang	14000	3200	7000	24200
	Ban Po	11000	4500	5000	20500
	Bang Pa Kong	13200	400	7000	24200
	Provincial average (15)	13500	4500	6000	24000
1977	SUPANBURI (2)	15000	12000	-	27000
1978	SUPANBURI:				
	Donchedi	13750	15000	-	28750
	Sriprachan	13500	15000	8000	36500
	Provincial average (21)	13625	15000	N.A.	33085

Note: *STH = Resale value of a rice thresher at the end of 1978,
SEN = Resale value of an engine at the end of 1978,
SBT = Resale value of a boat or small locally made truck at the end of 1978, and
S_{1978} = Resale value of a rice thresher and its complements at the ent of 1978.

Figures in parentheses indicate the number of observations.

N.A. = not available.

$$= (F_{1t} + E_{1t} + G_{1t}) + L_{1t} + S_{1t}$$

$$= PF_t \cdot FQ_{1t} + PE_t \cdot EQ_{1t} + PG_t \cdot GQ_{1t} + W_t \cdot LQ_{1t} + S_{1t}$$

$$VC_{2t} = M_{2t} + (L_{2t} + LO_{2t}) + S_{2t} \qquad \text{----------(4.20)}$$

$$= (F_{2t} + E_{2t} + G_{2t}) + (L_{2t} + LO_{2t}) + S_{2t}$$

$$= PF_t \cdot FQ_{2t} + PE_t \cdot EQ_{2t} + PG_t \cdot GQ_{2t} + W_t \cdot LQ_{2t} + WO_t \cdot LQO_{2t} + S_{2t}$$

Then,
$$R_t = \Big[(PF_t \cdot FQ_{1t} + PE_t \cdot EQ_{1t} + PG_t \cdot GQ_{1t} + W_t \cdot LQ_{1t} + S_{1t}) - (PF_t \cdot FQ_{2t} + PE_t \cdot EQ_{2t} + PG_t \cdot GQ_{2t} + W_t \cdot LQ_{2t} + WO_t \cdot LQO_{2t} + S_{2t})\Big] QF_t + W_t \cdot TSF_t + S_{2t} \cdot QOF_t - MA_t \qquad \text{----------(4.21)}$$

where R_t = the total net income from a thresher investment including both on farm and off farm uses in period t (baht),

NRF_t = the net income obtained from the on farm use of a rice thresher in period t (baht),

$NROF_t$ = the net income obtained from hiring out a rice thresher in period t (baht),

MA_t = the maintenance cost of a rice thresher and its complements in period t (baht/year),

CSF_t = the on farm cost saving of switching from traditional methods of threshing to a rice thresher in period t (baht),

$VTSF_t$ = the value of time saved on farm in switching from traditional methods of threshing to the use of a rice thresher in period t (baht),

QF_t = the amount of rice threshed on farm in period t (kwien),

QOF_t = the amount of rice threshed off farm in period t (kwien),

NCS_t = the cost saving per kwien of threshed rice in switching from traditional methods of rice threshing to a rice thresher in period t (baht),

TSF_t = the number of man-days saved on farm in switching from traditional methods to the use of a rice thresher in period t,

W_t = the real wage rate of farm labor during harvesting in period t (baht/man-day),

VC_{1t} = the variable cost of threshing rice with a tractor in period t (baht/kwien),

VC_{2t} = the variable cost of threshing rice with a rice thresher in period t (baht/kwien),

M_{1t} = the material costs of operating a tractor which include diesel oil (F_{1t}) engine oil (E_{1t}),and grease (G_{1t}) in period t (baht/kwien),

FQ_{1t} = the quantity of diesel oil consumed in threshing with a tractor in period t (litre/kwien),

PF_t = the diesel oil price at the farm level in period t (baht/litre),

EQ_{1t} = the quantity of engine oil consumed in threshing with a tractor in period t (litre/kwien),

PE_t = the engine oil price at the farm level in period t (baht/litre),

GQ_{1t} = the quantity of grease consumed in threshing with a tractor in period t (kilogram/kwien),

PG_t = the grease price at the farm level in period t (baht/kilogram),

L_{1t} = the labor cost in threshing rice with a tractor in period t (baht/kwien),

LQ_{1t} = the labor used in threshing rice with a tractor in period t (man-day/kwien),

S_{1t} = the tractor charge in threshing rice in period t (baht/kwien),

M_{2t} = the material costs of operating a rice thresher which include diesel oil (F_{2t}), engine oil (E_{2t}) and grease (G_{2t}) in period t (baht/kwien),

FQ_{2t} = the quantity of diesel oil consumed in threshing with a rice thresher (litre/kwien),

EQ_{2t} = the quantity of engine oil consumed in threshing with a rice thresher (litre/kwien),

GQ_{2t} = the quantity of grease consumed in threshing with a rice thresher (kilogram/kwien),

L_{2t} = the labor cost in threshing rice with a rice thresher in period t (baht/kwien),

LQ_{2t} = the labor used in threshing rice with a thresher (man-day/kwien),

LQ_{2t} = the labor used in operating a rice thresher (man-hour/kwien),

LO_{2t} = the labor cost of operating a rice thresher (baht/kwien),

WO_t = the wage rate paid for a rice thresher operator (baht/man-hour),

and S_{2t} = the rice thresher charge rate (baht/kwien).

2.3.2 The External Benefits to Thresher Users Who Do Not Own a Machine (RO_t)

The gains to farmers who do not own but use a rice thresher include the net cost and time saving of switching from traditional methods of threshing rice to a rice thresher through a contractor service. The net cost saving is equal to the rice threshing cost with the traditional method minus the rice threshing cost with a rice thresher. The time saved by using a thresher is the difference between the time consumed in threshing of the machine and the alternative method.

A rice thresher, therefore, not only provide internal returns to an owner, but it also results in external returns to other farmers who use the service of that thresher as well. In sum, the total external benefits generated by a thresher is

$$RO_t = NCS_t \cdot QOF_t + W_t(TSOF_t \cdot QOF_t) \quad \text{----------(4.22)}$$

$$= (NCS_t + W_t \cdot TSOF_t)QOF_t$$

where RO_t = the total external benefits generated by a rice thresher in period t (baht),

$TSOF_t$ = the time saved by not using the alternative method of threshing (hour/kwien),

There may be other external effects of adopting a rice thresher but these will not be introduced in this study.

3. Data Requirements

3.1 Quantity of Rice Threshed Off Farm (QOF_t)

The cross sectional comparison of the quantity of rice threshed by a machine in Table IV-3 indicates that the amount of rice threshed since 1975 has increased from year to year but by smaller increments. In Chachoengsao, the increment fell from 96.4 percent in 1977 to 8 percent in 1978. The sharp fall in the growth rate may be due to the capacity of the machine having approached its limit or to increased market competition through new entries and/or the shrinking of untapped customers. The latter is an important factor determining future investments in threshers since profitability of investing depends on :

1. The number of potential customers.
2. The density of rice threshers in the area.
3. The level and intensity of competing contractor services.

Thresher owners usually try to minimize travelling costs by moving the machine from place to place close to their own home but some machines have been found to move to neighboring provinces

TABLE IV-3

AVERAGE OFF FARM THRESHING OF A RICE THRESHER
BY INVESTMENT YEAR

(kwien/year)

Investment Year		1975	1976	1977	1978	1979[ex]	1980[ex]	1981[ex]	1982[ex]	1938[ex]
1975	CHACHOENGSAO (n=2)	70[a]	210	240	60[b]					
1976	CHACHOENGSAO (n=4)	-	165	324 (96.4%)	350 (8.0%)					
1977	CHACHOENGSAO (n=5)	-	-	287	315 (9.7%)					
1978	CHACHOENGSAO (n=15)	-	-	-	312					
1979	CHACHOENGSAO	-	-	-	-	320	340	360	380	400
1977	SUPANBURI (n=2)	-	-	215	420 (95.3%)					
1978	SUPANBURI (n=21)	-	-	-	339					
1979	SUPANBURI	-	-	-	-	340	360	380	400	400

Note: [ex]Extrapolated values
[a]The machine was first introduced among farmers in the dry season crop of 1975. The figure indicated only one season's services.
[b]Wet season crop only.

Figures in parentheses indicate the annual increase in percent.
n = number of observations.

where they spent a month there providing thresher services.

For farmers and/or businessmin who are in the stage of making investment decisions, it is rather difficult to forecast the situation in the long run since data available are insufficient to indicate a clear picture. However, when we look at the available time trend of rice threshed by the new thresher contractors in Chachoengsao Province since 1976, the average paddy threshed was 287 kwien in 1977 and 312 kwien in 1978. It is reasonable to think that the quantity of rice threshed off farm for a thresher will eventually settle at a long run equilibrium level. Unfortunately, it is unknown what the equilibrium level is. However, the highest level threshed in Chachoengsao is 350 kwien in 1978 for a machine bought in 1976. Given that the threshers introduced since 1977 were said to have a relatively higher capacity in threshing, it seems reasonable to think that the equilibrium level may be ligher than 350 kwien.

It is assumed in the study that farmers and/or businessmen who are in the decision making stage expect that they will probably be able to obtain off farm rice threshing of around 320 kwien in the first year and this will increse by approximately 20 kwien per year until it reaches 400 kwien which is arbitrarily chosen as the equilibrium level.

In Supanburi, where the adoption is 2 years behind Chachoengsao, figures show that the diffusion of rice threshers was

much faster once it took place. From only 2 machines in 1977, it increased by 21 machines within one year. The highest reported level of rice threshed off farm is 420 kwien in 1978 for a machine bought in 1977. This level seems high as compared to Chachoengsao. Such a level may be possible due to the relatively small supply of rice threshers in Supanburi relative to demand in 1978. However, as more thresher investments are made, this level may fall off. It will, thus, be assumed similar to Chachoengsao's case that the equilibrium level is 400 kwien. For those presently making the decision to invest, the expected level of rice threshed through contractor services in the first year will be assumed to be around 340 kwien and will increase by 20 kwien per year until it reaches 400 kwien. The starting level of Supanburi is assumed to be higher than in Chachoengsao since the market there is still relatively new with better prospects for investors.

3.2 Quantity of Rice Threshed On Farm (QF_t)

The average amount of rice threshed on farm (QF) is about 31 and 23 kwien for the first and the second crop, respectively, in 1978 in Chachoengsao whereas they are 28 and 20 kwien in Supanburi. If thresher owners use the machine to thresh all of their paddy, then QF will have the same value as the total output per year. In Table IV-4, the annual use of the machine on farm was recorded except in 1976 for machines bought in 1975 which was unavailable. The QF in 1975 of machines bought in 1975 was relatively smaller

TABLE IV-4

AVERAGE ON FARM THRESHING OF A RICE THRESHER
BY INVESTMENT YEAR

(kwien/year)

Investment Year	1975	1976	1977	1978	1979	1980[ex]
1975 CHACHOENGSAO	21.5*	62.1[e]	62.1	68.7		
1976 CHACHOENGSAO	-	54.3	52.5	57.7		
1977 CHACHOENGSAO	-	-	45.1	59.0		
1978 CHACHOENGSAO	-	-	-	44.5		
1979 CHACHOENGSAO	-	-	-	-	54.0[a]	54.0[a]---
1977 SUPANBURI	-	-	25.0	20.6		
1978 SUPANBURI	-	-	-	41.3		
1979 SUPANBURI	-	-	-	-	47.0[a]	47.0[a]---

Note : *Dry season crop only.
[e]Estimated value.
[a]Provincial average values.
[ex]Extrapolated values

than others because the machines were bought around September-Octorber and may only be used in the second crop season of 1975-76.

The quantity of rice threshed in a year depends on the total crop output of a farmer. Total crop output, in turn, depends on productivity and cultivated area.

Since the fertilizer application and planted area of each farm is expected not to change much, the expected quantity of rice

threshed on a farm (QF) in the future in both provinces will be assumed to remain the same as the average provincial output per year in 1978, that is, QF in 1979 and future years will be treated at 54 kwien/year for an average farm in Chachoengsao and 47 kwien/year in Supanburi.

3.3 Diesel, Engine Oil and Grease

One of the concerns of opponents of farm machinery is that the expected continual rise in gasoline and diesel prices will make the operating costs of machinery rise to such a high level that it will become unprofitable to use the machinery.

The experience from the oil crisis shows that the price of petroleum products is unpredictable except for its continual increase. The farmers, who are in the decision making stage, may find the forecasting of the prices of petroleum products difficult. This study will, therefore, experiment with a range of price increases of around 10-50 percent annually.

The physical units used of diesel oil, engine oil and grease will be assumed to remain constant at the quantity applied in 1978. This is probably reasonable when there are no or only minor changes in rice thresher technology in 1979. (Tables V-5 and V-6).

TABLE IV-5

THRESHING COST EMPLOYING TRACTOR TREADING, 1975-78

	Cost Item			CHACHOENGSAO				SUPANBURI	
				1975[ex]	1976[ex]	1977[ex]	1978	1977[ex]	1978
1.	FUEL	quantity	litre/kw	2.92	2.92	2.92	2.92	2.40	2.40
		price (diesel)	baht/litre[1]	2.87	2.74	2.90	3.03	2.94	3.33
		fuel cost	baht/kw	8.38	8.00	8.47	8.85	7.05	8.00
2.	ENGINE OIL	quantity	litre/kw	0.42	0.42	0.42	0.42	0.425	0.425
		price[a]	baht/litre	18.08	17.28	18.30	17.85	18.30	18.85
		engine oil cost	baht/kw	7.60	7.26	7.68	7.50	7.78	7.59
3.	GREASE	quantity	kg/kw	0.052	0.052	0.052	0.052	0.055	0.055
		price	baht/kg	18.08	17.28	17.22	17.00	17.22	17.00
		grease cost	baht/kw	0.94	0.90	0.895	0.88	0.93	0.93
4.	LABOR	time consumed	m-day/kw	2.22	2.22	2.22	2.22	2.74	2.74
		wage	baht/m-day[2]	30.13	34.55	32.29	37.00	32.29	34.00
		labor cost	baht/kw	66.90	76.70	71.66	82.10	88.47	93.16
5.	TRACTOR CHARGE	time consumed	hr/kw	2.365	2.365	2.365	2.365	2.84	2.84
		rental rate	baht/hr	17.65	17.65	17.65	17.65	14.74	14.74
		tractor cost	baht/kw	41.75	41.75	41.75	41.75	41.85	41.85
6.	TOTAL VARIABLE COST		baht.kw	125.57	134.60	130.47	141.08	146.08	151.53

Source: [1]Local price in real terms (From Appendix Table D)
[2]Wage rate in real terms (Table IV-8).

