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PREFACE

On behalf of CIAT (Centro International de Agricultura Tropical, Cali, Colombia), and with the funding of IDRC (International Development Research Centre, Ottawa, Canada) this study was undertaken with the general remit:

- to assess the potential of the human, animal and industrial starch markets for cassava;
- to relate these markets to producing countries in general, and Brazil and Thailand in particular;
- to derive from the analyses economically-based priorities for the cassava research programme being mounted by CIAT.

This report is divided into three parts: the first contains the analyses of the three distinct markets for cassava which are reconciled with supply of cassava; the second deals with brief case studies of the position of cassava in the Brazilian and Thai economies; and the third catalogues some areas requiring research.

The methodology of the report is to apply those techniques of analysis, be they descriptive or quantitative, which appear to be best suited to the problem at hand and to the data available. Quantitative results are, when possible, validated by best available information. If the results are shown to be untenable, adjustments are made to the data and/or techniques in order to produce an analysis which approximates *a priori* expectations. Where quantitative results are considered to be fallacious, they are dropped from the analysis.

In many instances, this study is a compilation of ideas which arose from numerous discussions concerning cassava which the author had with researchers, traders, bankers, producer-processors, and officials of governments and international organisations. The

contributions of all these individuals are gratefully recognised. While it is not possible to identify all individuals who assisted with the project, the author would like to name some of those individuals who, in addition to giving their time to meet with author, kindly assisted with the arrangements of other meetings.

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A word of thanks to the women in my life: Doreen Nicklin and Judy Gartley of the School of Agricultural Economics and Extension Education, University of Guelph, and Anne Barnes, IDRC, who produced this report with a smile even under duress. Furthermore, Doreen is to be thanked for the order which she was able to wrought from my disorder.

Finally, my wife and best friend, Michelle, is to be thanked and credited with any success this report may achieve. Not only did Michelle pose thought-provoking questions and ideas during the course of the study, she compensated for my lack of linguistic ability by providing translating services in French, Italian, Spanish, Portuguese and Chinese, her only failure being an inability to speak Thai.

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Part I

ANALYSIS OF THE MARKETS FOR CASSAVA

Chapter I

INTRODUCTION

> "Cassava is apparently emerging from its obscurity in the Tropics and is marching northward and southward to fill new roles in temperate climates."
>
> Franklin W. Martin.

Cassava, manioc, tapioca, mandioca and *yuca* are common regional names* of the shrubby perennial tropical root crop Manihot esculenta Cranz. Cassava is thought to have originated in tropical Brazil, from where it spread to other parts of Latin America (archeologists have found traces of cassava dating as early as 800 BC on the Colombia-Venezuela border [1, p.259].**) and in post-Columbian times, to other regions of the tropics.

Today cassava is successfully grown in zones ranging from latitudes 30^{o} north and south and at elevations of up to 2,000 metres (6,500 feet); it is tolerant of temperatures of 18^{o}C (65^{o}F) to 35^{o}C (85^{o}F), precipitation of 50 to 500 milimetres (20 to 200 inches) [2, p.15], and soils with ph's of 5 to 9 [3, p.12].

This ecological zone, for the nonce the 'Cassava Belt', coincides roughly with many FAO Economic Class 2, or less developed, countries (LDCs). This belt accounts for 46% of world arable land, 47% of world population, and only 13% of world Gross Domestic Product (GDP) [4,5].

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*The plant is called cassava in English-speaking regions of North America, Europe and Africa. In French-speaking areas it is called manioc. It is referred to as tapioca in English-speaking parts of Southeast Asia, as mandioca in Brazil, and as yuca in Spanish-speaking regions of South America.

** Numbers in brackets refer to references (found at the conclusion of each chapter) and pages of cited literature.

Cassava production amounts to 57% of tropical root and tuber production while utilising only 54% of tropical root and tuber acreage [5]. The crop's pre-eminence in less developed tropical countries is explained by its aforementioned ecological adaptability and its appropriateness to the agricultural conditions which often obtain in the Cassava Belt. The main attributes which favour the production of cassava are:

1. It is easily propagated -- seeds or roots are not required, propagation being a simple matter of planting stalk cuttings.

2. It is relatively high yielding.

3. It is relatively inexpensive to produce -- it is easily planted and harvested and requires little or no weeding because of its leafy canopy; it does not have a critical planting or harvesting time, hence is not season-bound.

4. It is a good risk aversion crop -- its hydrocyanic acid content makes it subject to minimal animal and pest attacks; it is capable of growing on soils often considered too poor for other crops.

5. It is a reliable staple and an excellent producer of carbohydrates.*

These five attributes make cassava well suited to small scale, subsistence agriculture. Propagation of cassava by cuttings means that in terms of net yield, cassava is relatively more productive than grains and many other root crops which require witholding a proportion of seeds or tubers for future planting. Moreover, as a root crop, cassava is biologically more efficient than grain since it does not require an elaborate structure to support its edible portion (viz., 63-85% of dry weight of cassava is edible, compared with 36% for wheat [6, p.265]).

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*Coursey and Haynes [6, p.265] have calculated the production of kilocalories/hectare/day (khd) of some major crops to be: cassava, 250 khd; maize, 200 khd; rice, 176 khd; sorghum, 114 khd; and wheat, 110 khd.

The cost of cassava production is low -- lower perhaps than is commonly recognized because labour*, the main input, tends to be improperly costed at average wage rates. Since the crop is not season-bound, the farmer is able to undertake planting and harvesting after other more crucial tasks are completed and at times when his opportunity cost of labour is, if not zero, very low. Moreover, cassava's almost weed-free growth and resistence to drought, pest and disease** mean that labour and other requirements for nurture are minimal.

Cassava's high yields mean that whether it is grown as a staple or risk aversion crop, a relatively small land base is required for its cultivation. This last point requires qualification, however. The practice of leaving roots in the ground until required*** is space-consuming, and it is estimated that as much as 20% of total cassava acreage is used solely for root storage [8]. Thus, despite high yields, the small farmer may because of risk aversion, incur substantial costs in terms of lost production opportunities (although development of an alternative, inexpensive, space-economising method of storage could free land for profitable uses while providing producers with a stock of cassava).

Interestingly, despite these attributes, production of cassava has not been encouraged. Several commonly held but inaccurate beliefs account for this fact. First, cassava has historically been discounted

*Estimates of labour input for cassava production vary from 370 man-hours/hectare for 10 tons to 1,867 man-hours/hectare for 25 tons [10, p.226].

**Tropical crops are reported to be subject to five to ten times as many diseases as non-tropical crops. Cassava, however, is generally reputed for its resilience. One of its unique properties is that it does not appear to suffer from the ravages of migratory locusts [7].

***It is reported that mature roots may be left in the ground for up to two years without any serious deterioration.

as a human food because of its high starch, low protein content. Second, cassava is considered to be an inferior food (implying, in economic terms, a backward sloping (negative) income demand schedule). Third, cassava is regarded as a soil depleting crop. Fourth, it is looked upon as a low value crop, and fifth, it is believed to incur high production costs because of large labour requirements relative to value.

These five points, which have been responsible for a lack of interest in the crop on the parts of governments, investors, traders, and researchers, are certainly questionable if not completely misleading. For example, great attention has been given by research organisations and institutions to the study of protein sources to meet a predicted future world protein shortage. However, there are now indications that future food shortages in LDCs may, in fact, take the much more alarming form of a carbohydrate gap [9]. In this context, adaptable, resilient, high yielding starch sources, such as cassava, take on a new importance. The assumption that demand for cassava, as an inferior food, will decrease as incomes in LDCs increase overlooks the fact that more than half of FAO estimates of cassava income demand elasticities* are greater than zero! Cassava is often criticised for being a soil depleting plant. However, its ability to grow in areas too exhausted to support other crops is hardly an expected attribute of a soil depleter. Cassava's low value has been criticised. It is true that value per unit weight of cassava is low. However, high per unit land value, owing to high yield, does allow cassava to compete with other commercial crops (viz., in Thailand, where market forces primarily determine agricultural prices, cassava returns per unit land are lower only than kapok, tobacco and coconuts). And finally, as already argued, low or negligible opportunity costs of labour mean low, not high, production costs for cassava cultivation, where labour is the primary input.

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*Chapter II presents detailed examination of FAO income demand elasticities.

This study takes as its point of departure the present very interesting situation in which conventional wisdoms regarding cassava are confronted by emerging markets, new contexts and reassessments. The situation is economically and politically interesting because it, of necessity, invokes (hopefully accurate) speculation on future trends of cassava production and marketing. Most importantly, the situation is humanly interesting because it involves the food source and livelihood of many millions of people living within the Cassava Belt.

Nature of the Study.

This report examines three distinct markets for cassava:

- the human food market
- the industrial starch market
- the animal feed market in the European Economic Community.

Case studies of the Brazilian and Thai cassava economies are presented. Potential supplies of cassava are examined, and future demand for the crop is projected. Finally, recommendations regarding market potentials and research needs are forwarded.

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Chapter II

CASSAVA AS A HUMAN FOOD

> All modern methods for processing manioc roots derived from Indian methods, and the ancient processes are still employed in many parts of the tropics. In fact, some of the tapioca of commerce is prepared by methods very little improved over those used in South America before the arrival of the Europeans. The Indian then removed the prussic acid by leeching, rotting, and heating, or by various combinations of these processes, and produced four principal kinds of food products: meal, flour, starch, and a stock for sauces and soups.
>
> William O. Jones.

The role of cassava in the human diet is inextricably related to general world food conditions. This chapter therefore prefaces the analysis of the human demand for cassava by a discussion of the world food situation.

2.1 World Food Situation

This analysis concentrates on past and possible future trends in world demand for food.* The post-1960 demand for food may be considered to be a function of population, income, prices and food supply. Whilst all these factors are influential, emphasis is on the first two factors since 1) population and income are considered to be the most important in determining long-run consumption patterns; 2) price data are not available in most instances; and 3) discussion of global food supply exceeds the scope of this study.

a) Population

Population has been and is expected to be the major factor determining food demand, owing to the low income demand elasticities for food.

*The time horizon of this analysis is approximately 1960 to 1985, but a few futuristic statements regarding the possibilities for the end of this century will be made.

Ceteris paribus, "population demand elasticity" for all food equals 1, while income demand elasticities are normally less than 1, except for high protein foods in LDCs (Table 1). It is anticipated that between 1970 and 1985 "... half (of the increased demand for food) will be due to increase in population ..." [1]. In LDCs it is estimated that population growth will account for 70% of the increased demand for food. [1]. Table 2 indicates past population changes (since 1960) as well as expected future changes. Clearly, the substantial variability in population growth rates (viz., 0.8% in Western Europe compared with 2.9% in Latin American and the Near East) will alter the distribution of world population (see Figure 1 which compares 1960 population distribution with projected 2000 population). The major projected changes are that Asian and Latin American shares of world population will increase to 71% (their 1960 share was 64%); that Europe's (inclusive of USSR) share will decrease to 15% (21% in 1960); and that other regions will maintain approximately fixed shares in world population. Given the importance of population in determining the demand for food, indications are that Latin America and Asia will experience the greatest increases in food demand. The pressures in these two areas will be accentuated by income changes and initial food situations. The following sections address these two topics.

b) Income

Differences in per capita Gross Domestic Product (GDP) growth rates between LDCs and developed countries which existed in the past are expected to continue (Table 3), but LDCs are expected to increase their share of world GDP (Table 4). The large increases expected in LDC per capita GDP growth rate (Economic Class 2 growth rate increases from 2.5%, 1965-1970, to 4.0%, 1970-1980), will exert two forces on the demand for food in these countries. First, rapid GDP growth rate means

Table 13

Comparison of Projections of Production and Projections of Demand for Cassava

Country	(Linear Function) 1980 Projection of Production	1980 T Projection of Demand	Deficit Areas(*)
Argentina	304	118	
Bolivia	312	163	
Brazil	40733	7436	
Colombia	715	748	*
Ecuador	559	124	
Paraguay	2409	552	
Peru	668	561	
Venezuela	417	395	
Ceylon	538	396	
Taiwan	449	10	
India	7058	3922	
Indonesia	11413	14708	*
Thailand	3317	872	
Vietnam N.	567	315	
West Malaysia	430	102	
Philippines	605	824	*
Vietnam Rep.	283	315	*
Angola	2007	1399	

Table 12 (continued)

Country	Million Calories: Demand for Cassava	Million Calories: Requirement of Calories	Percent: Demand for Cassava as % of Requirement
Sudan	9,328,800	18,533,572.15	50.00
Rwanda	270,400	4,177,852.05	6.00
Tanzania	5,208,580	14,892,653.35	34.00
Togo	2,014,480	2,096,596.50	96.00
Uganda	3,728,140	9,601,730.15	38.00
Zaire	35,422,400	19,203,460.30	184.00
Zambia	686,140	5,099,163.15	13.00
Lat. America	36,632,400	327,251,670.80	11.00
Africa	119,800,720	316,637,208.00	37.00
Far East	72,054,840	1,079,404,447.90	6.00
World	241,670,000	3,982,811,182.90	6.00

Table 12 (continued)

Country	Million Calories Demand for Cassava	Million Calories Requirement of Calories	Percent Demand for Cassava as % of Requirement
Angola	4,728,620	5,414,504.90	87.00
Burundi	175,760	3,752,565.00	4.00
Cameroon	2,507,960	6,261,666.25	40.00
Cent. Af. Rep.	2,298,400	1,630,403.90	140.00
Chad	182,520	3,673,305.25	4.00
Congo (Braz.)	1,740,700	926,424.75	187.00
Dahomey	1,791,400	3,046,884.95	58.00
Equat. Guinea.		4,351,716.15	
Gabon	645,580	481,537.20	134.00
Ghana	5,722,340	10,358,550.35	55.00
Guinea	1,521,000	4,351,716.15	34.00
Ivory Coast	1,172,860	5,825,301.45	20.00
Kenya	1,977,300	12,772,193.15	15.00
Liberia	953,160	1,231,539.20	77.00
Madagascar	2,240,940	7,548,601.50	29.00
Mali	246,740	5,332,686.50	4.00
Niger	432,640	4,697,739.80	9.00
Nigeria	31,684,120	78,495,381.60	40.00
Senegal	686,140	4,088,361.35	16.00
Sierra Leone	287,300	2,627,565.65	10.00

Table 12

Projected (Caloric) Demand for Cassava Compared with Total Calorie Requirements, 1980

Country	Million Calories: Demand for Cassava	Million Calories: Requirement of Calories	Percent: Demand for Cassava as % of Requirement
Argentina	398,840	24,194,218.45	1.00
Bolivia	550,940	5,513,631.60	9.00
Brazil	25,133,680	108,343,406.25	23.00
Colombia	2,528,240	25,042,266.75	10.00
Ecuador	419,120	7,397,608.30	5.00
Paraguay	1,865,760	2,872,933.25	64.00
Peru	1,896,180	16,044,239.30	11.00
Venezuela	1,335,100	13,287,857.85	10.00
Ceylon	1,338,480	12,696,707.50	10.00
Taiwan	33,800	14,741,422.90	---
India	13,256,360	574,692,416.05	2.00
Indonesia	49,713,040	127,476,644.20	38.00
Thailand	2,947,360	39,244,741.60	7.00
Vietnam N.	3,281,980	21,805,428.50	15.00
W. Malaysia	344,760	9,799,217.05	3.00
Philippines	2,785,120	44,199,120.20	6.00
Vietnam Rep.	1,064,700	18,953,376.90	5.00

Table 11 (continued)

Note: The empirically derived elasticity estimates were based on the following mathematical relationships:

1. $\ln Y = a + b\ln x$ $\quad E = b$

2. $Y = a + b\ln x$ $\quad E = b/Y$

4. $\ln Y = a - b/x - c\ln x$ $\quad E = (b/x) - c$

where Y = per caput demand

x = per caput GNP or private consumer expenditure.

Table 11 (continued)

Country	Elasticity	Eq. No.	Country	Elasticity	Eq. No.
Tanzania	0.2	4	South Asia	-0.27	2
Uganda	0.1	4	Ceylon	-0.2	2
Zambia	-0.1	2	India	-0.3	2
Latin America	-0.18	2	East & S.E. Asia	-0.01	2
Cent. America	-0.04	2	Khmer Rep.	0.2	2
Costa Rica	-0.2	2	China (Taiwan)	-0.5	2
El Salvador	0.2	2	Indonesia	0.2	2
Carib. Islands	0.23	2	Laos	0.2	2
Cuba	0.2	4	Malaysia	0.22	2
Domin. Rep.	0.2	2	Sabah	-0.2	2
Haiti	0.3	4	Sarawak	-0.2	2
South America	-0.16	2	Philippines	-0.2	2
Argentina	-0.02	2	Singapore	-0.2	2
Bolivia	-0.02	2	Thailand	-0.2	2
Brazil	-0.02	2	Vietnam Rep.	0.21	2
Paraguay	-0.04	2	Econ. Class 3	0.23	2
Surinam	0.3	4	As. Cent. Pl. Econ.	0.6	2
Venezuela	0.1	2	China (Mainland)	0.07	2
Near East	0.01	2	Vietnam N.	0.2	2
N.E. in Africa	0.13	4			
Sudan	0.2	4			
Asia & Far East	-0.03	2			

Source: Meetings with Commodity and Trade Division, FAO, September, 1972.

Table 11

Income Demand Elasticities and Equational Form
Used in Estimation

Country	Elasticity	Eq. No.	Country	Elasticity	Eq. No.
World Total	0.023	4	Sierra Leone	0.3	2
Economic Class 1	-0.02		Togo	-0.1	2
EEC	-0.05		Upper Volta	0.2	2
Oth. West. Eur.	0.06		C. Africa	0.51	2
Economic Class 2	0.0	4	Angola	0.2	4
Africa	0.62	4	Cameroon	-0.1	2
West Africa	-0.26	2	Cent. Af. Rep.	-0.2	2
Dahomey	0.2	4	Chad	0.3	2
Gambia	-0.3	2	Zaire	0.7	4
Ghana	-0.1	2	East Africa	0.07	4
Guinea	-0.1	2	Burundi	0.2	2
Ivory Coast	-0.04	2	Ethiopia	0.2	2
Liberia	0.2	4	Kenya	0.3	4
Gabon	-0.3	2	Madagascar	0.2	4
Mali	0.4	2	Malawi	0.4	2
Niger	0.2	2	Mozambique	0.2	4
Nigeria	-0.2	2	Rwanda	0.3	2
Senegal	-0.2	2	Somalia	0.2	2

$$D_{cjt} = [D_{cjo} + \eta_j (\Delta Y_j / Y_{jo})] P_{jt} \qquad \ldots(1)$$

where D_{cjt} = demand for cassava at time t; η_j = income demand elasticity for cassava (Table 11); ΔY_j = change of income; Y_{jo} = income at initial period; P_{jt} = population at time t; and j = j^{th} country.

It should be noted from Table 11 that 57% of income demand elasticities, which range from -.40 to .70, are greater than zero, indicating that cassava is not in general an inferior food. Admittedly, the magnitudes of the income demand elasticities are small, but there is a quantitative difference between positive and negative income demand elasticities. As a result of the combined effect of population growth and income growth (in those countries with positive income demand elasticities) the 1980 demand for cassava as a food in the tropics is expected to be 33% greater than the 1970 demand for cassava (Table 10). Converted into calorie equivalents the 1980 demand for cassava is equivalent to 37% of the projected demand for calories in Africa, 11% in Latin America and 6% in the Far East (Table 12). Thus, the FAO projections indicate that cassava will continue to be a popular source of carbohydrates.

Demand projections, especially aggregate projections, cease to be meaningful if supply is not available. This is particularly true for cassava since in the tropics trade in the form of food has been virtually non-existent. The following section, therefore, examines the projected demand for and supply of cassava on a country by country basis.

a) Comparison of Projected Supply of and Demand for Cassava

Table 13 presents a comparison of the demand for and supply of cassava by major producing countries. The demand projections are the 1980T projections (Table 10). Supply projections for cassava were

Table 10 (continued)

Country	1970	1975T	1975H	1980T	1980H
Singapore	3	3	3	3	3
Thailand	686	776	763	872	842
Vietnam Rep.	243	276	276	315	316
Economic Class 3.	734	846	862	971	1007
Asian Cent. Pl. Econ.	734	846	862	971	1007
Vietnam N.	734	846	862	971	1007

Source: Correspondence with Commodities and Trade Division of FAO, Rome, September, 1972.

*T represents a projection of past trends, and H represents 'high' alternatives based on targets established by the UN and its Regional Commissions for the Second UN Development Decade.

**See Chapter V for an adjustment of these figures.

Table 10 (continued)

Country	1970	1975T	1975H	1980T	1980H
Paraguay	416	477	472	552	534
Peru	396	476	477	561	561
Surinam	2	2	3	3	3
Venezuela	279	333	334	395	399
Near East	1978	2330	2330	2760	2754
Near East and Africa	1978	2330	2330	2760	2754
Sudan	1978	2330	2330	2760	2754
Asia and Far East	16422	18696	18667	21318	21154
South Asia	3529	3935	3876	4325	4183
Ceylon	333	365	364	396	393
India	3191	3563	3505	3922	3783
East-S.E. Asia	12893	14762	14791	16993	16971
Burma	7	7	7	8	8
Khmer Rep.	22	25	25	29	29
(China) Taiwan	12	11	11	10	9
Indonesia	11158	12771	12815	14708	14717
Laos	9	11	11	12	12
Malaysia	91	103	103	117	114
West Malaysia	81	91	90	102	100
Sabah	4	5	5	6	6
Sarawak	6	7	7	9	9
Philippines	581	690	690	824	824

Table 10 (continued)

Country	1970	1975T	1975H	1980T	1980H
Zambia	151	174	172	203	197
Latin America	8492	9593	9524	10838	10651
Central America	87	103	103	123	123
Costa Rica	11	13	13	15	15
El Salvador	10	13	13	15	15
Guatemala	6	7	7	8	8
Honduras	29	34	34	41	41
Nicaragua	15	18	18	21	21
Panama	16	19	19	23	23
Carib. Islands	464	527	529	598	595
Cuba	182	202	202	221	212
Domin. Rep.	121	146	146	175	177
Haiti	113	127	128	145	149
Jamaica	7	8	8	8	8
Puerto Rico	5	6	6	6	6
South America	7941	8963	8892	10117	9933
Argentina	109	114	113	118	116
Bolivia	124	142	142	163	164
Brazil**	5966	6658	6591	7436	7267
Colombia	548	642	642	748	748
Ecuador	89	105	105	124	124
Guyana	10	12	12	14	14

Table 10 (continued)

Country	1970	1975T	1975H	1980T	1980H
Senegal	164	183	183	203	203
Sierra Leone	67	75	76	85	87
Togo	457	519	516	596	589
Upper Volta	27	31	31	35	36
Central Africa	10953	12532	12613	14198	13889
Angola	1224	1314	1308	1399	1368
Cameroon	598	663	661	742	783
Central Af. Rep.	533	600	597	680	671
Chad	47	49	50	54	57
Congo (Braz.)	437	473	473	515	512
Gabon	181	185	178	191	179
Eastern Africa	5769	6507	6492	7358	7241
Burundi	42	47	47	52	53
Kenya	458	522	508	585	533
Madagascar	510	580	580	663	665
Malawi	128	151	154	181	185
Mozambique	2335	2581	2581	2857	2849
Rwanda	58	68	68	80	81
Somalia	19	22	22	26	26
Tanzania	1168	1338	1337	1541	1525
Uganda	848	965	962	1103	1060
Zaire	7824	9125	9221	10480	10231

Table 10

Projected Demand for Cassava Given High and Low Growth Assumptions (1000 Metric Tons)

Country	1970	1975T*	1975H*	1980T	1980H
World Total	55087	62736	62657	71500	70460
Economic Class 1	7	8	8	8	8
Western Europe	7	8	8	8	8
Other W. Europe	7	8	8	8	8
Portugal	7	8	8	8	8
Economic Class 2	54346	61883	61788	70521	69446
Africa	27328	31121	31124	35444	34727
Western Africa	10606	12081	12019	13888	13596
Dahomey	401	459	459	530	525
Gambia	6	6	6	7	7
Ghana	1240	1445	1445	1693	1689
Guinea	356	398	395	450	437
Ivory Coast	340	345	326	347	316
Liberia	234	260	228	282	217
Mali	57	64	65	73	75
Niger	93	108	110	128	130
Nigeria	7088	8109	8102	9374	9204

foods, especially frozen dinners; as a gelling agent in a number of 'convenience foods' and quick setting puddings; or as a binder in sweets and candies.

In the tropics it has been estimated that cassava is the staple food of approximately 200 million people [3]. As an estimate of the number of people who derive their basic source of carbohydrates from cassava, this estimate appears to be overstated if Food Balance Sheets are a good approximation of consumption. Food Balance Sheet information on cassava consumption [4] and cassava production data [5] suggests that cassava provides 13.5% of the calorie requirement in Africa; 3.5% in Latin America, and 2.3% in the Far East. These percentages represent a theoretical maximum of the percentage of people who completely derive their calories from cassava -- in 1970 this represents approximately 73 million people*.

If cassava maintains its relative position in the increasing demand for food, there will be a growing demand for cassava in the future. However, it is future populations and incomes which will largely determine the eventual demand for cassava** as well as for all other foods, and thus the relative importance of cassava may change.

Future demand estimates for cassava derived from Equation 1 are presented in Table 10.

