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VII Thailand

Rapid Growth Driven by Export Markets

Thailand has developed the premier agricultural export economy in the tropics at least in terms of its exports of carbohydrate sources This export orientation dates to the 1850's when the signing of the Bowing treaty removed a ban by the Thai king on exports of rice The market stimulus to a subsistence economy with surplus land resources was immediate and rice exports became the driving force in the Thai agricultural economy upto the Second World War The beginning of the post-war period marked the diversification of the Thai agricultural economy into upland crops again almost entirely directed to export markets Development of the upland sector has been the principal growth element in the Thai agricultural economy in the post-war period and has been based on expansion in maize kenaf cassava and sugar cane

The upland sector in the post-war period has gone through a series of commodity booms These were based on area expansion within a land and labor surplus agricultural economy i e the limited size of domestic markets or the lack of export infrastructure was the most binding constraint on agricultural production The success of these booms resulted in a relative shortage of labor in the 1970's inducing the development of a market for tractor-hire services The motor of this growth process thus was the opening of market channels for export and relative price incentives in these markets However this growth process also reflected the vagaries of world market demand as is epitomized by the rise and collapse of the kenaf industry

Cassava is the most recent of Thailand's commodity booms which is not to say that cassava is a recently introduced crop The exact date of introduction to Thailand is not known but cassava was apparently being grown as a food crop in the 18th century However unlike countries such as Indonesia and the Philippines Thailand was always able to meet its starchy staple requirements solely through rice Cassava thus never became more than a speciality food in the country The genesis for growth in the crop has always been non-food markets almost solely directed to export The initial development of such a market was in the 1930 s when cassava pearl was produced in the South for export through Malaysia (Scheltema 1938) [1/]

The Thai cassava industry was based on the starch export market up to about 1960 World War II briefly curtailed this market in Southeast Asia in the late 1940 s but following the war modern processing machinery was introduced into Chonburi in the eastern region A healthy starch industry was operating in this region by the mid-1950's supplanting the starch industry in Indonesia and in the south of Thailand However it was starch wastes that became the basis for the real expansion in the crop when a

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1/ Thai export statistics for cassava do not start until 1950 and the only suggestion of such an industry is Malaysian import statistics

West German importer in 1956 introduced cassava waste as an animal feed to Germany (Phillips 1974 Titapitnatanakun 1979) Low freight rates in this period its lack of alternative uses and high feedgrain prices in Germany made cassava waste particularly price competitive in Europe Since cassava waste was a by-product of starch manufacture shortages resulted and led to the importation of cassava meal starting in 1960 With the introduction of the Common Agricultural Policy in 1962 and the favorable tariff binding on cassava in the 1968 GATT negotiations the Thai cassava industry shifted to animal feed as its principal market Cassava chips became the dominant export in 1964 native pellets in 1969 and hard pellets in 1983 With this external stimulus Thailand went from a relatively minor producer of cassava in the 1950 s to the second largest (if not the largest) producer of cassava in the world

Production Trends

Production of cassava has increased from around 400 thousand tons in the mid-1950 s to almost 20 million tons in 1984/85 (Table 7 1) This represents a sustained growth rate of 16% per annum for over 25 years These sharp increases in production have been based exclusively on expansion in area planted and have been concentrated in a relatively limited number of regions within the country Production has continued to expand in the old starch producing region of Chonburi and Rayong However the bulk of cassava production has shifted from this zone to the Northeast Whereas the Northeast made up less than 10% of the total up to 1969 by 1979 the Northeast was producing over 60% of total cassava This represented a shift to relatively drier production conditions and a movement from the red-yellow podzolic soils to the more acidic latosols Cassava in part displaced kenaf in the Northeast and in part was planted on newly cleared forest areas

Cassava has grown from a relatively minor crop in the 1950 s to be the second most important crop after rice in terms of production volume (as measured on a dry weight basis) and in terms of foreign exchange earned As in previous commodity booms rapid production increases have been based on area expansion led by demand in international markets Capacity and growth in domestic markets would never have sustained the growth rates that have occured in cassava and the other major agricultural commodities To understand the cassava industry in Thailand the analysis first reviews the factors on the production side that formed the basis for such high growth rates and then turns to an analysis of the demand side which must necessarily consider the changing nature of international cassava markets

Cassava Production Systems

Agricultural development in Thailand has been based on exploitation of an agricultural frontier and reliance on international markets as a surplus vent Unlike Malaysia access to new land has been relatively uncontrolled although a ceiling on the size of land holdings fomerly in the public domain was set at 8 ha in 1936 With the expansion in international markets following World War II planted area expanded rapidly in many cases at the expense of forest lands A satellite census showed that forest land had been reduced from 57% of total land in 1961 to 37% in 1974 a loss of 10 million hectares in 13 years (Bertrand 1980)

Whereas the pre-war expansion was based principally on rice for which there was already a large production base diversification into upland crops has been the hallmark of post-war agricultural growth Crops such as maize sugarcane mung bean kenaf and cassava have expanded rapidly from relatively small production bases The final component of this extensive growth pattern was relatively rapid mechanization of the agricultural sector based on either animal or mechanical equipment Thus in 1963 68% of farms were using animal traction and 14% were using mechanical power or some combination of animals and tractors By 1978 33% of farmers were utilizing tractors

Cassava production systems therefore must be understood essentially in the context of rapid expansion of previously uncultivated land Certainly in the Northeast there was some substitution for kenaf whose area by 1981 had declined by about 330 thousand hectares from its peak in 1967 However cassava area in the Northeast increased by over 780 thousand hectares in the same period at the same time as maize production also expanded quite dramatically Given cassava s adaptation to the drier growing conditions of the Northeast and the profit levels as maintained by EC grain prices the crop expanded rapidly principally by opening up new land The process obviously introduces a dynamic element into characterizing cassava production systems especially in terms of adaptation of management practices as farmers learn the responsiveness of a new crop and the effects of continuous cassava cultivation on soil fertility

Using the agricultural census of 1963 and 1978 as reference points cassava expansion was based on a sizeable increase in the number of cassava growing farms (from 58 to 450 thousand) and in an increase in the average size of cassava plantings per farm from 1 4 to 2 1 ha In 1978 21/ of the farmers in the Northeast grew cassava and in most instances probably depended on cassava as their principal source of income By 1978 the modal farm size stratum for cassava farmers was between 3 2 and 6 4 ha (Table 7 2) This is large by overall Asian standards but still relatively small given the agro-climatic potential of most growing areas Moreover such a farm size has supported a market for tractor hire services but not actual tractor ownership The adoption of tractor hire services has in turn released grazing land formerly needed to support draft animals for cultivation

Given the very dynamic nature of the upland sector especially in the Northeast the degree of competition between cassava and other upland crops is difficult to define If crop area data are disaggregated by agroeconomic zone (Table 7 3) certain hypotheses at least emerge In the old cassava growing area of Chonburi and Rayong (agroeconomic zone 15) cassava made up 40% of total farm area with the only other upland crop being sugarcane Cassava dominates this zone so thoroughly that it appears blanketed by monoculture cassava In the Northeast the situation is more diverse In agroeconomic zones 1 and 5 cassava potentially competes with maize and kenaf In agroeconomic zone 3 cassava competes only with kenaf In none of these latter zones does cassava dominate the agricultural economy Moreover only in agroeconomic zone 5 do maize and cassava production areas really overlap In the two largest maize producing zones only very little cassava is produced In general in the Northeast there is

TABLE 7 1 Thailand Cassava Area Production and Yields 1956-85

Crop Year	Area (000 ha)	Production (000 t)	Yield (t/ha)
1956-57	39 2	396 0	10 1
1957-58	38 4	418 0	10 9
1958-59	44 1	487 0	11 0
1959-60	62 5	1 083 2	17 3
1960-61	71 5	1 222 3	17 1
1961-62	99 3	1 726 2	17 4
1962-63	122 7	2 076 9	16 9
1963-64	140 0	2 111 1	15 1
1964-65	104 9	1 556 7	14 8
1965-66	102 0	1 474 7	14 5
1966-67	130 3	1 891 7	14 5
1967-68	140 9	2 062 8	14 6
1968-69	170 6	2 611 5	15 3
1969-70	189	3 079	16 3
1970-71	224	3 431	15 3
1971-72	220	3 114	14 2
1972-73	328	3 974	12 1
1973-74	415	5 443	13 1
1974-75	497	6 765	13 1
1975-76	475	7 094	13 6
1976-77	692 4	10 230 0	14 8
1977-78	846 8	11 839 7	14 0
1978-79	1 165 0	16 357 8	14 0
1979-80	845 8	11 101 0	13 1
1980-81	1 159 9	16 540 0	14 3
1981-82[a]	1 243 1	17 744 0	14 3
1982-83	1 087 2	17 787 9	16 4
1983-84	1 017 8	18 988 5	18 7
1984-85	1 335 1	19 985 3	15 0

[a] Starting 1981-82 area figures changed from planted to harvested area this caused an artificial rise in yield figures

Source Center for Agricultural Statistics Office of Agricultural Economics Ministry of Agriculture and Cooperatives

TABLE 7 2 Thailand Distribution of Area Planted to Cassava by Farm Size 1978

Farm Size Strata (ha)	Cassava Farmers		Cassava Area	
	Number	Percent	Hectares	Percent
Less than 32	115	0 3	19	-
3 - 1 0	26 213	5 8	13 429	1 4
1 0 - 1 6	29 770	6 6	21 721	2 3
1 6 - 3 2	103 824	23 1	112 212	11 9
3 2 - 6 4	167 328	37 2	297 336	31 7
6 4 - 9 6	69 799	15 5	192 920	20 5
9 6 - 22 4	48 523	10 8	222 699	23 7
More than 22 4	4 759	1 0	78 732	8 4
Total	450 331	100 0	939 069	100 0

Source National Statistical Office 1978 Agricultural Census Report Thailand Bangkok

TABLE 7 3 Thailand The Relative Importance of Area Planted to Maize and Cassava by Agroeconomic Zone 1974-78

Agroeconomic Zone	Cassava			Maize		
	Area (000 ha)	Percent of Total Farm Area	Percent of Cassava Area	Area (000 ha)	Percent of Total Farm Area	Percent of Maize Area
Northeast						
1	57 3	3 1	7 7	106 1	5 7	8 4
2	8 2	0 8	1 1	3 8	0 4	0 3
3	107 5	5 7	14 4	3 4	0 2	0 3
4	53 4	3 5	7 1	31 0	2 0	2 4
5	180 6	12 7	24 1	192 0	13 5	15 1
North						
6	5 4	0 4	0 7	434 6	34 6	34 2
8	12 2	1 1	1 6	107 2	9 4	8 4
9	1 1	0 2	0 1	62 6	8 4	4 0
10	1 6	0 2	0 2	26 4	4 0	2 1
Central Plain						
7	3 8	0 6	0 5	259 5	38 7	20 4
11	12 8	0 8	1 7	10 7	0 7	0 8
12	19 4	2 6	2 6	13 4	1 8	1 0
13	73 4	16 0	9 8	7 0	1 0	0 6
14	-	-	-	-	-	-
15	176 0	39 6	23 6	-	-	-
16	28 2	12 6	3 8	5 8	2 6	0 5
South						
17	3 7	0 3	0 5	6 1	0 4	0 5
18	2 6	0 6	0 3	-	-	-
19	1 4	0 5	0 2	-	-	-
Total	748 6	6 1	100 0	1269 6	7 0	100 0

Source Pongsrihadulchai Apichart Supply Analysis of Important Crops in Thailand 1981

still significant scope for expansion of cassava area if not at the expense of other crops then in terms of currently under-utilized land already in farms or in the public domain