Note : [ex]Extrapolated values.
[a]Esso motor oil 10W, 30 40, 50.

TABLE IV-6

THRESHING COST EMPLOYING A RICE THRESHER, 1975-78

Cost Item			CHACHOENGSAO				SUPANBURI	
			1975[ex]	1976[ex]	1977[ex]	1978	1977[ex]	1978
1. FUEL	quantity	litre/kw	0.825	0.825	0.825	0.825	0.93	0.93
	price (diesel)	baht.litre	2.87	2.74	2.90	3.03	3.12	3.33
	fuel cost	baht/kw	2.37	2.26	2.40	2.50	2.90	3.10
2. ENGINE OIL	quantity	litre/kw	0.055	0.055	0.055	0.055	0.08	0.08
	price[a]	baht/litre	18.08	17.28	17.22	17.85	17.85	17.85
	cost	baht/kw	1.0	0.95	0.95	0.98	1.55	1.45
3. GREASE	quantity	kg/kw	0.006	0.006	0.006	0.006	0.006	0.006
	price	baht/kg	18.08	17.28	17.22	17.00	17.22	17.00
	grease cost	baht/kw	0.12	0.11	0.10	0.10	0.10	0.10
4. THRESHER OPERATOR COST	rate of operation	m-hr/kw	0.61	0.61	0.61	0.61	0.8	0.8
	wage	baht/m-hr	4.52	5.76	5.38	7.70	5.40	5.5
	operator cost	baht/kw	2.76	3.51	3.28	4.70	4.30	4.4
5. LABOR COST	# labor used	m-day/kw	0.674	0.674	0.674	0.674	0.88	0.88
	wage	baht/m-day	30.13	34.55	32.29	38.75	32.29	31.85
	labor cost	baht/kw	20.31	23.29	21.76	26.10	28.40	28.00
6. SERVICE CHARGE[1] (OPPORTUNITY COST ON FARM USE)		baht/kw	78.03	62.18	57.70	41.70	65.80	60.61
7. TOTAL VARIABLE THRESHING COST ON FARM (1+2+3+4+5+6)		baht/kw	104.60	92.30	86.20	76.10	102.50	98.00

Note: [ex]Extrapolated values
[a]Esso motor oil 10w, 30, 40, 50.
Source: [1]From Table IV-7.

3.4 Tractor Charge (S_{1t})

Statistics from the study reveal that the tractor charge of rice threshing in 1978 was found to be approximately 42 baht in both Chachoengsao and Supanburi even though the time consumed for treading and the rental rate of tractors in each province are different. Chachoengsao's tractor threshing consumes less time but it has a higher rental rate than Supanburi's. This might be because in Chachoengsao all farmers can grow a second crop of rice. This means they have to hurry in threshing the first crop and shift immediately to land preparation for the second crop. In addition, some areas of Chachoengsao, namely Ban Po and Bang Pa Kong, have to avoid possible damage of the first crop from the rise of the seawater by speeding up the threshing activity. This would increase the total demand for tractor during a given period. This may be why the rental rate of tractors is higher in Chachoengsao while less time is also required for threshing.

There are no statistics on the charge rate of tractors in the past except in Chancellor's study.[6] However, this study is mainly focused on four-wheel tractors (58h.p.) with an average capacity for rice threshing of 2.64 tons per hour. The service charge was 13 baht per hour in 1970. This information could not be

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[6]William J. Chancellor, "Survey of Tractor Contractor Operations in Thailand and Malaysia," (The Agricultural Development Council, New York, 1970), pp. 39-40.

applied for the present study since the tractor sizes (h.p.) are not the same. From the survey, it was found that two-wheel walking tractors with 6-7 h.p. engines were preferred for rice threshing in Chachoengsao whereas two-wheel tractors with 10-12 h.p. engines were favored in Supanburi. The tractor charge for threshing in 1978 were 41.75 and 41.85 baht per kwien in Chachoengsao and Supanburi, respectively. (See Table IV-5).

Since tractors have been used in threshing for quite some time now, it is reasonable to think that the market for tractors has reached an equilibrium level. It will, therefore, be assumed in the study that the charge rate for tractor threshing remains constant in the future at the 1978 level.

3.5 Rice Thresher Charge (S_{2t})

The rice thresher was first introduced to Chachoengsao farmers in 1975 with a charge rate of 70 baht per kwien including fuel cost. In later years, it declined to 60 baht per kwien. In 1978, the rate was in the range of about 45-50 baht per kwien in Chachoengsao and 70 baht per kwien in Supanburi (Table IV-7). The declining rate in Chachoengsao was probably due to the new entry of thresher contractors, creating more intense competition.

The charge rate of a rice thresher usually include expenses such as fuel cost, engine oil cost, grease cost, and compensation for a semi-skilled worker in operating the machine. In order to

TABLE IV-7

RICE THRESHER CHARGES BY PROVINCE, 1975-1980

Year	Contractor charge rate		Fuel cost (diesel oil)			Lubricant oil			Grease			Semi-skilled labor for operating thresher			Rice Thresher Charge (real)	% change
	nominal (฿/kw)	real at 1978 price*	quantity (lit/kw)	real price (฿/lit)	cost (฿/kw)	quantity (lit/kw)	real price (฿/lit)	cost (฿/kw)	quantity (kg/kw)	real price (฿/kg)	cost (฿/kw)	m-hour/ kw	real wage (฿/m-hr)	cost (฿/kw)	(฿/kw)	
CHACHOENGSAO																
1975	70	84.4	0.825	2.87	2.37	0.055	18.08	1.00	0.006	18.03	0.12	0.61	4.52	2.76	78.27	-
1976	60	69.1	0.825	2.74	2.26	0.055	17.3	1.00	0.006	17.28	0.11	0.61	5.76	3.5	62.34	-20.35
1977	60	64.6	0.825	2.90	2.40	0.055	18.3	1.00	0.006	17.22	0.10	0.61	5.38	3.3	57.9	- 7.12
1978	50	50.0	0.825	3.03	2.50	0.055	17.85	1.00	0.006	17.00	0.10	0.61	7.70	4.7	41.7	-28.00
1979	50[b]	45.6	0.825	4.85	4.00	0.055	18.25	1.00	0.006	17.00	0.10	0.61	6.39	3.9	36.7	-12.00
1980	60[b]	46.4	0.825	6.05	5.00	0.055	17.00	0.94	0.006	17.00	0.10	0.61	6.19	3.8	36.7	0
SUPANBURI																
1977	70	75.3	0.93	3.12	2.90	0.08	18.30	1.46	0.006	17.22	0.10	0.88	5.38	4.7	66.24	-
1978	70	70.0	0.93	3.33	3.10	0.08	17.85	1.55	0.006	17.00	0.10	0.88	5.0	4.4	60.95	- 8.00
1979	60[a]	54.8	0.93	5.02	4.67	0.08	18.25	1.46	0.006	17.00	0.10	0.88	6.4	5.6	43.10	-29.80
1980	60[a]	46.4	0.93	6.19	5.76	0.08	19.47	1.55	0.006	17.00	0.10	0.88	6.2	5.4	33.7	-21.80

Note : [a]Information obtained from the farm record keping of the IRRI Project on "The Consequences of Small Rice From Mechanization on Rural Employment, Income and Production," (Supanburi Province).
[b]Additional survey information.

*Adjusted by using the consumer price index.

come as close as possible to the service charge of a rice thresher, all the above-mentioned costs should be excluded from the contract charge rate as shown in Table IV-7.

It is rather difficult to deduce the long run equilibrium level of the real service charge of a rice thresher since only 4 years of data existed in Chachoengsao while only 2 years in Supanburi. But from additional data collected for 1979 and 1980, two years of additional information were available. In Chachoengsao, the service charge rates in 1979 and 1980 were found to be the same (at 36.70 baht/kwien). Looking at the steady decrease in the real service charge rate since 1975 in Chachoengsao, together with the constant charge rate in 1979 and 1980, it may be reasoned that the real service charge rate may have or is close to reaching the equilibrium level. But since those purchasing rice threshers in 1979 may not have the additional information we have here, it is uncertain what their expectations will be. This aside, the study will assume that potential purchasers in 1979 expect the service charge rate to level off at 35-36 baht/kwien in Chachoengsao and 32-33 baht/kwien in Supanburi.

3.6 Farm Wage Rate (W_t)

Trent J. Bertrand[7] (1977) reports on the farm wage rate in the Central Plain areas that :

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[7] Trent J. Bertrand, "Thailand Agricultural Prices and Subsidies: A Case Study," (AGRER Division Working Paper, 1977), Chapter II, pp.53-6 and p. 61.

> "...both prices and nominal wage rates have risen substantially relative to the 1960's. The 1970's inflation undoubtedly lowered real wages for some groups of wage employees. In addition, double cropping in the Northern Chao Phya irrigation area expanded rapidly in the 1970's with wage rates responding to the increased demand for labor... A major if short-lived public works program aimed at decentralizing control of government expenditures and absorbing the supposed massive dry season underemployment in rural Thailand put a huge 2.5 and 3.5 billion baht (US$125 million and $175 million) fiscal stimulus into rural Thailand in fiscal year 1975 and 1976, respectively. All these factors contributed to a rapid adjustment in the market wage rates.."

The average real wage rates employed in the calculation of labor cost in Tables IV-5, IV-6 and IV-7 are based on Bertrand's report of nominal wages of 25 and 30 baht[8] a day in 1975 and 1976, respectively. Unfortunately the wage rate in 1977 was not included in his study. The daily wage rate for farm labor in 1977 was reported to be 20-40 baht/ a day in the Central Region in another study.[9] The mid-point of 30 baht a day for 1977 was used since there are no other sources of data (Table IV-8).

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[8]The Tambol Development Project of 1975 and 1976 under the government of M.R. Kukrit Pramoj which was designed to increase the share of benefits from government expenditures accruing to the rural sector and to reduce alleged underemployment in rural Thailand provided a large impact on the increase in rural nominal wage rate in the Central Plain in Thailand. See Trent J. Bertrand, op.cit., p. II.58.

[9]Labor Department, Report on Labor Supply in Rural Area, 1977 (Bangkok: The Ministry of Interior, 1979), p. 29.

The tentative picture on rural wages is that they have significantly risen in real terms in areas where changes in cropping patterns, booming markets for certain crops, or expanded potential for water control have been experienced in the central plain of Thailand while remaining roughly constant in more isolated or less favored regions.[10] With time series data of real wages shown in Table IV-8, the compound rate of growth is found to be 3.2 percent per annum over the period of 1965-1977. This is quite close to the growth rate of real per capita GNP which is equal to 3.64 percent/year for the period of 1965-1977. (Appendix Table E)

The present study will employ a growth rate in real wages of about 3.2 percent a year for the future.

The farm wage rate given above applies only to labor other than thresher operators. But the operation of a rice thresher also requires a semi-skilled worker. Most thresher owners and/or their household members (e.g. son, cousin) prefer to operate the machine themselves. But some do hire an operator which in 1978 involved an average wage of 5-10 baht per kwien of threshed rice. This rate is rather high as compared to the market wage rate for unskilled labor. This is because during the peak period of threshing they work around 10-15 hours a day in 1975.

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[10] Trent J. Bertrand, op.cit., p. II. 62.

TABLE IV-8

FARM WAGE RATE FOR SELECTED YEARS, 1965-1978
IN THE CENTRAL PLAIN OF THAILAND

Year	Wage rate : nominal[a] (฿/m-day)	C.P.I. (1978=100)	Wage rate : real[d]	
1965	10.0	45.15	22.15	)
1967	10.0	49.21	20.32	)
1970	12.0	51.92	23.11	) Compound rate of
1972	12.6	53.63	23.50	) growth = 3.2%
1975	25.0	82.98	30.13	)
1976	30.0	86.82	34.55	)
1977	30.0[b]	92.91	32.29	)
1978	CH 37.00[c]	100.0	37.00	
	SP 34.00[c]		34.00	

Source: [a]Trent J. Bertrand, "Thailand Agricultural Prices and Subsidies: A Case Study," (AGRER Division Working Paper, 1977), Table 18, p. II. 54.

[b]Thailand, Ministry of Agriculture and Cooperatives, Department of Agricultural Economics, Report No. 38, 1978. (in Thai).

[c]Survey information.

[d]Adjusted by using the consumer price index (C.P.I.) for the Central Region obtained from the Bank of Thailand, Monthly Bulletin of Statistics, December 1979.

The real wage paid for such semi-skilled workers in the future in this study will be treated similar to unskilled workers discussed previously, that is, it will be assumed to increase at the constant rate of 3.2 percent per annum.

3.7 Amount of Time Saved on Farm (TSF_t)

Thresher owners and thresher users found that the adoption of rice threshers can help them finish their threshing in a short time and enable them to prepare the land for the next crop in time. Compared to preexisting methods of rice threshing, the time saved on an average farm per crop season is around 2-3 weeks or 20 days. The saved time may be spent for other kinds of farm work, non-farm work or leisure. (Appendix Table F). The actual allocation of time saved for various activities will be left for further studies. Here, to evaluate the value of time saved on farm, the market wage rate for farm labor will be applied.

The amount of time saved on farm in man-days of using the machine will be assumed to vary directly with the quantity of rice threshed (QF) (see Table III-6, p. 62). The crop output threshed on an average farm in the dry season is approximately 74 percent of those threshed on the farm in the wet season in Chachoengsao in 1978 whereas it is 76.8 percent for Supanburi (Table II-9). Since it has been assumed that the quantity of rice threshed on a farm both for the wet and dry seasons will be constant, the amount of time saved due to the adoption of a rice thresher will also be constant for every crop year.