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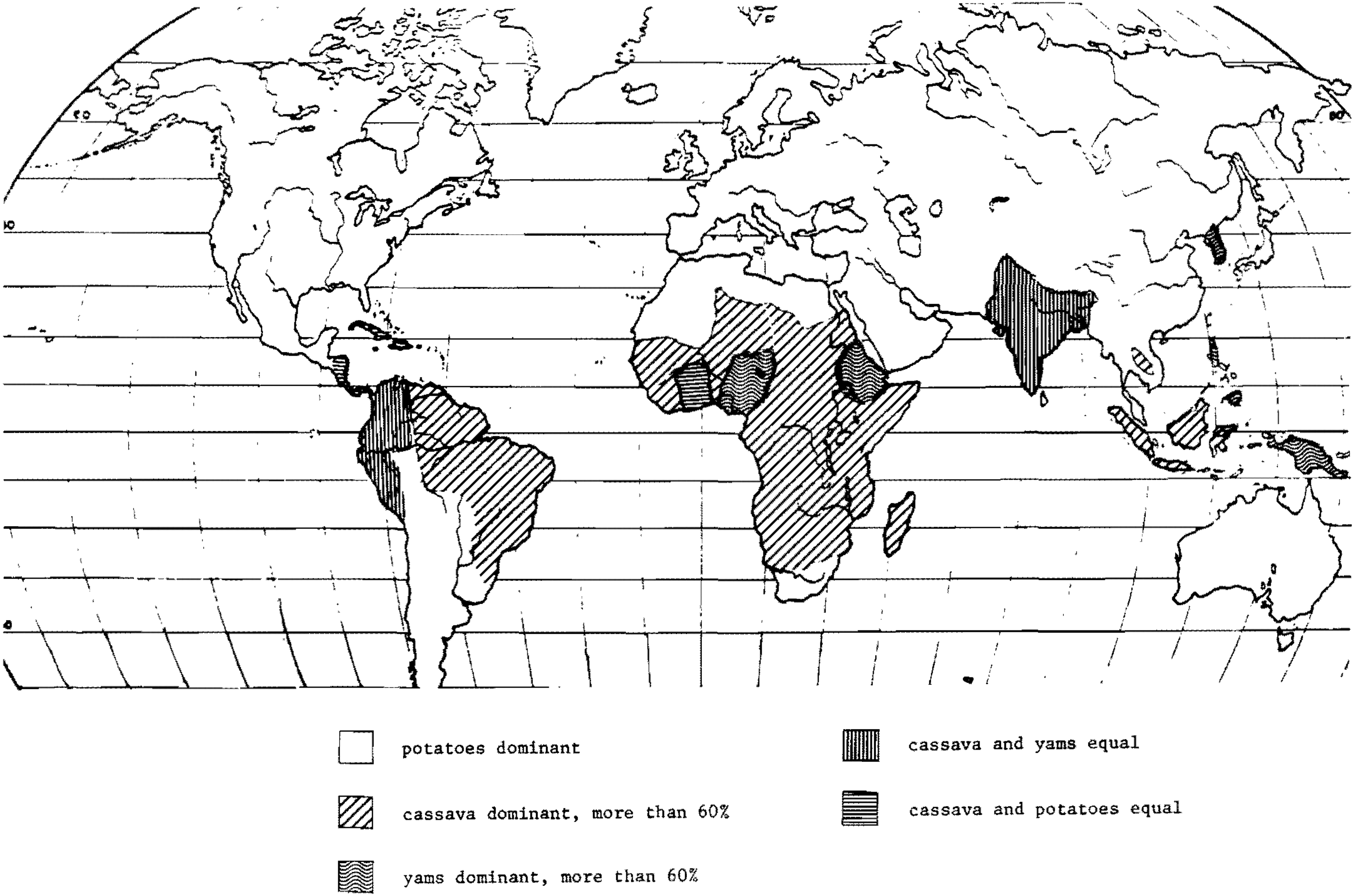
*The calculation entails summing the product of regional population (Table 2) and percentage of cassava in the diet. If a major staple is defined as providing 50% of caloric requirement then cassava could be a major staple for 146 million people.

**Price and relative prices will also affect the future demand for cassava, but there is little information upon which to estimate future prices. Thus the analysis is carried out on the basis that present price relativities are indicative of future conditions, or at least that cassava prices will not increase relative to other prices.

Fig. 3 AREAS OF IMPORTANCE FOR SPECIFIC ROOT CROPS



in this supply and demand balance is the ability of LDCs to produce sufficient calories. The single most important tropical root crop in terms of caloric production is cassava. The following sections examine the role which cassava may be expected to play in the future diet of populations in the Cassava Belt.

2.2 Cassava in the Human Diet

An indication of the importance of cassava in LDCs is derived from Figure 3 which indicates the countries which derive 60% or more of roots and tuber production from cassava, potatoes or yams. Clearly, in the tropical regions cassava is a ubiquitous crop.

The form in which cassava is consumed varies by country and region. In Africa cassava is universally consumed as a vegetable for baking or boiling, or in the form of pastes or mushes made from cassava flour. Other regional preferences encompass consumption of leaves, and pastes made from fermented roots (East Africa). Tapioca, fufu (made from pounded, boiled roots) and gari (dried, grated, fermented cassava) are basic dietary elements in West Africa [2, Ch.5] .

In South America cassava is eaten as a vegetable or in soups after being soaked overnight or cooked. In Brazil it is processed into a flour (farinha de mandioca) which is served as a complement to main courses, or boiled to produce a mush (farofa). In Colombia cassava flour is mixed with cheese and other flours to produce the popular pan de bono. It is also cooked in sugar syrup and served as a dessert; or fermented to make beer. In Indonesia cassava is used to make a flat bread with dried fish as an added component.

Cassava constitutes an insignificant proportion of carbohydrate intake in North America and Europe, where it is consumed as a dessert (tapioca pudding); used as a thickening agent in gravies of frozen pre-packaged

Fig. 2 AREAS WITH MORE THAN 100 CALORIES PER DAY DEFICIT

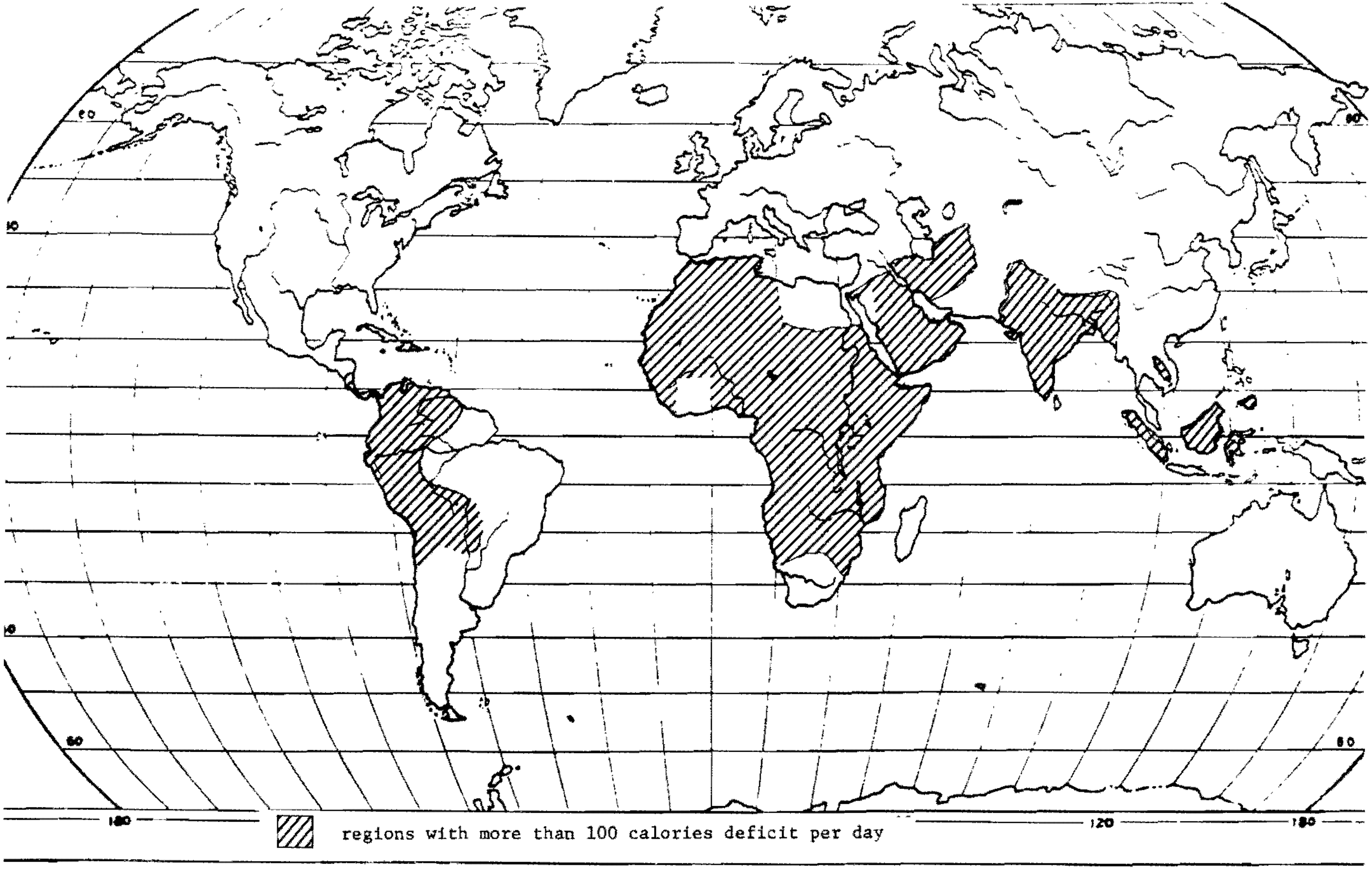


Table 9

Projected Food Supply in 1980.

Region	Total Cals.	Cal. Intake as % of Req.	Percent Cals. From Cereals & Starchy Staples	Grms. Total Prot.	Prot. Intake as % of Req.	Percent Prot. From Animal Source
World	2499	105	67.5	69.0	178	33.6
Econ. Class 1.	3111	122	45.6	92.8	237	62.0
North America	3301	125	38.4	99.0	249	73.3
Western Europe	3128	122	45.1	92.3	231	59.0
Oceania	3302	124	41.9	101.4	261	69.8
Other. Dev. Mkt. Econ.	2718	115	62.5	82.4	227	46.2
Econ. Class 2.	2307	101	74.6	59.5	155	21.8
Africa	2280	98	78.9	61.9	149	17.5
Latin America	2616	110	62.9	67.5	179	39.5
Near East	2472	101	71.1	69.4	153	22.4
Asia & Far East	2200	99	78.0	54.8	150	16.9
Oth. Dev. Mkt. Econ.	2525		71.6	72.8		29.2
Econ. Class 3.	2466	102	72.2	71.0	183	28.6
As. Cent. Pl. Econ.	2195	93	78.9	62.4	163	17.3
USSR & East Europe	3227	126	59.4	95.1	238	49.4

America,* and daily protein standards ranging from 36.6 grams per capita in the Far East to 45.5 grams per capita in the Near East. With daily World averages of 2400 calories and 38.7 grams protein, world food consumption in 1970 at the aggregate level represented 101% of calorie and 173% of protein requirements [1]. However, for LDCs food consumption provided only 96% of calorie requirements and 147% of protein requirements. Only in Latin America was food consumption sufficient to meet calorie requirements (106%). As might be expected, aggregation conceals national differences. For example, in South America only Argentina, Brazil, Chile, Paraguay, Uruguay and Venezuela consume within 100 calories per day of requirements (Figure 2).

It is projected that the apparent caloric shortage in LDCs will be overcome on average by 1980 (Table 9), but Africa and the Far East are expected to continue to consume below requirements. The increased per capita caloric consumption in LDCs implies a 3.6% year increased demand for food -- the rate in developed countries is 1.7%.

In summary, both the nutrition and the consumer points of view lead to the prediction that the demand for food in 1980 will increase more rapidly in LDCs than in developed countries. One implication of this greater increase is that agricultural production must grow more rapidly in LDCs if this food demand is to be met. Unfortunately, projections based on past trends indicate that the growth of agricultural production in LDCs will not match demand. However, movement to increased application of fertilizer, and to higher percentage of land devoted to arable crops could improve the production growth rate. In any event, it appears that in the coming years LDCs will have the substantial task of trying to meet consumption demands and nutrition requirements. A crucial element

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*Prior to April 1971 the daily adult reference calorie requirements were 3200 calories for men and 2300 for women; the revised standards, resulting from a 1971 FAO/WHO meeting, were 3000 for men, and 2200 for women. Protein requirements were reduced from .71 gramme per kilogramme to .57 gramme per kilogramme for men and .51 gramme per kilogramme for women. [1, Vol. I, p. 45].

Table 8

Regional Shares of World Agricultural Production

	Total Agr. Prod. 1960	1970	1980	Food and Feed 1960	1970	1980
World	100.0	100.0	100.0	100.0	100.0	100.0
High Income Count.	70.9	70.1	67.5	72.3	71.5	69.0
North America	24.2	21.7	20.8	24.5	22.3	21.5
Western Europe	19.2	19.1	17.9	20.3	20.0	18.7
Oceania	3.0	3.1	3.2	2.1	2.3	2.4
Other Dev. Mkt. Econ.	3.6	4.3	4.4	3.8	4.5	4.6
USSR & Eastern Europe	20.9	21.9	21.2	21.6	22.4	21.8
Developing Countries	29.1	29.9	32.5	27.7	28.5	31.0
Latin America	7.8	8.2	8.9	6.9	7.6	8.3
Africa	4.2	4.1	4.5	4.1	3.9	4.3
Near East	3.9	4.0	4.4	3.7	3.7	4.1
Asia and Far East	13.2	13.6	14.7	13.0	13.2	14.3

Source: Agricultural Commodity Projections 1970-1980, FAO, Rome, 1971.

Table 7

Past and Projected Gross Agricultural Production

	1980 Index Numbers. 1970=100 of Projected Prod. Total	Per caput	Annual Compound Rates of Growth Total Production 1959-69 Actual	1970-80 Proj.	Per Caput Prod. 1959-69 Actual	1970-80 Proj.
World	128	104	2.7	2.5	0.5	0.4
High Income Count.	123	111	2.5	2.1	1.3	1.1
Dev. Mkt. Econ.	123	111	2.3	2.1	1.2	1.0
USSR & E. Europe	124	112	3.1	2.1	2.0	1.2
Developing Count.	139	106	2.9	3.3	0.3	0.6
Latin America	138	104	3.3	3.3	0.4	0.4
Africa	139	106	2.4	3.4	0.1	0.6
Near East	141	106	2.9	3.5	0.2	0.6
Asia and Far East	139	107	2.9	3.3	0.3	0.6
Asian Cen. Pl.Econ	129	104	...	2.5	...	0.5

Source: Agricultural Commodity Projections 1970-1980, FAO, Rome, 1971

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Table 6

Fertilizer Consumption, 1970-71
(100 metric tons)

Region	Commercial Nitrogenous Fertilizer	Commercial Phosphate Fertilizer	Commercial Potash Fertilizer	Total Fertilizer Consumption	% Distn. of Fertilizer Cons. Regions.	Fert. Consumption/ Arable and Tree Crop Acre (kg/ha)
World	316077	198232	165380	679689	100.00	47
Western Europe	96748	78240	74846	249834	36.75	250
North America	74765	46282	39929	160979	23.68	73
Latin America	14073	9482	6905	30460	4.48	26
Near East	8003	3228	371	11602	1.70	14
Far East	40187	17284	12383	69854	10.27	26
Africa	4752	5210	2342	12304	1.81	7
Oceania	1629	10666	1954	14249	2.09	32
USSR	46050	22100	25850	94000	13.82	20
China (Mainland)	29870	5740	800	36410	5.35	33

Source: Production Year Book, FAO, 1971

in agricultural production. With respect to Africa and Latin America, however, low per unit productivity, relating to extensive farming practices (in particular, negligible application of fertilizer* (Table 6)) is a main obstacle to increased production.

As a consequence of low productivity and unfavourable man-land ratios, LDCs in 1970 accounted for only 30% of world agricultural production (Tables 7 and 8). While it is predicted that LDCs will increase their share of world production, it is obvious that their levels of production will not only be substantially below that of developed countries but also below self-sufficiency. Given accelerated applications of fertilizer, LDCs may be expected to account for a larger share of world production. Nevertheless, it must be anticipated that they will remain deficit regions in terms of both production and nutrients, as will be shown.

d) Requirements and Demand for Food

The world food requirements may be viewed from the nutrition or the consumer point of view. Consumer demand for food, while determined in part by protein and caloric requirements, is greatly influenced by cultural practices and beliefs, prices, and income. On the other hand, nutritionists often equate demand for food with requirements for food, requirements being determined on the basis of regional temperatures, body weight of individuals, age and sex distribution of population.

Such calculations result in daily caloric standards ranging from 2223 calories per capita in the Far East to 2560 calories per capita in North

*The low level of fertilizer application in all LDCs is perhaps a reflection of poor agricultural practices; it can also be accounted for by limited supplies and high prices of fertilizers, which are often driven up not by market forces but by the pricing policies of firms which wish to cover investments quickly, or import policies.

Table

Table 5

Land Utilisation and Distribution by Economic Classes and Regions 1970 (1000 ha.)

	Arable Land + Land Under Tree Crops	Permanent Meadows + Pasture	All Other Land	World Share of Agric. Land	Land-Man Ratio*
World	1,432,000	3,059,000	8,900,000	13,391,000	1.21
(%)	*10.69*	*22.84*	*66.46*	*100.00*	
Economic Class 1	383,000	913,000	2,019,000	3,315,000	1.78
(%)	*11.55*	*27.54*	*60.90*	*28.85*	
North America	220,000	280,000	1,468,000	1,968,000	2.20
(%)	*11.17*	*14.22*	*74.59*	*11.13*	
Western Europe	100,000	78,000	213,000	391,000	0.50
(%)	*25.57*	*19.94*	*54.47*	*3.96*	
Oceania	45,000	463,000	287,000	795,000	33.87
(%)	*5.66*	*58.23*	*36.10*	*11.31*	
Other Dev. Mkt. Econ.	18,000	92,000	51,000	161,000	0.85
(%)	*11.18*	*57.14*	*31.67*	*2.04*	
Economic Class 2	655,000	1,435,000	4,495,000	6,585,000	1.19
(%)	*9.94*	*21.79*	*68.26*	*46.53*	
Africa	181,000	729,000	1,472,000	2,382,000	3.23
(%)	*7.59*	*30.60*	*61.79*	*20.26*	
Latin America	119,000	505,000	1,432,00	2,056,000	2.20
(%)	*5.78*	*24.56*	*69.64*	*13.89*	
Near East	84,000	169,000	951,000	1,204,000	1.51
(%)	*6.97*	*14.03*	*78.98*	*5.63*	
Asia & Far East	269,000	31,000	597,000	897,000	0.29
(%)	*29.98*	*3.45*	*66.55*	*6.68*	
Other Dev. Mkt. Econ.	2,000	1,000	43,000	46,000	0.75
(%)	*4.34*	*2.17*	*93.47*	*0.06*	
Economic Class 3	394,000	711,000	2,386,000	3,491,000	0.90
(%)	*11.28*	*20.36*	*68.34*	*24.60*	
Asian Cen. Pl. Econ.	114,000	322,000	713,000	1,149,000	0.49
(%)	*9.92*	*28.02*	*62.05*	*9.70*	
USSR & East. Europe	280,000	389,000	1,673,000	2,342,000	1.92
(%)	*11.95*	*16.60*	*71.43*	*14.89*	

Source: Production Yearbook, FAO, 1971

*Land-man ratios (hectares per caput) are expressed in terms of agricultural land per individual (arable land and land under permanent crops plus permanent meadows and pastures).

that the income demand elasticity effect* will be greatest in LDCs. Second, this rapid increase in income could alter consumer preferences. Whilst estimates of cross-elasticities of some food items are available, it is argued here that confidence in projected changes in diet must be low since projected values are outside the original range of observations. It is possible that income demand elasticities for food will decline sharply as soon as diets are subjectively adequate (from the consumer's point of view), and that income demand elasticities for other goods and services will increase. This being the case, the change in diets will not be as great as indicated by either existing income elasticities or consumption patterns in developed countries, which LDCs are assumed to emulate. In fact, income disparities between developed and less developed countries are such that emulation is impossible, and it is suggested that the tendency to copy the food habits of developed countries is relatively low in the aspiration hierarchies of LDCs. A further inhibitor to radical changes in diets is the unavailability of a wide range of foods.

Two of the main factors upon which production depends, land and fertilizer, are now discussed.

c) Land

While LDCs, in terms of population, have a relatively small proportion of world agricultural land (Table 5), this condition owes primarily to the high population densities in Asia. Africa and Latin America, in fact, appear to have per capita land resources comparable to North America and substantially greater than Europe. Thus, where Far East Asian countries are concerned, land is a clearly identifiable constraint to rapid increases

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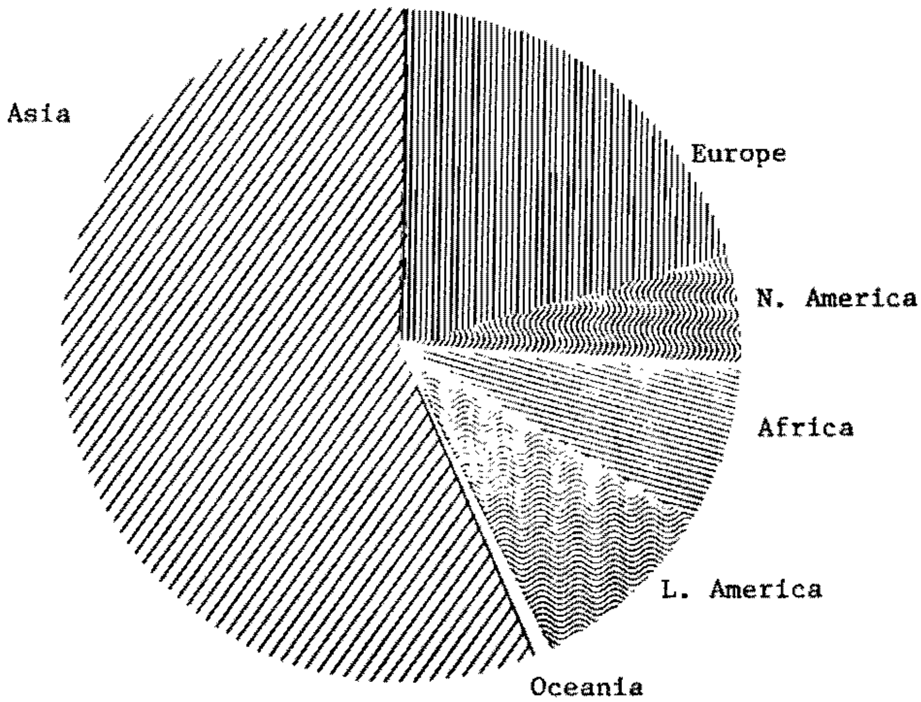
*Income demand elasticity is defined as the percentage change of consumption which results from a percentage change in per capita income. Income demand elasticity effect is, therefore, the amount by which per capita consumption increases for a given growth rate of per capita GDP. Since LDCs in general have higher income elasticities (Table 1) and higher income growth rates, they will have a proportionally higher growth rate in the demand for food than developed countries.

Fig. 1 WORLD POPULATION DISTRIBUTION, 1960 AND 2000

1960



2000

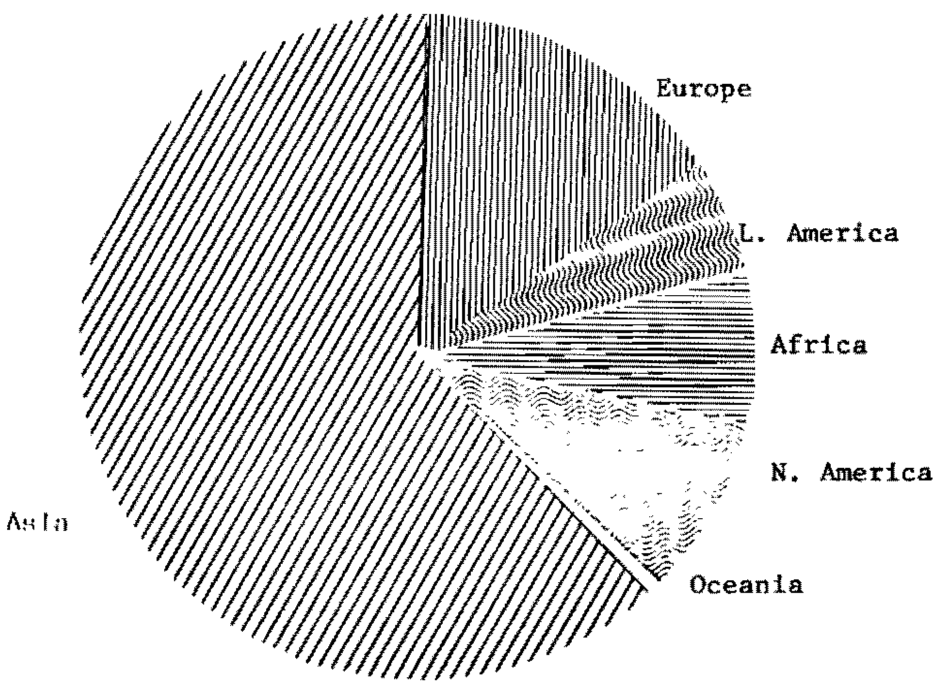


Table 4

Percentage Distribution of Gross Domestic Product
by Economic Classes and Regions

Region	1960	1970	1980
World	100.00	100.00	100.00
Economic Class 1	70.09	69.08	67.24
North America	38.73	35.46	31.61
Western Europe	25.51	24.72	23.13
Oceania	1.42	1.45	1.49
Other Dev. Mkt. Econ.	4.42	7.44	11.00
Economic Class 2	12.89	12.90	14.45
Africa	1.51	1.32	1.37
Latin America	5.13	5.15	5.90
Near East	1.62	1.92	2.25
Asia and Far East	4.58	4.45	4.87
Other Developing Mkt. Econ.	0.04	0.04	0.04
Economic Class 3	17.00	18.00	18.30
Asian Cent. Pl. Econ.	3.56	2.86	2.64
USSR & Eastern Europe	13.43	15.14	15.65

Source: Derived from Table 2.