The rainfall pattern in the Northeast and Central Plain is unimodal with a dry season from November to April and a wet season of varying intensity for the rest of the year as reflected in average annual rainfall for different sites from the Northeast to the South ranging from 900 to 3000 mm Moreover moving to the Northeast rainfall becomes more variable and uncertain Since most of the cassava is solar dried this rainfall pattern creates a trade-off between optimum drying period and optimum planting period The drying season starts in November and farmers rarely leave the cassava in the ground for longer than 12 months though it could be left much longer Where rainfall is more secure that is the Rayong and Chonburi area farmers plant in the dry season as well as the wet season Further to the northeast farmers tend to plant exclusively in the March to June period that is at the beginning of the rainy season (Figure 7 1) Experimental trails have shown that planting at the beginning of the rains gives significantly higher yields (Sinthuprama 1980)

Given a eight-to-twelve month growth cycle planting in the November-December period and harvesting in the same period coincide better with market demand Prices are at their seasonal high in the September-November period before declining to their seasonal low in March-April Also root starch content is much higher at the beginning of the dry season resulting in a further price premium There is greater demand for roots at this period because of the significant increase in through-put and thereby lower costs in the chipping plants due to shorter drying periods There is thus a significant increase in root sales in the dry season (Table 7 4) although harvest occurs throughout the year

Cassava production systems in and of themselves are relatively simple The land is prepared either by animal traction or by tractor hire services with the latter being increasingly common The cassava is planted either horizontally (sandy soils) or vertically (loamy soils) depending on the potential drought risk of the soil Planting material comes from recently harvested plants keeping stake storage time to a minimum Cassava is grown in a very strict monoculture system in that no other crop species are interplanted and a single variety tends to dominate throughout Thailand Rayong 1 In weeding hand labor is employed with some animal interrow cultivation Nevertheless in the these activities labor use is kept to the minimum necessary to adequately maintain the crop

The most critical issue in the rapid expansion of cassava production and the resultant extensive production systems is the maintenance of soil fertility In general fertilizer application is low in Thailand when compared to other Asian countries Fertilizer prices are not consistently subsidized in Thailand [2/] and are generally applied to those crops in which marginal returns are highest Of the major crops sugarcane has the

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2/ There are some programs which provide a credit subsidy for the purchase of fertilizer These programs are primarily oriented to rice

TABLE 7 4 Thailand Percentage Distribution of Monthly Farmer Sales of Cassava Roots during the Crop year 1973 and 1984

	North		Northeast		Central		Thailand	
	1973	1984	1973	1984	1973	1984	1973	1984
Oct	-	0 4	7 9	12 4	9 0	6 4	8 1	10 2
Nov	-	-	4 3	8 4	7 4	16 1	5 8	9 6
Dec	-	-	2 7	8 1	12 9	12 2	7 9	8 5
Jan	-	4 6	5 7	15 2	3 9	15 5	4 5	14 5
Feb	-	44 1	19 8	24 1	7 9	27 3	12 8	26 2
Mar	-	47 0	14 9	17 0	20 4	13 5	17 1	18 4
April	-	1 8	14 5	4 2	8 0	6 0	9 2	4 4
May	-	2 0	5 5	1 8	5 2	1 5	5 1	1 7
June	-	-	9 9	0 4	6 7	0 4	7 8	0 4
July	-	-	7 5	3 6	5 0	0 3	8 7	2 6
Aug	-	-	5 4	4 1	6 1	0 1	6 8	3 0
Sept	-	-	4 8	0 7	7 6	0 9	6 1	0 6

Source Center for Agricultural Statistics Office of Agricultural Economcis Ministry of Agriculture and Cooperatives Bangkok

highest application rate followed by rice According to the 1978 census rice consumes fully two-thirds of fertilizer availabilities Sugarcane vegetable and tree crops consume an additional quarter leaving less than 10% or less than 70 thousand tons available for all other major field crops

Fertilizer application on cassava is low In 1973/74 average fertilizer application per cultivated hectare of cassava was only 6 9 kg/ha (Koomsup 1980) On that area where fertilizer was actually applied (16% of cultivated area) rates were 43 kg/ha Recommended application rates are about 15 times this level By 1980/81 average application rates remained at the same level (Table 7 5) As would be expected fertilizer application is much higher in the old production zones around Chonburi and Rayong while in many areas of the Northeast fertilizer use on cassava is non-existent The very low fertilizer use in cassava raises two critical issues First has continuous cassava cultivation with only minimal levels of fertilizer use resulted in a declining yield trend? Second what would be the yield gains were fertilizer application to increase? To answer partially these issues the analysis turns to an evaluation of cassava yields

Yields

Average cassava yield levels of 13 to 14 t/ha in Thailand are high even by Asian standards Only India and Malaysia consistently have higher yields than Thailand Moreover Thailand has been able to maintain this level of productivity through the period of rapid expansion in the crop The national statistics suggest that yields have declined somewhat since 1960 In the early sixties average yields were around 17 t/ha and declined quite rapidly to 14 t/ha by the late sixties Yields have remained at about this level ever since having fallen below 13 t/ha only once These relatively high yields have been a significant part of Thailand s dominance of the international trade in cassava

The difference in agro-climatic conditions between the Northeast and the Central Plain is only partially reflected in yield differences The older production regions on average maintain a one-to-two ton yield advantage over production areas in the Northeast However yields have shown something of a rising trend in the Northeast especially if extended back to 1960 Yield trends in the Central Plain on the other hand initially declined in the 1960's and over the past half decade have been remarkably stable at around 15 t/ha Yield levels as expressed in the aggregate production statistics thus present a picture of relative stability and give no indication of progressive soil exhaustion

The micro-level data are only suggestive of the factors underlying the dynamics of cassava productivity To start with average yields of cassava mask a very wide yield dispersion The yield distribution is skewed with the largest segment of farmers producing quite normal yields by world standards of from zero to nine t/ha and with a very extended right-hand side where some farmers produce over 19 t/ha (Table 7 6) The second set of data is long-term fertility studies (Figure 7 2) These data show the expected decline in yields with continuous cropping after opening up new land However the decline is gradual and in one site yields only declined

TABLE 7 5 Thailand Average Fertilizer Application Rates on Total Cultivated Area 1980-81

Agroeconomic Zone	Application Rate [b] (kg/ha)
Northeast	
1	-
2	2 2
3	1 7
4	1 9
5	-
Central Plain	
7	0 7
11	0 6
12	4 4
13	- [a]
15	3 7 [a]
16	-

[a] The survey shows quite high average application rates for organic fertilizers

[b] Fertilizer expenditures by farmers were divided by an average fertilizer price of Baht 5 1/kg

Source Survey of Cassava Production Costs and Returns 1980-81 Office of Agricultural Economics Ministry of Agriculture and Coooperatives 1982

TABLE 7 6 Thailand Distribution of Cassava Yields 1974-75

Yield Level (t/ha)	Percent of Farmers		
	Chonburi Rayong Nakhonrachsima	Other Changwats	Thailand
0 to 9 4	35 7	31 1	33 2
9 4 to 12 5	20 6	23 1	21 9
12 5 to 15 6	21 4	14 0	17 4
15 6 to 18 8	10 1	17 8	14 3
More than 18 8	12 2	14 0	13 2

Source Phillips Truman A Profile of Thai Cassava Production Practices 1977

from around 30 t/ha to 20 t/ha in a sixteen year period One thorough study found that from an initial yield of 20 to 30 t/ha yields decrease by half within 9 to 20 years (Interim Committee for Coordination of Investigations in the Lower Mekong Basin 1979) With such rapid opening of new land as has occurred in the case of cassava the yield decline in older plots has been offset by the higher yields of new production areas As yield in older plots fall cassava supply becomes more sensitive to price changes particularly since more than half the farmers operate at below average yields

Mining of soil fertility has a longer-term social cost of enhanced erosion potential and a permanent decline in the productivity of the land resource This therefore puts prime importance on motivating increased application of organic and inorganic fertilizers as apparently already is happening in the Chonburi and Rayong area Two factors however complicate increased use of fertilizer on cassava First in most areas cassava must compete with either rice or sugarcane for capital resources for fertilizer Second cassava responsiveness to fertilizer application is not as certain as in these other two crops There is often no response in the first two to three years after opening up new land (Table 7 7) After that while responses can be shown they cannot be demonstrated consistently (Table 7 8)

What remains extraordinary in Thailand is the high yields that farmers achieve in even depleted soils Suttibursaya and Kummarohita (1978) report cassava being grown continuously for 25 years without fertilization and yet yields have declined to only 16-17 t/ha A fertility restoration experiment selected four farmers fields which had been continously cultivated for 15 years and the average yield of the check plots was 21 t/ha (Interim Committee for Coordination of Investigations in the Lower Mekong Basin 1979) This suggests that the dominant variety Rayong 1 is very efficient in the utilization of limited soil nutrients Moreover thirty years of experimental work both on the experiment station and in farmers fields suggest that 30 t/ha is an achievable target with an appropriate fertilizer regime

The results have made fertility management the principal research thrust in cassava in Thailand What is the advantage of a large investment in breeding if 30 t/ha is imminently achievable with the current variety? However defining a recommendation that gives a consistently profitable response has eluded researchers and inhibited adoption of fertilizer use in cassava Indeed farmers in Thailand utilize fertilizer they however do not apply it to their cassava Until the profitability of fertilizer response can be significantly increased probably by linking application rates to other environmental variables no effective extension program for fertilization of cassava will be successful except possibly in the very badly degraded soils such as now exist in Chonburi and Rayong

Thus the relatively high prices for cassava products obtained in the European Community was only part of the profit engine that resulted in the rapid expansion in cassava area The other component was the very high initial yields obtained by new adopters of cassava cultivation Initial yields in the 25 to 30 t/ha range provided a powerful stimulus to expand cassava area and lack of a viable crop alternative kept farmers in cassava However this raises the question of the longer term viability of cassava

TABLE 7 7 Thailand Cassava Yields in Long-term Fertilizer Experiments at Rayong 1964-70

Year	First Site			Second Site		
	Zero Fertilizer (t/ha)	Low [a] Application (t/ha)	Medium [b] Application (t/ha)	Zero Fertilizer (t/ha)	Low [a] Application (t/ha)	Medium [c] Application (t/ha)
1964	32 5	29 4	29 4	-	-	-
1965	22 5	22 5	21 3	25 0	25 6	25 0
1966	20 0	22 5	18 8	23 8	18 8	20 0
1967	14 4	26 3	28 1	23 1	26 3	31 3
1968	21 3	31 3	28 7	22 5	26 9	31 3
1969	22 5	29 4	28 7	17 5	21 3	25 6
1970	19 0	36 0	-	-	-	-

[a] Yearly application of 50-50-25 kg/ha of N P and K
[b] Yearly application of 75-75-120 kg/ha of N P and K
[c] Yearly applicaton of 50-50-50 kg/ha of N P and k

Source Interim Committee for Coordination of Investigations of the Lower Mekong Basin Agricultural Research Efficiency in Thailand Volume III Cassava 1979

TABLE 7 8 Thailand Summary of 121 Fertilizer Trials Across Three Different Soil Types 1968-70

Soil Series	No of Trials	Probability of Response to [a]		
		N	P	K
Huai Pong	14	+	-	-
Pattaya	25	+	-	-
Sattahip	82	++	±	±

[a] The probabilities are as follows

- not probable (< 25% of trials showed response)
± probable (25-49% of trials showed response)
+ fairly probable (50-67% of trials showed response)
++ highly probable (> 67% of trials showed response)

Source Sittibusaya Chote and K Kurmarohita Soil Fertility and Fertilization 1978

as the industry stabilizes as overall yields decline to a low level equilibrium and as output prices come under downward pressure The task is to transform a dynamic industry that has been fueled by private costs being lower than social costs to a sustainable industry where farmers must pay the full cost of soil nutrient extraction

Costs of Production and Labor Utilization

As yields decline the farmer's initial means of maintaining profits are by reducing costs By Asian standards cassava production systems in Thailand are relatively extensive in terms of labor and input use which in turn reflects the relatively high land-labor ratio existent in the country Moreover the existing agricultural frontier and the relatively liberal land policy have further reinforced extensive production practices The process has thus favored technologies that substitute for labor rather than those that substitute for land