TABLE IV-9

AMOUNT OF TIME SAVED ON FARM AFTER RICE THRESHER ADOPTION BY THRESHER OWNERS 1978/79

Investment year		Time saved (man-days)	
		dry season	wet season
1975	CHACHOENGSAO (2)	20.0	27.0
1976	CHACHOENGSAO (4)	18.0	24.5
1977	CHACHOENGSAO (5)	11.5	15.6
1978	CHACHOENGSAO (15)	12.0	17.0
1977	SUPANBURI (2)	10.0	13.0
1978	SUPANBURI (21)	15.3	20.0

Note : Figures in parentheses indicate the number of observations.

3.8 Maintenance Cost (MA_t)

Survey information provide only data on repair and maintenance cost in 1978. But since the data collected include different ages of machines, these were studied to see if there is any trend (see Figure IV-2). The level of such cost was found to increase sharply for machines in the third and fourth years. It is not clear whether this is due to the age of the machines or to the new models of threshers which became larger in 1977. To make this study possible, experiments of the increase in maintenance cost will be carried out. They range from 10-40 percent per year.

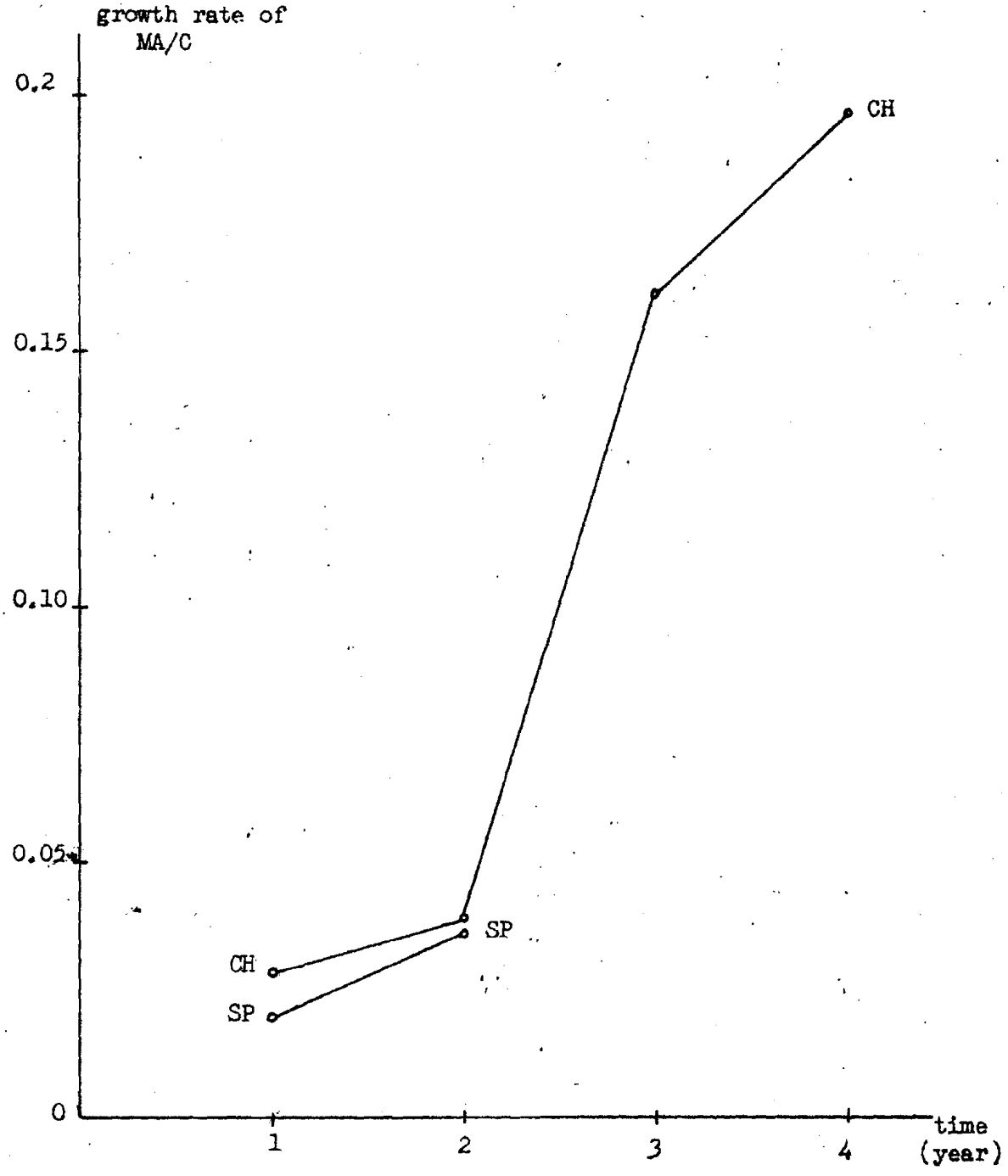
TABLE IV-10

AVERAGE MAINTENANCE COST OF A THRESHER AND ITS COMPLEMENTS IN 1978 BY AGE OF MACHINES

Age of machines (years)		Investment cost of a rice thresher and its complements (C)	maintenance cost of a rice thresher and its complements (MA)	MA/C
		(Baht)	(Baht)	
1	CHACHOENGSAO	27,200	750	0.0275
	SUPANBURI	38,520	750	0.0195
2	CHACHOENGSAO	26,500	1,000	0.0377
	SUPANBURI	28,000	1,000	0.0357
3	CHACHOENGSAO	23,500	3,800	0.1617
4	CHACHOENGSAO	23,000	4,500	0.1956

FIGURE IV-2

MAINTENANCE-INITIAL COST RATIO BY PROVINCE



CHAPTER V

EMPIRICAL RESULTS AND ANALYSIS

In this chapter, simulation experiments were carried out with the model presented in Chapter IV. Some of the empirical results are presented and analysed here. The experiments cover both thresher investments up to 1978 and possible investments in 1979.

A. Adoption Before 1978

1. Adoption Through Contractor Service

Farmers who do not own a thresher but contract for its service gain some benefits of switching from previously employed methods of threshing to a rice thresher. These benefits include the net cost saving and the time saving provided by a thresher. The maximum and minimum gains of using a thresher over tractor treading in the surveyed areas are shown in Tables V-1 and V-2. The maximum gains in Chachoengsao was about 4,000 baht in 1978 whereas the minimum gains was around 1,500 baht. For Supanburi the cultivated areas for both wet and dry seasons are relatively smaller than in Chachoengsao. The maximum and minimum gains in 1978 were therefore 1,285 baht and 960 baht, respectively. For an average farm in Chachoengsao, the gain was about 2,640 baht which was twice as large as those of Supanburi. Compared to buffalo treading, an average farm in Supanburi had a gain of 3,192 baht.

TABLE V-1

MAXIMUM, MINIMUM AND AVERAGE GAINS OF USING A THRESHER AS COMPARED TO TRACTOR TREADING IN THE SURVEY AREAS, 1978

(baht)

Area	net cost saving value[d]			value of time saved[e]			total gains		
	max.[a] (1)	min.[b] (2)	average[c] (3)	max.[a] (4)	min.[b] (5)	average[c] (6)	max. (7)=(1)+(4)	min. (8)=(2)+(5)	average (9)=(3)+(6)
Chachoengsao	3,466	1,334	2,315	488	188	326	3,954	1,522	2,641
Supanburi	1,113	831	964	172	129	136	1,285	960	1,100

TABLE V-2

MAXIMUM, MINIMUM AND AVERAGE GAINS OF USING A THRESHER AS COMPARED TO BUFFALO TREADING IN THE SURVEY AREAS, 1978

(baht)

Area	net cost saving value[d]			value of time saved[e]			total gains		
	max.[a] (1)	min.[b] (2)	average[c] (3)	max.[a] (4)	min.[b] (5)	average[c] (6)	max. (7)=(1)+(4)	min. (8)=(2)+(5)	average (9)=(3)+(6)
Chachoengsao	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-
Supanburi	1,972	1,473	1,703	1,881	1,406	1,484	3,853	2,879	3,192

Note: [a]Chachoengsao: total rice output = 31.9 Kwien for the wet season and 22.0 Kwien for the dry season.

Supanburi: total rice output = 10.3 Kwien for the wet season and 10.4 Kwien for the dry season.

[b]Chachoengsao: total rice output = 15.5 Kwien for the wet season and 5.3 Kwien for the dry season.

Supanburi: total rice output = 8.6 Kwien for the wet season and 6.9 Kwien for the dry season.

[c]Chachoengsao: total rice output = 22.0 Kwien for the wet season and 14.3 Kwien for the dry season.

Supanburi: total rice output = 9.5 Kwien for the wet season and 8.6 Kwien for the dry season.

[d]Calculation based on equation (4.16).

[e]Calculation based on equation (4.17).

The maximum and minimum gains provide us with only the absolute ranges of gains from using a rice thresher over tractor or buffalo treading in the survey areas, but it does not tell us whether small or large farms gain relatively more. Calculations were therefore made to study the gain per rai according to farm sizes. The results are presented in Tables V-3 and V-4.

It appears that small farms gain relatively more per rai than either medium or large farms of switching from traditional methods of threshing to a rice thresher. Medium size farms show the smallest gain. Such a pattern holds for both the gains from net cost savings and time saved. It is also true for both Chachoengsao and Supanburi. Comparison of a rice thresher either with tractor or buffalo treading also provides consistent results. This is because the average yield per rai was found to be highest for small farms while it was lowest for medium size farms (Table V-5).

A comparison of the two provinces found both types of gain larger in Chachoengsao. This is because the yield per rai, the wage rate and the net cost saving per kwien were all found to be higher in Chachoengsao as compared to Supanburi.

The gains realized from the use of a thresher in substitution for animal treading was found to be greater than that of substituting tractor treading. This is due to the much larger difference in the amount of time saved and the net cost saving per kwien in the former case.

TABLE V-3

AVERAGE GAIN PER RAI OF USING A THRESHER AS COMPARED TO TRACTOR TREADING IN THE SURVEY AREAS ACCORDING TO FARM SIZE[a], 1978

(baht/rai)

Area	net cost saving value[b]			value of time saved[c]			total gains		
	large (1)	medium (2)	small (3)	large (4)	medium (5)	small (6)	large (7)=(1)+(4)	medium (8)=(2)+(5)	small (9)=(3)+(6)
Chachoengsao	61.40	40.60	75.40	8.70	5.70	10.20	70.10	46.30	85.60
Supanburi	44.10	36.20	56.20	6.80	5.60	8.70	50.90	41.80	64.90

TABLE V-4

AVERAGE GAIN PER RAI OF USING A THRESHER AS COMPARED TO BUFFALO TREADING IN THE SURVEY AREAS ACCORDING TO FARM SIZE[a], 1978.

(baht/rai)

Area	net cost saving value[b]			value of time saved[c]			total gains		
	large (1)	medium (2)	small (3)	large (4)	medium (5)	small (6)	large (7)=(1)+(4)	medium (8)=(2)+(5)	small (9)=(3)+(6)
Chachoengsao	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-
Supanburi	78.20	64.20	99.60	74.60	61.25	95.10	152.80	125.50	194.70

Note: [a]Small farms: less than 15 rai.
Medium farms: 15 - 30 rai.
Large farms: more than 30 rai.

[b]Calculation is based on the following formula:
Net cost saving value = yield per rai (Kw/rai) x net cost saving per kwien (baht/kw).

[c]Calculation is based on the following formula:
Value of time saved = yield per rai (kw/rai) x time saved per kwien (hour/kw) x wage rate (baht/hour).

TABLE V-5

AVERAGE YIELD PER RAI BY FARM SIZE, [a]1978

(Kilograms/rai)

Area	Large		Medium		Small	
	1st crop	2nd crop	1st crop	2nd crop	1st crop	2nd crop
Chachoengsao	485	473	301	333	630	547
Supanburi	416	407	352	324	536	512

Note: [a]Small farms: less than 15 rai.
Medium farms: 15 - 30 rai.
Large farms: more than 30 rai.

2. Adoption Through Purchase

The year 1978 was selected as a base year. All benefits and costs are therefore converted into 1978 values. The analysis will be based on two approaches:

1. Present 1978 value, and
2. Internal rate of return.

2.1 Present 1978 Value

Present 1978 value is the net income stream over the life time of an investment converted into 1978 values. All returns and costs of the investment are translated into 1978 values by employing discount rates in the range of 12-30 percent. When the investment cost is subtracted from the calculated present value, the net 1978 values obtained were found to be positive for all discount rates chosen. These are presented in Tables V-6 and V-7.

Excluding investments in 1975, the figures for Chachoengsao show a decreasing net 1978 value for newer investments. There is one factor which explain why investments in 1975 did not show a higher value than the other years. This is because of the small number and special characteristics of the cases sampled. There were only two farms from the survey which invested in 1975. Both farm households consist of elderly people who have no desire to produce

TABLE V-6

NET PRESENT 1978 VALUE AND INVESTMENT COST IN 1978 VALUE AT DIFFERENT DISCOUNT RATES BY INVESTMENT YEAR, CHACHOENGSAO

(baht)

Discount rate (%)	net present 1978 value by investment year				investment cost in 1978 value by investment year			
	1975	1976	1977	1978	1975	1976	1977	1978
12	26,664	44,368	29,558	12,312	32,313	29,478	29,680	27,200
15	26,079	44,251	29,294	12,312	34,980	31,079	30,475	27,200
20	24,930	44,018	28,853	12,312	39,744	33,840	31,800	27,200
25	23,553	43,730	28,413	12,312	44,922	36,719	33,125	27,200
30	21,938	43,388	27,972	12,312	50,531	39,715	34,450	27,200

Sourse: Appendix H.