Table 3

Per Caput Gross Domestic Product at 1970 Constant Market Prices, by Economic Classes and Regions, Past and Projected Levels

Region	1960	1970	1980	Percent Per Year Comp. 1965-1970 Annual Rates of Growth	1970-1980
World	599	803	1111	3.0	3.4
Economic Class 1	1960	2838	4245	3.6	4.2
North America	3547	4674	6333	2.4	3.2
Western Europe	1423	2076	3066	3.6	4.0
Oceania	2037	2830	4055	4.2	3.7
Other Dev. Mkt. Econ.	710	1719	3747	10.4	8.3
Economic Class 2	173	219	319	2.8	4.0
Africa	125	140	188	1.5	3.0
Latin America	438	543	797	2.5	4.0
Near East	230	344	515	4.2	4.2
Asia and Far East	105	130	186	2.8	3.8
Other Developing Mkt. Econ.	231	299	400	3.3	3.0
Economic Class 3	301	437	636	4.3	3.9
Asian Cent. Pl. Econ.	91	97	124	1.0	2.6
USSR & Eastern Europe	782	1299	2071	5.9	4.9

Source: Agricultural Commodity Projections 1970-1980, Vol. II, FAO, Rome, 1971.

Table 2

World Population by Economic Classes and Regions: Past and Projected Levels (Millions)

Region	1960	1970	1980	1970-1980 Growth % per yr. Compound	1965-70
World	3038	3719	4575	2.1	2.0
Economic Class 1	651	727	805	1.0	1.0
North America	199	227	254	1.1	1.1
Western Europe	326	356	384	0.8	0.8
Oceania	13	15	19	2.0	1.8
Other Dev. Mkt. Econ.	113	129	149	1.4	1.4
Economic Class 2	1358	1760	2306	2.7	2.7
Africa	221	282	372	2.8	2.6
Latin America	213	283	376	2.9	2.9
Near East	128	167	223	2.9	2.7
Asia and Far East	793	1023	1330	2.6	2.6
Other Dev. Mkt. Econ.	3	4	5		
Economic Class 3	1029	1232	1464	1.7	1.8
Asian Centrally Pl. Econ.	717	884	1079	2.0	2.1
USSR Eastern Europe	313	348	384	0.9	0.9

Source: Agricultural Commodity Projections 1970-1980, Vol. II, FAO, Rome, 1971.

Table 1

Income Elasticities for Specified Food Groups by Selected Subregions Ranked in Declining Order of Per capita Income, 1960-62

Subregion	Per capita Income	Cereal	Vegetables	Milk	Meat	Eggs	Fish
	$ U.S.						
U.S.	2,342	0.5	0.25	0.05	0.35	0.0	0.3
Canada	1,482	0.5	0.35	0.10	0.40	0.15	0.3
Japan	395	0.17	0.5	2.0	1.7	1.0	0.5
River Plate	365	0.3	0.6	0.4	0.15	0.1	0.4
Brazil	211	0.15	0.5	0.9	0.7	1.0	0.6
S. Africa	360	0.1	0.5	0.6	0.5	0.5	0.6
N. Africa	112	0.20	0.6	1.0	1.2	1.2	1.0
India	69	0.5	1.0	1.7	1.4	2.2	1.5
Pakistan	69	0.5	0.9	1.7	1.6	2.2	1.5
Indonesia	82	0.5	0.9	3.0	1.6	2.0	1.0

Source: USDA, World Food Budget, 1970

Table 13 (continued)

Country	(Linear Function) 1980 Projection of Production	1980 T Projection of Demand	Deficit Areas(*)
Burundi	2087	52	
Cameroon	1308	742	
Cent. Af. Rep.	1084	680	
Chad	58	54	
Comoro Is.	179		
Congo (Braz.)	92	515	*
Dahomey	854	530	
Equat. Guinea	47		
Gabon	146	191	*
Ghana	2395	1693	
Guinea	545	450	
Ivory Coast	393	347	
Kenya	650	585	
Liberia	351	282	
Madagascar	1338	663	
Mali	197	73	
Niger	300	128	
Nigeria	6945	9374	*
Senegal	249	203	
Sierra Leone	78	85	*
Sudan	163	2760	*

Table 13 (continued)

Country	(Linear Function) 1980 Projection of Production	1980 T Projection of Demand	Deficit Areas(*)
Rwanda	566	80	
Tanzania	1737	1541	
Togo	1801	596	
Uganda	3530	1103	
Zaire	8145	10480	*
Zambia	153	203	*
Lat. America	48042	10838	
Africa	37107	35444	
Far East	26357	21318	
World	110581	71500	

estimated from time trend functions which regressed production of cassava on time (Equation 2), since desired economic production data were not available.

$$S_{ct\ t} = \alpha + \beta t \qquad \ldots(2)$$

where $S_{ct\ t}$ = production of cassava at time t, expressed in linear and logarithmic term, and t = time (data from 1955 to 1971 inclusive, were used).

As a check on production projections, acreage and yield were also projected*, their product being compared with the production projections. If large descrepancies existed between projected production and the product of acreage and yield, data and/or projections were altered to more closely reflect what appeared to be the realities of the situation. (Appendix A, Tables A.1 and A.2 contain summaries of the projection equations and projections, respectively). A comparison of supply and demand projections reveals that if present patterns continue, several tropical countries are expected to have cassava deficits, notably Colombia. Indonesia, Philippines, Vietnam Republic, Congo Brazzaville, Gabon, Nigeria, Sierra Leone, Sudan, Zaire and Zambia. Such deficits indicate that food (calorie) shortage may be critical in these countries. On the other hand, several countries are expected to have large surpluses, notable Brazil, Paraguay, Taiwan, India, Thailand, Angola, Burundi, Madagascar, Togo, Uganda and China.

A cassava deficit would be expected to increase the cassava selling price, and as such may result in increases in supply which could erase

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*The acreage and yield equations were similar to Equation 2, viz.,

$$A_t = \delta' + \beta' t$$

$$Y_t = \delta' + \beta' t$$

when A_t = acreage at time t; Y_t = yield at time t (both A and Y are expressed in linear and logarithmic terms); and t = time.

the deficit. In fact, the deficits appear to be inadequacies of supply rather than an excessively large increase in demand. Another alternative is that forseeable food shortages will be avoided by government policies which will affect the forces limiting the supply of food.

Countries with projected surpluses of cassava can consider the possibility of exporting cassava as an industrial starch or animal feed; or utilising cassava domestically in food processing, industry and mining, and livestock rearing. Surpluses of cassava may be maintained only if the alternative markets for cassava are viable and realisable. The exploitation of such markets will in many instances require a concerted effort on the parts of producers, processors and governments. It is therefore not surprising that a number of countries with actual or projected surpluses have requested assistance from the United Nations Development Programme and/or World Bank in carrying out feasibility studies on the potential of exporting cassava [7]. This study's findings on these matters are discussed in subsequent Chapters.

b) Recapitulation

The *ex post* analysis of the World food situation and the role of cassava in human diets leads to the following observations and conclusions:

. the demand for food will increase more rapidly in LDCs than in developed countries;

. LDCs particularly Africa and the Far East, could be faced with a carbohydrate shortage;

. Africa and Latin America appear to have a sufficient agricultural land base to meet future demands if productivity is increased;

. the Far East is faced with an agricultural land constraint if a high degree of self-sufficiency is desired;

. cassava is not an inferior food in 57% of the countries for which estimates are available;

. LDCs will consume more cassava in the future;

- . cassava will increase its importance in the human diet (e.g., in Africa, Latin America, and Far East, 37% 11% and 6% of calories, respectively, are expected to derive from cassava by 1980). At these rates cassava could supply 500 million people with half of their required calories;
- . Africa as a continent will be deficit in cassava by 1980, Nigeria having the greatest deficit in per capita terms;
- . Latin America and the Far East will have surpluses of cassava with the greatest amounts occurring in Brazil and Thailand.

These findings need to be viewed in terms of new developments, the effects of which, whilst difficult to quantify, may alter the present findings. The next section addresses some of their implications for human demand for cassava.

2.3 Human Demand for Cassava: Other Factors

Four factors which may influence future utilisation of and demand for cassava are a) concern over its hydrocyanic acid content (HCN); b) changes in production practices; c) its low protein content; and d) development and commercialisation of new food products utilising cassava.

a) Hydrocyanic Acid

HCN content, once thought to be a distinguishing characteristic of 'bitter'vs. 'sweet' cassava varieties, is now known to be primarily a function of production practices. 'Bitter' varieties (high in HCN) have been observed to convert to 'sweet' merely by planting in new environments and under different production practices [8, p. 189]. On the other hand, it is not an uncommon practice for small farmers to encircle cassava fields with bitter varieties to ward off pests such as pigs and monkeys. These varieties, though planted in the same soil and under similar practices as the sweet crop they are meant to protect, apparently remain bitter -- thus, in such instances region and production practices do not explain the bitter-sweet difference.

A recent study [9] has tested the numerous theories related to the production of HCN and has concluded that soil nutrients affect the development of HCN in the roots: nitrogen increases HCN, but potassium and farm yard manure decrease HCN, while phosphate, calcium and magnesium have little influence on HCN. It was found that prolonged drought can increase glucoside content, as does the presence of organic matter. It was also found, contrary to earlier studies, that age of plant has no effect on HCN content. Experiments revealed that root toxicity decreases with stem ringing, leaf elimination and stem cutting, because "... glucoside or products that cause its formation (amino acids) are synthesized in the leaves and transported, at least partially, to the tuberous roots". [9, p. 127]

b) Production Practices

Production practices are defined as planting, growing, harvesting and storing activities. At present cassava production is labour intensive. Attempts to 'modernise'* production practices have failed, in part, because of the small size of most plots, uneconomic costs (viz. high price of fertilizer), and finally because of the unavailability of appropriate techniques and equipment (for example, in Thailand the recommended use of 100 kg. of 8-8-4 fertilizer per rai*, besides being costly is, according to some studies, too low to induce an economic supply response). In short, the general lack of strong and coordinated cassava research programmes has resulted in the unhappy situation where practice deriving from empirical observations of small farmers are often more accurate than the recommendations of researchers. The work at CIAT, coupled with the emerging interest elsewhere in cassava, should overcome this state of affairs.

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*Modernise in the sense of increased use of fertilizers, herbicides, pesticides and labour-saving capital.

** 2.5 rai = 1 acre, 6.25 rai = 1 hectare

Thus it may be expected that new, applicable production practices could dramatically increase the availability of cassava and/or reduce the amount of land required for its production. This would be advantageous for countries having a cassava deficit, or for countries wishing to increase production for purposes other than human consumption. Such practices would also release land for diversification and cultivation of other commercial crops (labour permitting).

Of the several yield-improving developments related to cassava production, the following is a list of some of the more obvious techniques:

1) Improved field preparation, involving the use of 'walking tractors' or 2-wheeled tractors;
2) Indentification of optimum planting density for different planting times and different soil conditions;*
3) Improved cassava yields (volume, starch and protein) per unit of land and time;
4) Discovery of the fertilizer requirements of cassava;
5) Increased understanding of required growing practices (use of green manures, rotation patterns, etc.);
6) Development of herbicides and pesticides for cassava;
7) Breeding of easier-harvesting varieties (by hand or machine);
8) Development of planting and harvesting machines;
9) Development of non-space consuming storage methods.

A number of the above techniques are presently being researched, and once applied could substantially intensify production. Of course, not all techniques mentioned are applicable to all cassava planters, but it can be argued that these techniques will make improved production possible at all levels -- from backyard plot to estate. Insight into the magnitude of possible improvement can be gained from a comparison of

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*Research of this nature is underway in several locations. Appendix B contains a directory of cassava research programmes known to the author. The list, however, is not exhaustive.

of average world yields with CIAT experimental yields: 8 metric tons/ hectare, with production normally taking more than 12 months, vs. 75 metric tons/hectare in 9 months, respectively! Thus, appropriate application of existing research knowledge could overcome expected cassava deficits. The potential of a ten-fold increase in cassava production raises the question of whether or not a similar increase can be expected for cassava demand. The following sections discuss new products which could influence demand for cassava as a human food.

c) Protein Content of Cassava

Cassava is primarily a carbohydrate and therefore should not necessarily be viewed as a protein source. Cassava is blamed for the occurrance of "kwashiorkor" in regions of high per capita cassava consumption. This criticism seems unjustified because kwashiorkor is primarily a protein deficiency and not a calorie excess .

Given projected demand for cassava (Table 10) it can be calculated that cassava at 1% protein content would provide 2.2% of required protein for Economic Class 2 countries. Thus by extrapolation, development of a 5% protein cassava would imply that more than 10% of LDC protein requirements could be provided by cassava. However, the quality of cassava protein in terms of essential amino acids or even digestibility is not thought to be high. Furthermore, it appears that cassava protein can more easily be increased by microbiological means rather than by breeding improvements (see following section). In any event, the predicted calorie deficits insure that cassava will continue to be consummed, because it is a carbohydrate. Any developments which increase cassava protein content, without adversely effecting taste, will only serve to enhance the demand for cassava.

d) New Products

Apart from the use of cassava in beer and alcohal production in parts of the tropics, and as a gelling and thickener in convenience foods in North America and Europe, cassava destined for human consumption undergoes minimal processing. Research now underway shows that a number of new products can be made from cassava. Major advances are being made with the development of composite flours and baby foods, both utilising cassava,as well as the use of cassava as a substrate for growing protein.

Efforts with respect to the development of cassava flour has been greater than for other food aspects of cassava. In Brazil and Madagascar bread is manufactured from a mixed flour containing cassava. In Brazil a law passed in 1953 required that all bread contain 10 - 13% cassava flour as a means of reducing wheat imports. With increased wheat production the cassava content of bread decreased to a 1972 level of 1 - 3%, and it is likely that even these low limits are not enforced.*

The prospects for fortifying cassava either by an admixture of protein or by microbiological action are promising. The difficult part of the exercise is distributing the fortified product to needy consumers. The prime reason for fortification is to improve the diet of disadvantaged sectors of the economy; unfortunately it is this sector which is least likely to consume new products. Thus, the alternative of improving the protein content of cassava bears consideration.

The introduction of a higher protein variety of cassava into a region would certainly improve diets (assuming that the improved cassava can be and is used in the same manner as original varieties). However, to develop an improved cassava capable of being produced by traditional cultivation practices may take too much time. Thus, there could be

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*This information derives from conversations with academic, commercial and government officials in Brazil, December, 1972.

greater returns to research on genetic improvement of cassava. Additionally, educational programmes regarding nutritional requirements of the family could improve diets within the constraints of limited budgets.

2.4 Summary

World food projection results suggest in general that LDCs will continue to find it difficult to achieve or maintain self-sufficiency in agricultural commodities. It is expected that demand for agricultural goods will increase more rapidly than supply. Furthermore, that by 1980 most LDCs will be faced with a calorie shortage. It is in this context that the importance of cassava in the human diet stands out in bold relief.

Cassava in 1970 provided 13.5% of calories in Africa, 3.5% in Latin America, and 2.3% in the Far East. By 1980, it is predicted that cassava could provide 37% of calories consumed in Africa, 11% in Latin America, and 6% in the Far East. Some of these forecast consumption rates may not be achieved, however, because of insufficient cassava supplies. Colombia, Indonesia, Philippines, Vietnam Republic, Congo Brazzaville, Gabon, Nigeria, Sierra Leone, Sudan, Zaire and Zambia are identified as areas of potential cassava shortages.

If a cassava shortage is to be avoided, production of cassava in the above regions should be stimulated. If, however, alternative sources of carbohydrates become available, the dietary reason for promoting cassava may no longer be valid.

References Chapter II

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Chapter III

STARCH MARKET

> Evaluation of the competitive position of starch, not only in the present markets, but, more significantly, in future markets requires an understanding of certain basic information. This information includes: (a) the history of starch in the development of the food and chemical industry; (b) the factors governing the constant availability of starch at low price; (b) the possibility that one starch, for example corn starch, will dominate the market; (d) the possibilities for agronomic development of new, special starches; (e) the evaluation of competitive hydrocolloids, their persistance in future markets, and the changing costs which affect their selling price; (f) the ability of the chemist to gain a far better understanding of the relation between molecular structures and physical behaviour; and (g) the ability of the chemist to devise new low-cost reactions by which molecules can be tailored to fit specific end uses in either the food or chemical fields.
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> Roy L. Whistler

Starch, ($(C_6H_{10}O_5)_n$, where n is normally greater than 1000) is a widely employed commodity whose use dates from 4000 BC in Egypt [2 , p.2]. Starches are derived from numerous plant sources, the most important commercial starches today being maize, cassava, potato, sago, waxy-maize, wheat, sorghum, rice and arrowroot. Starches, in most instances, are substitutable and have numerous applications in the manufacture of foodstuffs, adhesives, textiles, paper, gelling and thickening agents, fillers, munitions, and drilling 'mud'. Not surprisingly, the relative importance of different types of starches varies between countries, with maize starch being most important in the United States and Canada; potato starch in Europe; sweet potato and rice in Japan and the Far East; and domestically produced starches of various types in LDCs. The major markets for cassava starch are Japan, United States and Canada, but even in these markets cassava accounts for less than 10% of total starch utilisation. Before dealing with these three markets, the attributes of the main categories of starch derivatives are briefly defined.

3.1 Starches and Starch Derivatives

The physical properties of individual starches are primarily determined by the structure, size and shape of grains. In general, the grains of starch, when heated in water, swell and burst at approximately 70°C to form a paste. Starches have a narrow density range of 1.50 to 1.53 and are insoluable in water. Starches may be divided into four categories [1, Ch.5] as indicated below. Derived and modified starches are also described.

Round Starches

Wheat Starch mostly round grains with both small and large diameter, 35-45μ*; the larger grains are oval or lenticular when rolled. With polarised light a cross is visible.

Barley Starch similar to but smaller than wheat starch (maximum size 35μ).

Rye Starch similar to but larger than wheat starch with sizes as great as 60μ.

Angular Starches

Rice Starch closely packed angular grains without hilum**, uniform in size measuring 6 to 9 μ. Compound grains, while common, are easily broken under pressure. A cross is visible under polarised light.

Oat Starch similar to but larger than rice starch, 10-11μ. Compound grains are not easily fractured by pressure, and oat starch does not exhibit a cross under polarised light.

Maize Starch grains are uniformly polygonal, usually with five to six sides, and measure approximately 15μ. There is a distinct hilum on most grains, and a well-defined cross when examined under polarised light.

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* 1μ = 0.001 mm

** The nucleus of the starch grain.

Oval Starch

Potato Starch composed of large oval or conchoidal grains with oyster-shell markings of less than 100μ, and smaller rounded or flattened grains approximately 15μ in size. A visible hilum is located near the end of the grain. The cross seen under polarised light is centred at the hilum.

Arrowroot Starches constitute both the largest (135μ) and smallest (7-12μ) starches, and are similar to potato starch.

Miscellaneous Starches

Cassava Starch the unswollen grains are roughly circular with concentric rings and usually a hilum. The size is approximately 15 to 25μ in diameter. Gelatinised cassava starch, commercially traded, is three times larger than unswollen starch, and has saucer-like shapes with no regular markings. The centre is usually dark.

Sago Starch similar to cassava starch with size ranging from 20 to 60μ.

Pea, Bean and Lentil Starches are similar, having an irregular bean-shape or elliptical form, and most grains have concentric markings. Bean starch grain are as large as 57μ, Pea starch grain are 15 to 47μ, and lentil starch grains are 20 to 40μ.

Starch Derivatives or Modified Starches

Acid Modified Starch formed by allowing starch to stand in contact with an aqueous acid solution. Superficially the starch granules do not change, however the acid modified starch differs from the parent starch by having a) less hot paste viscosity, b) higher alkali number, and c) higher ratio of cold to hot paste viscosity.

Hypochlorite-Oxidized Starches formed by treating a suspension of starch granules with an alkaline hypochlorite solution which is neutralised and freed of salts after the reaction. The distinctive properties are a) whiteness; b) granules lose birefringence at temperatures several degrees lower than unmodified starches; c) pasting occurs more rapidly and at lower temperatures; d) granules may completely disintegrate during cooking, producing an extremely clear solution; and e) aging with relatively little deterioration.

Dextrin is the generic name of degradated starch. Most dextrin involves an enzyme or acid modification of a parent starch followed by a heat treatment.* The important properties are a) that viscosity is reduced; b) that cold water soluability improves; and c) that sugar content decreases.

Starch Derivatives defined as "chemically modified starch in which the chemical structure of some of the glucose units has been altered ... (this) excludes acid modified starches but includes all oxidized starches" [3, p. 294]. Hypochlorite-oxidized starches are commonly excluded from this category, because their commercial use preceded the development of other starch derivatives. Starch derivatives are produced to form products which have physical or chemical properties which are required for specific applications. The more common starch derivatives are: *Starch Phosphate, Starch Acetate, Cationic Starch, Hydroxyethylstarch, Dialdehyde Starch*, and *Cross-Bonded Starch*.

The preceding discussion suggests approximately half the complexity of the starch industry because it relates only to the supply side. Because starches, modified starches, and starch derivatives (to a lesser extent) are highly interchangeable, it is extremely difficult to unravel

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* It is claimed that dextrin was accidentally discovered following the 1821 fire of a Dublin textile mill. An observant workman noticed that unused starch which was burnt dissolved easily in water to produce a thick adhesive paste [2, p.3].

the complex factors which determine the demand for starch. It proved impossible within the confines of this study to attempt a detailed examination of starch-using industries. However, the results of analyses of available data pertinent to international trade of starch, especially cassava starch, are presented in subsequent sections.

3.2 World Trade of Starch

In aggregate the world trade of starch has increased but not without some setbacks (Tables 1 and 1a). Unfortunately, the Standard International Trade Classification (SITC) 599.5, upon which Table 1 is based, does not necessarily include all types of starch*, and basically omits cassava flour (starch). Therefore, Table 1 may understate the extent of starch trade, particularly with respect to North American and Japanese imports.

Sixty-five percent of OECD Europe imports of starch by quantity is internally generated, with exports from the Netherlands (potato) accounting for 46.8% of OECD European Trade. OECD Europe imports a further 58% of its requirements from the United States and Canada (maize), and 28.6% from less developed countries. American starch imports by origin are: OECD Europe 28.4%; Canada 8.1%; Australia, New Zealand, and South Africa 27.7%; and less developed countries 36.0%. Japan derives 9.9% of its starch imports from OECD Europe, 2.2% from the United States and Canada, and 87.9% from less developed countries. Thus, in terms of SITC 599.5, only Japan provides a sizeable market for LDC starch products.

The failure of LDCs to realise a larger proportion of the international starch market may be partially accounted for by a) the inability of LDCs to provide a steady supply of starch of a desired quality; b) a tendency in developed countries to trade with neighbouring countries**;

* SITC 599.5 includes: starches and insulin; gluten and gluten flour; casein, caseinates and other casein derivatives; casein glues; albumins, albuminates and other albumin derivatives; gelatin and gelatin derivatives; peptones and other protein substances and their derivatives; dextrins, soluable or roasted starches and starch glues; prepared glues [4, p.22]. Cassava starch (flour) is included under SITC 055.45.

** Transportation costs can be an important element in price since starch is often shipped in small quantities (100 kg.).

Table 1
QUANTITY OF STARCH (SITC 599.5)
TRADED INTERNATIONALLY SINCE 1965
(Metric tons)

	1965	1966	1967	1968	1969	1970
U.S.A.	97665	95577	80591	91203	90237	104969
Japan	56256	65416	121425	115965	109731	108552
OECD (EUR)	570627	608247	591999	660148	790737	829495
EEC	219527	259547	258677	277631	347872	377473
EFTA	312010	309404	298640	348142	406185	418878
Total	1256085	1252171	1651332	1493089	174462	1839367

Table 1a
VALUE OF STARCH TRADED INTERNATIONALLY
SINCE 1965
(1000 $US)

	1965	1966	1967	1968	1969	1970
Canada		10249	10855	9902	11372	12382
U.S.A.	40790	45496	40630	42075	42276	50710
Japan	12106	18812	26122	24448	22528	25704
OECD (EUR)		150786	144843	155049	181521	199255
EEC		78335	73542	77670	92746	102722
EFTA		61963	61538	67232	77718	84946
Total		365641	357530	376376	428161	475719

Source: Trade by Commodities, Statistics of Foreign Trade OECD Series C, Organisation for Economic Cooperation and Development, Paris.

Table 2

1970 VALUE OF STARCH IMPORTED BY SOURCE

(1000 $US)

From/To	Canada	USA	Japan	OECD (Europe)	EEC	EFTA
Canada	x	4,088	5	1,067	390	386
USA	7,982	x	558	10,585	3,193	6,128
Japan	4	5	x	427	69	187
OECD (Europe)	2,258	14,392	2,538	130,203	70,550	52,225
EEC	756	11,797	874	112,132	66,244	40,684
EFTA	1,502	2,576	1,336	15,991	4,173	9,816
OECD(Total)	10,244	18,495	3,101	142,282	74,202	58,926
Other	2,138	32,215	22,603	56,973	28,520	26,038

Table 2a

1970 QUANTITY OF STARCH IMPORTED BY SOURCE

(Metric ton)

From/To	Canada	USA	Japan	OECD (Europe)	EEC	EFTA
Canada	n.a.	6,794	5	1,150	43	619
USA	n.a.	x	239	14,106	2,496	8,014
Japan	n.a.	64	x	444	55	147
OECD (Europe)	n.a.	32,169	2,502	624,115	301,352	297,124
EEC	n.a.	28,459	602	570,380	295,006	257,357
EFTA	n.a.	3,682	1,890	41,186	6,258	29,940
OECD (Total)	n.a.	39,027	2,746	639,815	303,946	305,904
Other	n.a.	65,942	105,806	189,680	73,527	112,974

Source: Trade by Commodities, Statistics of Foreign Trade OECD Series C, Organisation for Economic Cooperation and Development, Paris.

and c) non-competitiveness of LDC prices.