Labor is the major cost component in cassava production systems Estimates of labor input per hectare range from 70 to 100 man days Only maize and broadcast rice have a lower labor input (Table 7 9) Additionally because cassava can be planted almost anytime of the year and can be harvested over a relatively long period labor activities can be scheduled in relation to other demands for labor Since upland crops must compete with rice for labor this flexibility in labor use gives cassava an advantage over other upland crops Finally cassava gives the highest average returns per manday of labor input (Boobst et al) Cassava thus is very well adapted to the labor economy of Thailand

The trend is toward further reductions in labor input Land preparation through tractors has rapidly spread through the Northeast With movement to planting in rows interrow cultivation with animals was employed in those areas that still maintained draft animals Increases in sales of herbicides have been reported in the major cassava producing area of Chonburi especially since there were no such sales prior to 1973 (Interim Committee for Coordination of the Lower Mechong Basin 1979) Thus farmers have been very responsive to technologies that have substituted for labor they have not been responsive in the adoption of land substituting technology

Labor or mechanization costs make up over 85/ of total cassava production costs (Table 7 10) Input and fixed costs make up the remainder Moreover normally about half of production costs are paid in cash the rest reflects the opportunity costs (evaluated at market prices) of farmer-owned resources The cost structure reflects some flexibility in absorbing price declines at least in the short-run since price declines can be absorbed in terms of lower returns on farmer-owned resources Major increases in fertilizer costs would significantly shift this balance again highlighting the importance of a consistent yield response for adoption

Supply Response

The reasons behind the rapid expansion in cassava area in Thailand over the last two decades can now be summarized First and foremost the crop was very profitable During the 1974-1984 period average returns to

TABLE 7 9 Thailand Average Labor Requirements and Returns by Crop Enterprise Northeast 1973-74

Crop	Labor Requirements (Man-Days/Hectare)	Returns per Man-Day Net of Nonlabor Variable Costs (Dollar/Man-Day)
Rice	87 56	1 18
Cassava	100 65	2 02
Kenaf	161 36	0 55
Peanuts		
Rainy season	161 78	1 08
Cool season	112 67	0 93
Dry season	155 60	1 24
Vegetables	772 05	0 48

Source Bobst Barry et al Enterprise Selection and Farm Employment in Northeast Thailand 1980

Table 7 10 Thailand Average per Hectare Costs of Production of Cassava Roots Northeast 1980-81

Cost Item	Cash (Baht/ha)	Non-Cash (Baht/ha)	Total (Baht/ha)
Variable Costs	2810 6	2054 3	4864 9
Labor Costs	2590 1	1290 6	3880 7
Land Preparation	1875 3	882 9	2758 2
Man	58 6	97 6	156 1
Oxen	52 9	93 5	146 4
Tractor	921 6	65 8	987 4
Seed Selection	8 7	31 3	39 9
Planting	251 5	154 8	406 3
Weeding			
Man	575 6	439 1	1014 6
Oxen	1 8	-	1 8
Harvesting	572 1	334 6	906 8
Transporting			
Man	69 1	72 6	141 6
Oxen	2 6	0 5	3 1
Tractor	71 0	-	71 0
Input Costs	207 0	242 0	449 0
Stakes	134 1	242 0	376 1
Agr Equipment	26 1	-	26 1
Gasoline and Oil	26 0	-	26 0
Chemical Fertilizer	20 8	-	20 8
Other Costs			
Repair Agr Equip	18 3	-	18 3
Working Capital	-	521 8	521 8
Fixed Costs	58 0	673 2	731 2
Land use	58 0	647 5	705 5
Depreciation Agr Equip	-	25 7	25 7
Total Cost	2868 6	2726 6	5595 2
Cost per ton (Baht/t)	-	-	406
Price (Baht/t)	-	-	510

Source Survey of Cassava Production Costs and Returns 1980-81 Office of Agricultural Economics Ministry of Agriculture and Cooperatives 1982

cassava never dropped below 25% and were as high as 145% (Table 7 11) Second the kenaf industry was in decline and even further land was available on which to expand Given the high yields on uncultivated land cassava as an income source was unmatched and led to a major increase in incomes in the relatively depressed area of the Northeast Third farmers did not face a labor constraint as tractor hire services expanded rapidly in the cassava producing areas

All of these factors are reflected in cassava supply response Pongsrihandulchai (1981) has estimated supply equations for cassava by agro-economic zone and as might be expected found a very high short-run price elasticity of between 0 58 to 2 78 (the median was 1 77) Price responsiveness in cassava was much higher than in rice (0 27) maize (0 70) kenaf (0 87) or sugarcane (0 62) Moreover the supply equations suggested that cassava principally competed for land with kenaf except in the Rayong-Chonburi region where there were no competing crops with cassava These equations were estimated while cassava prices were on the whole increasing The question arises whether farmers would be equally responsive to declining prices and the answer would probably be no There is limited effective competition between cassava and other crops reflecting few other cropping alternatives for land in cassava Farmers would only significantly reduce area if they were operating at a cash loss

Technology Development

Research on cassava in Thailand started in 1956 with the creation of the Huai Pong Experiment Station in Rayong The station comes under the Field Crop Division of the Department of Agriculture and since 1956 has beeen the principal locus of cassava research although research on other field crops is also done at the station As research on cassava has increased with the expansion in the crop other field crop research stations in the northeast have also conducted experimental work on cassava all of which is coordinated by the Root Crops Branch within the Field Crop Division of the Department of Agriculture

For the first two decades cassava research focused on soil management and fertilization (see Sittibursaya and Kurmardrita 1978 for a summary of this research) The principal features of this work are well summarized by the Committee for the Lower Mekong Basin (1979) namely high yearly yield fluctuations probably related to rainfall conditions rapidly declining yields of unfertilized plots and variable response to fertilizers While the research has led to a set of fertilizer recommendations broken down by soil type and while a series of farm level demonstration trials were also carried out only minor adoption of fertilizer has occurred Some research in this area continues to be done even though it follows virtually the same approach The few deviations have been toward evaluation of green and organic manures These have shown promising results (Table 7 12) but have not led to any recommendations

Lack of progress in the area of fertilization gave impetus to the development of a varietal improvement program Local clones were collected in 1956 These were evaluated for agronomic characters and yielding ability but were found not to show significant differences One was selected and named Rayong 1 which was used as a check variety in all

TABLE 7 11 Thailand Average Costs of Production and Returns for Cassava 1974-1983

Crop Year	Per Hectare Costs			Per Hectare Yield	Per Ton Cost	Farm Price [a]
	Cash (Baht/ha)	Non-Cash (Baht/t)	Total (Baht/ha)	(t/ha)	(Bath/t)	(Bath/t)
1974-75	1593	1558	3151	13 0	242 4	290
1975-76	1854	1674	3528	13 7	256 9	410
1976-77	1701	2390	4091	12 6	325 6	460
1977-78	1696	2116	3812	12 9	294 9	450
1978-79	2059	2089	4148	14 9	282 6	370
1979-80	2217	2227	4444	10 7	415 9	770
1980-81	3114	2757	5871	14 3	411 8	750
1981-82	2820	3221	6041	14 0	432 4	450
1982-83	3399	3018	6417	13 9	446 0	540

[a] Average price for the crop year Oct-Sept

Source Production Economic Section Office of Agricultural Economics Ministry of Agriculture and Cooperatives Bangkok

succeeding experimental work While some selection from collected open-pollinated seed started in 1971 a controlled hybridization program did not begin till 1974 (Sinthruprama 1978) Initial crosses were between Rayong 1 and other local cultivars In 1977 varieties from CIAT were introduced as well as seed from controlled hybridization This served to significantly expand the germplasm on which the crossing program was based

Initial selection is based on high root yield and high starch content In later evaluations earliness and appropriate plant type for intercropping are introduced as selection characteristics Promising materials are evaluated for drought tolerance resistance to the few cassava diseases and pests that occur in Thailand and in some cases for edible quality characteristics A testing program of regional and on-farm trials resulted in the release in 1983 of the first promising variety Rayong 3 Its principal advantages over Rayong 1 are a higher starch content and a higher response to chemical fertilizer As yet it is too early to evaluate the adoption of this variety

New production technology has not been necessay to the rapid expansion in cassava cultivation The high yields obtained with the local variety as new land was cultivated and the high prices set by the European Community were sufficient to maintain high profits in cassava cultivation These profit levels are now coming under pressure from two sources the decreasing yields as soil fertility declines and uncertain access to the European Community as the EC attempts to reduce cassava imports The latter will require lower price levels as Thailand looks to alternative international markets which in turn will result in a cost-price squeeze at the farm level effectively increasing the demand for improved technology The research program is in a position where a new variety in and of itself will not have a high probability of markedly improving yields This will occur only if the variety is combined with a viable soil fertility management strategy The first signs of farmer adoption of fertilizer are occurring in the old production areas of Chomburi and Rayong Motivating this trend will provide the base for yield gains though new varieties

Markets and Demand

The development of the Thai cassava economy (together with that of Malaysia) has followed the reverse of the normal pattern That is growth in production was initially driven by export market development Only after export market channels were well in place did domestic markets of any size begin to develop Price formation was always based on cassava as a tradeable good in international markets and Thai farmers and cassava processors based their decisions on price incentives set in these markets An analysis of the Thai cassava economy in thus dependent on an evaluation of cassava demand in international markets (see Chapter VIII) and of price formation in these markets

The Cassava Pellet Export Market

The export market for cassava chips and pellets dominates the Thai cassava economy High grain prices in Europe first in West Germany and

TABLE 7 12 Thailand Yield Effect of Various Green Manure Crops on Succeeding Crop of Cassava 1970

Treatment	Yield (t/ha)
Crotalaria juncea	26 8
Dolichos biflorus	29 6
Vigna sinensis	32 2
Phaseolus mungo	27 3
Phaseolus calcaratus	25 5
N-P-K (50-50-25)	27 3
No green manure	20 4

Source Interima Committee for Coordination of Investigation of the Lower Mekong Basin Agricultural Research Efficiency in Thailand Cassava 1979

later within the larger EEC have provided the genesis for Thai chip and pellet exports These markets have been able to absorb the rapid expansion in export volumes to the extent that Thailand has not had to diversify its markets that is uptil 1983 Thai success however has given rise to European discontent and in 1982 a agreement for voluntary export restraint was negotiated and signed between the two parties (a lengthy discussion of the structure of the European market of the history of cassava imports into Europe and of the details of the quota is found in Chapter VIII) The quota while slowing growth in Thai exports nevertheless has not stopped it completely (Table 7 13)

The pattern of growth in the Thai cassava industry is relatively unique when compared to cases of rapid expansion in other agricultural commodities especially the grains The difference comes in the fact that cassava has to be processed very close to the production point because of its bulkiness and rapid perishability Sugar cane and palm oil have similar characteristics and in their case relatively large scale processing units have usually been linked to core plantations though if properly planned smallholders can provide a certain percentage of the raw material production However in the case of cassava the expansion in root production and processing has been based on linking small-scale producers to relatively small-scale processing capacity Decentralized small-scale processing is thus a solution to the problem of minimizing transport costs where in the case of sugar cane or palm oil the solution is plantations Moreover growth in production can be more easily syncronized with needed investment in processing capacity This is typical of cassava development other examples are gari in West Africa and farinha de mandioca in Brazil This development pattern allows cassava both to maintain a small-farm focus to maximize the employment generation in production and processing and to distribute more equitably income growth as the industry expands

The development of investment in processing capacity is portrayed in Table 7 14 The data suggest a pattern that first depends on concentration of investment in a few limited areas About 78% of all chipping plants in 1973 were located in only four changwats 60% were located in only two Rayong in the Central Plain and Nakhon Ratchasima in the Northeast By 1978 these same four changwats accounted for just 41% of all chipping plants Root production followed much the same organic growth process That is development of the industry was based initially on the establishment of growth nodes where increasing density of production made for a more efficient cassava root market This concentration in turn allowed the orderly evolution of market channels to the export points By 1978 the next phase in this growth process is apparent i e rapid expansion of processing capacity into other changwats especially in the Northeast and expansion in processing scale in those original areas where production density had reached a certain critical point such that transport costs were not a constraint on scale expansion A certain production density is necessary to support efficient large-scale cassava processing