TABLE V-7

NET PRESENT 1978 VALUE AND INVESTMENT COST IN 1978 VALUE AT DIFFERENT DISCOUNT RATES BY INVESTMENT YEAR, SUPANBURI

(baht)

Discount rate (%)	net present 1978 value by investment year		investment cost in 1978 value by investment year	
	1977	1978	1977	1978
12	37,005	16,314	31,360	38,520
15	36,597	16,314	32,200	38,520
20	35,918	16,314	33,600	38,520
25	35,238	16,314	35,000	38,520
30	34,558	16,314	36,400	38,520

Source: Appendix H.

any significant degree of output surplus and do not feel compelled to hire out their rice threshers to utilize the machines' capacity fully. This is shown by the relatively low level of rice threshed in 1975, 1976, 1977 and 1978 of 70, 210, 240 and 60 kwiens, respectively.

In spite of all this, investments in 1975 show positive net 1978 values for all interest rates chosen. The lowest of these is 21,938 baht for a discount rate of 30 percent. This is about 43.4 percent over the initial investment cost.

The benefit-cost ratios for 1976 investors are 2.19 and 2.09 for discount rates of 25 and 30 percent, respectively. (Table V-8) Since 1976, the net 1978 values and the benefit-cost ratios all show a rapid decline reflecting the relatively more intense competition faced by new investors. There were only 2 threshers in 1975 in the area surveyed, but this increased to 26 in 1978. The benefit-cost ratio for 1978 investors is about 1.45.

For Supanburi where thresher adoption was two years later than Chachoengsao, the statistics for 1977 and 1978 also show a similar trend. The net 1978 values and the benefit-cost ratios declined significantly for 1978 as more competition or more rice threshers were bought and utilized.

The decline in the net present value or the benefit-cost ratio would have been even more spectacular had manufacturers been

TABLE V-8

BENEFIT-COST RATIOS AT DIFFERENT DISCOUNT RATES
BY INVESMENT YEAR

Discount rate (%)	Year of Investment					
	CHACHOENGSAO				SUPANBURI	
	1975	1976	1977	1978	1977	1978
12	1.83	2.51	2.00	1.45	2.18	1.42
15	1.75	2.42	1.96	1.45	2.14	1.42
20	1.63	2.30	1.91	1.45	2.07	1.42
25	1.52	2.19	1.86	1.45	2.01	1.42
30	1.43	2.09	1.81	1.45	1.95	1.42

Source: Derived from Tables V-6 and V-7.

able to produce more threshers in 1977. But information obtained from talking to manufacturers pointed out that the production capacity had already been fully utilized in that year.

2.2 Internal Rate of Return

Estimation of the profitability of a rice thresher investment was also carried out using the internal rate of return approach. Unlike the benefit-cost ratio in the previous section, the internal rate of return calculated is not net of interest but instead must be compared to the interest rate. If it is higher than the market rate of interest or the cost of borrowing, the investment is profitable and vice versa.

From the survey, the sources of funds for investments in rice threshers were found to come from farmers' own cash, the Bank for Agriculture and Agricultural Cooperatives (BAAC), the Agricultural Cooperatives (AC), and local money lenders. The investment on threshers would be worthwhile if the internal rate of return is greater than or equal to the interest rate charged by these sources. The estimated internal rates of return shown in Tables V-9 and V-10 ranges from 35 to 63.5 percent in Chachoengsao and 42-62 percent in Supanburi depending on the investment year. The interest rates charged by different sources are also shown. For institutional sources, it is between 12-15 percent while it is between 20-30 percent for other sources. The results show that irrespective of the sources of

TABLE V-9

INTERNAL RATE OF RETURN OF INVESTING IN A RICE THRESHER CHACHOENGSAO

internal rate of return and interest rate (%)	Year of Investment			
	1975	1976	1977	1978
IRR	35	63.5	60	45.3
BAAC	12	12	12	12
AC	15	15	15	15
Commercial Bank	15	15	15	15
Money lender	20-30	20-30	20-30	20-30

Note: BAAC = The Bank for Agriculture and Agricultural Cooperatives.

AC = The Agricultural Cooperatives.

TABLE V-10

INTERNAL RATE OF RETURN OF INVESTING IN A RICE THRESHER SUPANBURI

internal rate of return and interest rate (%)	Year of Investment	
	1977	1978
IRR	62	42
BAAC	12	12
AC	15	15
Commercial Bank	15	15
Money lender	20-30	20-30

Note: BAAC = The Bank for Agriculture and Agricultural Cooperatives.

AC = The Agricultural Cooperatives.

investment funds, a rice thresher investment would be profitable. They differ only on the degree of profitability obtained. As the market for thresher services becomes more competitive, the source of financing would become more important in determining thresher investments.

Similar to the present 1978 value approach, results from the internal rate of return approach also provided similar results showing declining internal rates of return for both provinces as time passes. But the internal rates of return for investments in 1978 in both provinces show values of higher than 40 percent. Given that interest rates are lower than this figure, investments of threshers in 1978 are still highly profitable.

B. External Benefits of a Rice Thresher

In addition to the positive net private benefits of thresher owners, a rice thresher also provides external benefits to other farmers who rent for its services. This is because of the lower cost of threshing provided by a rice thresher. For an average thresher, the external benefits generated are approximately 30,500 baht for Chachoengsao and 23,000 baht in Supanburi in 1978 (Table V-11). The external benefits generated by a rice thresher vary according to its level of capacity utilization.

TABLE V-11

EXTERNAL BENEFITS GENERATED BY AN AVERAGE RICE THRESHER, 1978*

(baht/year)

Area	net cost saving (1)	time saved value (2)	total benefits (3) = (1) + (2)
Chachoengsao	26,744	3,772	30,516
Supanburi	19,853	3,079	22,932

Source: The calculation is based on equation (4.22).

*Calculated based on the average amount of rice threshed of 417 kwien in Chachoengsao and 370 kwien in Supanburi.

C. Expected Profitability of Investing in a Rice Thresher in 1979 in Comparison to Threshing With a Tractor

Threshing is an activity that must be done in the production of paddy. It would, therefore, not be useful, let alone feasible, to measure the profitability of a rice thresher absolutely. In addition, there is more than one method of threshing rice. Farmers must, therefore, compare the benefits and costs of each method. In the following sections, profitability of investing in a rice thresher is measured in comparison to tractor treading. Buffalo treading will not be included here since it was not found to be an important alternative in the survey areas. It will be left for further studies.

The present value model in the previous chapter was employed for such a purpose. Since the present value obtained is sensitive to the interest or discount rate chosen, a number of experiments

ranging from discount rates of 12-30 percent were employed. All these results are presented in the Appendix H.

It is difficult to choose an appropriate discount rate since funding may come from different sources. If if comes from the Bank for Agriculture and Agricultural Cooperatives, an interest rate of 12 percent may be obtained. However, if it comes from local money lenders, the rate is much higher and may vary. From the survey, it was found that the interest rate charged by local money lenders ranges between 20-30 percent. However, the result from the survey shows that about 70 percent of thresher owners purchased their machines using their own money.[1] The author believes that under such a condition, it would be better to employ the interest rate charged by local money lenders, since it would better reflect the opportunity cost of funds in that area. In the following pages, discussion of thresher investments will be based on a discount rate of 25 percent.

There are a number of variables which affect the present value of thresher investments and are difficult to determine. They include the machine life span, petroleum product prices and maintenance cost.

For machine life span, the study has arbitrarily chosen twenty years as the cut off point. Although the machine might

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[1] See Table III-4, p. 60.

still be functional after 20 years, there is a high probability that a newer type of thresher with a better performance or a better threshing technology may be available to make the 1979 machine obsolete. In addition, if a limit on the number of years is not employed, the calculation can go on forever for some experiments.

Since the market for petroleum products is unpredictable, it is difficult to estimate these prices except to say that their real prices would probably rise in the foreseeable future. The study therefore experimented with a number of fixed growth rates for these prices. Only three are presented in this study. They are 10, 30 and 50 percent per annum.

Similar to petroleum product prices, the maintenance cost for each year is difficult to forecast due to insufficient information with threshers being a relatively new product. Experiments on maintenance costs were therefore undertaken with various different rates of growth.

Tables V-12 and V-13 show the experiments based on various combinations of the change in petroleum products prices, the change in maintenance cost and the life span of the machine. The values are obtained using a discount rate of 25 percent. However, other experiments based under different discount rates are available in Appendix H.

TABLE V-12

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SET OF ASSUMPTIONS, CHACHOENGSAO (DISCOUNT RATE = 25%)

(1979 Baht)

Machine life span (Years)	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	13030	12970	12909	12850	13147	13087	13027	12967	13265	13205	13145	13085	12996
2	24009	23839	23658	23469	24353	24182	24002	23813	24735	24565	24384	24195	23394
3	33239	32917	32555	32156	33910	32539	33226	32827	34736	34414	34053	33654	31713
4	40990	40480	39877	39176	42081	41570	40962	40269	43565	43056	42455	41753	38375
5	47479	46752	45850	44732	49079	48352	47436	46338	51494	50768	49867	48755	43706
6	52703	51738	50474	48831	54893	53928	52653	51021	58581	57615	56352	54709	47959
7	56924	55702	54014	51125	59784	58561	56857	54558	65135	63913	62227	59913	51371
8	60328	58834	56661	52976	63933	62439	60243	57118	71439	69946	67774	64630	54099
9	63066	61291	58570	53875	67485	65710	62972	58831	77751	75976	73256	69100	56278
10	65271	63207	59877	53967	70573	68509	65169	59806	84323	82258	78927	73551	58017
11	67059	64700	60693	-	73316	70957	66937	60096	91405	89045	85038	78207	59414
12	68507	65848	61097	-	75789	73130	68361	-	99259	96602	91853	83302	60536
13	69671	66714	61154	-	78041	75083	69505	-	108169	105213	99657	89082	61428
14	70611	67355	-	-	80135	76879	70425	-	118449	115195	108763	95822	62139
15	71365	67815	-	-	82102	78552	71162	-	130456	126905	119530	103834	62706
16	71975	68133	-	-	83991	80148	71753	-	144601	140757	132367	113478	63162
17	72481	68344	-	-	85877	81739	72224	-	161366	157232	147756	125179	63536
18	72881	68499	-	-	87695	83273	72599	-	181316	176898	166262	139437	63762
19	73195	68542	-	-	89455	84762	72897	-	205122	200428	188555	156850	63956
20	73467	-	-	-	91349	86371	73131	-	233585	228614	215432	178136	64104
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE V-13

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, SUPANBURI (DISCOUNT RATE = 25%)

(1979 baht)

Machine life span (Years)	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	14465	14405	14345	14285	14555	14495	14435	14375	14645	14585	14525	14465	18270
2	26646	26476	26296	26106	26909	26738	26558	26369	27200	27030	26850	26660	32886
3	36879	36557	36196	35796	37392	37068	36708	36309	38022	37699	37339	36939	44578
4	45457	44948	44346	43643	46290	45779	45179	44477	47438	46928	46327	45624	53941
5	52355	51629	50728	49616	53576	52850	51948	50836	55447	54721	53820	52707	61432
6	57903	56938	55486	53863	59345	58390	57140	55517	62410	61445	60182	58538	67415
7	62365	61144	59268	56974	64318	63105	61432	59107	68667	67444	65757	63442	72211
8	65954	64461	62100	58976	68474	66990	64832	61676	74480	72986	70813	67666	76047
9	68841	67066	64156	59227	71984	70217	67511	63343	80109	78307	75586	71428	79107
10	70985	69098	65577	-	74982	72925	69608	64221	86025	83647	80317	74944	84551
11	72852	70670	66474	-	77577	75226	71232	64391	92448	89268	85262	78433	83515
12	74354	71875	66937	-	79859	77210	72475	-	99572	95392	90641	82084	85091
13	75563	72784	67039	-	81897	78950	73407	-	107676	102217	96658	86076	86347
14	76534	73458	-	-	83749	80503	74085	-	116993	110023	103587	90639	87351
15	77316	73943	-	-	85268	81919	74557	-	127893	119046	111672	95983	88151
16	77944	74278	-	-	86878	83235	74822	-	141092	129653	121271	102405	88790
17	78449	74494	-	-	88415	84483	74984	-	156408	142557	133065	110432	89327
18	78856	74616	-	-	89904	85688	75029	-	171723	157588	146937	120060	89738
19	79182	74663	-	-	91366	86871	-	-	189452	175046	163196	131579	90058
20	79445	--	-	-	92818	88049	-	-	212129	197438	184223	146786	90332
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

1. Experiments Based on Changes in the Prices of Petroleum Products (g_F)

From Tables V-12 and V-13, it can be seen that increases in petroleum products' price resulted in increases in the present value of thresher investment. This is because the physical units employed of diesel oil, engine oil and grease of tractor treading are higher than that of a thresher. (Table II-6, Chapter II). Therefore any increase in the prices of these products would increase the profitability of a thresher investment. Due to this factor, it can be seen that if petroleum product prices increase high enough, instead of witnessing ever decreasing 1979 value of net income stream for years further. into the future, these values will start to go on an increasing pattern. Experiments in Table V-12 and Appendix Table H-5 show that for PV31, PV32, PV51, PV52, PV53 and PV54, such a phenomenon took place. For example, the decreasing trend of annual 1979 value for PV51 was reversed in the ninth year for a discount rate of 25 percent. The result shows that if petroleum product prices increase sufficiently enough, the profitability of investing in a rice thesher will become unquestionable. Since it is reasonable to believe that petroleum product prices are likely to increase in the future, rice threshers would be in a good market position over tractors in threshing.

However, since the comparison made in this study is only with respect to tractor treading, the results may not be conclusive.

As petroleum product prices rise sufficiently, a rice thresher investment may not be profitable when compared to buffalo treading or threshing with human power since these methods do not require the use of petroleum products. Assuming threshing with methods other than threshers or tractors are not available, the annual net income stream of a thresher investment may also become zero beyond a certain point if the unit cost of threshing with a rice thresher is higher than the price received for the unit of output. It would be better for the farmers under such a circumstance to stop production which incurs no increase in net loss rather than thresh their rice which only increases their net loss. Since there is no reason to believe that the real price of paddy will increase in the long tern while prices of petroleum products may go on increasing, such a situation may occur in the future which will result in a shorter life span for a thresher investment. The study has not taken this into account. It will be left for future studies.