Of these factors, only the first and perhaps third can be directly influenced by LDCs. Even so, while the inability to consistently supply quality starch may result in loss of buyers, the mere ability to do so does not necessarily assure a place in the market -- viz., any improvement in LDC starch supplies (and one might anticipate some improvement to have occurred over the six years covered in Table 1) was not accompanied by greater LDC market shares. Moreover, the ability of LDCs to be price competitive is limited, for while labour costs are less than in developed countries, LDC starch production normally does not realize the economies of scale of the latter. In brief, while the combined effects of labour cost and scale of production are insufficient to insure that either developed or less developed countries can manufacture starch more cheaply, it does appear that the latter cannot necessarily produce starch at substantially lower costs than the former and thus, cannot expect substantial price-induced growth in the demand for their product. Furthermore,the advent of starch derivatives in the past two decades* could mean that these specifically designed starches could replace the normally unmodified LDC starches.

The extent to which the demand for cassava starch in the United States, Canada and Japan is likely to be influenced by the aforementioned is examined in the following section.

3.3 United States Demand for Cassava Starch

The United States is virtually self-sufficient in starch. Currently, 92% of American starch output derives from maize, with wheat and potato accounting for small amounts. Imports are equivalent to approximately 8% of American starch production (Table 3). Maize starch production appears to utilise approximately 5% of maize production.**

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* Hypochlorite-oxidized starch were the only starch derivatives commercially available, as early, in fact,as 1896 [5, p. 238].

** 1970 maize production was 4,110 million bushels. Maize sales from the farm were 2,178 million bushels, and maize starch manufacturing utilised 230 million bushels. Expressed in percentages, maize starch production utilised 5.6% of maize production and 10.6% of maize sales [7].

Table 6

LIVESTOCK PROJECTIONS

(1,000 M. Tons)

	Esselman 1980	Ferris 1980	FAO 1980	OECD 1975	OECD 1985
W.GERMANY					
cows			1,458	1,315	1,448
pigs	3,100		2,754	2,645	3,057
poultry	400		731	285	427
FRANCE					
cows			2,045	1,978	2,307
pigs	1,750		1,816	1,751	2,104
poultry	950		926	733	912
ITALY					
cows			730	525	590
pigs	650		574	510	660
poultry	950		646	565	760
NETHERLANDS					
cows			350	312	323
pigs	950		441	621	749
poultry	430		117	194	269
BEL.- LUX					
cows			247	244	256
pigs	550		313	328	404
poultry	140		111	130	160
EEC					
cows			4,830	4,374	4,924
pigs	7,000		5,899	5,855	6,974
poultry	2,870		2,531	1,907	2,528
UNITED KINGDOM					
cows		1,219	1,132	883	1,016
pigs		1,194	1,640	1,051	1,269
poultry		732	820	615	775
DENMARK					
cows		260	173	210	201
pigs		947	156	849	919
poultry		68	27	85	94

The United Kingdom and Denmark, following the implementation of CAP, are expected to experience pressures to increase livestock production, resulting from increased livestock prices. These pressures will be countered by increasing feed prices.

Numerous studies have been undertaken to quantitatively estimate the future demand for livestock products, animal feeds, and compound feeds in EEC countries [3,4,5,6,7,8,9,10]. To varying degrees, these studies assume that compound feed demand derives from livestock product demand and thus project the former on the basis of estimates of the latter.

Table 6 summarises the livestock projections of four of the above mentioned studies (Esselman [3], Ferris [4], FAO [10] and OECD [9]). The projections all result in like values -- not surprisingly, since similar data and techniques were employed. These projections, combined with projected compound feeding rates, produce the estimates of 1980 demand for compound feeds shown in Table 7.

The basic finding of the summarised studies is that the demand for compound feeds will increase substantially in both original and new EEC countries. Thus, the task remains to determine what proportion of this growing market can be met by cassava imports.

4.2 History of Cassava in the EEC

The economic potential of the EEC as a market for cassava has been developed largely through German effort (in particular, German establishment over the past fifteen years of several processing plants in cassava producing countries)* German processing plants encouraged production of cassava by providing both demand and supply, in the form of 1) a ready market for the crop as an ingredient in compound feeds; and 2)

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*Early ventures in northeastern Brazil met with failure. Ventures in Thailand, however, have proved to be quite successful. See Chapter VII on the development of the Thai cassava industry.

Changing market shares of specific compound feeds are partially explained by compound feeding rates in different countries (Table 4). Clearly, the Netherlands, United Kingdom, Belgium-Luxembourg and Denmark generally employ compound feeds at much higher rates than their fellow members. This, of course, suggests that the latter countries (Germany, France and Italy) will in the future experience highest growth rates in the consumption of compound feeds than the former because of the relatively low levels of feed technology presently existing in these countries.

Additionally, demand for compound feeds is affected by changes in livestock numbers. Data of the 'sixties reveal that the Netherlands, Italy, Germany, and the United Kingdom experienced greater increases in livestock numbers than the other countries under investigation. This suggests that growth in livestock numbers may in the future be greater in the latter countries since it may be assumed that some maximum exists for livestock numbers.

The future demand for compound feeds in the EEC of six* will be a function of a) changing composition of reared livestock; b) changing dependency on compound feeds; and c) increasing livestock numbers. It is suggested that:

1. demand in Italy will increase the most rapidly;
2. demand in France will increase only slightly less rapidly than in Italy;
3. demand in Netherlands will not increase greatly;
4. demand in Belgium-Luxembourg will increase only slightly more quickly than in the Netherlands;
5. demand in Germany will change at about the average rate.

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*The United Kingdom and Denmark are not included in this summary because changes resulting from the introduction of CAP will invalidate most trends based solely on <u>ex post</u> observations.

Table 10 (continued)

Proportion of Total Concentrate Feeds Used by Class of Animal

* 1000 tons

** 1960/61, 1965/66 and 1969/70 figures

Sources: W. Esselmann, "Development of Future Mixed-Feed Consumption in the Common Market", a paper presented at the Eighth European Mixed-Feed Congress, Rotterdam, 19 May, 1972.

John Ferris et al., The Impact on U.S. Agricultural Trade of the Accession of the United Kingdom, Ireland Denmark and Norway to the European Economic Community, Research Report No. 11, Institute of International Agriculture, Michigan State University, 1971.

Table 5

Proportion of Total Concentrate Feeds Used by Class of Animal
(%)

	Germany	France	Italy	Netherlands	Belgium	Luxembourg	EEC Total	United** Kingdom	Denmark**
1960	(28.8)	(17.8)	(6.5)	(34.5)	(12.4)	(0.0)	(100)		
TOTAL PRODUCTION*	3592.5	2217.5	800.0	4300.0	1550.0	3.6	12463.6	8979.0	n.a.
Cattle & Calves	27.0	22.5	20.0	22.7	27.5	.	24.3	40.0	29.9
Pigs	29.9	27.0	25.0	39.5	36.3	.	33.2	24.3	55.6
Poultry	41.6	46.3	50.0	35.5	35.5	.	40.1	30.0	13.4
Other Livestock	1.5	4.2	5.0	2.3	0.7	.	2.4	5.7	1.1
1965	(31.0)	(21.3)	(9.4)	(26.4)	(11.7)	(0.2)	(100)		
TOTAL PRODUCTION*	6596.8	4543.5	2000.0	5625.0	2478.5	48.5	21292.3	9850.0	2712.0
Cattle & Calves	26.5	21.4	22.0	28.9	29.0	33.0	25.9	39.1	29.9
Pigs	28.2	30.9	25.0	39.1	38.1	43.3	32.5	28.7	60.0
Poultry	42.7	41.0	48.0	30.7	30.3	23.7	38.2	28.9	9.7
Other Livestock	2.6	6.7	5.0	1.3	2.6	-	3.4	3.3	
1970	(30.4)	(20.3)	(11.4)	(24.5)	(13.4)		(100)		
TOTAL PRODUCTION*	9727.0	6474.5	3632.5	7850.6	4282.3	.	31966.9	10680.0	2405.0
Cattle & Calves	25.9	21.9	37.0	30.7	20.2	.	26.8	38.5	28.8
Pigs	34.5	35.3	18.0	42.1	51.2	.	36.9	25.9	47.1
Poultry	37.7	35.5	41.5	25.9	26.2	.	33.2	32.2	22.0
Other Livestock	1.9	7.3	3.5	1.3	2.4	.	3.1	3.4	2.8

(continued)

Table 4

Compound Consumption Rate by Class of Animal (kg/head) 1960-1970

Date	Cattle	Pigs	Poultry	Date	Cattle	Pigs	Poultry
	Germany				**France**		
1960.	170.97	68.03	23.48	1960.	50.82	69.71	9.96
1961.	161.76	64.47	24.99	1961.	54.25	79.60	10.66
1962.	213.10	97.06	29.93	1962.	59.56	114.81	12.40
1963.	210.98	82.20	28.76	1963.	67.10	106.59	15.09
1964.	250.13	83.97	30.70	1964.	91.11	129.57	16.02
1965.	300.29	105.14	33.17	1965.	100.14	151.83	17.23
1966.	344.35	120.01	34.93	1966.	110.46	165.67	17.98
1967.	335.98	118.32	36.09	1967.	119.97	186.10	19.25
1968.	325.20	118.63	35.06	1968.	121.18	175.94	19.29
1969.	378.85	135.61	32.21	1969.	143.16	203.50	21.04
1970.	438.33	160.03	36.38	1970.	148.00	203.40	21.27
	Netherlands				**Belgium-Luxembourg**		
1960.	609.77	579.41	44.55	1960.	395.92	356.17	19.84
1961.	506.80	550.67	45.42	1961.	479.34	367.46	17.65
1962.	726.74	589.35	47.17	1962.	575.40	432.05	18.70
1963.	745.49	582.40	43.55	1963.	559.93	435.51	19.91
1964.	828.33	595.74	45.00	1964.	587.63	443.17	21.31
1965.	957.01	551.79	41.32	1965.	683.05	484.93	22.67
1966.	1038.94	617.80	39.77	1966.	735.52	512.41	24.69
1967.	1045.84	583.15	40.63	1967.	717.81	560.69	23.75
1968.	1046.61	587.94	40.47	1968.	703.28	566.65	24.87
1969.	1052.58	565.88	33.61	1969.	748.28	450.59	25.49
1970.	1267.53	536.99	34.46	1970.	791.84	546.12	25.98
	E.E.C.				**United Kingdom**		
1960.	141.83	124.09	15.68	1960.	776.97	308.18	28.32
1961.	145.77	126.16	16.56	1961.	734.23	306.14	27.99
1962.	179.93	159.60	18.22	1962.	753.28	319.40	28.99
1963.	185.57	145.40	18.87	1963.	729.58	297.42	28.35
1964.	217.23	157.72	19.97	1964.	747.46	276.87	28.08
1965.	254.40	181.86	21.48	1965.	790.68	277.85	28.19
1966.	286.25	203.54	22.65	1966.	772.02	263.74	27.35
1967.	293.15	211.47	23.31	1967.	807.35	283.52	27.22
1968.	297.64	206.91	23.27	1968.	822.94	289.83	26.31
1969.	337.24	209.17	23.85	1969.	735.92	307.59	31.45
1970.	391.09	279.67	25.24	1970.	743.02	315.03	28.18
	Italy				**Denmark**		
1960.	50.16	46.14	4.44	1960.	1188.46	514.72	30.19
1961.	60.05	50.25	4.84	1961.	1123.91	468.36	25.78
1962.	74.37	56.58	5.00	1962.	1187.97	472.64	24.78
1963.	76.97	65.62	5.90	1963.	1257.10	476.41	27.77
1964.	99.82	69.33	6.55	1964.	1411.68	477.84	26.76
1965.	129.91	96.60	8.73	1965.	1500.00	473.75	30.45
1966.	158.80	103.93	9.55	1966.	1525.93	490.27	29.78
1967.	191.10	113.21	9.68	1967.	1400.30	478.79	31.96
1968.	317.96	76.54	13.15				
1969.	283.45	55.64	13.43				
1970.	378.31	72.78	13.71				

Source: Production Yearbook, FAO, Rome.

Table 3

Index of Per Capita GNP, Industry, Agriculture and Compound Feed Production, 1970 (1963=100)

Country	Compound Feed Production	Agriculture	Industry	Per Capita GNP*
Belgium	213	120	139	127
Denmark	98**	100	157	132
France	189	121	149	132
Germany	198	111	153	127
Ireland		113	152	128
Italy	279	124	150	135
Luxembourg	- ***	- ***	128	126
Netherlands	160	127	175	141
United Kingdom	104	118	124	115

* 1969 figures

** 1964 = 100

*** Included in Belgium figures

Sources: Statistical Yearbook, United Nations, 1971.

W. Esselmann "Development of Future Mixed-Feed Consumption in the Common Market", a paper presented at the Eighth European Mixed-Feed Congress, Rotterdam, 19 May, 1972.

Study on the Factor(s) Influencing the Use of Cereals in Animal Feeding, OECD, Paris, 1971.

Table 2

Production of Compound Feeds in EEC, United Kingdom and Denmark

1960 to 1970

Year	W. Germany	France	Italy	Netherlands	Bel-Lux	EEC of Six	United Kingdom	Denmark
1960	3,592,500	2,217,500	800,000	4,300,000	1,553,595	12,463,595	8,979,000	n.a.
1961	3,853,400	2,551,560	900,000	4,600,000	1,849,067	13,754,027	9,489,000	n.a.
1962	5,085,700	3,130,910	1,050,000	5,050,000	2,217,448	16,534,058	9,464,000	n.a.
1963	4,916,800	3,420,772	1,300,000	4,900,000	2,030,018	16,568,173	9,283,000	n.a.
1964	5,576,400	4,010,800	1,500,000	5,370,000	2,209,019	18,666,019	9,667,000	2,630,000
1965	6,596,800	4,543,531	2,000,000	5,625,000	2,526,967	21,292,298	9,850,000	2,712,000
1966	7,531,600	4,951,331	2,300,000	6,128,400	2,900,959	23,812,290	9,475,000	2,739,000
1967	7,722,500	5,581,982	2,500,000	6,385,889	3,119,060	25,309,431	10,114,000	2,575,000
1968	7,545,300	5,516,179	3,098,000	6,629,296	3,240,346	26,029,121	10,394,000	n.a.
1969	8,190,800	6,243,619	3,300,000	7,116,873	3,636,132	28,487,924	10,680,000	2,405,000
1970	9,727,000	7,441,000	3,633,000	7,891,000	4,210,000	32,902,000	9,700,000	2,574,000

Sources: The Markets for Manioc as a Raw material for Compound Animal Feedingstuffs, International Trade Centre, UNCTAD/GATT, Geneva, 1968

Markets for Cassava, FAO, (unpublished), Rome, 1972.

Study of the Factor(s) Influencing the Use of Cereals in Animal Feeding, OECD, Paris, 1971

The Major Inport Markets for Oilcake, International Trade Centre, UNCTAD/GATT, Geneva, 1972.

a) <u>Feed Compounding in Western Europe</u>

Commercial feed mixing or compounding in the original EEC has experienced substantial growth since 1963 (Table 2), greater than that of agriculture, industry and GNP (Table 3). In contrast, the production of compound feeds in the United Kingdom, Denmark and Ireland have been relatively fixed*.

In the early 'sixties, per animal compound feed consumption rates, (Table 4) appear to have been inversely related to growth in production of compound feeds. Those countries with relatively high feeding rates in the early 'sixties, United Kingdom, Denmark and Netherlands, had the least dynamic increases in consumption of compound feed. Conversely the country with the lowest general compound-feed utilisation rate (Italy) experienced the greatest increase in compound feed production, 279%. It seems likely, therefore, that the growth rates which prevailed during the 'sixties will not continue. Nevertheless, the <u>ex post</u> analysis does provide information which may enable prediction of the general nature of future developments.

During the 'sixties the growth in demand for compound feeds was accompanied by a changing dependency on compound feeds by the major categories of livestock (Table 5). In Germany, France, Netherlands, and Belgium the percentage of compound feed consumed by pigs increased, while in Germany, France, Belgium and the United Kingdom the percentage of total compound feed consumed by cattle and calves decreased. In all countries the percentage of compound feeds consumed by poultry generally decreased.**

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*Ireland and Luxembourg are not specifically accounted for in the analyses of this chapter because of the small size of these countries in terms of consumption of compound feeds.

**This is not surprising because high initial levels of consumption in poultry production in all countries meant that growth in demand was determined almost entirely by increase in poultry numbers. Other livestock categories experienced increased compound feed consumption through higher feeding rates per animal and/or increased animal units, hence the relative decline of poultry ration consumption.

Duisburg. The threshold price is the indicative price less transportation costs between Rotterdam, the main port of entry, and Duisburg. Variable levies are applied to imports to insure that threshold prices are met.

intervention price - the price at which "intervention agencies" will guarantee to buy cereal of the specified quality. The intervention price is 8% lower than the indicative price.

Intervention prices are determined for different points* or centres in each country. These centres are meant to be buyers of last resort, but farmers in some countries sell directly into intervention to avoid storage, handling and other costs. Variable levies are defined as the "... difference between the threshold price in the month of importation and the average c.i.f. price in the first twenty-five days of the previous month" [1, p. 58].

Full variable levies are not applied to cassava**, vegetable protein (soybean cakes, rape seed extract, etc.) and many non-cereal energy sources. This means that within the EEC, conventional vegetable energy sources are relatively more expensive than protein sources in comparison to prevailing world patterns.

Given EEC price relativities, feed compounders in the Common Market have been forced to seek new cheaper ingredients which would enable them to avoid sharp price increases while maintaining nutritional standards. The nature of ingredient changes is briefly examined in the following discussion.

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*There are 11 intervention agencies in Germany; 11 in France; 1 in Holland; 10 in Italy; 2 intervention centres in Belgium; and 1 intervention centre in Luxembourg.

** Cassava chips and pellets are subject to a 6% ad valorum tariff whilst cassava meal and other cassava by-products are subject to an 11% tariff. Regulations as of the first of January 1972 reduced the tariff on chips and pellets to 3% ad valorum [2, p. 355].

Table 1 (continued)

LIVESTOCK**

Year	MILK***			COWS			POULTRY			PIGS		
	EEC	United Kingdom	Denmark	EEC	United Kingdom	Denmark	EEC	United Kingdom	Denmark	EEC	United Kingdom	Denmark
1960	64,340	12,086	5,399	21,367	4,013	1,438	318,586	127,500	25,340	33,340	5,724	6,147
1961	66,050	12,554	5,524	22,010	4,154	1,493	340,247	139,100	32,240	36,082	6,043	7,095
1962	66,872	12,910	5,355	22,257	4,268	1,463	349,350	134,300	30,270	35,764	6,722	7,181
1963	67,357	12,599	5,086	21,809	4,260	1,408	361,410	137,300	26,110	35,317	6,859	7,334
1964	67,518	12,381	5,233	21,488	4,126	1,370	371,620	143,300	26,120	37,969	7,379	8,011
1965	70,251	12,857	5,367	21,691	4,204	1,350	378,290	143,000	21,510	38,116	7,979	8,591
1966	72,430	12,658	5,306	21,720	4,268	1,350	386,350	144,000	22,030	39,117	7,333	8,120
1967	74,168	13,065	5,193	22,036	4,355	1,329	388,500	151,000	19,900	42,004	7,107	8,486
1968	75,970	13,348	5,127	22,062	4,377	1,295	388,720	153,000	19,950	44,077	7,387	8,003
1969	75,759	12,764	4,877	22,227	5,309	1,232	415,950	126,514	19,610	48,368	7,783	8,022
1970	76,211	13,000	4,600	21,910	5,409	1,232	421,092	143,420	19,730	51,340	8,088	8,378

** 1000 livestock units except where noted

*** 1000 metric tons

Table 1

PRODUCTION OF SELECTED AGRICULTURAL COMMODITIES

CEREALS*

Year	WHEAT			BARLEY			MAIZE			OATS		
	EEC	United Kingdom	Denmark	EEC	United Kingdom	Denmark	EEC	United Kingdom	Denmark	EEC	United Kingdom	Denmark
1960	24,051	3,040	320	9,763	4,309	2,801	6,649	-	-	7,239	2,091	681
1961	23,055	2,614	434	9,145	5,054	2,808	6,432	-	-	6,991	1,851	684
1962	29,493	3,974	644	10,873	5,865	3,299	5,173	-	-	7,791	1,775	609
1963	24,436	3,046	495	12,010	6,705	3,399	7,618	-	-	7,757	1,460	671
1964	29,133	3,793	541	11,752	7,522	3,900	6,122	-	-	7,103	1,346	821
1965	30,347	4,171	564	11,841	8,191	4,125	6,832	-	-	6,790	1,232	780
1966	26,385	3,475	400	12,360	8,723	4,159	7,976	-	-	7,133	1,120	864
1967	31,158	3,902	421	15,877	9,214	4,382	8,192	-	-	8,031	1,386	904
1968	32,018	3,571	461	15,155	8,406	5,059	9,444	-	-	7,738	1,231	861
1969	31,547	3,364	428	15,876	8,664	5,255	10,651	-	-	6,328	1,308	765
1970	29,605	4,172	452	14,003	7,494	5,000	12,771	-	-	5,463	1,233	637

* 1000 metric tons

intra-EEC trade are removed; and that EEC agriculture is protected from external competition. The latter two goals have clearly been achieved. The former goal has not. CAP policies have raised farm prices, but they have not promoted the structural change required to make all agriculture viable. In fact, higher prices have probably enabled small, inefficient farmers to remain in farming. Therefore, effort is now being directed towards the formulation of policies which are specifically concerned with structural change.

Development of CAP has been coincidental with substantial production changes (Table 1). Cereal production other than oats has increased, and maize production has virtually doubled between the early 'sixties and 1970. Livestock production has also rapidly expanded, owing to both increased number and productivity. Milk production has increased by 18%, while cow numbers have remained nearly constant.

It is the EEC grain policy which has to a large degree been responsible for the importation of 'new' ingredients, such as cassava, for the production of compound animal feeds.* In essence, the grain policy is based on three prices specified by the EEC council. These prices** are:

indicative price
- the expected wholesale price of different grains at Duisburg, Germany; Duisburg is regarded as the area with greatest cereal defficiency.

threshold price
- the import price which ensures that imported cereals do not enter the market below indicative price at

*Compound animal feeds is loosely defined for the purposes of this study as those feeds which are commercially mixed by cooperative and private firms. When possible farm mixed feeds are excluded from the analysis, as those feeds will not normally contain cassava.

**These prices may also be defined as target, minimum import and support prices.

Chapter IV

THE ANIMAL FEED MARKET

> "It is likely that concessions suggested by Europe may be directed in favour of developing countries rather than the U.S. or Canada. Nevertheless, changes in the CAP can and will occur. The most constructive approach of outside suppliers may be one of mutuality of interest in solving common problems rather than direct confrontation and conflict. Europe too has a stake in a satisfactory outcome of the trade talks."
>
> Tim Josling.

The growth in demand for cassava as an ingredient in animal feed coincides with the development of the EEC's Common Agricultural Policy (CAP). World market price relativities between energy, protein and cereals were altered by CAP, making it attractive for European compounders to use large quantities of relatively cheap protein and energy sources (viz., soybean meal and cassava, respectively) rather than cereals in the production of compound feeds. In short, a product of superior quality to cereal is fabricated from an appropriate mix of soybeans and cassava. The development of the European market for cassava must be preceded by an understanding of the effects of CAP and the developments which have transpired in the EEC compound feed industry itself. To this end, the analysis of the future European demand for cassava is prefaced by a brief discussion of the history of the EEC animal feed market.

4.1 History of EEC Animal Feed Market

The Common Agricultural Policy (CAP), centred on cereals, has greatly influenced EEC agriculture. As a consequence of CAP the EEC cereal market is highly organised and regulated. In essence, CAP attempts to insure that EEC agricultural is viable; that barriers to

References Chapter III

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4) Standard International Trade Classification Revised, Statistical Papers Series M No. 34, United Nations, New York, 1961.

5) Barrett L. Scallet and Ernest A. Sowell, "Production and Use of Hypochlorite-Oxidized Starches", Starch: Chemistry and Technology, Vol. II, (eds. Roy L. Whistler and Eugene F. Paschall), Academic Press, New York, 1965, pp. 237-251.

6) H.E. Bode, "History of the Corn Starch Industry", Starch: Chemistry and Technology, Vol. I., (eds. Roy L. Whistler and Eugene F. Paschall), Academic Press, New York, 1965, pp. 11-21.

7) Agricultural Statistics, United States Department of Agriculture, Washington, D.C.

8) Paul L. Farris, "Economics and Future of the Starch Industry", Starch: Chemistry and Technology, Vol. I, (eds. Roy L. Whistler and Eugene F. Paschall), Academic Press, New York, 1965, pp. 23-41.

9) The Market for Starch in Selected Industrial Countries, International Trade Centre UNCTAD/GATT, April 1969.