This organic development of the Thai cassava industry has induced a continual search for cost reductions especially in processing storage and transport In the 1960 s this was policy induced as the EEC varied its tariff rates on meal versus chips (see Chapter VIII) The binding of the duty in 1968 provided the market security to justify investments leading to other cost reductions The first large investments came in the form of

TABLE 7 13 Thailand Exports of Cassava Products Destined for Animal Feed Use 1960-83

Year	Chips (000 t)	Meal (000 t)	Pellets (000 t)	Waste (000 t)	Total (000 t)
1960	3 0	64 6	-	25 0	93 6
1961	8 4	188 4	-	18 6	215 4
1962	12 7	267 7	-	9 6	290 0
1963	93 4	189 8	-	22 4	305 6
1964	339 4	202 3	-	45 5	587 2
1965	400 5	79 0	-	97 8	577 3
1966	359 8	65 8	-	107 9	533 5
1967	337 4	174 8	-	70 2	582 4
1968	323 2	388 8	-	33 1	853 7
1969	56 4	27 7	752 7	16 9	1 181 9
1970	8 1	4 0	1 163 9	5 9	972 1
1971	2 5	1 5	963 9	4 2	1 181 6
1972	2 4	0 6	1 177 4	1 2	1 659 0
1973	18 2	0 6	1 638 7	1 5	2 139 6
1974	105 3	1 0	2 031 5	1 8	2 240 5
1975	70 6	-	2 168 7	1 2	3 484 9
1976	43 4	0 2	3 441 3	-	3 752 9
1977	65 6	0 5	3 686 7	0 1	6 052 3
1978	255 6	0 2	5 796 1	0 4	6 052 3
1979	142 0	0 4	3 695 8	0 3	3 838 5
1980	159 2	2 7	4 811 2	-	4 973 1
1981	334 4	0 6	5 620 2	0 6	5 955 8
1982	523 1	9 7	6 892 8	0 5	7 426 1
1983	280 0	4 8	4 545 1	0 3	4 830 2

Source Center for Agricultural Statistics Office of Agricultural Economics Ministry of Agriculture and Cooperatives Bangkok

TABLE 7 14 Thailand Evolution of Processing Capacity for Cassava Chips and Pellets by Changwat 1973–85

Changwat	Chip			Pellet		
	1973 (number)	1978 (number)	1985 (000 t capacity)	1973 (number)	1978 (number)	1985 (000 t capa
North	88	95	90 0	10	24	2312 4
Kamphaeng Phet	80	35	24 3	6	5	360 0
Nakhon Sawan	5	34	18 4	1	10	943 2
Chiang Rai	-	10	7 1	-	1	-
Phitsanulok	-	6	35 5	2	4	345 6
Uthai Thani	2	4	0 1	1	2	532 8
Northeast	421	1 777	7 860 7	24	305	20 736 0
Kalasin	36	159	625 0	2	5	381 6
Khon Kaen	-	252	775 0	-	58	4 406 4
Chaiyaphum	2	41	632 5	-	17	1 044 0
Nakhon Phanom	6	28	172 3	1	7	871 2
Nakhon Ratchasima	356	617	3 934 2	10	114	7 855 2
Buri Ram	4	108	543 7	4	21	1 036 8
Maha Sarakharm	1	60	284 3	-	23	396 0
Roi Et	3	97	221 1	-	7	475 2
Nong Khai	1	45	203 4	2	9	410 4
Udon Thani	4	18	234 1	3	235	1 540 8
Surin	-	24	22 2	-	10	1 483 2
Central Plain	641	1 375	1 812 3	141	287	19 843 5
Kanchanaburi	25	58	63 9	4	5	158 4
Suphan Buri	29	62	47 9	4	8	828 0
Chachengsao	40	134	315 8	-	29	3 420 0
Chon Buri	113	348	991 2	115	126	8 553 6
Trat	27	58	21 8	-	-	15 6
Prachin Buri	32	230	120 4	-	33	1 785 6
Rayong	345	328	176 6	11	62	2 368 8
Total Thailand	1 152	3 254	13 698	175	618	42 892

Source Division of Factory Control and Industrial Economics Ministry of Industry Bangkok

pelleting capacity The objective here was to reduce transport costs by increasing the density (Table 7 15) These were first based on the importation of European pelleters but this was shortly followed by the manufacture of pelleting machines in Thailand This gave rise to a quality distinction of brand versus native pellets with the latter having a lower density being softer and not having a pure composition (Mathot 1974 explores in detail the technical and economic factors determining pellet quality in Thailand)

According to export statistics Thailand converted from exporting meal and chips in 1968 to exporting virtually all pellets in 1969 that is 750 thousand tons Reports suggest the first pelleters were established in 1967 Investment in pelleting capacity was thus rapid and was independent of chip processing Investment in pelleting relied on a significant chip production capacity and a margin defined by transport cost advantages both internally and in the export trade Nevertheless pelleting plants were not large A 1974/75 survey identified three types of plants a small-scale plant with an annual capacity of 1260 tons a medium-scale plant producing 3310 tons and large-scale plants with a capacity of 7280 tons (Titapiwatanakun 1979) Interestingly these were not much larger than the average production capacity of chip plants and thus suggest no economies of scale in pelleting That is since chipping and drying gets over the perishability and transport constraint and since chip production was relatively concentrated any economies of scale in pelleting would have suggested investment in larger centralized plants

There were no economies of scale in native pellets however for hard pellets produced with steam and/or a vegetable oil binder scale economies did seem to exist The cost savings on the utilization side in hard pellets are three First density is greater so there is a transport savings Second for feed concentrate manufacturers hard pellets do not require as much modification in factory transport systems i e essentially adapted for grains Third hard pellets can be stored longer allowing fewer storage losses Also there was a significant decline in dust pollution which previously had remained an externality and was dealt with by public funds in ports such as Rotterdam The price differential resulting from these savings however was through the 1970 s never sufficient to motivate a larger production of hard or brand pellets Most major cassava users in Europe especially in the Netherlands made the necessary investments to handle the higher meal content of native pellets in the feed plants and the ports

Investment in hard pelleting capacity started to increase in 1982 at the start of the quota and by 1985 over 80% of pellet exports were in the form of hard pellets What is ironical is that investment came at a time when prospects in the EEC market were very uncertain Two factors prompted this conversion First the quota resulted in a large stock build-up initially due to the quota restriction and beginning in 1983 as a means for the Thai government to allocate the quota (see Chapter VIII) Storage costs (pellet density) and storage time thus become key constraints leading to an internal demand for hard pellets Second the quota allocation procedure forced the big shippers [transnational corporations in the international grain trade (see Titapiwatanakun 1982) who managed the European end of the market] to secure more certain control over

supplies in order to guarantee their forward contracting in Europe They did this by backward integration into large-scale hard pelleting plants usually of European manufacture Thai manufacturers did follow with their own cheaper models to upgrade native pelleting plants These produced a quasi-hard-pellet an intermediate product between native and hard pellets

As the industry developed large investments were also made in storage and loading facilities at export points A reflection of this investment is the change in size of ship that carried cassava Table 7 16 charts the progressive change to larger bulk-cassava carriers which in turn implied investment in loading facilities in Thailand In 1980 the average cargo size for a ship hauling cassava was 87 thousand tons This compares to an average size of 41 thousand tons for ships hauling grains of North American origin The Thai cassava trade was able to capture significant economies of scale in ocean transport with Rotterdam being the only port that could take advantage of these scale economies Prices of cassava pellets in Hamburg for example are as much as 50 deutsche marks more expensive per ton than in Rotterdam Moreover cassava shipments to the United Kingdom are usually unloaded in Rotterdam and sent on lighter to U K ports

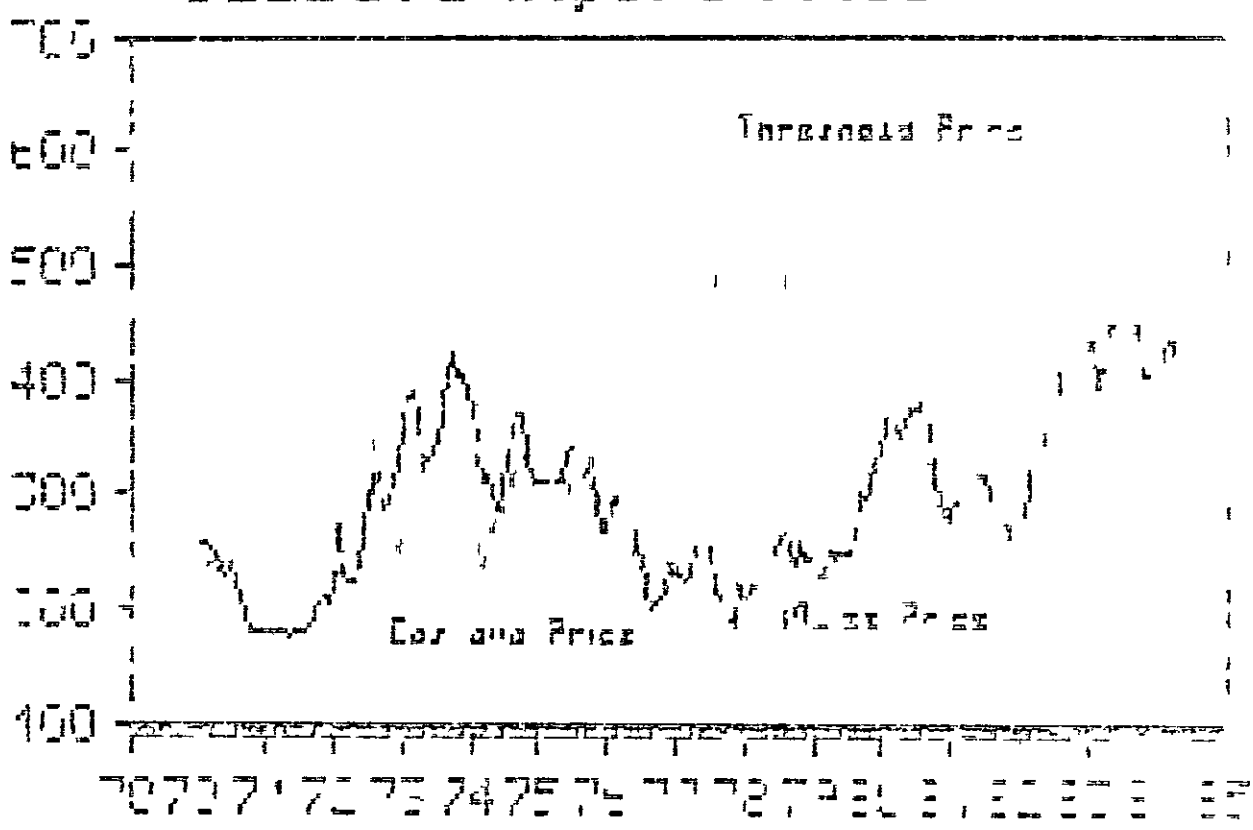
As in biology so in economics growth is a far more complex process than surface -- or macro -- appearances would suggest Thailand in many ways offers an idealized growth pattern for cassava Early growth based on small-scale production and processing insures syncronization between the two in the growth process Economies of scale are possible then when critical market size and production densities are reached It is important to visualize cassava in this more dynamic sense when the comparative advantage of cassava versus grains is discussed later in the chapter Also what is important about the Thai cassava case is the rapid growth in investment in a industry characterized by relatively small-scale plants and the forward linkages that were made to domestic manufacturing capacity Investment in small-scale rural based industries is a particular characteristic of Asian agriculture -- one is tempted to attribute this to the constrained land resource base and the need for alternative employment in the rural sector the history of investment in the rural sector particularly irrigation and generally low incomes which makes even margins in small-scale processing attractive Cassava is in more ways than one well adapted to Asian conditions (see Chapter IX)