2. Experiments Based on Changes in Maintenance Costs (g_{MA})

It seems reasonable to assume that in general the maintenance cost in later years will be higher than earlier years due to its obsolescence and age. Experiments were therefore made based on assuming fixed rates of increases for maintenance cost as shown in Tables V-12 and V-13.

As expected, the increase in maintenance costs reduced the 1979 value of an investment. The results show that the rapid increase in maintenance cost (30-40 percent) will significantly reduce the net income stream. For some experiments, the net income beyond a certain year in the future will approach zero. (Appendix G). This means the end of the machine life. Such cases in Tables V-12 and V-13 include experiments PV13, PV14, PV33 and PV34.

3. Experiment Based on Constant 1978 values

This experiment was carried out on the assumption that the investor would use the available data and/or information in 1978 to estimate the present value of a rice thresher investment. The quantity of rice threshed both on farm and off farm, the price of petroleum products, the wage rate, and the maintenance costs are all assumed to be based on real unchanged 1978 values throughout the machine's life.

4. Profitability of a Rice Thresher Investment

The expected benefit-cost ratios of a possible investment in 1979 by province are shown in Tables V-14 and V-15. These experiments are based on a chosen discount rate of 25 percent. Chachoengsao's case yielded a relatively higher degree of profitability than those of Supanburi for the same set of assumptions except for the experiment based on the constant 1978 value.

TABLE V-14

BENEFIT-COST RATIOS BASED ON VARIOUS SETS OF ASSUMPTIONS, CHACHOENGSAO

(Discount rate = 25%)

Machine life span (Years)	BC11	BC12	BC13	BC14	BC31	BC32	BC33	BC34	BC51	BC52	BC53	BC54	BC78
1	0.42	0.42	0.42	0.41	0.42	0.42	0.42	0.42	0.43	0.43	0.42	0.42	0.42
2	0.77	0.77	0.76	0.76	0.79	0.78	0.77	0.77	0.80	0.79	0.79	0.78	0.75
3	1.07	1.06	1.05	1.04	1.09	1.05	1.07	1.06	1.12	1.11	1.10	1.09	1.02
4	1.32	1.30	1.29	1.26	1.36	1.34	1.32	1.30	1.40	1.39	1.37	1.35	1.24
5	1.53	1.51	1.47	1.44	1.58	1.56	1.53	1.49	1.66	1.64	1.61	1.57	1.41
6	1.70	1.70	1.63	1.58	1.77	1.74	1.70	1.64	1.89	1.86	1.82	1.76	1.55
7	1.84	1.80	1.75	1.65	1.93	1.89	1.83	1.76	2.10	2.06	2.01	1.93	1.66
8	1.95	1.90	1.82	1.71	2.06	2.01	1.94	1.84	2.30	2.26	2.18	2.08	1.75
9	2.03	1.98	1.89	1.73	2.18	2.12	2.03	1.90	2.51	2.45	2.36	2.23	1.82
10	2.10	2.04	1.94	1.74	2.28	2.21	2.10	1.93	2.72	2.65	2.55	2.37	1.87
11	2.16	2.08	1.96	-	2.37	2.29	2.16	1.94	2.95	2.88	2.74	2.52	1.92
12	2.21	2.12	1.97	-	2.44	2.36	2.21	-	3.20	3.12	2.96	2.69	1.95
13	2.25	2.15	1.97	-	2.52	2.42	2.24	-	3.48	3.39	3.21	2.87	1.98
14	2.28	2.17	-	-	2.59	2.48	2.27	-	3.82	3.72	3.51	3.09	2.00
15	2.30	2.19	-	-	2.65	2.53	2.30	-	4.21	4.09	3.86	3.35	2.02
16	2.32	2.20	-	-	2.71	2.59	2.31	-	4.67	4.54	4.27	3.66	2.04
17	2.34	2.21	-	-	2.77	2.63	2.33	-	5.21	5.07	4.77	4.03	2.05
18	2.35	2.21	-	-	2.83	2.69	2.34	-	5.85	5.71	5.36	4.49	2.06
19	2.36	2.21	-	-	2.89	2.89	2.35	-	6.62	6.47	6.08	5.06	2.06
20	2.37	-	-	-	2.95	2.79	2.40	-	7.54	7.37	6.95	5.75	2.07
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

Source: Table V-12 divided by investment cost of 31,000 baht.

TABLE V-15

BENEFIT-COST RATIOS BASED ON VARIOUS SETS OF ASSUMPTIONS, SUPANBURI

(Discount rate = 25%)

Machine life span (Years)	BC11	BC12	BC13	BC14	BC31	BC32	BC33	BC34	BC51	BC52	BC53	BC54	BC78
1	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.33	0.32	0.32	0.32	0.47
2	0.59	0.59	0.59	0.58	0.60	0.60	0.59	0.59	0.61	0.60	0.60	0.59	0.85
3	0.82	0.82	0.81	0.80	0.83	0.83	0.82	0.81	0.85	0.84	0.83	0.82	1.15
4	1.01	1.00	0.99	0.97	1.03	1.02	1.01	0.99	1.06	1.04	1.03	1.02	1.40
5	1.17	1.15	1.13	1.11	1.19	1.18	1.16	1.13	1.24	1.22	1.20	1.18	1.60
6	1.29	1.27	1.24	1.20	1.32	1.30	1.27	1.24	1.39	1.37	1.34	1.31	1.75
7	1.39	1.36	1.32	1.27	1.43	1.41	1.37	1.32	1.40	1.50	1.47	1.42	1.87
8	1.47	1.44	1.39	1.32	1.53	1.49	1.45	1.38	1.66	1.63	1.58	1.51	1.97
9	1.53	1.50	1.43	1.32	1.61	1.57	1.51	1.41	1.79	1.75	1.69	1.59	2.05
10	1.58	1.54	1.46	-	1.67	1.63	1.55	1.43	1.72	1.87	1.79	1.67	2.11
11	1.63	1.58	1.48	-	1.73	1.68	1.59	1.44	2.06	1.99	1.39	1.75	2.17
12	1.66	1.60	1.49	-	1.78	1.72	1.62	-	2.22	2.13	2.02	1.83	2.21
13	1.69	1.62	1.50	-	1.83	1.76	1.64	-	2.40	2.28	2.16	1.92	2.24
14	1.71	1.64	-	-	1.87	1.80	1.65	-	2.61	2.45	2.31	2.02	2.27
15	1.72	1.65	-	-	1.90	1.83	1.66	-	2.85	2.66	2.49	2.14	2.29
16	1.74	1.66	-	-	1.94	1.86	1.67	-	3.15	2.89	2.71	2.28	2.30
17	1.75	1.66	-	-	1.97	1.88	1.67	-	3.49	3.18	2.97	2.46	2.31
18	1.76	1.66	-	-	2.01	1.91	1.67	-	3.83	3.52	3.28	2.68	2.33
19	1.77	1.67	-	-	2.04	1.94	-	-	4.23	3.91	3.64	2.94	2.34
20	1.77	-	-	-	2.07	1.96	-	-	4.73	4.41	4.11	3.28	2.34
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

Source: Table V-13 divided by investment cost of 44,800 baht.

However, such comparisons must be made with care since engines utilized in rice threshers in Chachoengsao are second-hand ones while those in Supanburi are brand new. Assumptions based on the same pattern of maintenance cost and machine life span may therefore not be reasonable to permit comparisons to be made.

Anyway, the results in Tables V-14 and V-15 show that the cost of investment in Chachoengsao can be recovered much faster than in Supanburi. Almost all experiments show that it takes Chachoengsao three years to break even while in Supanburi's case, it takes four years. This is not surprising since the investment cost in Chachoengsao is ฿ 31,000 baht while that in Supanburi is ฿ 44,800. The only exception where an investment in Supanburi took three years to break even and show a higher benefit-cost ratio for the same given period over Chachoengsao is in the case of experiment BC78. The assumptions used in such an experiment are based on using real values in 1978 for the entire life span of the machine. This means that there is assumed to be no increase in fuel cost, thus making thresher investments which are more economical in fuel consumption relatively less profitable.

When the expected benefit-cost ratios of a rice thresher investment in 1979 are compared to such an investment before 1979, it is interesting to see that if rice thresher investments last up to 11-15 years, most of the ratios are larger for investments in 1979 rather than past investments which is a reverse of past trends. This may be explained by the large increase in petroleum

product prices since 1979. However, for experiment BC78 which is based on constant 1978 values, the benefit-cost ratios are also higher for investments in 1979 if the machine life is at least six years. This may mean that farmer's expected resale value of the machines could be smaller than the actual remaining value of the machines in 1978. The reason could be that farmers expect rice threshers to have a short life span. With threshers being a relatively new product whose average age is still unknown, this may be possible.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A. Summary and Conclusions

next to planting activities, farmers in Chachoengsao and Supanburi would like to see threshing mechanized. In both provinces, there has been a very rapid change from traditional to machanical techniques of production over the past 2-4 years. There is also a wide range of adoption and use of modern varieties in response to the installation and expansion in irrigation facilities during the past decade.

The first adoption of a rice thresher was in the Chachoengsao area in 1975 and has spread out widely in areas with relatively good irrigation and double-cropped areas. The diffusion of the machine was carried out jointly between the Thai-IRRI office located at the Agricultural Engineering Division and small local manufacturers. The original design was obtained from an IRRI blue-print. It was tested and modified to suit the main rice variety grown and other conditions in Thailand.

Rice threshers could provide farmers with two main benefits, namely, the net cost saving and the time saving. Farmers who switched from hiring animal treading to a rice thresher would obtain the net cost saving of about 95 baht per kwien whereas it is 53-64 baht per kwien for switching from hiring a tractor. For time saving, a thresher takes about 0.6-0.8 hour per kwiwn while

animal and tractor treading take 22 and 2.63 hour per kwien, respectively. The time saved with machanical threshing may be used for better farm management, increased leisure activities or some other income generating activities.

Contracting, rather than syndicate or co-operative ownership, is the main way in which machine services are made available to farmers who have not the capital to buy a machine for themselves. The average charge per kwien in 1978 is 50 and 70 baht in Chachoengsao and Supanburi, respectively. This charge rate covers only the semi-skilled labor cost of operating a thresher, fuel cost (diesel oil), transportation cost and a machine service charge. The customers have to find another 5-6 laborers for threshing.

Farmers who own a rice thresher gain from two sources. One from their own use and the another from off-farm contracting services.

Employing the present value and the internal rate of return approaches, it was found that the investment of threshers up to 1978 yielded rather high profitabilities in both Chachoengsao and Supanburi provinces. Expectations of profitability of a rice thresher investment in 1979 were also quite favorable.

A rice thresher not only provide internal benefits to the owners but it also results in external benefits to other farmers

who rent the service as well. Such benefits generated by a thresher in 1978 is approximately 30,500 baht in Chachoengsao and 23,000 baht in Supanburi.

Eventhough there exist positive net benefits of using and investing in a rice thresher, other factors such as organizational and institutional factors may act as constraints on thresher investment. The availability of credit seems to be an important institutional factor. Another very important factor affecting investments seems to be the availability of customers.

B. Tentative Policy Implications

Since rice threshers possess net benefits over other methods of threshing, it may be a good policy to promote the adoption and diffusion of this machine more widely. However, any policy of promoting rice thresher use need take into consideration that present utilization are mainly confined to well irrigated areas. This may be because double cropping is possible in these areas. If farmers want to practice double cropping, the labor bottleneck during threshing becomes more binding since farmers must also prepare the fields for another crop at the same time. The use of threshers will help overcome this constraint. Another possible reason may well be that farmers in irrigated areas are more well off, thus, they are able to afford buying a rice thresher. This can be seen by the high percentage of thresher buryers who use their own funds to buy the machines. It therefore seems that any promotion of rice thresher utilization must take into consideration

the level of agricultural development.

One instrument which can be used to promote rice thresher diffusion is through the provision of loans to farmers for such investments at reasonable rates of interest. The present loan facility for thresher investment at the BAAC could be expanded to provide more credit. The machine itself may be used as the collateral.

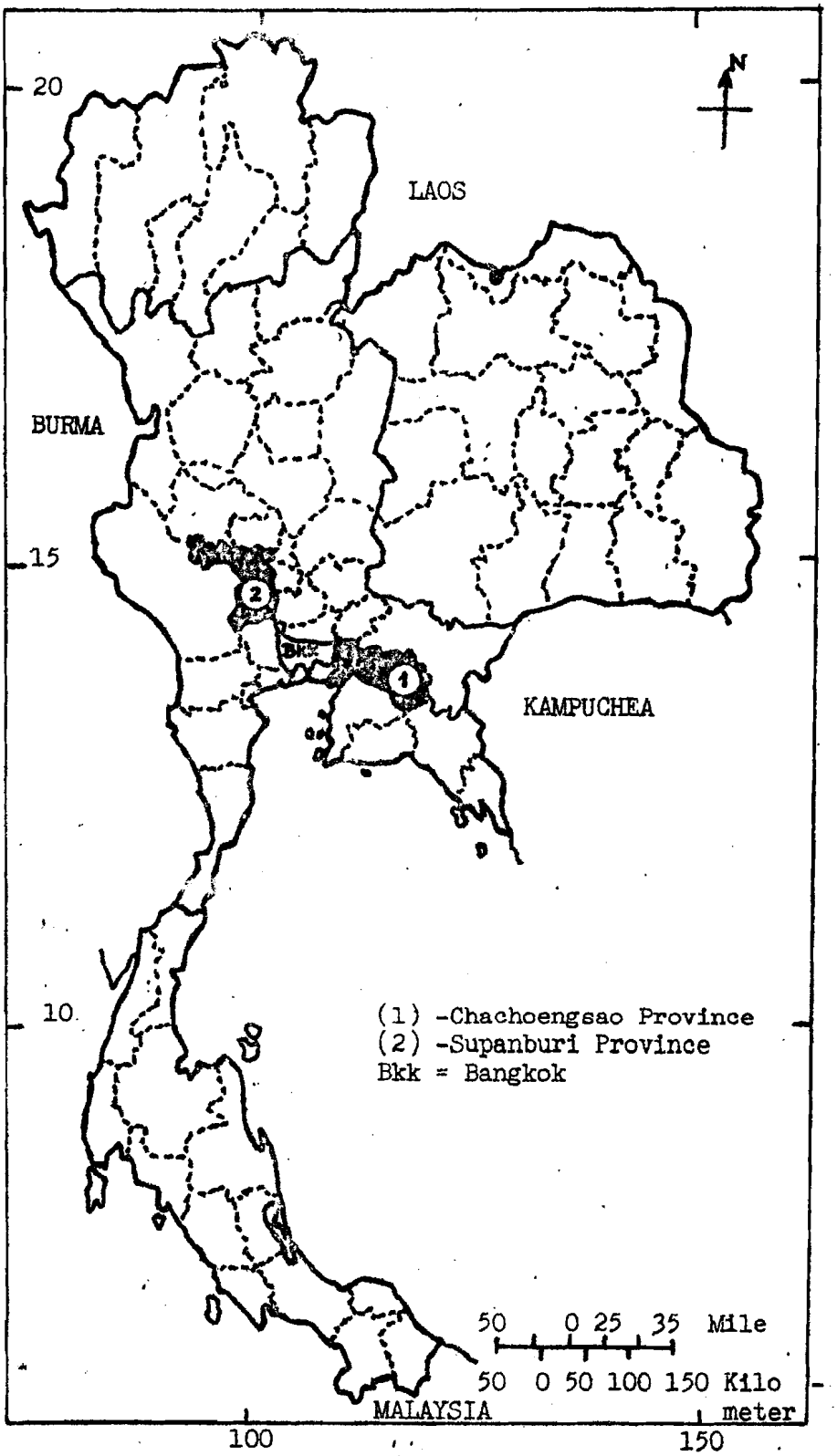
In addition to providing some advantages to farmers, threshers also provide a link between agriculture and industry. This is because all of the rice threshers used in the country are now locally produced. The promotion of threshing machines may therefore benefit both these sectors which means the development of agriculture and industry may take place simultaneously.