3.6 Summary

Similarities between starches, as well as the ability of chemists to tailor starches, means that the market for a given starch can be drastically altered in a matter of years. The future of cassava starch in this context is less definite than that of domestically produced starches, in the United States, Canada and Japan. The latter starches are partially protected from competition by the ologopolistic nature of domestic starch industries, and in the case of Japan, agricultural price support policies. Additionally, the proximity of starch supply and demand in North America results in suppliers of starch being aware of emerging markets for starch before most exporters. It is possible that North American starch manufacturers can coordinate the development and marketing of new starch products with emerging demand, thereby virtually excluding other supplies from the market.

There are several applications for which cassava starch is preferred, newsprint and cardboard production, glues for stamps and envelopes, and food preparation, but even in these areas alternative starch products are appearing. Thus the uncertainty of the starch market should be borne in mind when examining the projected 1980 demand for cassava. The high and low projections are:

	Low Estimate	High Estimate
United States	41,000 metric tons	340,000 metric tons
Canada	20,000 metric tons	21,000 metric tons
Japan	50,000 metric tons	50,000 metric tons
Total	111,000 metric tons	411,000 metric tons

The total projected 1980 demand for cassava starch is 20 to 447% greater than 1970 levels. These figures suggest that the collective demand for cassava starch in the seventies will grow at a compound annual rate of 2 to 16%. Furthermore, the range of the projections indicate the uncertainty of the future of international starch markets.

because Japan is not a major producer of starch and because Japan imports a high proportion of starch from LDCs in the Far East. Political considerations*, in the form of specific agricultural support policies, have enabled potato and sweet potato starch rather than rice starch to predominate in Japan. Moreover, although the prices of both cassava and maize starch are competitive with potato starch ($90/metric ton, $120/metric ton, and $230/metric ton, respectively, in 1972/73), Japanese restrictive policies on the former** encourage use of the latter. The Japanese 1972/73 quota on cassava starch is fixed at 50,000 tons, thereby precluding greater use of this cheaper starch, and quotas and licensing policies on maize starch are such that use of domestic potato starch is promoted -- the author was informed that maize starch import licenses are generally linked to use of potato starch on approximately a one-to-one basis. Thus, the manufacturer requiring maize starch or larger quantities of starch than are domestically available must utilise potato starch in order to obtain an import license.

The substantial political component in starch policy suggests that future developments of Japanese demand for starch are very hard to predict, but it is probable that the potential for cassava starch imports are limited. However, the high degree to which Japanese trade policy in general is determined by bilateral trade arrangements could well entail increased Japanese purchase of cassava starch from Far East producers in return for access to particular markets. The only sound conclusion to be drawn with respect to Japan, therefore, is that Japan, with its impressive industrial growth, will increase starch consumption. It is impossible at this juncture to suggest the future relative importance of various starches.

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*Many of the contentions of this section are derived from interviews with individuals in the Japanese Ministry of Agriculture, and Mitsubishi and Kanematsu-Gosho companies.

**The 1969 International Trade Centre Report [9] does not mention licensing of imports, but the author was told in January 1973 that licensing of maize starch now exists. The full extent of the licensing could not be determined.

where

D'_{sct} = Canadian demand for cassava starch;
P'_{s1t} = price of cassava starch;
P'_{s6t} = price of rice starch;
P'_{s7t} = price of potato starch;
Y'_{t} = GNP;
subscript t = time.

This model suggests that the demand for cassava starch will increase when GNP increases, and will decrease if cassava price increases relative to either rice or potato starch prices. Thus, the model behaves according to a priori expectations. Equation 4 is used to derive projections of the future demand for cassava starch. The assumptions made are a) that GNP will be within the levels indicated by FAO and OECD projections; and b) that cassava price relative to rice and potato starch prices will remain constant; and c) that past patterns will persist in the future. Using these assumptions, it is estimated that the 1980 demand for cassava starch could range from 44 million to 46 million pounds, a 293% to 307% increase over the 1965-70 average.*

As with the previous starch projections (section 3.3), the above must be tempered by the possibilities that new, competitive products may enter in the future, that cassava starch may not be available in sufficient quantity or quality, and that maize starch producers may be able to capture the entire market. The cassava starch exporter wishing to assess the Canadian market potential at different points in time must therefore continually monitor those developments which may alter the cassava demand model or the projection assumptions.

3.5 Japanese Demand for Cassava Starch

The Japanese market differs substantially from the North American market

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* Increase between early and late 'sixties was approximately 442%, thus the growth in demand for cassava starch is predicted to be decreased in the 'seventies.

Table 4

CANADIAN STARCH IMPORTS AND
ESTIMATED MAIZE STARCH PRODUCTION

Year	Maize lbs.	Maize $/lb.	Rice lbs.	Rice $/lb.	Potato lbs.	Potato $/lb.	Cassava lbs.	Cassava $/lb.	Tapioca* lbs.	Tapioca* $/lb.	Dextrin lbs.	Dextrin $/lb.	Maize Starch** Production (lbs)
1960	15580000	0.12	1765792	0.09	6484103	0.07	4350303	0.05	1450090	0.13	1022928	0.13	
1961	16800000	0.12	1716960	0.09	2821735	0.09	3970474	0.05	1739248	0.13	539901	0.22	
1962	17920000	0.12	2232160	0.10	3458214	0.09	3418731	0.06	1474963	0.14	366121	0.27	
1963	15333472	0.12	1925840	0.10	4615854	0.10	3424700	0.07	2595248	0.12	301105	0.29	
1964	21918848	0.12	1711696	0.09	8343332	0.08	6575082	0.07	1671266	0.15	3528272	0.20	
1965	19955488	0.13	950992	0.11	14768785	0.06	9684593	0.06	1465071	0.14	3236223	0.23	
1966	21672896	0.13	1061872	0.10	9544896	0.08	12704984	0.05	1276126	0.14	3011514	0.21	71984
1967	20562304	0.13	798000	0.13	6850883	0.09	20113811	0.05	1626118	0.14	2864450	0.26	72906
1968	22355848	0.11	1093568	0.12	7726865	0.09	15812139	0.06	2308654	0.12	3099643	0.22	77559
1969	24397856	0.11	1096592	0.12	13669531	0.06	14586669	0.06	1923040	0.08	2249490	0.30	93266
1970	10313632	0.12	920752	0.13	19818269	0.06	20132730	0.05	1374402	0.13	3096724	0.26	108987
1971	5610080	0.14	1087744	0.12	2882938	0.10	9240636	0.07	1435960	0.13	2828043	0.31	

Source: Annual Statistics, Information Canada, Ottawa.

* The distinction between cassava and tapioca starch may be the state of processing.

**Maize starch production is estimated as the sum of starch exported and starched consumed minus starch imports.

3.4 Canadian Demand for Cassava Starch

The Canadian starch market resembles that of the United States to the degree that maize starch predominates and that similar levels of technology exist in both countries. While domestic starch production constitutes a major share of starch, Canada does, because of lower maize production, import a substantial quantity of maize starch (Table 4), primarily from the United States.

Estimate of Canadian starch production was not available because only two companies in Canada manufacture starch (by law precluding publication of data). However, data are available on the quantity of starch imports, exports and use in particular industries.* Starch production,therefore, was estimated as the sum of starch utilisation plus exports minus imports. It was, of course, not possible to validate this calculation by published data, however 1972 starch production is estimated by the trade to be ~120,000,000 pounds**, which suggests that the 1970 estimate is of the right order of magnitude. Under these circumstances, it did not seem advisable to attempt to quantitatively derive a maize starch demand function.

Attempts to quantitatively estimate a cassava demand function similar to Equation 2 met with only limited success. The most satisfactory function occurred when cassava starch imports were regressed on GNP, price of cassava relative to rice, and potato starch price (Equation 4).

$$D'_{sct} = -8240040 - \underset{(1.50)}{1.26\text{x}10^7} \left(\frac{P'_{s1t}}{P'_{s6t}}\right) - \underset{(1.35)}{9.82\text{x}10^6} \left(\frac{P'_{s1t}}{P'_{s7t}}\right) + \underset{(5.14)}{2.87\text{x}10^5}\, Y'_t \qquad \ldots (4)$$

$R^2 = .93$ D.W. = 2.11

---

* Industries for which starch utilisation data are available are: Paper mills,consuming 75% of starch; cotton yarn 13%; other chemical production 6%; and miscellaneous 6%.

** Officials of the National Starch and Chemical Co. (Canada) Ltd., provided these estimates.

indicated in Equation 1; and 3) consumption of starch will be 3,863 to 4,241 million pounds by 1980.*

Substituting the resulting values into Equation 3 produces the estimates of 1980 demand for cassava starch of 90 to 750 million pounds. The implications of these assumptions are that cassava starch may share in the expected demand increase with maize starch, and, more specifically, that the demand for cassava starch could decrease by as much as 55% or increase by as much as 375% in comparison to the 1965-70 average.** This range is perhaps indicative of the volatility of the American starch market.

These estimates must be viewed in the context of the assumptions of the projection models, namely a) that cassava price will maintain its present relativity to non-specified and maize starch; b) that cassava starch will conform to quality standards;*** and c) that new starches, modified starches, or starch derivatives**** do not replace cassava starch. These are factors which cassava starch exporters to the United States should consider when assessing their long-term export prospects.

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* Projections are based upon the equations $D_{st} = 215.98\text{x}10^7 + \underset{(10.99)}{7.10\text{x}10^7 t} \qquad R^2 = .90$

and $D_{st} = -120{,}384{,}835 + \underset{(1.73)}{1.33\text{x}10^7\ Y_t} + \underset{(0.44)}{1.37\text{x}10^5 X_1 X_{1t}} + \underset{(1.59)}{6.22\text{x}10^5 X_{2t}} \qquad R^2 = .93$

where D_{st} = total demand for starch; Y_t = GNP; X_{1t} = newsprint production; X_{2t} = cotton yarn production.

** Employing averages of projected demand for starch and production of maize starch provides an estimate in 1980 for demand for cassava starch of 180,000,000 pounds, a 10% decrease on the 1965-70 average.

*** Appendix C summarises standards of some of the major American starch users and the attributes which make cassava starch desirable.

**** Farris notes that starches may have to compete with resin glue, latex, resin finishes and synthetic polymers, all of which have properties which make them more desirable for specific uses [8, p. 33].

D_{st} = demand for all starches; and
MS_t = production of maize starch.

Newsprint and cotton yarn production were excluded from the model because the coefficients were not significantly different from zero. However, the indications were that cotton yarn production was more influential than newsprint production in determining demand for cassava starch. The GNP variable was also excluded because its coefficient was not significantly different from zero (but greater than zero as expected), and because it reduced the degrees of freedom.*

The implications of Equation 3 are 1) an increase of cassava starch prices relative to non-specified or maize starch prices will reduce the demand for cassava starch, as will increased maize starch production; 2) however, increased consumption of all starches will increase the demand for cassava starch -- *ceteris paribus*, a 1% increase in the demand for starch resulted in a 1.3% increase** in the demand for cassava starch. Since 1963, cassava price relative to non-specified and maize starch has decreased. Thus, the demand for cassava starch has positively benefited from decreasing price and generally increased demand for starch, while suffering from the effect of increased maize starch production.

Equations 1 and 3 provide the basic ingredients for projections of future demand for cassava starch, if past pattern are assumed to continue. For projection purposes 3 assumptions are made: 1) price relativities between cassava starch and non-specified or maize starch will remain constant; 2) maize starch production will increase, as

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* That is, newsprint and cotton yarn production and GNP were not explicitly included in Equation 3, but because D_{ST} may be assumed to be a function of these factors they are implicitly included in Equation 3.

** The elasticity, η_{ms}, is defined from Equation 3 as $\eta_{ms} = 1.41 \frac{MS_t}{D_{sct}}$ which for 1971 is evaluated as 1.3. ($= 1.41 \frac{3,010,000,000}{3,227,997,658}$).

Two things should, of course, be borne in mind. First, the volume of cassava starch imported makes up only a small fraction of total starch used, and second, even though cassava imports may increase, its share of the total market may not improve.

Multiple factors undoubtedly account for the continuing demand for cassava, the most important being price of cassava starch, price of other starches, production levels of starch-using industries, maize starch production, and GNP. The specification of Equation 2 tests the influences of these factors on the demand for cassava starch.

$$D_{sct} = \alpha + \sum_{i=1}^{k} \beta_i' P_{sit} + \beta_1 Y_t + {}_2MS_t + \sum_{j=1}^{m} \beta_j'' X_{jt} + u_t \qquad \ldots (2)$$

where

D_{sct} = demand for cassava starch;
P_{sit} = price of the i^{th} starch (i=1,2...6);
Y_t = GNP
MS_t = maize starch production;
X_{jt} = production of the j^{th} starch-consuming industry (j=1,2);
u_t = error term with the expected properties $E(u) = 0$;
$E(u^2) = \sigma^2$ and $E(u_i u_j) = 0$; subscript t signifies time.

After fitting numerous modifications of Equation 2, the following was found to be the best in terms of <u>a priori</u> expectations and statistical significance:*

$$D_{sct} = 767{,}233{,}566 - \underset{(4.9)}{2.98\text{X}10^8} \left(\frac{P_{s1t}}{P_{s4t}}\right) - \underset{(2.7)}{4.29\text{x}10^8} \left(\frac{P_{s1t}}{P_{s6t}}\right) + \underset{(12.7)}{1.28}\, D_{st}$$

$$- \underset{(11.8)}{1.41}\, MS_t \qquad R^2 = .998 \qquad D.W. = 2.8 \qquad \ldots (3)$$

where

P_{s1t} = price cassava starch;
P_{s4t} = price non-specified starches;
P_{s6t} = price maize starch;

---

* Values in parentheses are t-values.

Farris' model appears to be still applicable, since prediction of maize used in wet milling in 1969 is within 10% of the actual figure*, 226 million bushels. Equation 1 may be used to project the future demand for maize used in wet milling for given assumptions regarding future GNP and price of maize. Estimates of 1980 demand, given two estimates for GNP and corn price**, suggest that demand could be within the range of 436 to 461 million pounds, an increase of 188% to 195% over the 1970 levels. These projections must be evaluated in the context of possible changes in a) the importance of different industrial sectors; b) starch uses; and c) competition of alternative starch products.

With respect to the first and second points, the forecast is for expansion. Newsprint production, a prime user of starch is growing at a rate at least equivalent to GNP***, thus suggesting that the demand for starch will increase more rapidly than GNP growth rate. Furthermore, new developments in pre-packaged foods are providing greater markets for starch as a thickener and gelling agent. The last point is more difficult to assess, but it is assumed that competition among starch products will be an extremely important factor in determining future starch demand.

The greatest competition for maize starch may come from cassava starch. American imports of cassava starch peaked during the inter bellum years at 390 million pounds.**** Although this level has not been duplicated since World War II, cassava starch imports have exceeded all others (Table 3).

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* Significantly, this estimate is considered sufficiently accurate for the purposes of this study.

** GNP = $1,089 billion (FAO); or GNP = $1,144 billion (OECD), and corn price = $1.00 or $0.85, the high and low price of the past five years (1957-59 = 100).

*** Whilst complete data are not available, the production of newsprint and cottonyarn (taken as proxy measures of paper product and textile production) have grown at 4.5% and 0% per annum. GNP has grown at 3.75% per annum.

**** It is reported that corn starch was first modified to replace Indonesian cassava starch which ceased to be available during World War II.

Maize starch has not always ruled supreme in America. Wheat and potato starch plants were established in the nineteenth century, more than 20 years before the first maize starch plants (Ca. 1842). However, by the late 1800's maize starch had come to the fore, annual corn starch production in 1895 equalling 200 million pounds, potato starch production 24 million pounds, and wheat starch production 8.3 million pounds [5, p.122]. By 1970, maize starch production equalled 310 million pounds.

Data on the current demand for maize starch is not readily available, but 1958 data indicate the following breakdown of utilisation: 44% for paper products; 24.5% for grocers, brewers and bakers; 15.3% for textiles; 9.9% for building materials and laundries; and 5.9% for export.*

The demand for starch derives from the demand for specific manufactured goods, and these, in turn depend on per capita income and population. Farris has attempted to quantify the effect of some of these factors on the demand for maize starch [8]. Using ordinary least squares (OLS) methods, he estimated a demand equation (Equation 1):

$$Y = \underset{}{61.62} - \underset{(4.084)}{8.496X_1} + \underset{(0.044)}{0.334X_2} - \underset{(0.570)^{**}}{1.174t} \qquad R^2 = .98 \; \ldots \; (1)$$

where Y = million bushels of maize used in wet milling (the process by which starch is extracted);

X_1 = price of No. 3 corn at Chicago in 1957-59 dollars;

X_2 = GNP in billion dollars in 1963 dollars; and

t = time, (t=70 for 1970, etc.).

This model suggests that demand for starch is proportionally influenced by GNP changes and inversely influenced by price and time changes. The negative time factor may imply that starch extraction rate has improved over time, hence requires less maize to produce a given amount of starch.

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* Original data are presented in Starch, U.S. Tariff Commission Report, 1960, and republished by Farris [8, p. 27].

** Values in parentheses are standard errors.

Table 3

UNITED STATES MAIZE STARCH PRODUCTION
AND STARCH IMPORTS

Year	Cassava lbs.	Cassava $/lb.	Arrowroot lbs.	Arrowroot $/lb.	Potato lbs.	Potato $/lb.	Non-specified lbs.	Non-specified $/lb.	Dextrin lbs.	Dextrin $/lb.	Maize Starch Production (lbs)
1957	163463850	0.048	6513662	0.083	6561404	0.053	12378097	0.053	19613158	0.093	2043776786
1958	178654430	0.045	8106129	0.082	5987008	0.056	7256990	0.059	19363484	0.094	2063133929
1959	226145870	0.037	7321327	0.091	3504273	0.057	27851086	0.048	24817482	0.091	2190491071
1960	279980480	0.036	6159603	0.102	7018177	0.060	41865005	0.047	24246225	0.091	2127758929
1961	306639730	0.035	4660095	0.106	5518873	0.065	28759726	0.049	25439469	0.094	2158928571
1962	163248040	0.037	5924001	0.110	2445683	0.065	37267280	0.040	22846426	0.100	2341375000
1963	244438200	0.037	5841163	0.118	27258387	0.041	34751736	0.040	24584967	0.095	2355473214
1964	294419520	0.032	4260372	0.111	7652382	0.043	17773588	0.046	2361634	0.092	2495062500
1965	358027960	0.034	4912779	0.105	28510481	0.041	29190741	0.041	25462755	0.097	2636883929
1966	340604360	0.034	3025030	0.093	1538779	0.056	21958319	0.053	33556648	0.099	2755901786
1967	304078400	0.035	3515071	0.108	1460621	0.071	6876290	0.063	25230413	0.100	2707500000
1968	193799390	0.036	3432979	0.099	1092117	0.063	4659456	0.095	27057640	0.093	2680714286
1969	195068990	0.035	2977561	0.089	795055	0.125	2912465	0.123	24854828	0.094	2850000000
1970	206763600	0.034	3499399	0.115	3003431	0.086	3886092	0.086	27541506	0.097	2930000000
1971	182021670	0.039	3230854	0.100	5091538	0.076	2626385	0.117	25027211	0.108	3010000000

Sources: US Foreign Trade Statistics FT 141, Department of Commerce, Washington, D.C.
Agricultural Statistics, United States Department of Agriculture, Washington, D.C.

Table 18

COMPOSITION OF ANIMAL FEED IN FRANCE

percent

Type Feed	Cow Standard	Beef and Calf	Layer Medium	Poultry Grower	Broiler	Broiler Finisher	Pig Starter	Pig 0 to 30 Kg.	Pig 30 to 100 Kg.	Sows
Cost*	66.34	70.55	75.74	99.45	84.52	77.93	75.06	73.68	72.28	70.41
Cereals	-	-	58.7	64.8	40.0	40.0	-	10.0	10.0	-
Cereal Byproducts	17.3	24.8	8.0	8.0	3.0	15.0	20.0	17.0	10.0	30.0
Oil Cakes & Seeds	23.6	34.2	10.2	7.8	19.6	16.6	25.3	20.8	21.8	7.5
Animal Meal	4.0	5.0	9.0	16.3	12.0	6.6	6.3	7.8	5.8	10.0
Cassava	42.3	21.7	3.0	-	20.8	14.7	47.3	36.4	44.5	37.2
Other	12.7	14.1	11.0	3.0	4.2	6.9	0.9	7.8	7.6	15.1

* u.a./metric ton

high cost of transporting cassava to internal regions. In 1972, however, compounders in Brittany found it economic to include 15% cassava in pig feed rations for the six months of the year immediately prior to cereal harvest. Breton compounders characterise the substitution effect as being [15].

19% wheat + 1% bran = 15% cassava + 5% soybean meal;
and 15% maize + 4% bran = 15% cassava + 4% soybean meal.

French animal feed compounding is expected to grow, inducing an increased demand for cassava, if cassava prices remain favourable. Esselmann has predicted substantial increases in all categories of mixed feed, based on enlarged animal numbers and increased feeding rates. Consumption of compound feed for cattle is expected to increase by a spectacular 348% in 1980 reflecting an 882% increase in feeding rate over 1970. This expansion is possible because the French feeding rate is much lower than for other EEC countries, and even for the projected 1980 feeding rate*.

Estimated French pig and poultry rations contain greater amounts of cereals (reflecting France's cheaper cereal prices) and in consequence, less cassava (Table 18), compared with similar Dutch, German or Belgian feeds. On the other hand, cassava content in French cattle rations is higher and more stable than for all other EEC countries. The competitive-complementary relationships already noted between cassava, cereal by-products, cereal, and oilseed and cake are again discernible for France (Figures 4a, 4b and 4c).

Employing the assumptions of fixed price relativities, constrained and unconstrained cassava content, the 1980 demand for cassava is projected to be 1,108 to 1,958 thousand metric tons. If cassava price is assumed to be $95.00 rather than $90.00/metric ton, the projected demand decreases

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*The projected feeding rate of 750 kg/cow is substantially below the 1970 Dutch feeding rate of 1091 kg/cow.