Price Formation Price is the trottle that has controlled growth in the Thai cassava industry Understanding how prices for cassava pellets are formed will thus provide a basis for assessing both future prospects and an appropriate response to the EEC quota Because the major portion of Thai pellets are exported of which almost all go to the EEC the price of pellets in Thailand and the price of pellets in Europe are interdependent The policy history of cassava in the EEC is discussed in Chapter VIII but suffice it here to say that since the binding in GATT of cassava at a 6/ ad valorem duty in 1968 cassava has had a competitive edge over grain imports which must enter under the EEC s variable levy system Since domestic grain prices in the EEC are normally well above world grain prices and through the Common Agricultural Policy insulated from international market conditions the cassava price is formed within the relative confines of the EEC market The implications for the cassava price is shown in Figure 7 3 where the Rotterdam cassava price and the maize threshold price

TABLE 7 15 Thailand Weight per Unit Volume for Different Cassava Products

Product	Weight/Volume (g/cm^3)	Percentage Increase in Density (%)
Chips	412	-
Native Pellets	569	38
Hard Pellets (Steam)	808	96

Figure 13 EEC: Comparison of Maize Threshold Price and Maize CIF [illegible]



[illegible]

TABLE 7 16 Thailand Size of Ship Unloading Cassava in the Rotterdam Port 1967-80

Year	Percent of Cassava Trade Carried by		
	Twin Deck Vessel (%)	Bulkcarrier Less than 60 000 tons (%)	Bulkcarrier More then 60 000 tons (%)
1967	100	0	0
1970	100	0	0
1975	43	57	0
1980	2	8	90

Source Graan Elevator Maatschappij (g e m) b v Rotterdam

are compared to the cif price of maize in Rotterdam World market maize prices and internal EEC maize prices have significantly diverged over the last decade and a half However although cassava prices have remained above world market maize prices (at least on a feed equivalent basis) cassava has gotten relatively cheaper compared to EEC priced grains Export demand for Thai cassava and therefore the export price is determined by the prices for feed components in the EEC -- import demand for cassava in Europe is analyzed in Chapter VIII -- however supply side factors may as well be affecting price formation in cassava

The structure of the pellet market argues for the formation of cassava prices in the EEC feed component market with European prices being transmitted back to Thailand The carriers or shippers are key agents in price formation and transmission They are the interface between the European and Thai markets Moreover cassava is sold on an fob basis in Rotterdam That is the shippers assume ownership of the cassava until its unloading in Europe Grains on the other hand are sold on a cif basis where the feed compounder has assumed ownership in say the Chicago market As well the major portion of cassava is sold on a forward basis That is a compounder contracts a certain quantity of cassava at a specified price for delivery some months forward and the shipper in turn buys in Thailand in order to lock in the margin on his sale The shipper obviously must be in a position to monitor market conditions in both Thailand and Europe and companies such as Krohn & Co Peter Cremer and Alfred C Toepfer are European-based companies with significant investments in Thailand

To demonstrate the price linkage between the two markets and to evaluate the locus of price formation European and Thai cassava prices are analyzed in a framework which evaluates "causality between the two price series The concept of Granger causality is used in the sense that European prices cause Thai prices if the European prices lead the Thai prices in a sense defined by correlation between lags in the two series (see Bessler and Brandt 1982 Spriggs Kaylen and Bessler 1982 and Adamowicz Baah and Hawkins 1984) The methodology rests on prefiltering any autocorrelation in each series using an ARIMA estimation In this case the series of residuals could be reduced to a white noise series using the same prefilter -- this allows a valid test of Granger causality (Sims 1972) The residuals were then cross-correlated with varying lags The correlations then suggest the degree to which European prices lead (cause) Thai cassava prices

Four European price series are utilized representing two markets Rotterdam and Hamburg and representing spot market prices and the two-month forward contract price All European prices are from the German agricultural market intelligence paper Ernahrungsdienst These series are analyzed in relationship to the Bangkok wholesale price for cassava pellets published by the Thai Tapioca Trade Association in their Tapioca Products Market Review Prices were available on a bi-weekly and a monthly basis and a series of both time periods are analyzed from 1974 through 1985 The period is divided into two pre-quota and post-quota in order to assess the impact of import restrictions on price relationships between the two markets

The cross-correlations between the Thai and European price series are presented in Table 7 17 First considering only the bi-weekly series two

TABLE 7 17 Thailand Cross-Correlations between Prefiltered Price Series for Thailand and Europe 1974–85

Thailand Leads(+) or Lags(−) over Europe	Two Month Forward Price								Spot Price							
	Rotterdam				Hamburg				Rotterdam				Hamburg			
	Jan 1974 Sept 1982		Oct 1982 Dec 1985		Jan 1974 Sept 1982		Oct 1982 Dec 1985		Jan 1974 Sept 1982		Oct 1982 Dec 1985		Jan 1974 Sept 1982		Oct 1982 Dec 1985	
Biweekly																
+3 periods	0 10		0 06		0 03		0 04		−0 03		0 02		−0 06		0 05	
+2 periods	0 07		0 01		0 09		0 03		0 07		0 01		0 09		0 00	
+1 period	0 21**		−0 07		0 44**		0 12		0 19**		0 20*		0 18**		0 25*	
simultaneous	0 52**		0 29**		0 32**		0 21*		0 44**		0 26*		0 44**		0 26*	
−1 period	0 06		0 29**		0 11		0 20*		0 07		0 13		−0 01		−0 07	
−2 periods	0 09		0 05		0 01		0 06		0 04		−0 02		0 06		0 02	
−3 periods	0 08		0 11		0 03		−0 10		0 03		−0 09		−0 05		0 08	
Monthly																
+3 periods	0 05		−0 10		0 06		−0 17		0 15		−0 20		0 06		−0 19	
+2 periods	0 19*		0 11		0 03		0 33*		0 07		0 00		0 05		0 06	
+1 period	0 15		0 13		0 14		0 29*		−0 06		0 11		−0 09		0 01	
simultaneous	0 51**		0 23		0 62**		0 27		0 54**		0 30**		0 48**		0 43**	
−1 period	0 22**		0 38*		0 22**		−0 08		0 25**		0 27		0 23**		0 03	
−2 periods	0 07		0 12		0 07		0 22		0 08		−0 02		−0 02		0 14	
−3 periods	−0 11		0 23		−0 23**		0 39*		−0 23		0 40*		−0 23		0 24	

Note ** implies significance at 1% level and * implies significance at 10% level

Source CIAT

structural features of the market are confirmed that is the forward price generally gives a higher correlation between markets than the spot price and in the case of the forward price the Rotterdam market is more closely linked to the Thai market then is the Hamburg market (for the spot price the correlations are virtually the same comparing Rotterdam and Hamburg) Considering then only the case of the forward price Bangkok and Rotterdam prices in the 1974-82 period are significantly instantaneously correlated i e within the two-week time frame This represents relatively efficient flows of information between the two markets and therefore relatively close price integration Somewhat contrary to expectation there is also some residual tendency for the Bangkok price to lead (cause) the Rotterdam price In the very short-run this indicates that the short-term supply situation in Thailand i e the ability of the shipper to fill his forward contracts influences the price negotiated in Europe This situation is even more marked in the case of Hamburg and again indicates that Hamburg is not as rapidly integrated with the Bangkok market as is Rotterdam

The quota has radically changed this situation The strength of integration between the two markets has declined as reflected in the lower correlation coefficients As will be shown later this has resulted in a widening in the margin between the two price series Moreover although instantaneous causality between the two series is still apparent European prices under the quota lead Bangkok prices Under the quota short term supply needs are adequately met by stocks while in Europe cassava supplies are constrained by the quota Cassava does not have to sell at much of a discount to grains in order to move available supplies Therefore short-term price formation shifted over to demand side factors but with a decline in the strength of the direct price transmission back to Thailand

Price transmission between Europe and Thailand in the past has run in both directions but for monthly data at least the analysis suggests that Europe leads the Thai price The price transmission process is then analyzed by making Thai cassava prices a function of European prices at varying lags the transport costs and a dummy variable for the quota period The results in Table 7 18 suggest that only 49% of price changes in Europe is passed back to Thailand in the first month and another 29% in the second month The transport cost variable was negative as expected but not significant This was due to the inability to construct a series that reflected the change in scale of shipping during the period the variable as specified assumes the same size ship Finally the dummy variable for the quota period is negative implying that the margin between Europe and Thailand has widened under the quota This is to be expected with upward pressure on cassava prices in Europe due to a constrained supply and downward pressure on prices in Thailand due to rising stock levels As is explained in Chapter VIII Thai quota management policy has utilized this larger margin to finance third-country exports rather than allowing a windefall profit to accrue to cassava export companies

The previous analysis argued that the locus of price formation in this cassava market occurs either at the level of negotiations between the shipping company and European feed manufacturer or between the shipping company and Thai suppliers the type of supplier depending on how far back into the market the shipping company is integrated This implies that root and chip prices are determined by pellet prices whether set in Europe or

TABLE 7 18 Thailand Estimates of Price Transmission Equations between Europe and Thailand 1974-8 4

	Dependent Variable	
	European Price	Thai Price
Intercept	8 36 (2 05)	-1 66 (2 31)
Price (no lag)	0 64 (0 08)	0 48 (0 06)
Price (one month lag)	0 11 (0 09)	0 28 (0 06)
Price (two month lag)	0 14 (0 08)	0 02 (0 06)
Transport Cost Index	0 07 (0 02)	-0 03 (0 02)
Quota Dummy	4 30 (0 98)	-1 73 (0 99)
R^2	0 62	0 55

Note European prices were monthly two month forward cassava pellet prices in Rotterdam Thai prices were monthly wholesale Bangkok prices for cassava pellets Extimates were corrected for second-order autocorrelation Numbers in parentheses are standard deviations

Source CIAT

in Thailand This pattern is distinct from grains were normally processing is a mark-up on grain prices set in bulk wholesaling markets In the cassava situation the standard accounting for the chip and pelleting processing are

$$P_c = c_c P_r + C_c + R_c \quad \text{and}$$

$$P_p = c_p P_c + C_p + R_p$$

where P represents price c is conversion rate C is operating cost and R is operating profit and the subscripts refer to roots(r) chips(c) and pellets (p) However given the assumptions on price formation price transmission equations for cassava chips and roots are as follows