C. Data Deficiency

This study has tried to investigate the profitability of a rice thresher investment since its adoption up to 1979. Time series data are required for such a purpose. However, since the data were collected only in 1978, some respondent farmers could not recall information in the past. In addition, data from other sources were also incomplete. This study was therefore carried out by experimenting with some assumptions and restrictions. The results are based on data collected from two well-known rice production provinces in Thailand, Chachoengsao and Supanburi.

It is hope that this study would help provide better understanding of rice thresher adoption and diffusion elsewhere as well. Other interesting points which are left for further studies include comparision of a rice thresher investment to alternative methods of threshing other than tractor treading, the effect of petroleum product price changes on the chosen method of rice threshing and the better understanding of maintenance costs and the life span of the machines.

APPENDICES

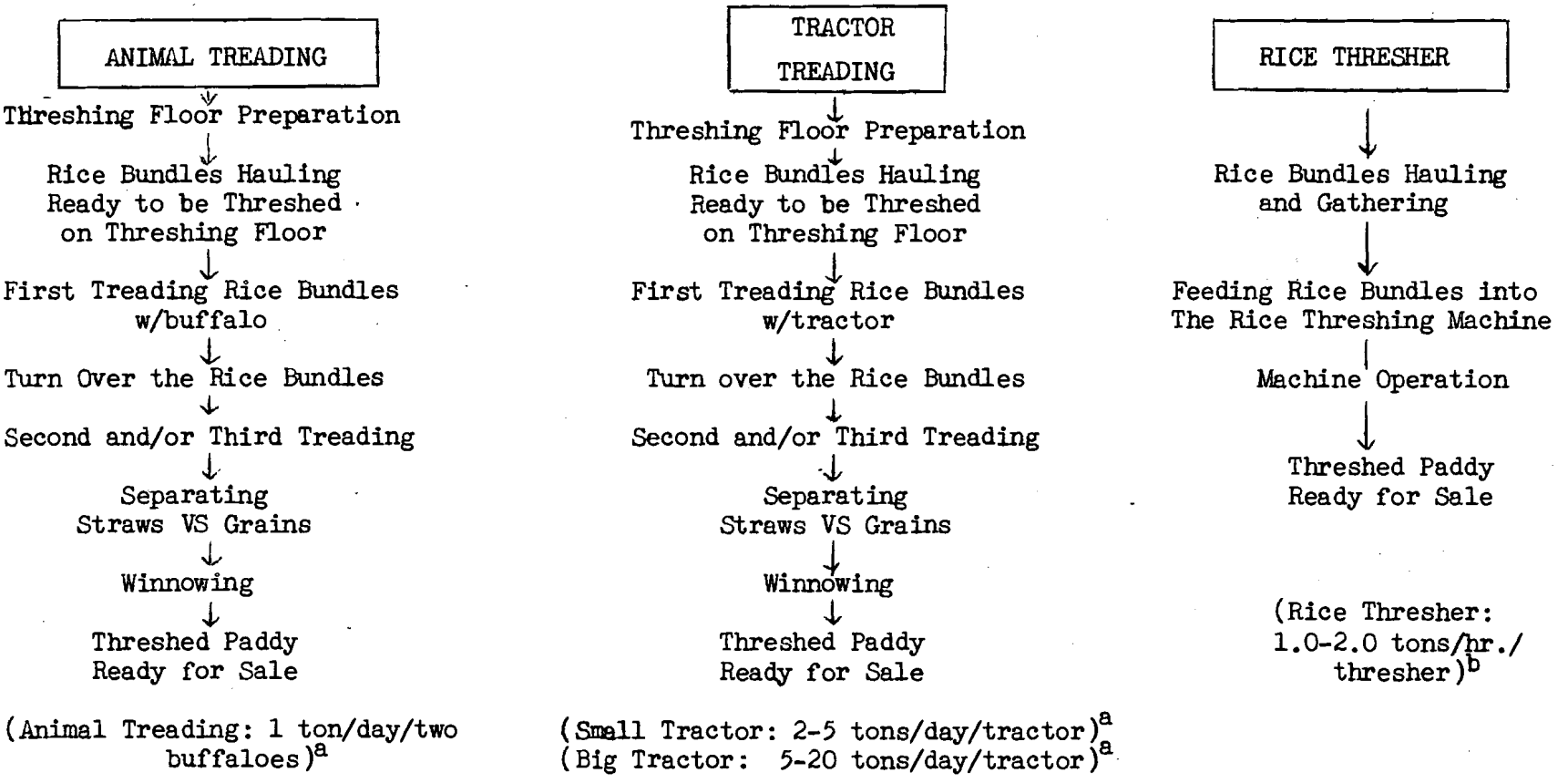


APPENDIX FIGURE A

MAP OF THAILAND WITH SPECIFIC INDICATION OF SITES OF STUDY

APPENDIX CHART B

STAGES OF RICE THRESHING BY VARIOUS METHODS



Source: [a]From The Survey on Post-Harvest Practices in Thailand 1976. The Department of Agriculture, Ministry of Agriculture and Cooperatives, 1978, p. 60.

[b]Field survey, 1979.

APPENDIX TABLE C-1

COST OF RICE THRESHING BY TRACTOR TREADING, 1978

Cost Item	Unit	CHACHOENGSAO		SUPANBURI	
		Ban Po (N=2)	Bang Pa Kong (N=5)	Donchedi (N=10)	Sri-prachan (N=19)
FUEL COST					
Fuel consumption	litre/kw	4.5	3.00	2.66	2.013
Price	baht/litre	4.9	2.95	3.48	3.08
Fuel cost	baht/kw	22.05 (14.2%)	8.85 (6.5%)	9.25 (5.7%)	6.20 (4.6%)
ENGINE OIL					
Lubricant oil	litre/kw	1.0	0.238	0.491	0.378
Price	baht/kw	9.0	15.0	17.8	16.10
Lubricant cost	baht/kw	9.00 (5.8%)	3.57 (2.6%)	8.74 (5.4%)	6.10 (4.5%)
GREASE					
Grease consumption	kg/kw	-	-	0.0625	0.042
Price	baht/kg	-	-	20.0	20.0
Grease cost	baht/kw	-	-	1.25 (0.8%)	0.84 (0.6%)
LABOR COST					
Labor used	m-day/kw	2.33	2.09	2.73	2.76
Wage rate	baht/m-day	34.50	40.00	37.10	29.92
Cost of labor	baht/kw	80.40 (51.8%)	83.76 (61.7%)	101.40 (62.0%)	82.61 (60.8%)
TRACTOR CHARGE					
Time consumed	hour/kw	2.48	2.24	2.74	2.94
Price	baht/hour	17.65	17.65	15.56	13.60
Treading cost	baht/kw	43.77 (28.2%)	39.54 (29.2%)	42.60 (26.1%)	40.00 (29.5%)
TOTAL VARIABLE COST	baht/kw	155.22 (100.00%)	135.72 (100.00%)	163.24 (100.00%)	135.75 (100.00%)
WEIGHTED AVERAGE TOTAL VARIABLE COST BY PROVINCE	baht/kw	140.20		151.60	

APPENDIX TABLE C-2

COST OF RICE THRESHING BY A RICE THRESHER, 1978
(51 THRESHER OWNERS)

Cost Item	Unit	CHACHOENGSAO PROVINCE				SUPANBURI PROVINCE	
		Bang Nam Prieo	Muang	Ban Po	Bang Pa Kong	Don Chedi	Sri Prachan
		(N=13)	(N=4)	(N=9)	(N=2)	(N=12)	(N=11)
1. FUEL COST							
Fuel consumption	litre/kw	0.83	0.78	2.2	2.35	1.06	1.02
Price	baht/litre	3.00	3.00	5.02*	5.48*	3.09	2.87
Fuel cost	baht/kw	2.49	2.34	11.04	12.88	3.28	2.93
2. ENGINE OIL							
Lubricant consumption	litre/kw	0.07	0.08	0.054	0.05	0.08	0.09
Price	baht/litre	17.29	15.28	14.9	15.60	16.08	15.04
Lubricant cost	baht/kw	1.20	1.22	0.80	0.78	1.29	1.35
3. GREASE COST	baht/kw	0.14	0.09	0.05	0.03	0.10	0.08
4. THRESHER OPERATOR COST							
Rate of operating	m-hour/kw	0.61	0.65	0.58	0.6	0.7	0.86
Wage rate of thresher operator	baht/m-hour	7.90	6.98	6.29	6.9	4.71	5.32
Thresher operator cost	baht/kw	4.82	4.54	3.65	4.14	3.30	4.57
5. LABOR COST							
# Labor used	m-day/kw	0.60	0.78	0.65	0.70	0.85	0.90
Wage	baht/m-day	40.00	37.00	38.70	36.0	33.00	31.00
Labor cost	baht/kw	24.00	28.86	25.15	25.2	28.05	27.90

APPENDIX TABLE C-2 --Continued

Cost Item	Unit	CHACHOENGSAO PROVINCE				SUPANBURI PROVINCE	
		Bang Nam Prieo	Muang	Ban Po	Bang Pa Kong	Don Chedi	Sri Prachan
		(N=13)	(N=4)	(N=9)	(N=2)	(N=12)	(N=11)
6. SERVICE CHARGE	baht/kw	45.08	39.20	40.30	42.00	63.00	60.10
7. TOTAL VARIABLE THRESHING COST ON FARM (1+2+3+4+5+6)	baht/kw	77.73	76.25	81.00	85.03	99.00	96.93

Note: *Gasoline consumption is relatively more expensive than diesel oil.

APPENDIX TABLE D

RETAIL PRICE OF DIESEL OIL BY PROVINCE, 1971-1980

	Maximum retail price of high speed diesel in Bangkok (฿/litre)	Official retail price of H.S.D. (฿/litre):nominal		Local retail price of H.S.D. (B//litre):nominal		Official retail price of H.S.D. : real[d]		Local retail price of H.S.D. : real[d]	
		CH	SP	CH	SP	CH	SP	CH	SP
Before July 4, 1973	0.98	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1973 July 4	1.05	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Nov. 14	1.41	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Dec. 17	1.60	1.65	1.69	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1974 Feb. 27	2.33	2.38	2.42	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1975	2.33	2.38	2.42	2.38	2.42	2.87	2.91	2.87	2.92
1976	2.33	2.38	2.42	2.38	2.42	2.74	2.79	2.74	2.79
1977 Mar. 15	2.64	2.69	2.73	2.69	2.90	2.90	2.94	2.90	3.12
1978	2.64	2.69	2.73	3.03[a]	3.33[a]	2.69	2.73	3.03	3.33
1979 July 13	4.88	4.95	5.01	5.30[b]	5.50[c]	4.52	4.57	4.84	5.02
1980 Feb. 9	7.39	7.49	7.57	7.83[b]	8.00[c]	5.79	5.85	6.05	6.19
Mar. 20	6.54	6.64	6.72	7.38[b]	8.00[c]	5.14	5.20	6.05	6.19

Source: 1971-1978 - National Energy Administration
1979-1980 - Internal Trade Department, Ministry of Commerce

Note: [a]Survey information conducted by the author

[b]Information obtained from five thresher owners in Muang District, Chachosao province.

[c]Information obtained from the farm record keeping of the IRRI Project "The Consequences of Small Rice Farm Mechanization on Rural Employment, Income and Production," (Supanburi Province).

[d]Adjusted by using the consumer price index (CPI) for the Central Region obtained from the Bank of Thailand, Monthly Bulletin of Statistics, various issues.