Table 17

Projected Demand for Cassava*
in Belgium-Luxembourg 1980
(1000 metric tons)

	Low	High
Cattle	110	165
Poultry	65	65
Pigs	297	495
TOTAL	472	725
Increase over 1970	176%	271%

*Cassava price assumed to be $90.00/metric ton

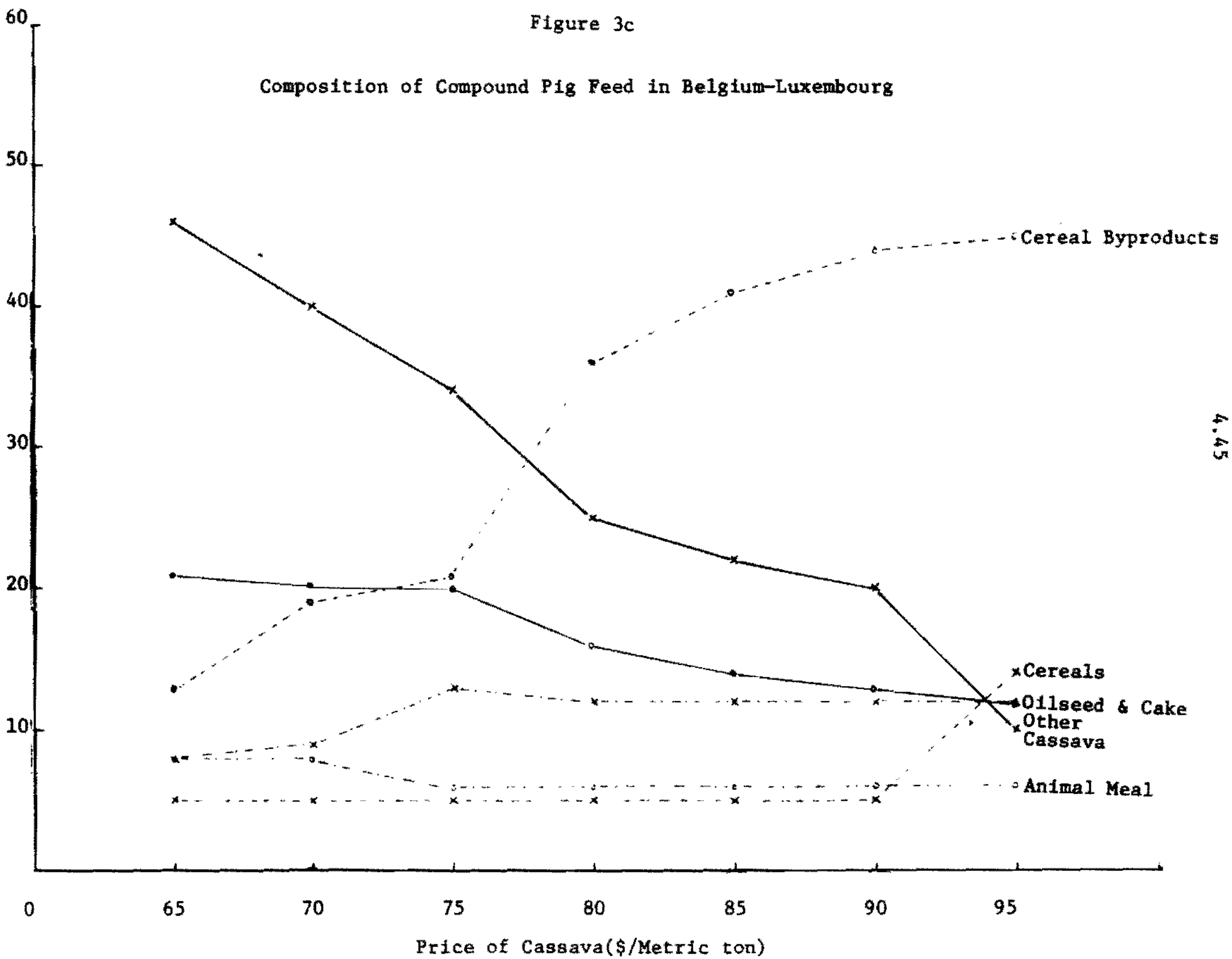

Figure 3c

Composition of Compound Pig Feed in Belgium-Luxembourg

Figure 3b

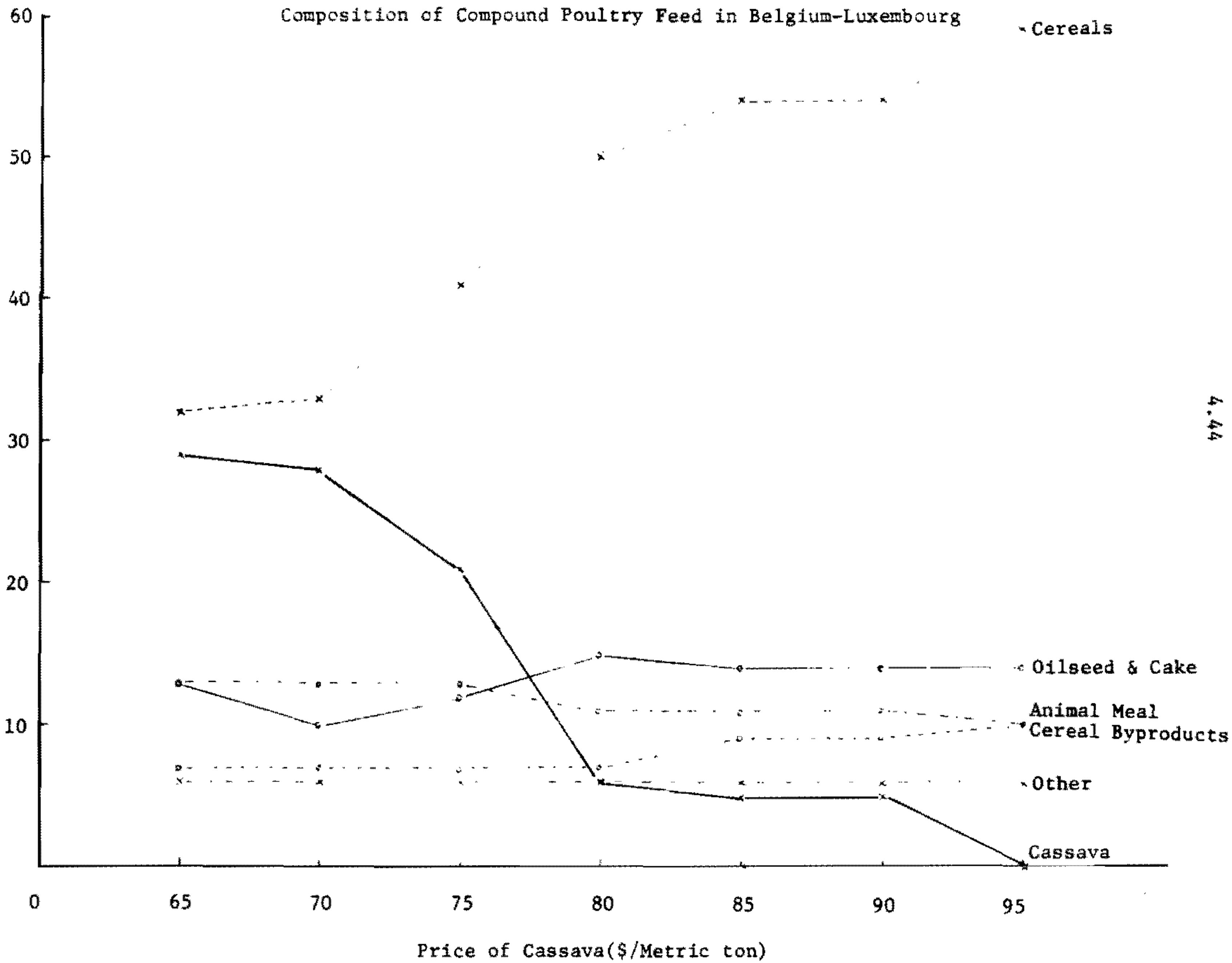
Composition of Compound Poultry Feed in Belgium-Luxembourg
60
50
40
30
20
10
0
65
70
75
80
85
90
95
Cereals
Oilseed & Cake
Animal Meal
Cereal Byproducts
Other
Cassava
Price of Cassava($/Metric ton)

Figure 3a

Composition of Compound Cattle Feed in Belgium-Luxembourg

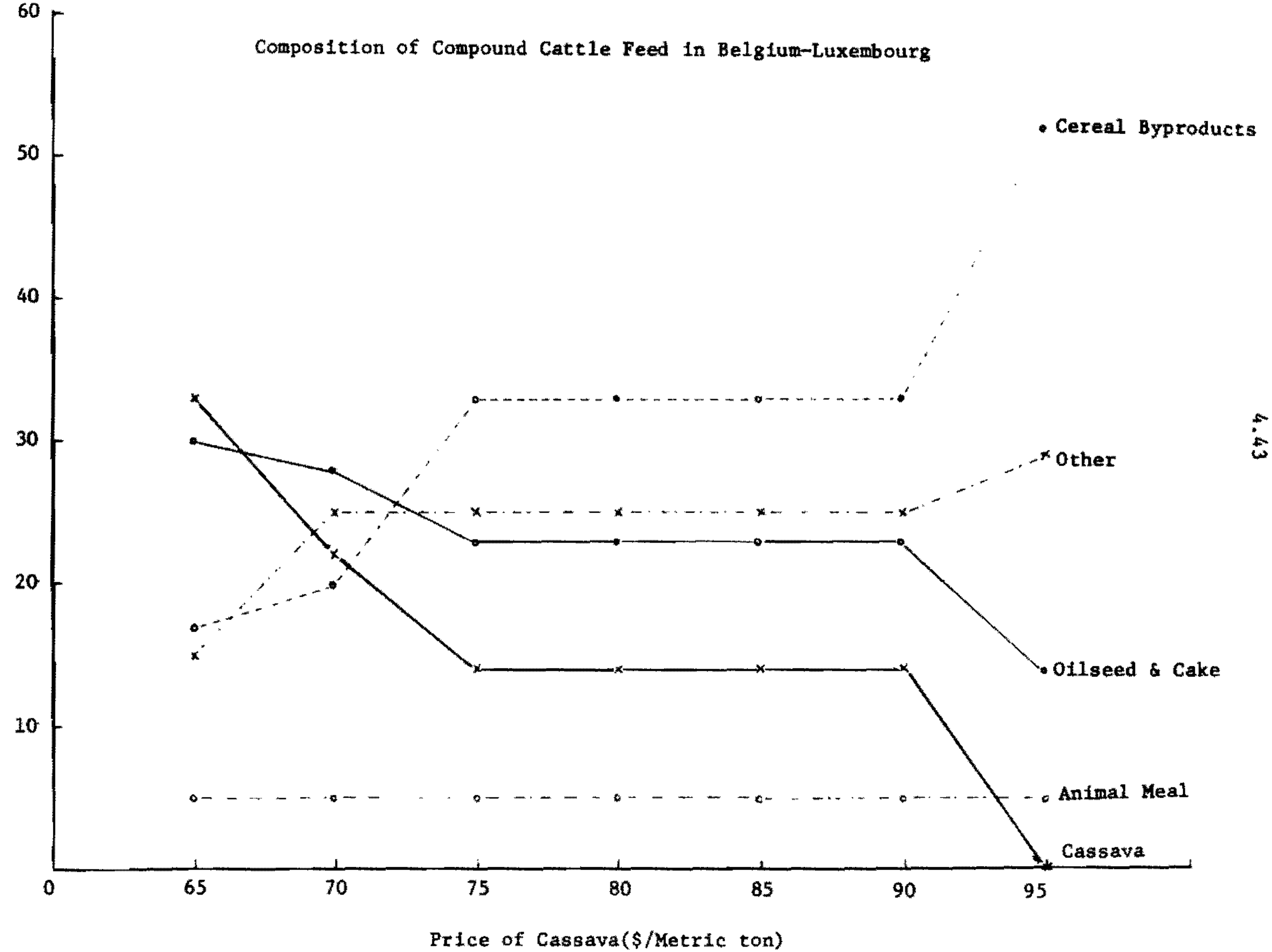

Table 16

COMPOSITION OF ANIMAL FEED IN BELGIUM-LUXEMBOURG

percent

Type Feed	Cow Standard	Beef and Calf	Layer Medium	Poultry Grower	Broiler	Broiler Finisher	Pig Starter	Pig 0 to 30 Kg.	Pig 30 to 100 Kg.	Sows
Cost*	67.04	71.46	86.04	108.64	91.04	82.26	75.46	74.94	73.38	71.23
Cereals	-	-	35.2	51.5	28.8	13.3	-	10.0	10.0	-
Cereal Byproducts	15.0	19.7	8.0	8.0	3.0	8.0	20.0	10.0	10.0	10.0
Oil Cakes & Seeds	24.0	35.8	13.9	4.9	16.8	15.4	25.3	23.3	21.8	13.8
Animal Meal	4.3	5.0	9.0	18.2	14.2	10.7	6.3	7.6	5.8	10.4
Cassava	43.1	22.7	22.8	14.3	33.1	47.5	47.3	40.8	44.5	49.6
Other	13.4	16.6	10.9	3.0	3.9	4.9	0.9	8.0	7.6	16.0

* u.a./metric ton

therefore, is obliged to conform faithfully to Belgium standards if sales are to be cleared, and increased cassava utilisation is possible only if standards are met.

Esselmann's projections of 1980 compound feed for cattle and pigs represent a continuation of trends of the 'sixties, while the projection of poultry feed represents a sharp decline caused by a reduction in the growth rate of poultry production and the limited scope in Belgium for increasing compound feed consumption rate. Nevertheless, in aggregate the prediction is that compound feed demand for Belgium-Luxembourg will increase by 17%.

The estimated feed rations for Belgium (Table 16) are similar to those of the Netherlands and Germany, although Belgian cereal consumption in poultry feed and cassava consumption in cattle feed are greater than in either of the other two countries. The effects of long-term increases of cassava price (Figures 3a, 3b, and 3c) indicate the competition between cassava and cereal by-products in cattle and pig feeds, and between cassava and cereal in poultry rations; and the complementarity of cassava and oilseed and cake in cattle and pig rations.

The assumptions that existing price relativities persist, that cassava price remains constant and that cassava percentages in feed rations will be between present constraints and economic maximum, results in a projected increase in Belgium-Luxembourg demand for cassava of 176% to 271% by 1980 (Table 17).

France

Prior to 1972, very little cassava* was used in compound feed in France, owing to the availability and relatively low price of cereals, and to the

*An interesting exception being rabbit feed, compounded in the Loire Valley, and based primarily on cassava, grass and alfalfa meal. This region produces a major proportion of total French production.

Table 15

Projected Demand for Cassava*
in Germany 1980
(1000 metric tons)

	Low	High
Cattle	106	106
Poultry	125	125
Pigs	446	930
TOTAL	677	1161
Increase over 1970	115%	196%

*Cassava price to user assumed to be $90.00/metric ton.

few years feed compounders in southern Germany have not included cassava in feed rations, using instead denatured wheat, the denaturing of which is subsidised under CAP. The wheat price reduction resulting from this subsidy premium and the additional transportation cost for cassava to reach southern Germany are sufficient to make denatured wheat economically more attractive than cassava. Thus, for projection purposes it is assumed that only 60% of German compound feeds will contain cassava, this percentage representing approximately the proportion of production which occurs north of Bonn, the demarcation line for cassava utilisation*.

The assumptions used in projecting 1980 German demand for cassava are:

a) that existing price relativities will persist in the future;

b) that cassava utilisation will be constrained by present maximums;

c) that cassava utilisation will not be constrained; and

d) that only 60% of 1980 compound feed will contain cassava.

The projections (Table 15) indicate that demand for cassava may not grow as rapidly as the demand for compound feeds. These projections depend primarily upon the growth in demand for compound feeds and the price competitiveness of cassava. Thus, adverse movement of either could limit cassava demand.

Belgium - Luxembourg

Cassava used in Belgium**has generally been of a higher quality than in other EEC countries, owing to stricter quality regulations [1 , p. 38]. It is reported that compounders check the quality of cassava received in Belgium [1 , p. 40], because quality certificates issued by exporters have been found in some instances to be unreliable. The exporter of cassava,

*A more accurate estimate could be derived if percentages of specific feeds produced North and South of Bonn were known. However, such data were not available to the author.

**Luxembourg is assumed to behave similarly to Belgium.

Figure 2c

Composition of Compound Pig Feed in Germany

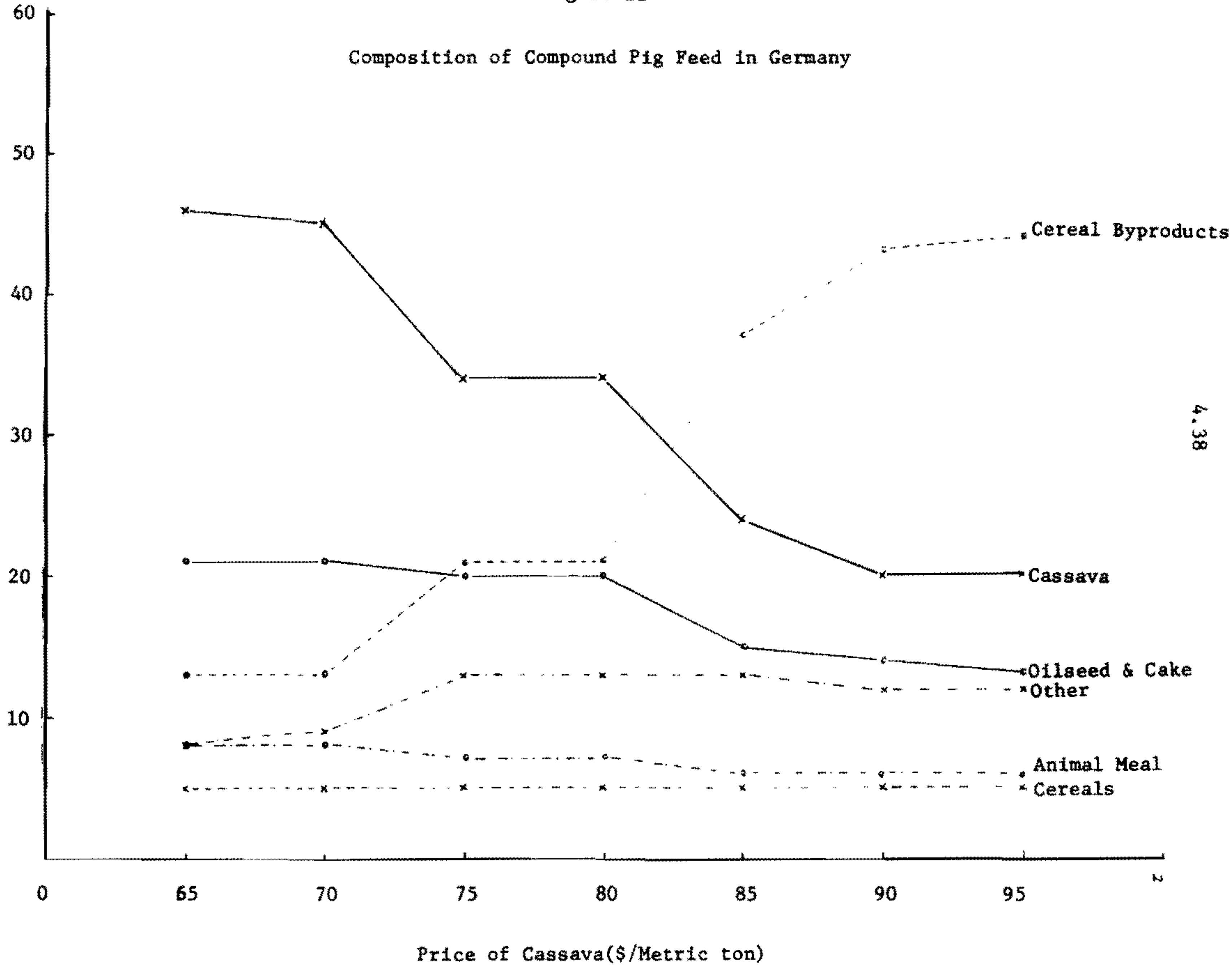

Figure 2b

Composition of Compound Poultry Feed in Germany

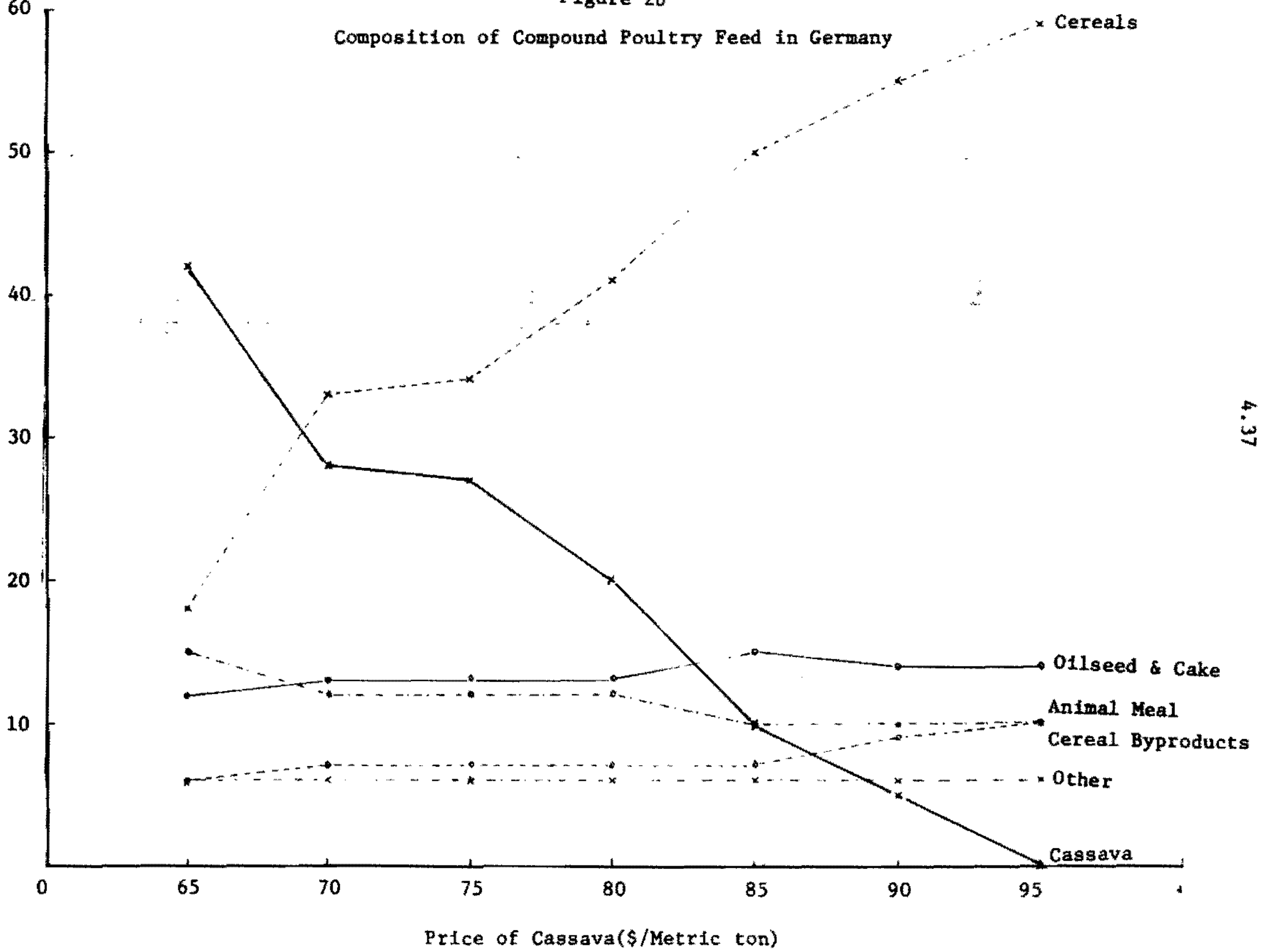

Figure 2a

Composition of Compound Cattle Feed in Germany

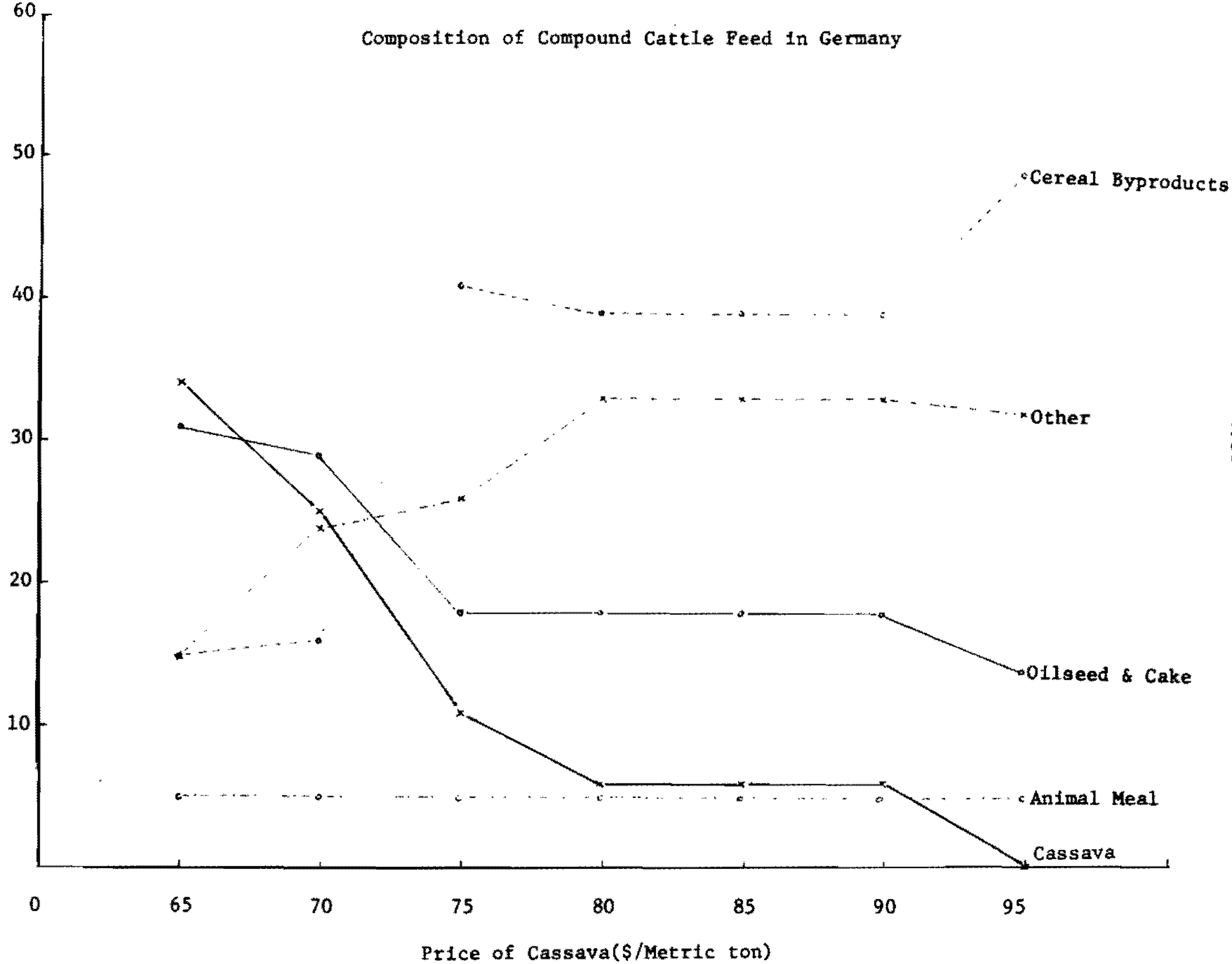

Table 14

COMPOSITION OF ANIMAL FEED IN GERMANY

percent

Type Feed	Cow Standard	Beef and Calf	Layer Medium	Poultry Grower	Broiler	Broiler Finisher	Pig Starter	Pig 0 to 30 Kg.	Pig 30 to 100 Kg.	Sows
Cost*	67.48	72.03	88.0	111.17	91.36	82.59	75.76	75.54	73.98	71.53
Cereals	-	-	26.4	45.7	-	-	-	10.0	10.0	-
Cereal Byproducts	13.4	17.3	8.0	8.0	3.0	6.1	20.0	10.0	10.0	10.0
Oil Cakes & Seeds	24.7	36.6	11.2	3.1	17.0	15.1	25.3	23.3	21.8	13.8
Animal Meal	4.5	5.0	12.0	20.0	16.5	12.4	6.3	7.6	5.8	10.4
Cassava	43.2	24.1	31.6	20.0	56.2	60.1	47.3	40.8	44.5	49.6
Other	14.0	16.8	10.6	3.0	6.9	6.1	0.9	8.0	7.6	16.0

* u.a./metric ton

The feed rations evaluated for Germany have the same basic linear programming matrix as the Dutch rations*, but prices of ingredients are altered to reflect differences resulting from CAP and transportation costs (Appendix E, Table E.3). The procedure in the case of wheat, barley, oats and maize was to weight Dutch end-user prices by the relativity of German-Dutch producer prices, assuming the ratio of producer prices:user prices to be equal. For sorghum, wheat middlings, wheat bean, brewers grain, and rice bran, average price relativities of intervention prices between the Netherlands and other countries were used to weight Dutch end-user prices. Remaining ingredient prices were held constant for all countries.