$$P_r = \frac{1}{c_c} P_c - (C_c + R_c) \quad \text{and}$$

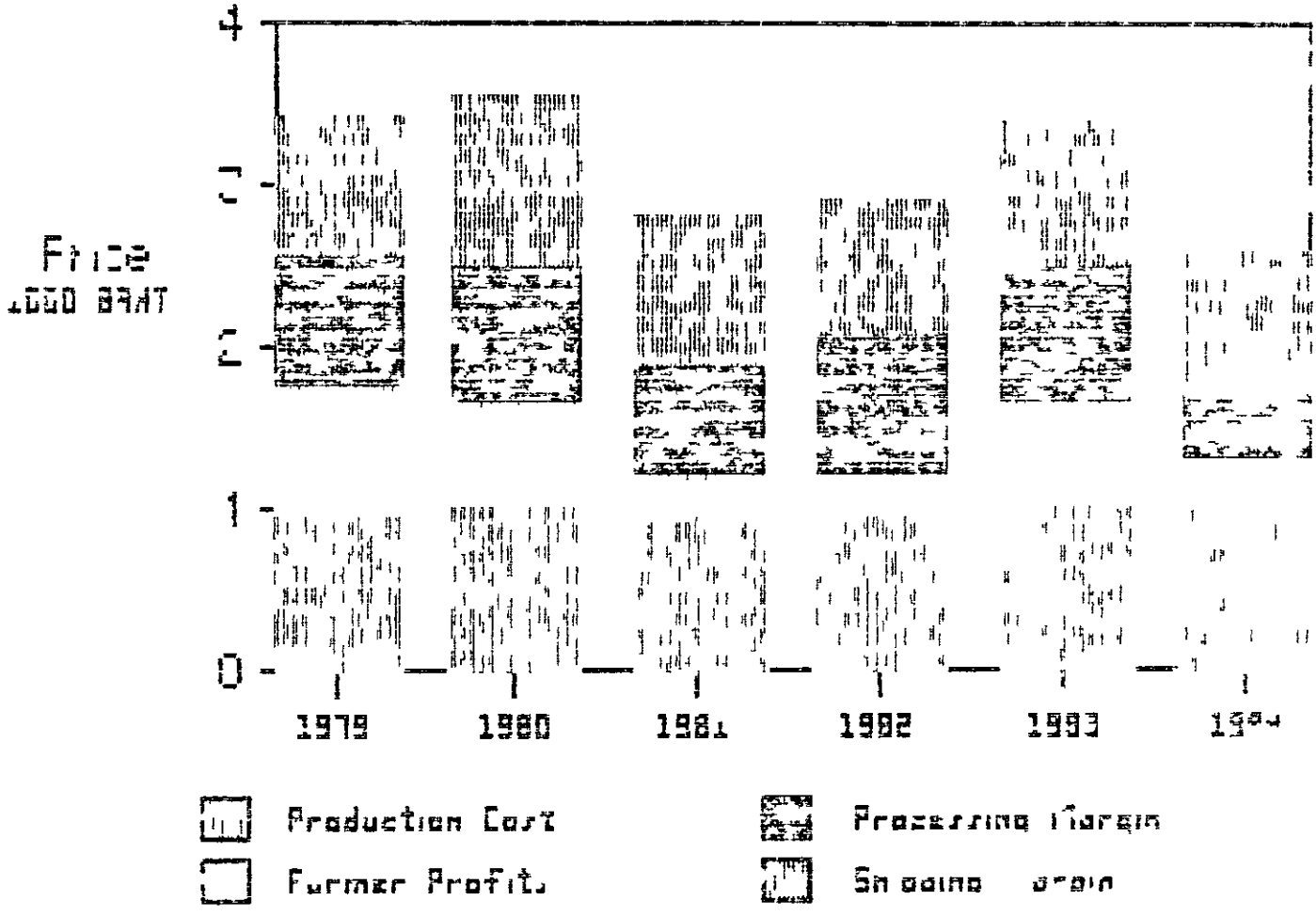
$$P_c = \frac{1}{c_p} P_p - (C_p + R_p)$$

Making the variables stochastic and assuming an error term the above equations were estimated and the results are presented in Table 7 19 The pellet equations follow expectations with the estimated conversion rates being within a reasonable range of but somewhat below the figure of 976 cited by industrial sources The estimated operating margin (per 100 kg) however is significantly below the actual budgeted costs of pelleting (see below) Nevertheless what the price transmission equations for pellets do suggest is quite restricted margins and therefore a very competitive industry

The chip equations on the other hand only partially confirm expectations The conversion rates in Chonburi and Rayong are very close to the 372 figure used by industrial sources while the estimated conversion rate in Korat is unreasonably high suggesting a far higher level of efficiency than can be expected to be the case On the other hand the operating margin estimates cover a wide range from being reasonable in Korat to being significantly positive in Chonburi i e reflecting operating losses The equations suggest a delicate balance between operating margins and conversion rates a binding charactistic in the profitable operation of a chipping plant The equations again demonstrate the limited margins within which the chipping plants have to operate to turn a profit Given the chip price competition within the industry has generated relatively high root prices and limited operating margins

Price formation in summary in the Thai-European pellet market is efficient reflecting the very competitive nature of the Thai cassava industry Any excess profits when they occur either accrue to cassava farmers or result in inflated margins for the shipping companies (Figure 7 4) The later has occurred as a result of the imposition of the quota but Thai policy has issured that these windfall profits are directed towards opening up new markets for cassava pellets

Figure 7.1 Thailand Margin Development for Cassava Pellets Prices between Europe and Farm-level



Profitability of the Cassava Pellet Industry The very marked rate of growth in the Thai cassava industry was driven by the relative profitability of the industry especially since prices set in Europe were efficiently transmitted to cassava root producers The profitability of cassava at the farm level is shown in Figure 7 4 which presents a graphic picture of margin development in the cassava industry Farm-level profits were highly variable but even in years with low prices profits were significant Not surprisingly root production showed continuous growth even with quite significant variability in prices

Another major characteristic of the cassava industry is that the farm-level root price makes up only between 40 to 50% of the eventual f o b price By comparison farm level production costs make up 83% of f o b costs of maize in the U S A (Ortmann Stulip and Rask 1986) The ability of cassava to compete with grains thus lies in its relatively low production costs and an efficient processing industry As seen in Figure 7 4 the processing margin did not vary significantly over the 1975-84 period

Cassava is very profitable for Thailand A complete cost accounting for 1981 is summarized in Table 7 20 (see Appendix 7 2 for details) The costs are disaggregated by domestic factor costs foreign import costs and government taxes including tariffs All costs are at 1981 market prices with interest rates being at the commercial loan rate of 19% There are no indications of any market imperfections that would cause market prices of factors to deviate from their opportunity cost (see Bertrand 1980 and Lokaphadhana 1981) Nor until the quota was there any intervention by the government in the cassava export trade The Thai cassava industry was one of the few examples of an industry that functioned without government intervention Deducting taxes and tariffs thus closely approximates social costs of producing cassava

The cost breakdown suggests that root production costs are two-thrids of total f o b costs of cassava pellets Chipping pelleting and export costs relatively equally divide the other third Labor is by far the largest cost component making up 47% of total costs Import costs are relatively low making up only 11% of production costs Comparing costs to 1981 prices implies that almost 30% of the f o b price was garnered by the economy as social profit with almost two-thirds of that going to the cassava farmer From a social point of view cassava was very profitable to the Thai economy and especially for the incomes of the population in the poorest sector of the economy the rural Northeast

The quota has made apparent the political underpinnings of the international market for cassava pellets Uncertainty about long-term access to the European market has raised the question about the ability of the Thai cassava industry to compete in the larger international feedgrain market The first point to emphasize is that because Thailand did not sell cassava in the international feedgrain market up till the quota does not necessarily imply that cassava could not compete in that market The analysis to date and that presented in Chapter VIII clearly shows that Thailand could sell all its production in Europe at prices above what could have been obtained on the world feedgrain market obviously it was more profitable for Thailand to sell all its production in the European market This situation has changed with the quota and the issue of cassava's

TABLE 7 19 Thailand Estimated Equations for Margin Determination for Chips and Pellets 1974-84

	Roots to Chips			Chips to Pellets	
	Chonburi	Rayong	Korat	Chomburi	Korat
Margin (Baht/100kg)	8 63 (2 19)	0 53 (2 05)	-18 09 (3 35)	-6 39 (1 81)	-8 41 (2 12)
Conversion Rate	0 35 (0 01)	0 37 (0 01)	0 52 (0 02)	0 94 (0 01)	0 91 (0 01)
R^2	0 77	0 82	0 79	0 98	0 97

Note Numbers in parentheses are standard deviations

Source CIAT

TABLE 7 20 Thailand Social Cost Accounting of Cassava Pellet Exports 1980-81

	Farm (Baht/t)	Chipper (Baht/t)	Pelleter (Baht/t)	Exporter (Baht/t)	Total Costs (Baht/t)
Purchase Price	-	1480	1792	1958	-
Sales Price	1480	1792	1958	2471	2471
Factor Costs					
Land	140 4	-	-	-	140 4
Labor	655 1	45 4	51 1	43 7	795 3
Capital	251 8	74 9	119 1	131 4	577 2
Foreign Exchange Costs	76 4	48 0	59 2	-	183 6
Total Costs	1123 7	1648 3	2021 4	2133 0	1696 5
Government Tax	22 7	23 6	27 9	18 4	92 6
Rent	333 6	120 1	-91 3	319 5	681 9

Source Appendix 7 2

TABLE 7 21 Comparison of Costs of Maize from Major Exporters and Cassava (on a maize equivalent basis) from Thailand cif Japan

	Maize			Cassava
	U S A ($/t)	Argentina ($/t)	Brazil ($/t)	Thailand ($/t)
Production Costs				
Variable Costs	60 0	37 9	66 6	52 6
Fixed Costs	59 8	32 9	68 2	7 7
Total Costs	119 8	70 8	134 8	60 3
Marketing and Processing	24 7	25 3	33 9	33 8
F O B Costs	144 5	96 1	168 7	94 1
Freight to Japan	26 0	32 4	34 2	10 0
C I F Costs	170 5	128 5	202 9	104 1
Yield (t/ha)	6 25	3 36	2 22	5 22

Note All costs are at 1985 prices and exchange rates Thai cassava costs represent 1981 costs multiplied by wholesale price index and divided by 1985 exchange rate Costs are then put on a maize equivalent basis by dividing by 0 7

Source Maize Ortmann G U J Stulp and N Rask International Trade and Economic Development Examples of Comparative Costs in International Commodities 1986 and Cassava CIAT

ability to compete in the wider feedgrain market is now a policy concern (In Chapter VIII the issue is addressed of how Thailand develops this wider market while continuing to garner the social profits from the quota allotment)

International comparative advantage has commonly been analyzed within a domestic resource cost framework (Pearson Akrasanee and Nelson 1976) This methodology takes border prices (f o b prices for exporters and c i f prices for importers) as the measure against which comparative advantage is assessed A good summary statistic is the resource cost ratio (Page and Stryker 1981) where any country with a ratio less than one has a comparative advantage in the production of that commodity For cassava in 1981 using Thai f o b prices the RCR was 71 indicating significant comparative advantage in supplying cassava to the European market To evaluate social profitability of selling on the international grain market the break-even price (the f o b price at which the RCR is one) is calculated This price is $77/t Assuming that under normal circumstances cassava competes with maize at about 7 of the maize price (see Chapter VIII) then the maize equivalent price is $110/t This compares very favorably to the f o b price of maize in Thailand and in the U S in the 1980's

The issue can be taken one step further and f o b costs compared to f o b costs of major maize exporters (Table 7 21) Comparing Thai cassava costs on a maize equivalent basis with those developed by Ortmann Stulip and Rask (1986) shows that cassava is very competitive with major maize exporters How much cassava Thailand will produce at currently declining world market maize prices is another issue but the same could be asked of countries such as the United States and France if price and income support policies were eliminated

In summary the Thai cassava industry has shown itself to be very responsive to export opportunities and to the vagaries of policy changes in import markets The EEC became virtually the sole market for Thai pellets essentially because it was the most profitable outlet Moreover because of efficient price transmission between the two markets Thailand could respond very quickly to the changing needs of the European market The imposition of the quota in 1982 has forced Thailand to begin to restructure its export markets a subject discussed in Chapter VIII What that analysis shows is that Thailand has adjusted to the quota by opening new markets in East Asia thereby allowing domestic production to continue to grow

The growth of the Thai pellet industry also offers a more general lesson about the development of comparative advantage in the crop Comparative advantage of cassava versus grain substitutes is based on certain physical characteristics particularly the availability of land with low opportunity cost and an agricultural sector with a relatively small farm-size structure However there is also a time and scale dimension to comparative advantage because of the critical importance of the processing component since it makes up from a third to a half of the total costs In cassava economies of scale in processing develop over time in relation to the concentration of production on the one hand and the size of the output market on the other Malaysia and Indonesia have

attempted to force the issue through plantation development but in cassava these have not been notably successful The social equity benefits from cassava development (marginal agricultural areas small-scale producers and rural employment in small-scale agro-industry) provide strong support in certain circumstances for an infant industry argument to support cassava in the initial development of its processing capacity In Thailand this initial protection was provided by the EEC market The Thai case suggests that cassava can compete with grains but in the evaluation of the comparative advantage of cassava in the feedgrain market a time perspective should be incorporated for processing costs

The Cassava Starch Market

The cassava industry in Thailand developed initially on the basis of the market for starch Starch production and exports have continued to grow throughout the post-war period but the industry has declined in relative importance having been eclipsed by the cassava pellet market Nevertheless the cassava starch industry in Thailand vies with Indonesia as being the largest in the world It continues to be dynamic suppling starch to both an expanding export market and an increasing domestic market