CH = Chachoengsao

SP = Supanburi

N.A. = Not available

APPENDIX TABLE E

THAILAND: NOMINAL AND REAL GNP PER CAPITA
1955-1978

Year	Nominal GNP per capita[1] (baht)	GNP deflator (1978 = 100)	Real GNP per capita (1978 = 100)
1955	1725	37.7	4576
1956	1742	38.2	4566
1957	1843	41.8	4413
1958	1855	43.0	4316
1959	1920	41.7	4605
1960	1989	42.9	4638
1961	2102	44.5	4724
1962	2197	44.5	4936
1963	2272	43.9	5180
1964	2409	45.1	5340
1965	2633	47.2	5577
1966	3063	50.6	6053
1967	3171	49.9	6350
1968	3311	49.6	6669
1969	3527	50.8	6937
1970	3751	50.5	7426
1971	3859	51.3	7520
1972	4257	55.8	7636
1973	5445	67.0	8125
1974	6674	79.6	8383
1975	7132	81.8	8711
1976	7830	84.7	9248
1977	8879	91.9	9665
1978	10502	100.00	10502
1955 - 1978	(7.6%)		(3.6%)
1971 - 1978	(13.3 %)		(4.8%)

Source: [1]Office of the National Economic and Social Development Board (NESDB), Office of the Prime Minister, Bangkok, Thailand.

Note: Figures in parentheses indicate compound rates of growth.

APPENDIX TABLE F

HOW FARMER USERS SPENT TIME SAVED ON FARM*

Activity	Farmer owners-users		Farmer users	
	household	percent	household	percent
Leisure	16	24.4	45	28.8
Land preparation for next crop	34	54.0	19	12.2
Hire out thresher	19	30.2	0	0
Labor for land preparation	1	1.6	12	7.7
Labor for harvesting	0	0	2	1.3
Exchange labor for threshing	1	1.6	4	2.6
Fishery	4	6.3	16	10.2
Government officer	1	1.6	1	0.6
General job	7	11.11	16	10.2
No comment/no answer	0	0	44	28.2
	(N = 63)		(N = 156)	

*More than one choice is allowed.

TABLE G-1

UNDISCOUNTED NET INCOME STREAM OF A RICE THRESHER INVESTMENT (R_t) BY INVESTMENT YEAR

(1978 baht)

Year	CHACHOENGSAO				SUPANBURI	
	Investment Year				Investment Year	
	1975	1976	1977	1978	1977	1978
1975	6,059	-	-	-	-	-
1976	15,579	12,730	-	-	-	-
1977	10,584	20,623	17,691	-	14,408	-
1978	69	12,279	15,924	25,512	25,228	21,749
S_{1978}	19,000	22,500	23,500	24,000	27,000	33,085
C	23,000	23,500	26,500	27,200	28,000	38,520

Note: S_{1978} = Resale value of a thresher and its complements at the and of crop year 1978/79.

C = The investment cost of a thresher and its complements.

TABLE G-2

UNDISCOUNTED NET INCOME STREAM OF A RICE THRESHER
CHACHOENGSAO

(1979 baht)

Year	R11	R12	R13	R14	R31	R32	R33	R34	R51	R52	R53	R54	R78
1979	16287	16212	16137	16062	16434	16359	16284	16209	16582	16507	16432	16357	16275
1980	17750	16983	16795	16593	17509	17336	17149	16946	17922	17749	17562	17359	16275
1981	18027	17730	17378	16968	18666	18368	18016	17606	19534	19236	18885	18474	16275
1982	18904	18447	17860	17121	19930	19473	18886	18147	21557	21099	20513	19773	16275
1983	19785	19127	18209	16960	21335	20677	19758	18509	24196	23537	22619	21370	16275
1984	19940	19029	17649	15622	22192	21281	19901	17874	27030	26120	24739	22712	16275
1985	20100	18874	16855	13655	23287	22063	20044	16844	31257	30032	28013	24813	16275
1986	20264	18647	15754	10804	24697	23080	20187	15237	37575	35958	33065	28115	16275
1987	20434	18333	14249	6707	26513	24411	20328	12785	47032	44931	40848	33305	16275
1988	20609	17910	12215	860	28859	26160	20465	9110	61202	58503	52808	41453	16275
1989	20789	17357	9488	-	31869	28463	20585	3665	82443	79010	71142	54211	16275
1990	20975	16642	5856	-	35835	31501	20715	-	114297	109963	99177	74131	16275
1991	21167	15731	1040	-	40947	35511	20820	-	162074	156693	141948	105136	16275
1992	21364	14583	-	-	47587	40806	20905	-	233743	226962	207061	153253	16275
1993	21567	13145	-	-	56217	47795	20961	-	341255	332833	305999	227715	16275
1994	21777	11357	-	-	67437	57017	20978	-	502540	492120	456081	342644	16275
1995	21993	9144	-	-	82028	69180	20943	-	744492	731644	683406	519604	16275
1996	22215	6418	-	-	101006	85209	20837	-	1107450	1091650	1027280	791472	16275
1997	22444	3070	-	-	125693	106319	20638	-	1651940	1632570	1546880	1208320	16275
1998	22680	-	-	-	157805	134097	20317	-	2468730	2445020	2331240	1846280	16275
Assumptions													constant
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	at 1978
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	values

TABLE G-3

UNDISCOUNTED NET INCOME STREAM OF A RICE THRESHER
SUPANBURI

(1979 baht)

Year	R11	R12	R13	R14	R31	R32	R33	R34	R51	R52	R53	R54	R78
1979	18081	18006	17931	17856	18194	18119	18044	17969	18306	18231	18156	18081	22839
1980	19033	18860	18673	18470	19303	19130	18943	18740	19618	19446	19258	19056	22839
1981	19987	19689	19337	18927	20474	20176	19824	19414	21137	20839	20487	20077	22839
1982	20942	20485	19898	19159	21725	21268	20681	19942	22967	22509	21923	21183	22839
1983	21051	20394	19475	18226	22235	21577	20658	19409	24418	23760	22841	21592	22839
1984	21164	20253	18872	16845	22883	21972	20591	18564	26575	25664	24284	22257	22839
1985	21277	20051	18032	14832	23711	22485	20466	17266	29793	28567	26548	23348	22839
1986	21391	19774	16881	11931	24774	23157	20264	15314	34604	32987	30094	25143	22839
1987	21507	19406	15322	1875	26146	24045	19961	12419	41808	39707	35623	28081	22839
1988	21624	18925	13230	-	27920	25222	19526	8172	52606	49907	44212	32857	22839
1989	21741	18308	10440	-	30218	26785	18917	1987	68798	65365	57497	40566	22839
1990	21859	17525	6739	-	33200	28867	18081	-	93086	88753	77967	52920	22839
1991	21977	16541	1851	-	37073	31638	16948	-	129524	124089	109398	72586	22839
1992	22094	15313	-	-	42109	35328	15427	-	184192	177411	157510	103702	22839
1993	22211	13789	-	-	48657	40235	13402	-	266212	251190	230956	152672	22839
1994	22327	11907	-	-	57177	46758	10718	-	389268	378848	342809	229372	22839
1995	22442	9593	-	-	86263	55413	7178	-	573888	561039	512802	349000	22839
1996	22554	6757	-	-	82690	66894	2522	-	850860	835063	770690	534880	22839
1997	22663	3289	-	-	101466	82094	-	-	1266370	1247000	1161320	822749	22839
1998	22769	-	-	-	125901	102195	-	-	1889710	1866000	1752220	1267260	22839
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	constant
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	at 1978 values

TABLE H-1

DISCOUNTED NET INCOME STREAM OF A RICE THRESHER INVESTMENT BY INVESTMENT YEAR

Year	discount rate	CHACHOENGSAO				SUPANBURI	
		1975	1976	1977	1978	1977	1978
1	12	8512	15969	19814	15512	16137	21749
2		19542	23098	15924	-	25228	-
3		11854	12279	-	-	-	-
4		69	-	-	-	-	-
1	15	9215	16835	20345	15512	16569	21749
2		20603	23716	15924	-	25228	-
3		12172	12279	-	-	-	-
4		69	-	-	-	-	-
1	20	10470	18331	21229	15512	17290	21749
2		22434	24748	15924	-	25228	-
3		12701	12279	-	-	-	-
4		69	-	-	-	-	-
1	25	11834	19891	22114	15512	18010	21749
2		24342	25779	15924	-	25228	-
3		13230	12279	-	-	-	-
4		69	-	-	-	-	-
1	30	13312	21514	22998	15512	18730	21749
2		26329	26810	15924	-	25228	-
3		13759	12279	-	-	-	-
4		69	-	-	-	-	-

TABLE H-2

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, CHACHOENGSAO (DISCOUNT RATE = 12%)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	14544	14477	14410	14343	14676	14609	14540	14475	14805	14738	14671	14604	14531
2	13672	13535	13386	13224	13955	13817	13671	13506	14287	14149	14000	13839	12974
3	12836	12624	12373	12081	13290	12366	12824	12535	13904	13692	13442	13150	11584
4	12023	11732	11359	10889	12676	12385	12002	11541	13699	13409	13036	12566	10343
5	11218	10845	10324	9616	12097	11724	11211	10495	13729	13356	12835	12126	9235
6	10110	9648	8948	7920	11251	10790	10082	9062	13694	13233	12534	11507	8245
7	9085	8531	7619	6172	10526	9972	9067	7613	14139	13585	12672	11224	7362
8	8187	7534	6365	4365	9978	9324	8153	6156	15176	14523	13354	11355	6573
9	7377	6618	5144	2421	9571	8812	7330	4616	16960	16203	14730	12010	5869
10	6636	5767	3933	277	9292	8424	6589	2933	19705	18836	17003	13347	5240
11	5967	4981	2723	-	9154	8169	5918	1052	23700	22714	20451	15584	4679
12	5391	4277	1505	-	9210	8096	5317	-	29337	28225	25456	19027	4177
13	4847	3603	238	-	9377	8132	4771	-	37143	35898	32539	24094	3730
14	4380	2990	-	-	9755	8365	4289	-	47828	46441	42369	31359	3330
15	3947	2406	-	-	10288	8746	3830	-	62346	60807	55905	41603	2973
16	3550	1851	-	-	10992	9294	3422	-	81975	80275	74397	55893	2655
17	3211	1335	-	-	11976	10100	3050	-	108431	106560	99534	75677	2370
18	2888	834	-	-	13131	11077	2710	-	144012	141958	133587	102922	2116
19	2604	356	-	-	14580	12333	2396	-	214818	189552	179603	140294	1890
20	2359	-	-	-	16412	13946	2106	-	255933	253467	241672	191398	1687
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-3

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, CHACHOENGSAO (DISCOUNT RATE = 15%)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	14170	14104	14039	13974	14298	14233	14160	14102	14419	14354	14289	14223	14152
2	12969	12839	12697	12544	13237	13106	12967	12811	13551	13421	13279	13126	12306
3	11862	11666	11435	11165	12282	11428	11846	11585	12844	12648	12417	12147	10701
4	10813	10552	10216	9793	11401	11139	10798	10380	12322	12064	11728	11306	9305
5	9833	9506	9050	8429	10604	10276	9823	9199	12030	11702	11246	10625	8091
6	8614	8221	7624	6749	9587	9194	8604	7721	11686	11292	10695	9819	7036
7	7558	7097	6338	5134	8756	8296	7535	6333	11751	11290	10531	9328	6118
8	6626	6098	5152	3533	8076	7547	6599	4982	12283	11754	10809	9191	5320
9	5803	5207	4047	1905	7530	6933	5778	3631	13370	12772	11611	9467	4626
10	5090	4424	3017	213	7128	6462	5059	2250	15128	14461	13053	10247	4023
11	4470	3732	2040	-	6858	6120	4425	788	17721	16983	15291	11652	3498
12	3922	3112	1095	-	6701	5891	3872	-	21363	20553	18537	13856	3042
13	3450	2564	170	-	6674	5788	3384	-	26342	25458	23071	17088	2645
14	3012	2056	-	-	6710	5754	2954	-	33036	32076	29264	21659	2300
15	2653	1617	-	-	6915	5879	2576	-	41938	40903	37606	27985	2000
16	2330	1215	-	-	7216	6101	2242	-	53704	52590	48739	36617	1739
17	2045	850	-	-	7629	6434	1946	-	69183	67989	63506	48285	1512
18	1799	520	-	-	8182	6902	1684	-	89488	88211	83009	63955	1315
19	1571	215	-	-	8799	7442	1450	-	116074	114713	108692	84903	1144
20	1383	-	-	-	9626	8180	1241	-	150840	149391	142439	112808	994
Assumptions													constant
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	at 1978
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	values

TABLE H-4

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, CHACHOENGSAO (DISCOUNT RATE = 20%)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	13567	13505	13442	13380	13690	13627	13570	13502	13818	13756	13693	13631	13562
2	11906	11786	11656	11515	12151	12031	11909	11761	12446	12326	12196	12055	11302
3	10438	10265	10062	9824	10807	10635	10426	10194	11304	11132	10929	10691	9418
4	9112	8892	8609	8252	9606	9386	9108	8747	10396	10175	9892	9536	7849
5	7954	7689	7320	6818	8577	8312	7940	7441	9724	9459	9090	8588	6541
6	6680	6375	5912	5233	7434	7129	6665	5988	9052	8747	8285	7606	5450
7	5608	5266	4703	3810	6498	6155	5594	4700	8723	8381	7818	6925	4542
8	4722	4345	3671	2517	5754	5378	4695	3550	8739	8363	7690	6539	3785
9	3964	3557	2764	1301	5143	4736	3940	1476	9115	8708	7917	6455	3154
10	3339	2902	1979	139	4675	4238	3305	495	9884	9449	8529	6695	2629
11	2807	2343	1281	-	4306	3803	2770	-	11096	10634	9575	7296	2190
12	2349	1864	656	-	4014	3528	2323	-	12819	12333	11123	8314	1825
13	1968	1463	97	-	3803	3303	1946	-	15148	14640	13267	9826	1521
14	1666	1137	-	-	4426	3183	1628	-	18205	17677	16127	11936	1268
15	1402	854	-	-	4385	3107	1360	-	22149	21603	19861	14780	1056
16	1176	613	-	-	3642	3079	1135	-	27181	26618	24668	18533	880
17	990	412	-	-	3691	3113	944	-	33557	32978	30803	23420	734
18	844	244	-	-	3838	3238	783	-	41597	41004	38586	29729	611
19	696	95	-	-	3897	3296	646	-	51707	51101	48419	37821	509
20	590	-	-	-	4103	3487	530	-	64394	63776	60808	48158	425
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-5