The estimated German feed rations with unconstrained cassava content (Table 14) resembled the Dutch results at low cassava prices. The major differences are that greater percentages of cassava are used in German broiler starter rations than in Dutch rations; and that in this ration the Germans use no cereal whilst the Dutch use 10% cereal. Varying the price relativities of cassava to other ingredients (Figures 2a, 2b, and 2c) again produces results similar to those of the Netherlands, although German demand for cassava is decreased more rapidly to increased price changes than in the Netherlands. In Germany, cassava is not used in cattle or poultry rations, if its price is equal to or greater than $95.00/metric ton. Again, cassava's competition with cereal by-products and complementarity with oilseed and cake, are indicated in cattle and pig rations (Figures 2a and 2c). In poultry rations, cassava competes with cereals.

As in the Dutch projections, feed rations are combined with projected compound feed demand to estimate the 1980 demand for cassava. In the past

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*Information collected by the author from German compounders indicates that only minor differences exist between German and Dutch compounded feeds.

Table 13

Projected Demand for Cassava*
in Netherlands 1980
(1000 metric tons)

	Low	High
Cattle	255	255
Poultry	218	392
Pig	547	1733
TOTAL	1020	2380
Increase over 1970	203%	474%

*Cassava price assumed to be $90.00/metric ton.

used in the estimation of future demand for cassava. The first point is taken at average price and existing maximum cassava limits; the second point is taken at average price and economic maximum of cassava.

Thus, the low projections of demand for cassava in pig feeds are derived by

1) multiplying projected consumption of pig feed (4,560,000 metric tons) by 12% , the average maximum limit of cassava now allowed in the ration; and the high projection is derived by

2) multiplying projected consumption of pig feed by the economic maximum percentage of cassava in the ration (38%).

The resulting projections of the demand are 547,200 metric tons and 1,732,800 metric tons. Projections of the 1980 demand for cassava in cattle and poultry rations (Table 13) were similarly calculated. The combined effect of these projections is that the 1980 demand for cassava will be 1 to 2.4 million metric tons -- at least a doubling of the 1970 demand.

The method used for projecting 1980 Dutch cassava demand is now applied to the markets of Germany, Belgium-Luxembourg, France, Italy, the United Kingdom and Denmark. In many cases similarities with the Dutch situation are exhibited. To avoid redundancies, the discussion will deal primarily with characteristics peculiar to each market.

Federal Republic of Germany

Germany, formerly the major importer of cassava products, lost its position to the Netherlands in 1971. Germany will likely remain a large market for cassava, but it is expected that Holland will dominate. However, German consumption of compound feeds is predicted to be pre-eminent in the EEC, with France forecast as a near second (Table 7). A substantial proportion of this projection results from anticipated enlargement of the national pig heard and greater use of compound feeds.

This somewhat unexpected complementarity between cassava and oilseed and cake is to a large extent the product of least-cost feed ration techniques. Least-cost linear programming techniques do not compare one specific ingredient with another (thus, the popular assumption that cassava competes with barley is not wholly accurate). Rather, the technique selects the least-cost combination of ingredients (thus, cassava competes with barley or other cereal *energy*, while soybean cake replaces barley or other cereal *protein*).

With respect to the other feed types, the demand for cassava in poultry rations (Figure 1b) is constant.

The demand for cassava in poultry rations is constant up to $80.00/ metric ton, and then drops to 20% of ration at $95.00/metric ton. Unlike cattle feeds cassava in poultry rations competes primarily with cereals, not 'other' feeds. The demand for cassava in pig feeds is also fairly insensitive to price change (Figure 1c) (cassava percentage dropping from 45 to 35% as price increases from $65.00 to $95.00/ton). Cassava competes mainly with cereal by-products and 'other' feeds. There is also a slight decrease in the use of oilseed and cake, once again suggesting a complementarity between cassava and oilseed and cake.

1980 projections of the Dutch demand for cassava may be derived from the cassava demand functions (Figure 1a, b and c) and the projected demand for compound feed (Table 7). The procedure is to multiply the appropriate demand projection* by the percentage of cassava in the diet for specific conditions. Two points from each cassava demand function are

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*Because consumption projections (Table 8) relate only to categories of feed and not specific rations, it is possible to estimate only the demand for cassava by feed categories. When projections of specific feeds become available, they can be used with the compound feed demand functions (presented in Appendix E), to estimate the demand for cassava for each feed. This latter approach would be expected to improve the accuracy of the projected demand for cassava.

Figure 1c

Composition of Compound Pig Feed in Netherlands

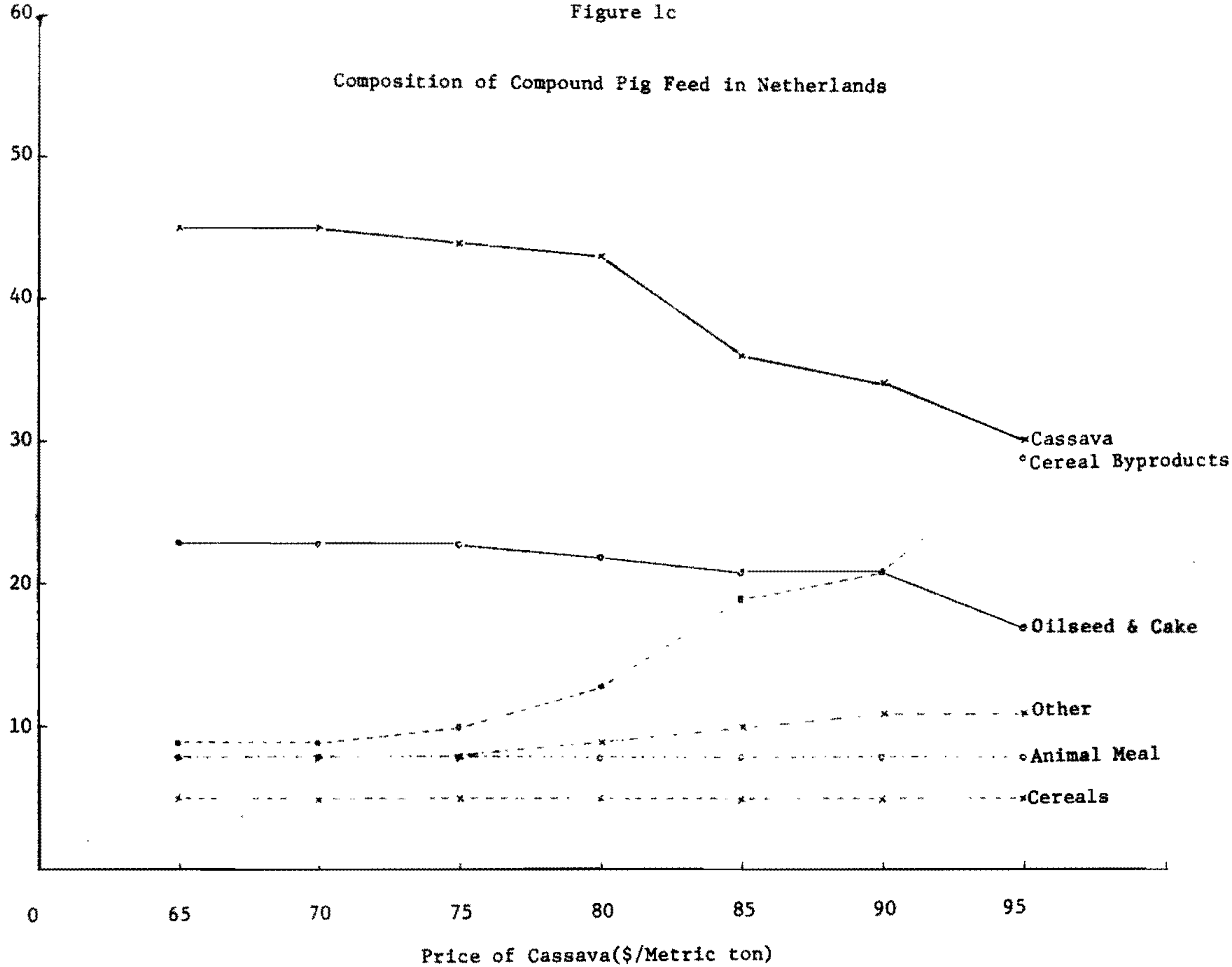


Figure 1b

Composition of Compound Poultry Feed in Netherlands

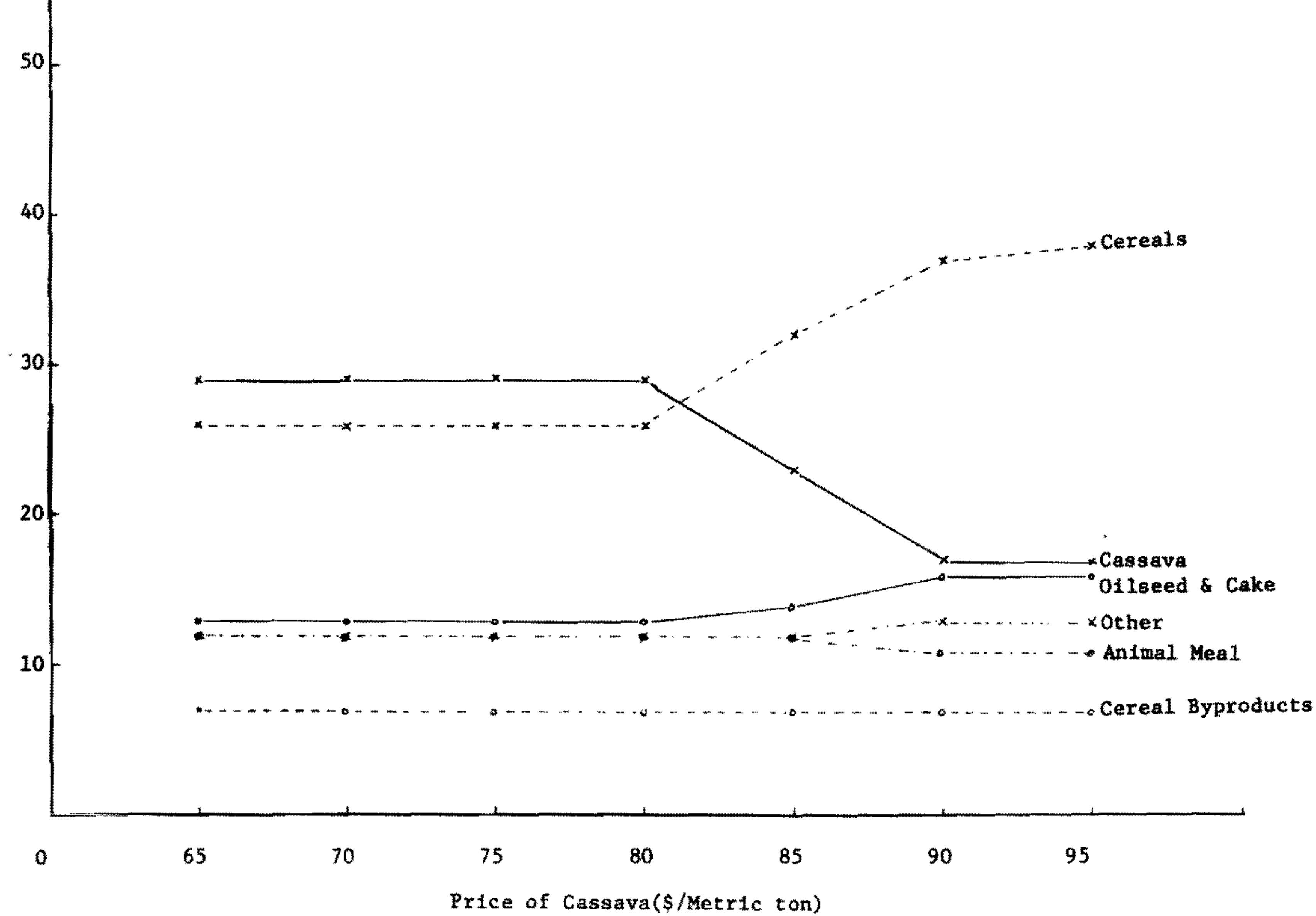
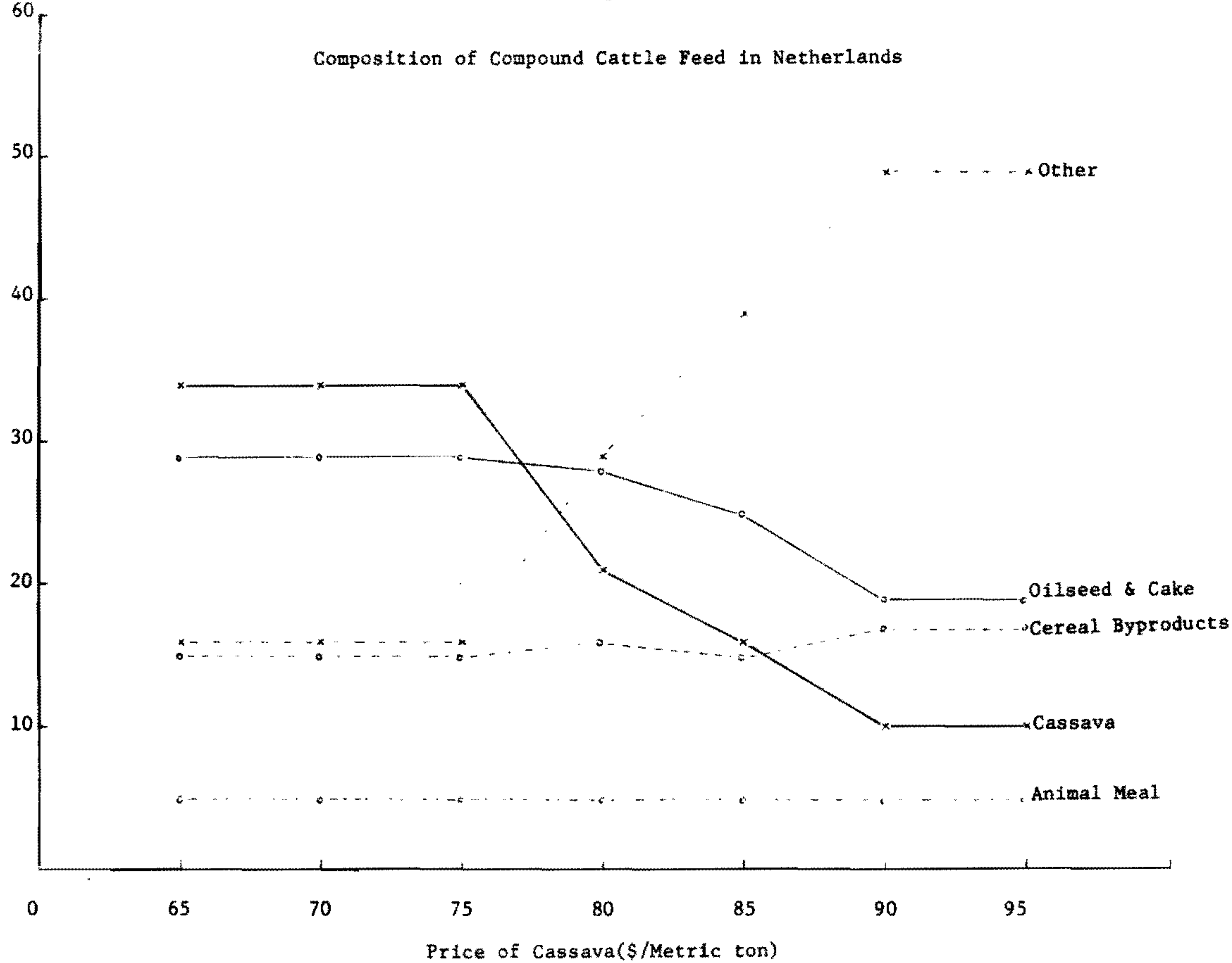


Figure 1a



Composition of Compound Cattle Feed in Netherlands
60
50
40
30
20
10
0
65
70
75
80
85
90
95
Other
Oilseed & Cake
Cereal Byproducts
Cassava
Animal Meal
Price of Cassava($/Metric ton)

Table 12

Demand Elasticities for Cassava in Netherlands

	η_c* for Price Increase	η_c for Price Decrease
Cow Stan.	2.84	2.81
Cow & Calves	-	7.16
Layer Med.	10.74	0.10
Poultry	-	-
Broiler Rear.	5.32	-
Broiler Fin.	50.73	0.57
Pig Start.	5.02	-
Pig 0-30 kg.	3.44	2.27
Pig 30-100 kg.	0.29	1.59
Sows	7.09	6.66

* $\eta_c = -\frac{\Delta Q/Q}{\Delta P/P}$

where Q = quantity of cassava in ration;
and P = price of cassava.

ΔQ and ΔP are the maximum changes which can occur in the ration without changing ingredients in the ration.

Calculated short-run demand elasticities* (Table 12) for cassava by feed category indicate that cassava utilisation in broiler finishing feeds is most sensitive to price increases, while cassava utilisation in beef and calf feeds is least sensitive.

The analysis suggests, therefore, that on average a 1% increase of cassava price would in the short-term reduce the demand for cassava in cow feeds by 1.4%; in pig feed by 15%; and in poultry feeds by 4.0%. Conversely a 1% decrease in the price of cassava would increase the demand for cassava in cow feeds by 5.0%; in pig feeds by 3.5%; and in poultry feeds by 2.6%.

Long-run price changes (Figures 1a, 1b and 1c) vary in effect depending upon feed type**. Where cow feeds are concerned (Figure 1a), cassava is competitive with other energy sources and to a lesser extent cereal by-products, (a cassava price increase results in decreased utilisation of cassava and increased utilisation of cereal by-products and of 'other' feed ingredients). The complementarity between cassava and protein sources should also be noted, viz., utilisation of cassava and oilseed and cake decrease together. This complementarity is not commonly appreciated, and consequently the degree to which cassava utilisation can be adversely affected by policies or events which limit the supply of vegetable protein sources in the EEC is not widely realised. In short, if high protein sources were not available, cassava would cease to be utilised in compound feeds.

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*Short run demand elasticity is defined as the percentage change in the quantity demanded divided by the percentage change in price, given that other prices remain constant and that no ingredients are added or removed from the compound feed ration. For those familiar with IBM's MPSX or MPS linear programming package the elasticities are calculated from the range section. Because the demand schedule is linear by definition, the elasticity is the actual demand elasticity and not an arc elasticity.

**Appendix E, Table E.1, summarises the effects of cassava price changes for each ration.

Table 11

Composition of Animal Feed in Netherlands
(Unconstrained Cassava Limit)

Type of feed	Cow Stand	Beef & Calf	Layer	Poultry	Broiler	Broil. Fin.	Pig Start.	Pig 0-30	Pig 30-100	Sow
Cost*	*74.79*	*78.63*	*100.04*	*134.26*	*111.27*	*100.42*	*92.22*	*91.10*	*87.04*	*87.98*
Cereals	-	-	38.7	59.8	32.6	20.0	-	10.0	10.0	-
Cereal By-products	19.6	15.0	8.5	8.0	3.0	8.0	45.0	17.0	17.0	35.0
Oil cakes & Seeds	18.9	35.4	13.3	12.8	23.7	19.8	15.8	24.0	21.6	8.2
Animal Meal	4.2	5.0	11.0	16.0	9.2	6.2	8.5	7.6	7.2	9.0
Cassava	11.0	9.2	16.9	0.0	18.7	31.5	26.3	33.4	29.8	30.6
Other	46.3	45.4	13.9	3.4	12.5	14.3	4.1	7.7	14.2	16.9

*u.a./metric ton

Table 10

Composition of Maximum Animal Feed in Netherlands (Constraint on Cassava*)
(Percent)

Type of feed	Cow Stand	Beef & Calf	Layer	Poultry	Broil.	Broil. Fin.	Pig Start.	Pig 0-30	Pig 30-100	Sow
Cost**	74.97	78.63	100.87	134.26	[illegible]	[illegible]	97.40	93.72	[illegible]	[illegible]
Cereals	-	-	49.0	59.8	50.0	46.5	23.5	27.8	17.8	11.0
Cereal By-products	19.6	15.0	8.0	8.0	3.0	3.0	28.6	17.3	19.0	45.0
Oil Cakes & Seeds	18.9	35.4	11.0	12.8	21.0	22.6	16.4	16.1	16.0	-
Animal Meal	4.2	5.0	9.0	16.0	8.9	5.4	7.4	6.4	5.5	8.2
Cassava	11.0	9.2	10.0	0.0	5.0	10.0	5.0	10.0	15.0	7.0
Other	46.3	45.4	13.00	3.4	12.1	12.5	19.1	22.4	26.7	28.2

*Cassava maximums are Cow Standard 20%; Beef and Calf 20%; Layer Medium 10%; Poultry Grower 0%; Broiler 5%; Broiler Finisher 10%; Pig Starter 5%; Pig 0-30 kg, 15%; Pig 30-100 kg, 15%; and Sows 7%.

**Unit of account (u.a.)/metric ton. Exchange rate used 1 u.a. = $1.00 .

altering Esselmann's projections, it was decided in the first instance to err on side of conservatism and to utilise his estimations of the future magnitude of Dutch compound feeds.

Of this anticipated magnitude, what percentage of the compound feed market may cassava be expected to claim? The initial results of equations 1 and 2 are presented in Tables 10 and 11. They indicate, given present price relativities, that

a) cassava percentages, if permitted, will exceed their present allowable maximum in layer, broiler rearing, broiler finishing and all pig rations;

b) cereal percentages will decrease, with no cereal being found in cow, beef, pig starter and sow rations;

c) oil cake and seed percentages will increase.

The largest increase in cassava utilisation is predicted to occur in pig feeds. If constraints on cassava are dropped*, utilisation of cassava will increase at the expense of cereals and 'other' ingredients. In general, the removal of constraints and increased use of cassava could reduce the cost of compound feeds by as much as $5.18/metric ton, or by as little as $0.63/metric ton**.

As already noted, fixed prices or price relativities have been assumed. However, it is of interest to evaluate the possible effects of price changes. Linear programming techniques permit the quantification of short and long-run price change effects .

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*One of Europe's largest feed compounders successfully trial-fed cassava at the 60% level, thus no technical constraint hinders its increased use.

**Of course, cow, beef and poultry starter rations, which experience no increase in cassava utilisation will not experience cost changes if cassava constraints are removed.

Feed compounding in Holland is undertaken by both private firms and cooperatives, with the latter being slightly more important and of larger average capacity. In 1970/71 cooperatives accounted for 51% of production and averaged 24,846 metric tons per plant, against a private average of 6,104 metric tons per plant [14, p. 22-23]. Feed compounding accounts for virtually all swine and poultry feed and 90% of high protein feeds*.

High swine dependency on compound feeds and the rapid growth of pig numbers (the national pig herd nearly doubled during the 'sixties) have been mainly responsible for greatly increased Dutch demand for compound feeds. In fact, it appears that compound pig feed consumption is increasing at an exponential rate with no indication of leveling off in the near future (Figure 1). However, it is difficult to project this rate in the Dutch context, particularly since expansion of pig numbers may eventually be inhibited by pollution regulations [2]. Certainly, Esselmann's projections do not extrapolate this trend (Table 6). He assumes that market shares will alter slightly between 1970 and 1980, that demand for pig meat will increase by 20% by 1980, and thus that Dutch pig production will increase by 29% by that same date.

Esselmann's projections, however, are probably low. The 1971 consumption of pig feed was 15% above his projected 1970 level, and 1972 consumption is estimated to have already exceeded the 1980 forecast. Furthermore, his projection of total demand for compound feeds for 1980 may have been exceeded in 1972**. Faced with the choice of accepting or

*Data on the importance of compound feeds in cattle rearing are not available, but it is assumed that perhaps 90% of cattle feed is manufactured by compounders. Certainly, most grains used in cattle rearing are used as an ingredient in compound feed since 96% of all cereals fed are used in mixed feeds [15, p. 4].

**Esselmann's projection of 1980 total compound feed consumption is equivalent to an increase of approximately 144,000 tons/year. This increase is probably modest. One large Dutch feed compounder informed the author that the long-run projected increase for his plant alone was 100,000 tons/year.

evaluation of British and Danish least-cost rations. The Dutch constraints were used in all other instances.

The analysis did not attempt to estimate the future costs of ingredients. Instead, secondary price projections or existing prices relativities were assumed to be applicable for projection purposes. The United Kingdom analysis employed prices projected by Ellis [11] which detailed expected changes for the transition period, 1973-1978. For the remaining EEC countries it was assumed that current price relativities will prevail in the future. This assumption is crucial to the analysis; to the extent that CAP maintains a single policy for feed grains, and that inflation rates apply equally to all feed grains, the price assumption is tenable; to the degree that price relativities change, the following analysis will be subject to biases, although several sensitivity analyses are attempted to determine the possible extent and direction of such biases.

The following is a discussion of the projection results for cassava utilisation by country.

Netherlands

Since 1962, demand for cassava has increased more rapidly in Holland than in any other EEC country. Today the Netherlands is the most important European market for cassava. This growth is the consequence of

1) a high animal:land ratio which invokes heavy dependence on purchased feeds;
2) an efficient and relatively inexpensive water transportation system which enables imported feeds to be easily shipped to any part of the country;
3) development of a large compound feed industry which utilises computer formulation in feed rations;
4) overall increased demand for compound feeds.

Subsequent sections examine these expectations, and quantify possible changes to the year 1980.

4.3 Future Demand for Cassava in the EEC

Most feed compounders in the EEC determine feed formuli by linear programming technique. In essence, this technique minimises the cost of feed ration while satisfying specified nutrient (e.g., protein, energy, lycine, etc) and quality requirements. The general cost function is shown in Equation 1, while the constraint set is illustrated by Equation 2.

$$Z = \Sigma a_i X_i \qquad \ldots(1)$$

where Z = cost of ration; a_i = cost of i^{th} ingredient; and X_i = amount of i^{th} ingredient used in the ration.

$$A \lesseqgtr C \qquad \ldots(2)$$

where A = linear programming matrix (k x n); C = vector of length k which contains the constraint set. (Appendix D Table D.1 gives an example of the basic linear programming model used in this study.)