Constructing a supply and utilization series for cassava starch must rely on data from different sources and this produces some inconsistencies The series in Table 7 22 is developed from independent export production and utilization estimates and represents the author s efforts at achieving consistency between the estimates What the data suggests is quite significant growth in starch production driven through the 1970 s by rising domestic consumption and in the 1980 s by a sudden spurt in the export market

Cassava starch has a wide number of end markets in Thailand The principal use is as a raw material in the production of monosodium glutamate In this industry starch competes directly with molasses which is interchangeable with cassava starch Starch is also important in the expanding pulp and paper industry in textile production and in food industries All of these are growing industries and cassava starch will continue to enjoy an increasing domestic market throughout this century However unlike other starch markets in East Asia one market which cassava starch has not entered is the glucose and sweetner market This is principally because Thailand is a producer and net exporter of sugar High fructose sweetners derived from cassava have been advocated as another possible market since 52% of industrial sugar consumption is for beverage production (Frankel 1981) Moreover the Thai government has a policy of subsidizing sugar exports when world prices are low and taxing exports when prices are high (Lokaphadhana 1981) Nevertheless the price variability in cassava starch prices has made the investments needed in large-scale plant and capacity too risky and there has been no development in this market

Thailand is virtually the sole exporter of cassava starch and the largest exporter in the world of starch in general The export market was relatively stable through the 1960 s and 1970 s but increased dramatically in the 1980 s as new non-traditional importers came into the market (see

Chapter VIII) Thailand between 1980 and 1985 was able to expand exports by 50% in two years and virtually to double export volumes in four years without too much affect on domestic consumption levels This suggests the investment in significant excess production capacity for starch on the one hand and the ability of the starch industry to compete effectively with the pellet industry for roots -- in 1984 and 1985 root prices were relatively low due to the quota

The starch industry needs to be very competitive in the sense that its margins are defined by root prices principally set by the pellet export market in the EEC and starch export prices set principally by international maize prices i e the dominant cost in maize starch production (see Chapter VIII) The starch industry very early began a search for scale economies in processing essentially based on large-scale plants but with equipment manufactured in Thailand -- in Indonesia on the other hand these scale economies in starch production do not exist (Nelson 1984) Based on the development of this market Thailand is a now net exporter of cassava starch equipment including complete plants However with this competition to invest in order to lower processing costs excess processing capacity was created allowing the industry to respond so quickly to new export markets

Price Formation and Profitability Like other cassava processing industries profitability in starch production is primarily dependent on the conversion rate and the margin between the root buying price and the starch selling price Unlike the pellet industry where the price of the processed product leads the price of roots the starch industry must take the root price as a given The starch industry rarely has been able to underbid the chipping plants The root price thus sets the price of starch Competition for limited markets in turn insures both downward pressure on margins and the search for reductions in processing costs

The above scenario for price formation is adequately captured in the price transmission equations in Table 7 23 and the processing cost analysis in Table 7 24 Note that contrary to the chip industry starch price is the dependent variable in the regression equation The estimated conversion rates are only slightly higher than the estimate of 4 34 tons of roots for every ton of starch given by industrial sources Even the estimated rates suggest very high technical efficiency in starch extraction The estimated operating margin compares favorably with the budgeting analysis in Table 7 24 Again the evidence suggests a very competitive industry where there is no indication of excess profits Moreover a domestic resource calculation would be redundant in the case of Thai starch since Thailand sets the world price for cassava starch and apart from import duties on starch processing equipment there is no government intervention in the starch market

Continued growth in the starch industry is dependent principally on the supply price of starch which in turn is dependent on the root price and the changing dynamics of the pellet market The tendency in the medium term is for cassava starch prices to come in line with maize starch making cassava starch more competitive The other major factor of course is growth in export markets Prospects in the international starch market are

TABLE 7 22 Thailand Cassava Starch Production and Disappearance 1970-83

Year	Domestic Consumption					Export (000t)	Total Disappearance (000t)	Production (000t)
	Monosodium Glutamate (000t)	Paper Industry (000t)	Textile Industry (000t)	Food Industry (000t)	Other (000t)			
1970	23 4	6 8	6 8	36 0	7 1	144 7	224 8	173 6
1971	29 0	7 9	8 4	37 1	8 1	149 8	240 3	157 6
1972	33 3	10 4	9 0	38 2	10 7	129 2	230 8	201 1
1973	34 6	10 3	10 1	39 3	13 9	176 7	284 9	286 8
1974	34 6	13 3	10 0	40 4	17 4	252 5	368 2	315 7
1975	36 6	11 2	10 8	41 5	20 5	144 7	265 3	409 9
1976	33 5	15 4	13 1	42 5	24 6	236 3	365 4	513 0
1977	37 2	18 9	13 5	43 6	28 8	200 8	342 8	538 5
1978	40 8	20 1	14 3	44 7	33 2	235 9	389 0	411 0
1979	38 2	24 7	14 5	45 7	38 7	122 5	284 3	305 0
1980	37 2	26 2	15 8	46 0	43 1	243 6	411 9	432 9
1981	57 7	31 3	14 3	46 9	36 1	308 1	494 4	504 1
1982	54 7	37 3	14 8	47 8	42 9	387 0	584 5	590 1
1983	60 8	44 4	15 3	48 8	47 2	363 5	580 0	573 9

Note Disappearance and production data are derived from different sources Moreover change in stocks are not included There is a definite discrepancy in the 1970-72 period

Source Production Industrial Economics and Planning Division Ministry of Industry Bangkok
Domestic Consumption Titapiwatanakun Boonjit 'Domestic Tapioca Starch Consumption in Thailand 1982
Exports Center for Agricultural Statistics Office of Agricultural Economics Ministry of Agriculture and Cooperatives Bangkok

TABLE 7 23 Thailand Estimated Equations for Margin Determination in Starch Processing 1974-84

	Chonburi	Rayong
Margin	108 7 (25 6)	116 4 (20 3)
Conversion Rate	4 73 (0 35)	4 91 (0 29)
R^2	0 61	0 70

Note Numbers in parentheses are standard deviations

Source CIAT

TABLE 7 24 Thailand Costs of Production of Starch in Large-Scale Processing Plant 1981

Cost Item	Cost (Baht/t of starch)
Variable Costs	
Roots	2608 7
Labor	142 0
Electricity	366 7
Fuel for drier	235 0
Fuel for vehicles	16 0
Repair and maintenance	264 8
Transport to Bangkok	120 0
Working capital	30 6
Sub-total	3783 8
Fixed Cost	
Administration	41 8
Capital depreciation	116 3
Fixed capital costs	251 7
Sub-total	409 8
Total Costs	4193 6
Costs no including roots	1584 9
Starch Price	3750
Value of Cassava Waste	365

Note The capacity of the plant is 100t of starch per day and produced 15 5 thousand tons in average year The conversion rate is 4 35 tons of roots for 1 ton of starch

Source CIAT survey

analyzed in Chapter VIII and suggest that markets open only where the country loses the ability to meet its own domestic needs

The Animal Feed Market

There is no better illustration of the lack of integration between world market maize and cassava prices than the comparative role that these two export crops have played in the development of Thailand s domestic feed concentrate industry Maize has formed the carbohydrate base for this rapidly growing industry basically because it has been more profitable to export the cassava On those relatively rare occassions when the prices of the two commodities have come into line cassava has been used domestically in the manufacture of animal feeds This has happened more often since the imposition of the quota and given the current size of the domestic market the animal feed market could start to play a larger role in putting an absolute floor under cassava prices

Starting in the late 1960's basic structural changes in the production of both swine and poultry have formed the basis for the rapid expansion in the feed concentrate industry Prior to this time both swine and poultry were raised in small-scale integrated crop-livestock systems Swine continues to be raised principally in the central plain This region is relatively close to the Bangkok market and forms the main rice growing area where rice bran and other by-products provide a plentiful feed source Commercial operations of over 50 hogs have increased their production share from approximately 12% in 1974 to 14% in 1978 to around 15% in 1983 (Chesley 1985) Development of commercial swine operations however has been constrained by the Animal Slaughtering and Meat Control Act of 1959 which allows only local authorities to establish slaughterhouses and prohibits shipment of carcasses outside the legally defined market area of each slaughterhouse This has resulted in local monopsonies in slaughter facilities resulting in high costs and inefficient wholesaling of carcasses (see Chesley 1985 for further discussion) A high percentage of the slaughter is done illegally but this is difficult for large commercial growers Nevertheless swine numbers have continued to increase especially since the mid-1970 s (Table 7 25)

Structural change in the poultry industry has been even more rapid (Table 7 25) often motivated through vertical integration of feed companies backwards to commercial poultry production units The broiler industry has been by far the most dynamic animal sector in Thailand increasing nine-fold in the 1974-82 period Partly this arises from the restrictions on the pork sector and partly from the very rapid technical change in the poultry sector The later is reflected in the declining relative price of chicken compared to other meats (Figure 7 5) and a virtual doubling of per capita consumption of chicken over the course of the 1970 s The only limits on growth in this industry a technically efficient industry with access to cheap feed sources is the size of the domestic market With total per capita meat consumption still at relatively low levels and population and income still projected to grow there is no hint yet of a downturn in growth Moreover Thailand is developing as a major exporter of poultry in the East Asian and Middle Eastern market

TABLE 7 25 Thailand Swine and Poultry Population 1970-82

Year	Swine (thousand)	Poultry			
			Commercial		
		Village Chickens (million)	Layers (million)	Broilers (million)	Total (million)
1970	3215				136 3
1971	3348				150 7
1972	3335				166 8
1973	3004				182 2
1974	3256	-------- 154 2 --------		36 4	190 6
1975	3866	-------- 156 9 --------		41 6	198 5
1976	5201	-------- 148 2 --------		58 2	206 4
1977	5420	126 2	7 4	78 0	211 6
1978	6713	105 9	7 0	104 0	216 9
1979	7343	83 1	8 9	130 0	222 0
1980	6589	92 9	9 0	200 0	301 9
1981	6448	76 9	9 6	234 0	320 5
1982	n a	61 1	10 4	286 0	357 5

Source Derived from Chesley Merritt The Demand for Livestock Feed in Thailand 1985

The dynamism in the meat sector has been integrally linked to a dynamic industrial feed sector Production of balanced feeds have increased from a mere 64 thousand tons in 1968 to 2 1 million tons in 1984 Although initially based on swine feeds the real growth in production has come in broiler feeds This expansion in the feed sector has induced rapid increases in the derived demand for carbohydrate sources This demand has been met almost exclusively by domestically produced maize The maize sector has also been very dynamic in the last two decades (Table 7 26) increasing from a production level of just over half a million tons in 1960 to well over 4 million tons in 1984 Production growth in the 1960's went almost exclusively into exports However since about 1970 a growing share has gone to meet the needs of the domestic feed sector and since that point exports have been relatively stable at around 2 million tons

Cassava's potential as a carbohydrate source in the animal feed market is defined in Table 7 27 and Figure 7 6 Cassava comes into the least cost feed ration when its price is about 67 of the price of maize This ratio is somewhat low because the prices of soybean meal which is principally imported are maintained relatively high through import taxes These taxes have risen from 5 to 6 percent in the late 1970 s to 8 5 percent in 1983 (Chesley 1985) Thus cassava came into the ration in 1981 and again in 1984 Over the period 1971-85 cassava was never competitively priced with maize for any extended period of time (Figure 7 6) Thus cassava has never been a feature of the domestic feed market Nevertheless in 1985 feed manufacturers for the first time began to use significant volumes of cassava in their feed mixtures An estimated 625 thousand tons was used in feeds in 1985 However these competitive price relationships did not last through the end of 1985 and cassava again moved out of the ration

This situation is in fact quite favorable for cassava producers The animal feed industry has a solid raw material supply in maize but when substitutes are cheaper manufactures can profitably mix them in their rations Price is the determining factor for these feed components not continuity of supply Since cassava is readily available feed manufacturers can easily move into cassava when price relatives are favorable As domestic feed manufacturers gain experience in using cassava initially in swine feeds the domestic feed market could put an absolute price floor under the cassava market At these times cassava will essentially be competitive with world market feedgrain prices but the logical market on which to sell is the domestic rather then the export market When cassava prices are above maize prices the cassava producer is much the better off The domestic animal feed market is now large enough that it can play such a role in supporting cassava prices