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, CHACHOENGSAO (DISCOUNT RATE = 25 %)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	13030	12970	12910	12850	13148	13088	13028	12968	13265	13205	13145	13085	13020
2	10979	10869	10749	10619	11206	11095	10975	10846	11470	11359	11239	11110	10416
3	9230	9078	8898	8687	9557	9404	9224	9014	10001	9849	9669	9459	8333
4	7751	7563	7323	7020	8171	7984	7736	7440	8830	8642	8402	8099	6666
5	6490	6274	5972	5563	6998	6782	6474	6071	7928	7713	7412	7003	5333
6	5224	4986	4624	4093	5814	5576	5217	4683	7086	6847	6485	5954	4266
7	4221	3964	3540	2294	4891	4633	4204	3537	6555	6298	5875	5204	3413
8	3404	3133	2647	1851	4149	3877	3387	2560	6304	6033	5547	4717	2730
9	2738	2457	1909	899	3553	3271	2728	1713	6313	6031	5482	4470	2184
10	2205	1916	1307	92	3088	2799	2197	975	6571	6282	5670	4451	1748
11	1788	1493	816	-	2743	2448	1768	290	7082	6787	6111	4657	1398
12	1447	1148	404	-	2473	2174	1424	-	7854	7557	6815	5094	1118
13	1164	865	58	-	2252	1953	1145	-	8910	8611	7804	5780	895
14	940	642	-	-	2094	1795	919	-	10280	9982	9107	6740	716
15	755	460	-	-	1968	1637	738	-	12007	11711	10766	8012	573
16	610	318	-	-	1888	1597	590	-	14145	13852	12838	9645	458
17	506	210	-	-	1887	1591	472	-	16764	16475	15389	11700	366
18	400	156	-	-	1818	1534	375	-	19950	19665	18506	14258	293
19	314	43	-	-	1760	1489	297	-	23807	23528	22293	17414	235
20	272	-	-	-	1894	1609	234	-	28463	28189	26877	21286	188
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-6

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, CHACHOENGSAO (DISCOUNT RATE = 30%)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	12525	12467	12409	12352	12368	12580	12527	12465	12755	12698	12640	12582	12519
2	10156	10054	9943	9823	10365	10263	10147	10032	10605	10502	10392	10272	9630
3	8202	8067	7907	7720	8493	8357	8200	8011	8891	8756	8596	8409	7408
4	6616	6457	6251	5992	6976	6816	6613	6351	7548	7388	7525	6923	5698
5	5322	5145	4898	4562	5739	5562	5322	4979	6517	6339	6029	5756	4383
6	4128	3939	3653	3234	4594	4405	4123	3700	5600	5411	5125	4705	3372
7	3196	3001	2680	2171	3703	3508	3194	2678	4981	4786	4464	3954	2594
8	2493	2294	1938	1329	3038	2839	2475	1874	4606	4408	4053	3447	1995
9	1921	1723	1339	630	2492	2295	1917	1202	4435	4237	3852	3141	1535
10	1540	1308	892	63	2107	1910	1485	665	4439	4244	3831	3007	1181
11	1164	972	531	-	1786	1594	1149	205	4650	4408	3970	3025	908
12	902	716	252	-	1541	1355	889	-	4906	4720	4257	3182	699
13	698	519	34	-	1351	1172	687	-	5351	5172	4687	3471	537
14	534	365	-	-	1190	1020	531	-	5937	5764	5259	3892	413
15	431	263	-	-	1124	956	410	-	6667	6502	5987	4449	318
16	327	170	-	-	1012	855	315	-	7552	7396	6854	5149	245
17	264	110	-	-	984	830	242	-	8606	8458	7900	6007	188
18	200	58	-	-	909	767	185	-	9848	9707	9135	7038	145
19	157	22	-	-	880	744	141	-	11300	11167	10581	8256	112
20	113	-	-	-	789	671	107	-	12990	12865	12267	9715	86
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-7

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, SUPANBURI (DISCOUNT RATE = 12%)

(1979 baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	16141	16077	16010	15943	16245	16177	16110	16043	16345	16278	16211	16144	20392
2	15173	15035	14886	14724	15388	15251	15101	14940	15639	15502	15352	15191	18207
3	14226	14014	13764	13472	14573	14361	14110	13816	15045	14833	14582	14290	16256
4	13309	12564	12646	12176	13807	13516	13143	12674	14596	13806	13932	13463	14515
5	11945	11572	11051	10342	12617	12243	11722	11013	13856	13482	12961	12252	12959
6	10722	10261	9561	8534	11593	11132	10432	9405	13464	13002	12303	11276	11571
7	9625	9070	8157	6709	10726	10171	9258	7810	13478	12922	12009	10562	10331
8	8640	7986	6818	4818	10006	9353	8184	6185	13976	13323	12154	10155	9224
9	7756	6998	5525	676	9429	8371	7198	2631	15076	14319	12846	10126	8236
10	6962	6093	4260	-	8989	8121	6287	571	16937	16069	14235	10579	7353
11	6250	5263	3001	-	8687	7700	5387	-	19778	18791	16529	11662	6566
12	5610	4498	1730	-	8521	7409	4640	-	23892	22780	20012	13538	5862
13	5036	3791	424	-	8496	7250	3884	-	29683	28436	25071	16635	5234
14	4521	3133	-	-	8616	7229	3157	-	37689	36302	32230	21220	4673
15	4058	2519	-	-	8890	7351	2449	-	48637	47098	42196	27893	4173
16	3642	1942	-	-	9327	7629	1748	-	63497	61798	55919	37415	3726
17	3268	1397	-	-	9942	8071	1045	-	83581	81710	74685	50828	3326
18	2933	879	-	-	10753	8699	328	-	110646	108592	100221	69556	2970
19	2631	328	-	-	11781	9532	-	-	147038	144789	134841	95529	2652
20	2360	-	-	-	13052	10595	-	-	195906	193448	181653	131377	2368
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-8

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, SUPANBURI (DISCOUNT RATE = 15%)

(1979 baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	15723	15658	15592	15527	15821	15755	15690	15625	15918	15861	15796	15731	19860
2	14392	14261	14119	13966	14596	14465	14324	14170	14834	14701	14559	14406	17270
3	13142	12946	12715	12445	13640	13266	13035	12765	13898	13712	13480	13211	15017
4	11974	11712	11377	10954	12421	12160	11824	11402	13131	13326	12540	12117	13058
5	10466	10139	9683	9062	11055	10727	10271	9650	12140	11809	11352	10731	11355
6	9150	8756	8159	7283	9893	9499	8902	8026	11489	11087	10491	9615	9874
7	7999	7538	6779	5576	8914	8453	7694	6491	11200	10741	9982	8779	8586
8	6993	6462	5519	3900	8099	7570	6624	5006	11312	10787	9841	8222	7466
9	6114	5516	4356	533	7432	6835	5674	3530	11874	11277	10117	7995	6492
10	5345	4678	3270	-	6901	6234	4826	2020	12994	12327	10920	6936	5645
11	4673	3935	2244	-	6495	5757	4066	427	14792	14053	12362	8722	4909
12	4086	3276	1260	-	6205	5396	3379	-	17407	16597	14580	9896	4269
13	3572	2689	301	-	6026	5142	2755	-	21112	20227	12709	11832	3712
14	3123	2164	-	-	5951	4993	2180	-	25971	25015	22209	14622	3228
15	2730	1695	-	-	5979	4946	1647	-	32744	31708	28408	18779	2807
16	2386	1272	-	-	6110	4997	1145	-	41652	40537	36681	24543	2441
17	2086	892	-	-	6344	5150	667	-	53372	52177	47691	32457	2122
18	1822	546	-	-	6681	5405	203	-	68920	67640	62426	43325	1845
19	1592	231	-	-	7129	5768	-	-	88975	87290	81292	57592	1605
20	1391	-	-	-	7693	6244	-	-	115461	113826	106885	77303	1395
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-9

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, SUPANBURI \DISCOUNT RATE = 20%)

(1979 baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	15068	15005	14943	14880	15162	15098	15036	14974	15249	15187	15124	15062	19023
2	13217	13097	12967	12827	13405	13285	13155	13014	13615	13495	13365	13225	15860
3	11566	11394	11190	10953	11848	11676	11472	11235	12238	12066	11862	11625	13217
4	10099	9879	9596	9239	10477	10257	9974	9617	11070	10850	10567	10210	11014
5	8460	8196	7827	7325	8936	8671	8302	7800	9816	9551	9182	8680	9178
6	7088	6783	6320	5641	7663	7358	6896	6217	8903	8598	8135	7456	7649
7	5938	5596	5032	4139	6617	6275	5712	4819	8312	7970	7407	6514	6374
8	4975	4599	3926	2775	5762	5386	4713	3562	8063	7686	7012	5858	5312
9	4168	3761	2970	363	5067	4660	3869	2407	8111	7703	6911	5448	4426
10	3492	3057	2137	-	4509	4074	3154	1320	8522	8085	7162	5323	3689
11	2926	2464	1405	-	4067	3605	2546	267	9288	8824	7762	5477	3074
12	2452	1966	756	-	3724	3238	2028	-	10426	9940	8732	5927	2562
13	2054	1546	173	-	3465	2957	1584	-	12046	11540	10174	6751	2135
14	1721	1193	-	-	3280	2752	1202	-	14367	13838	12286	8089	1779
15	1442	895	-	-	3150	2612	870	-	17304	16756	15012	9924	1482
16	1208	644	-	-	3093	2529	580	-	21021	20458	18512	12386	1235
17	1011	432	-	-	3077	2498	324	-	25825	25247	23076	15705	1029
18	847	254	-	-	3106	2512	95	-	32333	31732	29286	20325	858
19	709	103	-	-	3176	2570	-	-	39258	38657	36001	25505	715
20	594	-	-	-	3284	2665	-	-	49133	48516	45558	32949	596
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA} (%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-10

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTIONS, SUPANBURI (DISCOUNT RATE = 25%)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	14465	14405	14345	14285	14555	14495	14435	14375	14645	14585	14525	14465	18271
2	12181	12071	11951	11821	12354	12244	12124	11994	12556	12445	12325	12196	14617
3	10233	10081	9901	9691	10483	10330	10150	9940	10822	10670	10489	10279	11694
4	8578	8391	8150	7848	8899	8711	8471	8168	9416	9229	8988	8685	9355
5	6898	6683	6382	5972	7286	7070	6769	6360	8009	7793	7492	7082	7484
6	5548	5309	4758	4247	5770	5640	5192	4681	6963	6724	6362	5831	5987
7	4462	4205	3782	3111	4973	4716	4292	3590	6257	5999	5575	4903	4790
8	3589	3318	2832	2002	4156	3885	3400	2569	5813	5542	5056	4224	3832
9	2887	2605	2057	252	3509	3227	2679	1667	5602	5321	4774	3763	3065
10	2144	2032	1421	-	2998	2708	2097	877	5629	5340	4731	3516	2452
11	1868	1573	897	-	2596	2301	1625	171	5917	5621	4945	3489	1962
12	1502	1204	463	-	2282	1984	1243	-	6423	6124	5380	3652	1569
13	1208	909	102	-	2038	1740	932	-	7124	6825	6017	3992	1256
14	972	673	-	-	1852	1554	679	-	8104	7806	6930	4563	1004
15	781	485	-	-	1519	1416	472	-	9317	9023	8084	5344	804
16	629	335	-	-	1610	1316	266	-	10900	10608	9599	6422	643
17	505	216	-	-	1537	1248	162	-	13199	12904	11794	8027	514
18	406	122	-	-	1489	1205	45	-	15316	15031	13872	9628	411
19	327	47	-	-	1462	1183	-	-	17729	17458	16259	11519	329
20	263	-	-	-	1452	1178	-	-	22677	22392	21027	15207	263
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

TABLE H-11

DISCOUNTED NET INCOME STREAM BASED ON VARIOUS SETS OF ASSUMPTION, SUPANBURI (DISCOUNT RATE = 30%)

(1979 Baht)

Year	PV11	PV12	PV13	PV14	PV31	PV32	PV33	PV34	PV51	PV52	PV53	PV54	PV78
1	13909	13851	13793	13736	13995	13937	13880	13822	14077	14020	13962	13904	17568
2	11262	11160	11049	10929	11422	11320	11209	11089	11614	11512	11401	11281	13514
3	9097	8962	8802	8615	9319	9184	9023	8012	9617	9184	9322	9135	10396
4	7333	7172	6967	6708	7607	7447	7241	6982	8038	7878	7673	7414	7997
5	5670	5493	5245	4904	5986	5811	5564	5228	6569	6391	6144	5808	6154
6	4385	4196	3910	3490	4741	4552	4266	3846	5501	5312	5027	4607	4732
7	3391	3196	2874	2364	3779	3583	3262	2752	4737	4542	4221	3712	3640
8	2622	2424	2069	1463	3037	2839	2484	1877	4256	4057	3702	3093	2800
9	2028	1830	1445	177	2466	2267	1882	1171	3930	3732	3349	2640	2154
10	1569	1373	960	-	2025	1830	1416	593	3840	3643	3228	2399	1657
11	1213	1022	583	-	1686	1495	1056	111	3853	3660	3220	2272	1274
12	938	752	289	-	1425	1239	776	-	4003	3816	3353	2276	980
13	726	546	61	-	1224	1045	560	-	4274	4095	3610	2395	754
14	561	389	-	-	1070	897	392	-	4605	4435	3938	2593	580
15	434	269	-	-	951	786	262	-	5324	5156	4619	3053	446
16	336	179	-	-	859	703	161	-	5839	5683	5142	3441	343
17	259	111	-	-	789	641	83	-	6887	6732	6154	4188	264
18	201	60	-	-	735	595	22	-	7658	7516	6936	4814	203
19	155	23	-	-	649	562	-	-	8865	8729	8129	5759	156
20	120	-	-	-	662	538	-	-	9449	9330	8761	6166	120
Assumptions													
g_F (%)	10	10	10	10	30	30	30	30	50	50	50	50	Constant at 1978 values
g_{MA}(%)	10	20	30	40	10	20	30	40	10	20	30	40	

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