Conclusions

Cassava led the rapid post-war expansion in upland agriculture in Thailand While maize and sugarcane expanded principally in the Central Plain provinces cassava area increased first in the East and then expanded rapidly in the poorest area of Thailand the Northeast Thailand was able to base exploitation of an agricultural frontier aided by labor-substituting technologies in the 1970 s on development of export markets This was as true for maize as it was for cassava The expansion in cassava started in the 1950's and continued through the early 1960's

TABLE 7 26 Thailand Maize Production and Utilization 1960-61 1982-83

Cropyear[a]	Total[b] Production (000 t)	Exports (000 t)	Domestic Use		Total Domestic Use as % of Total Production (%)	Feed Use As % of Total Domestic Use (%)
			Total (000 t)	Feed Use (000 t)		
	---------- (1000 tons) ----------					
1960-61	544	519	10	2	2	20
1961-62	598	589	15	4	3	27
1962-63	665	722	15	4	2	27
1963-64	858	923	20	6	2	30
1964-65	935	896	25	10	3	40
1965-66	1021	1132	29	10	3	34
1966-67	1122	1180	35	13	3	37
1967-68	1315	1214	55	25	4	45
1968-69	1507	1289	104	75	7	72
1969-70	1700	1502	176	140	10	80
1970-71	1938	1663	220	180	11	82
1971-72	2300	2111	280	235	12	84
1972-73	1315	1039	295	270	22	92
1973-74	2339	2112	348	300	15	86
1974-75	2500	1872	608	560	24	92
1975-76	2863	2442	313	250	11	80
1976-77	2675	1982	787	730	29	93
1977-78	1677	1297	397	365	24	92
1978-79	2791	2155	614	560	22	91
1979-80	2863	1825	652	590	23	90
1980-81	2998	2418	797	749	25	94
1981-82	3449	3079	846	821	24	97
1982-83	3002	2244	971	942	31	97

a All data are for July-June cropyears

b Does not include beginning or ending stocks therefore exports and domestic consumption do not add up to production

Source Chesley Merritt The Demand for Livestock Feed in Thailand 1985

Figure 7.8 Inward Ratio of Petrol Pr
to Maize Prices - Series

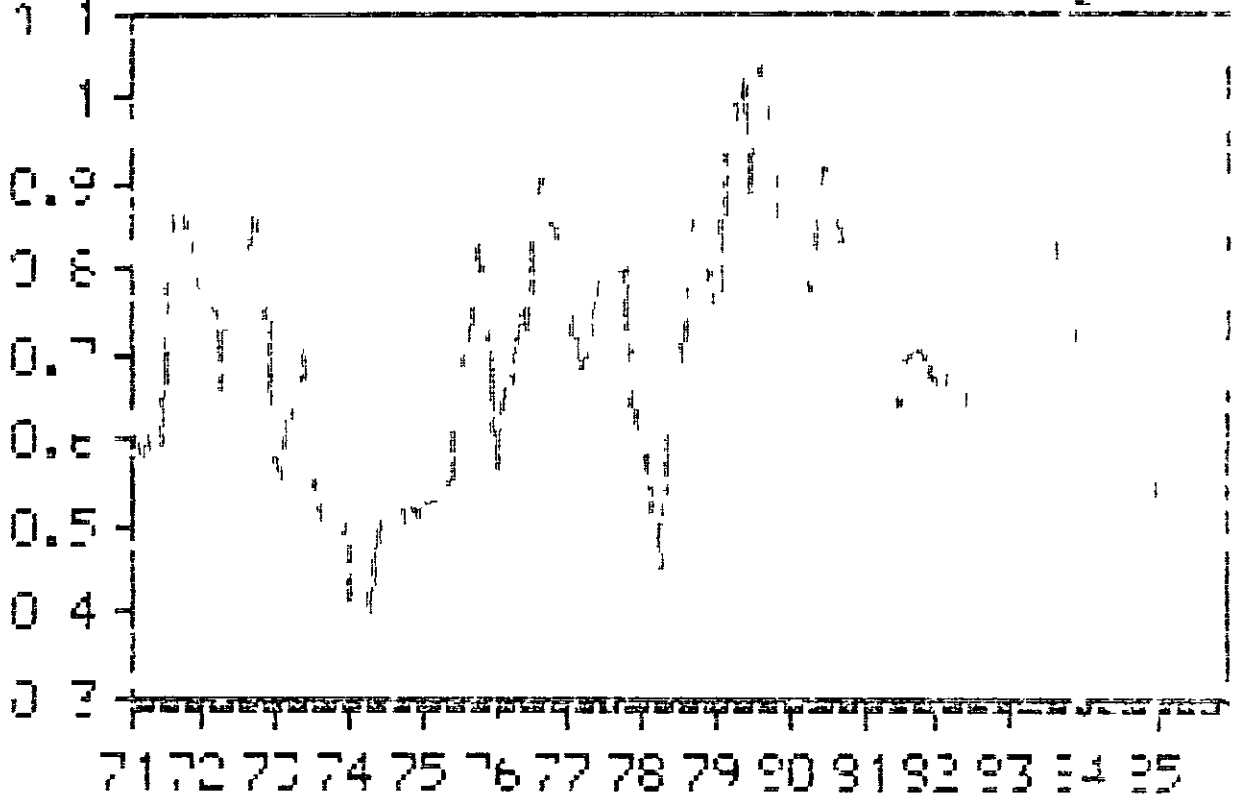


TABLE 7 27 Thailand Optimal Composition of Poultry Rations Derived in Least Cost Feed Formulation 1981-84

Ingredient	1981		1982		1983		1984	
	Price (Baht/kg)	Entry (%)	Price (Baht/kg)	Entry (%)	Price (Baht/kg)	Entry (%)	Price (Baht/kg)	Entry (%)
Cassava	1 91	9 6	2 11	0	2 51	0	1 70	25 0
Maize	2 91	45 8	2 87	56 7	3 15	56 7	3 08	25 3
Soybean Meal	7 74	21 4	7 46	14 4	7 46	14 4	7 50	24 9
Fish Meal	11 09	7 5	10 54	7 5	10 99	7 5	11 00	7 5

Note All ingredients are not shown here Kapok meal entered at a significant level in 1982 and 1983

Source Prices are wholesale Bangkok and are from the Office of Agricultural Economics the model was developed by CIAT

being based principally on the starch export market It is a mark of Thailand s ability to take optimum advantage of changes in international market conditions that with the GATT binding of the cassava tariff in 1968 creating a hole in the EEC s variable levy system Thai cassava exports could respond so rapidly Thus the Thai cassava boom should not be seen as uniquely determined by a favorable tariff rate in the EEC but equally important was the dynamism of upland agriculture and the additional land and labor resources that could be brought into production in response to profitable export markets

Thai success in cassava however has been at the expense of the EEC s political objectives The resulting voluntary export quota has created an air of uncertainty as Thailand has had to rapidly develop its own policy response and control procedures It is ironical indeed that Thailand's only policy intervention in the cassava sector is a negative one even though forced by the EEC The uncertainty however should not be interpreted as portending eminent decline in the cassava industry Rather a period of structural adjustment has been forced on the industry which in the end will lay the basis for more diversity in end markets and even more efficient production The short-run policy problem for Thailand has been to develop a policy that allows the country to capture the social profits earned in the EEC and to the extent possible to transfer these benefits to cassava producers especially in the Northeast The solution requires an analysis of alternative export markets and this is left till Chapter VIII Suffice it to say that Thailand has managed to make the adjustment and expand its export markets principally in East Asia Moreover root production has even increased during the quota period Future growth will be based on continued penetration of these new export markets

Nevertheless there has been downward pressure on farm-level prices under the quota and the more the need to export to third-country markets the more the downward pressure on root prices Over the past twenty years Thailand has significantly reduced cassava processing costs Farmers have also adjusted to rising labor costs by adopting labor-saving technologies What has not happened and what is becoming critical as root prices come down is the adoption of yield-increasing technology Yields have remained relatively constant over the past twenty years even though area has expanded into more marginal areas and fertilizer has not been used in traditional growing areas Under current monocropping conditions yields will eventually decline catching farmers in a cost-price squeeze A fertilization and soil management strategy that quarantees a profitable return is needed to complement improved varieties This will insure the ability of Thai cassava to compete in the wider feedgrain market allowing Thailand the required flexibility in restructuring its export markets Most important of all cassava will then have achieved parity with grains in international markets establishing a new claim for carbohydrate exports from the tropics a role palm oil has recently carved out in the world vegetable oil market

Appendix 7 1 A Synthesis of Production and Utilization

Cassava production has grown rapidly in the last two and a half decades with most of the root production being processed for export Domestic consumption of cassava is limited to starch and the occasional use of chips in animal feed concentrates Thailand should be a country therefore where cassava utilization and production data are relatively consistent

A production series is produced both by the Division of Agricultural Economics (DAE) and the Department of Agricultural Extension (AEX) both of which form part of the Ministry of Agriculture and Cooperatives Both the DAE and AEX maintained the same series through the 1968/69 crop year but diverged then when the DAE changed procedures In general the DAE series is most utilized in the literature and is the one reported by FAO Both series show the same basic upward trend but in any particular year can diverge by as much as 25%

Converting exports to a fresh weight basis and comparing this export series to the production series (Table 7A 1) shows that the production data tended to be consistently underestimated in the case of the AEX before 1973/74 and in the case of the DAE before 1982/83 Titapiwatanakun (1979) reviews this discrepancy in some detail and attributes the difference to a failure to accurately monitor the rapid expansion in area especially where cassava was being planted in more frontier-like conditions in the Northeast The DAE production series thus provides a relatively consistent underestimate of actual production and the export series probably provides a more accurate minimum estimate of actual production

The Ministry of Commerce has developed supply and utilization estimates for cassava (Table 7A 2) These clearly highlight the dominance of the export market but also identify a not unimportant domestic market for both starch and animal feed The other dominant component is the very high stock levels being held in this period The production estimate constructed from utilization data is about 11% larger than the DAE estimate of production Thus Thailand provides one of the few cases (Malaysia is the other) where cassava production tends to be underestimated

TABLE 7 A 1 Thailand Comparison of Root Production Series with Implied Production from Export Series 1960-85

Year	Agricultural Economics (000 t)	Extension (000 t)	Export Series (000 t)
1960	1083	1083	1109
1961	1222	1222	1706
1962	1726	1726	1298
1963	2077	2077	1341
1964	2111	2111	2089
1965	1557	1557	1864
1966	1475	1475	1850
1967	1892	1892	2265
1968	2063	2063	2487
1969	2611	2611	2684
1970	3079	2474	3645
1971	3431	2432	3169
1972	3114	3673	3575
1973	3974	4436	4995
1974	5443	7770	6554
1975	6765	9503	6238
1976	7094	11 638	9778
1977	10 230	13 554	10 242
1978	11 840	13 024	15 953
1979	16 358	12 877	10 023
1980	11 101	13 864	13 442
1981	16 540	17 204	16 160
1982	17 744	n a	20 147
1983	17 788	n a	13 718
1984	18 989	n a	17 014
1985	19 985	n a	18 812

Source Office of Agricultural Economics Ministry of Agriculture and Cooperatives and Department of Agricultural Extension Ministry of Agriculture and Cooperatives

TABLE 7 A 2 Thailand Supply and Disappearance of Cassava (fresh weight basis) 1984-85

	Fresh Root Equivalent (000 t)
Disappearance	
Domestic Consumption	
Starch	1 100
Animal Feed	625
Export	
Starch	2 435
Pellets and Chips	15 365
Change in Stocks	1 731
Total	21 256
Production	
Harvested	21 256
Unharvested	1 000
Total	22 256

Source Ministry of Commerce Bangkok