Because this technique is widely used in Europe, the future demand for a particular ingredient such as cassava, therefore, may be estimated through the development and evaluation of least-cost feed matrices for different rations and countries. For this study, 61 different formuli were estimated.

Two distinct matrices were developed, based on Dutch and United Kingdom constraints. The differences between these matrices rest mainly with differences of ration type rather than with nutrient requirements for similar feeds*. The United Kingdom constraint matrix was used in the

*Rations estimated with the United Kingdom matrix were: dairy, 3.5 gallons/day/cow; dairy, 4.0 gallons/day/cow; beef fattening; grazing cake; layer medium ration; poultry grower; broiler raiser; broiler finisher; pig grower; pig fattening. Dutch rations were: Cow standard; beef and calf; layer medium energy; poultry grower; broiler raiser; broiler finisher; pig starter; pigs 0-30 kg; pigs 30-100 kg; sows. Technical coefficients were derived from Hulptable [12], instead of Morrison [13] which is commonly used in North America. The former was thought to be more appropriate for European conditions.

Table 9

Major Ingredients in Compound Feeds
of Some European Countries, 1960-70
(%)

Ingredient	1960	1965	1970	1960	1965	1970
		Netherlands			Germany	
Cereal	63.2	50.2	33.7	43.9	37.1	n.a.
Oilseed & Cake	15.9	21.2	25.5	20.8	23.9	37.7
Animal Meal	4.4	3.4	1.9	3.7	4.3	6.4
Cassava	n.a.	1.1	5.6	2.8	6.4	5.6
		France			Belgium	
Cereal	50.8	43.8	51.9	n.a.	40.0	43.3
Oilseed & Cake	20.0	22.3	23.1	n.a.	15.9	18.9
Animal Meal	5.4	4.6	3.3	n.a.	4.3	2.9
Cassava	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: Study on the Factor(s) Influencing the Use of Cereals in Animal Feeding, OECD, Paris, 1971.

The Markets for Manioc as a Rawmaterial for Compound Animal Feedingstuffs, ITCm UNCTAD/GATT, Geneva, 1968.

The Major Import Markets for Oilcake, ITC, UNCTAD/GATT, Geneva, 1972.

auger equipment - hence the popularity of pellets. Availability has been somewhat of a problem with respect to cassava, the supply of which may be inconsistent or even unavailable.* Where large feed compounders find it too expensive to stockpile feeds, especially bulky feeds, or to change feed ingredients continually (viz., leading United Kingdom compounders estimate that the short-term cost of changing a feed ration is between £1.25 to £2.00/long ton of feed added), consistent supply of an ingredient becomes crucial.

Since the formation of the EEC, the composition of compound feeds has altered substantially. It should be noted, however, that the United Kingdom and Denmark have not up to now participated in these changes (Table 9). The overriding pattern for the EEC of Six has been a decline in the percentage of cereals used coupled with a relative increase in the percentage of cereal by-products and oilseed cakes. The most dramatic change has occurred in the Netherlands where cereal content dropped from 63% to 34%; oilseed and cake content increased from 16% to 26%; and animal meal decreased to 2%. At the other end of the spectrum, France, with its relatively cheap cereals, continued to include high percentages of cereals in compound feeds in the 'sixties. Denmark and the United Kingdom, with relatively constant prices (relative to price changes wrought by CAP) also maintained cereal at a high level.

As already noted, consumption of cassava has grown at a rate exceeding consumption of compound feeds. Thus, a third trend of particular interest to this study has been the increased percentage of cassava in compound feeds (cassava content of Dutch feeds, for example, has increased from 0.0% to 5.4%). EEC policies when fully applicable** will undoubtedly induce Danish and British compounders also to decrease cereal content and increase cassava and cereal by-product content in compound feeds.

*In economic terms, a short-run inelastic supply schedule is implied.

**Technically EEC policies are now applied to all member countries.

Table 8

Imports of Cassava Products into the European Economic Community (1962-1970)
(1000 m. tons)

	1962	1963	1964	1965	1966	1967	1968	1969	1970
W. Germany	366	387	462	520	702	533	481	548	591
France	23	20	18	17	16	na	na	na	35
Italy	0	0	0	1	0	na	na	na	14
Netherlands	1	5	17	76	96	159	237	444	502
Belgium	23	72	105	100	70	113	127	212	268
TOTAL	413	484	602	714	884	(805)	(845)	(1204)	1410

Source: 1962-66 -, The Markets for Manioc as a Raw material for Compound Animal Feedingstuffs, International Trade Centre, UNCTAD/GATT, Geneva, 1968.

1967-70 -, Commodities and Trade Division, FAO, Unpublished Data.

relatively constant shipments to Europe. German investments have proven timely in view of the growth of demand for cassava which has occurred since the early 'sixties (Table 8). In 1962, demand for cassava was 413,704 tons; by 1971 the market had expanded to 1,500,000 tons, an increase of 363%. In 1972 demand for cassava is estimated to have been approximately 1,700,000 tons. The average annual growth rate in European cassava consumption over the past decade has been 13%, exceeding the growth rate of consumption of compound feeds (10%), thereby implying increased utilisation of cassava in compound feeds.

In most instances*, the composition of compound feeds is determined by least-cost linear programming techniques. The use of specific feeds is determined by

- relative prices;
- nutritional composition of feed;
- nutritional requirements of ration;
- quality requirements of ration (e.g., layer rations may be required to have a minimum amount of maize).

Of all the factors listed above, cassava's low price and high energy content relative to cereals have been primarily responsible for making it an economically attractive compound feed ingredient. With the application of CAP, compound feed manufacturers have found that cassava mixed with appropriate amounts of high protein feeds (such as 40% protein soybean meal and extract) produces a cheaper feed than could be produced if large quantities of cereal are used.

Two additional factors, physical quality and availability, also influence the demand for specific feeds. Physical quality of a feed ingredient is becoming more important because modern feed handling techniques are not as flexible as earlier systems. For example, cassava chips exceeding 15 cm. are not easily handled by pneumatic or small bore

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*Even on-farm compounding often utilises computer formulated rations. In several EEC countries grain merchants, farm management consultant firms, and cooperatives will develop least-cost feed rations for farmers.

Table 7

PROJECTIONS OF THE DEMAND FOR COMPOUND FEEDS
IN 1980, IN THE EEC

(1,000 M.Tons)

Types of Livestock	W.Germany[1]	France[1]	Italy[1]	Netherlands[1]	Belgium/ Luxembourg[1]	United Kingdom[2]	Denmark[2]	EEC
Cattle & Calves	3,550	4,250	2,200	2,550	1,100	6,689	2,283	17,667
Hogs	6,200	5,250	1,300	4,560	2,475	5,571	5,070	30,644
Poultry	4,180	4,195	4,530	2,180	1,305	5,937	554	18,481
TOTAL	13,930	13,695	8,030	9,290	4,880	18,197	7,907	66,792

Source: 1. W. Esselmann, Development of Future Mixed-Feed Consumption in the Common Market, A paper given at the eighth European Mixed-Feed Congress in Rotterdam on 19 May, 1972.

2. John Ferris et al., The Impact on U.S. Agricultural Trade of the Accession of the United Kingdom, Ireland, Denmark and Norway to the European Economic Community, Research Report No. 11, Institute of International Agriculture, Michigan State University, 1971. (Table 2.9, p.87, and Table 4.8, p.176).

Figure 4a

Composition of Compound Cattle Feed in France

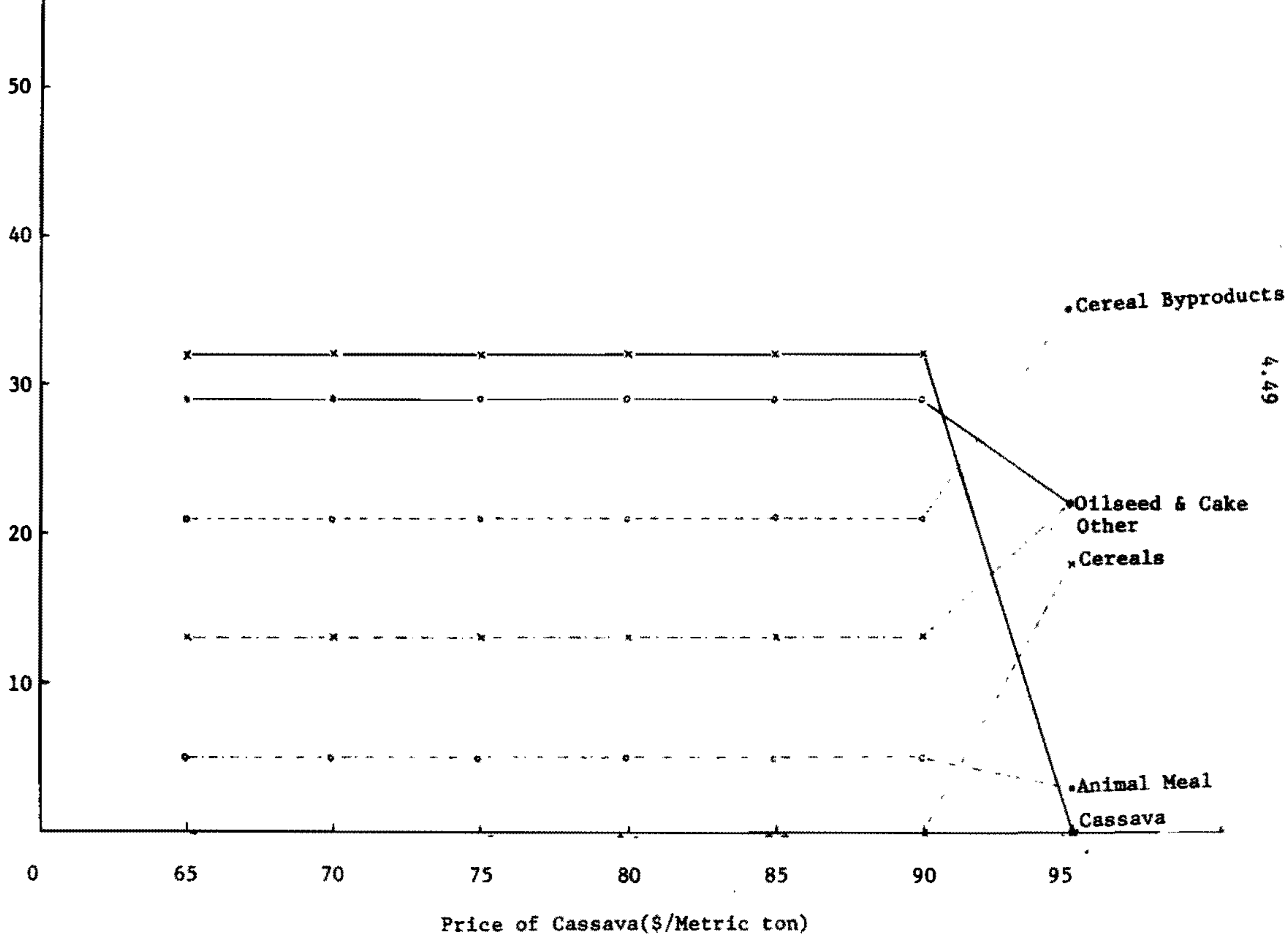


Figure 4b

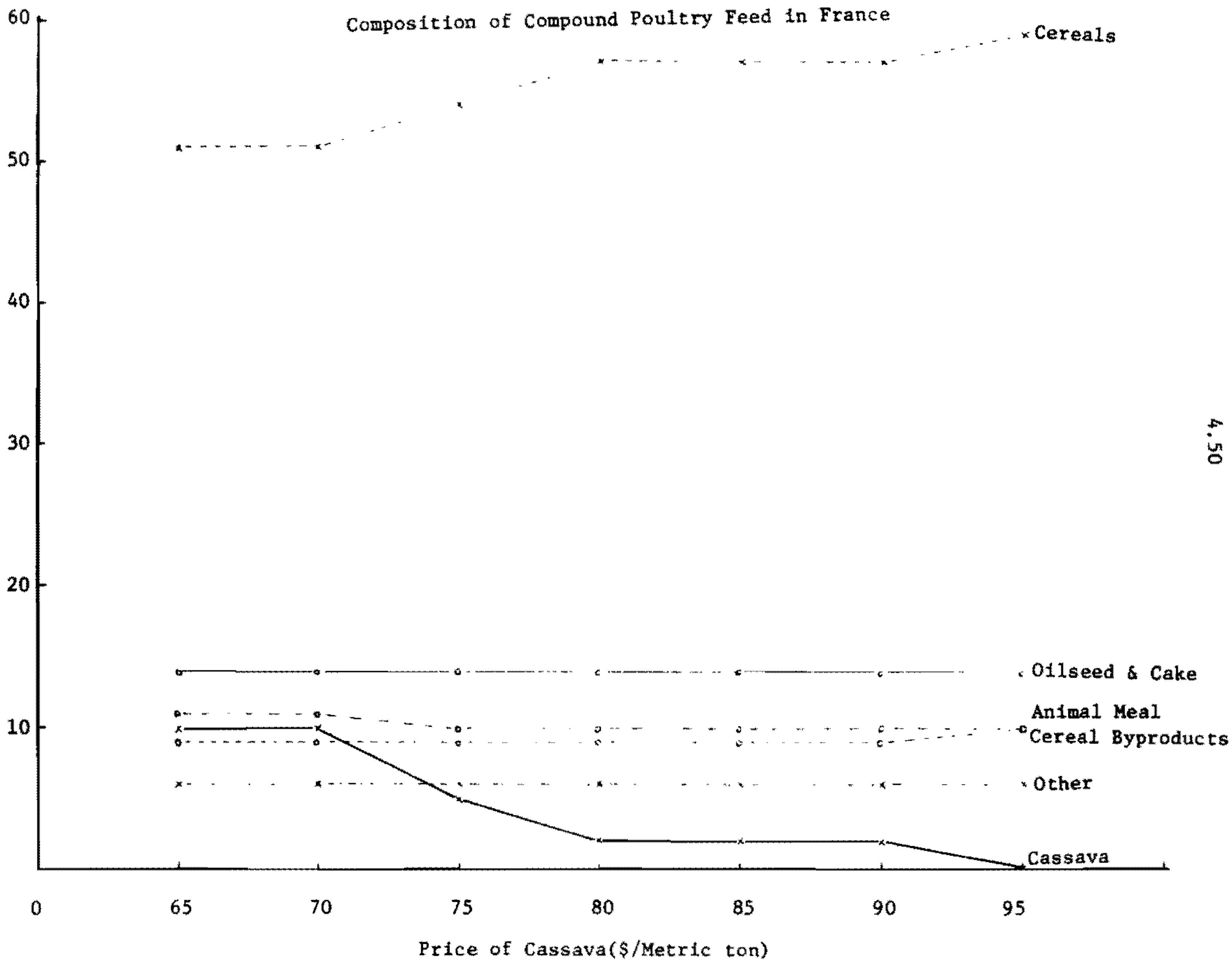
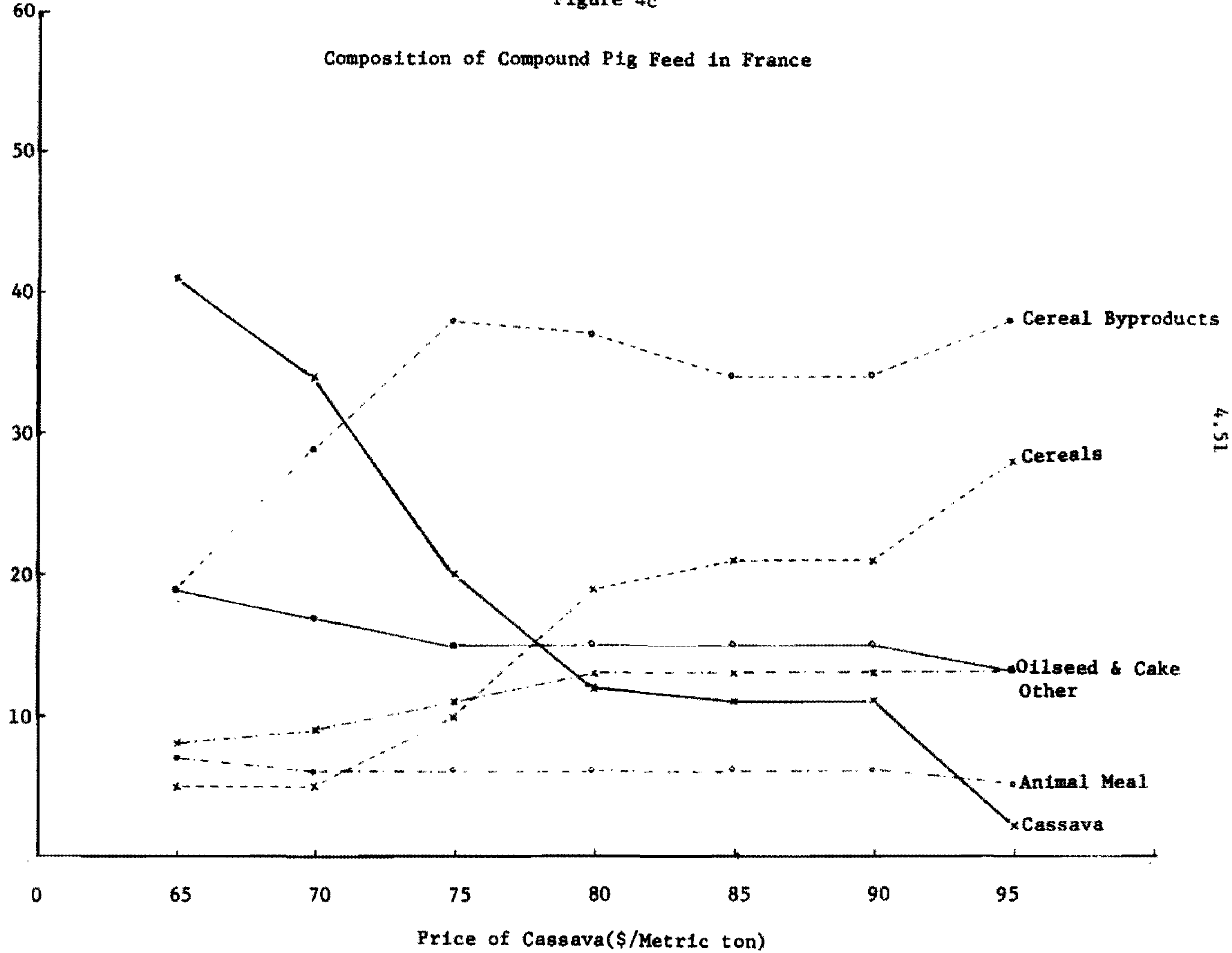

Composition of Compound Poultry Feed in France
60
50
40
30
20
10
0
65
70
75
80
85
90
95
Cereals
Oilseed & Cake
Animal Meal
Cereal Byproducts
Other
Cassava
Price of Cassava($/Metric ton)

Figure 4c

Composition of Compound Pig Feed in France



to 157,000 thousand metric tons. This estimate in the final analysis will be used as the low projection of demand (Table 19).

Italy

Italy has not employed large quantities of cassava in the past because of her limited use of compound feeds and low maize prices (resulting from a preferential CAP policy). Esselmann projects a 129% increase in Italian compound feed consumption by 1980 (approximately equal to the French rate), with growth mainly resulting from a major expansion of poultry production.

Estimated Italian least-cost feed rations resemble those of France (Table 20), although cassava content in poultry rations is higher in Italy. For all feed, as cassava price rises, its content decreases (Figures 5a, 5b and 5c), with cassava not being utilised when its price reaches the $95.00/metric ton level.

The projections contained in Table 7 combined with values derived from Figures 5a, b, and c, given the assumptions of fixed price relativities and constrained and unconstrained cassava content, result in a 1980 demand of between 117,000 thousand metric tons (cassava price = $95.00/ metric ton) and 577,000 thousand metric tons (cassava price = $90.00/ metric ton).

United Kingdom

United Kingdom entry into the EEC will undoubtedly induce many changes in British agriculture. Numerous predictions for British agriculture exist but in almost all instances there is no precedent upon which to base projections of future events. The evaluation of compound feed rations avoids much of this problem because it is based on the clearly defined concept of minimising costs of mixed feeds. The estimation of future demand for livestock products and compound feeds is more difficult,

Table 19

Projected Demand for Cassava in France 1980
(1000 Metric ton)

	Low		High**
	L_1*	L**	
Cow	0.0	425.	1275
Poultry	0.0	126.	126
Pigs	157.	557.	557
Total	157.	1108.	1958

* Cassava price assumed to be $95.00/metric ton.

**Cassava price assumed to be $90.00/metric ton.

Table 20

COMPOSITION OF ANIMAL FEED IN ITALY

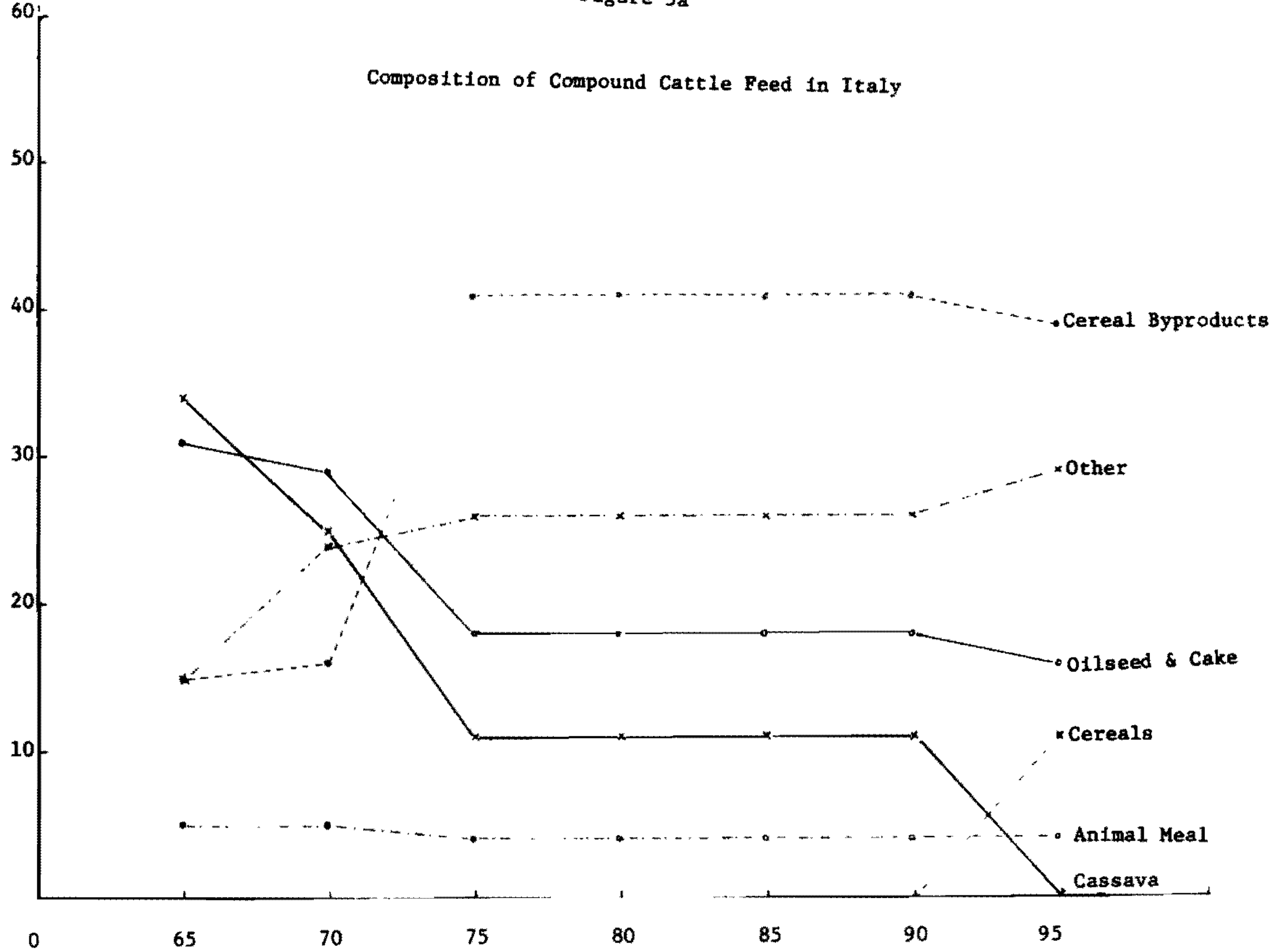
percent

Type Feed	Cow Standard	Beef and Calf	Layer Medium	Poultry Grower	Broiler	Broiler Finisher	Pig Starter	Pig 0 to 30 Kg.	Pig 30 to 100 Kg.	Sows
Cost*	67.38	71.93	80.84	104.68	87.85	80.86	75.66	75.24	73.68	71.43
Cereals	-	-	55.0	45.7	32.8	15.5	-	10.0	10.0	-
Cereal Byproducts	13.4	17.3	8.0	8.0	3.0	8.0	20.0	10.0	10.0	10.0
Oil Cakes & Seeds	24.7	36.6	10.8	3.1	17.3	15.4	25.3	23.3	21.8	13.8
Animal Meal	4.5	5.0	9.0	20.0	13.7	10.4	6.3	7.6	5.8	10.4
Cassava	43.2	24.1	9.0	20.0	29.1	44.5	47.3	40.8	44.5	49.6
Other	14.0	16.8	8.0	3.0	3.6	5.8	0.9	8.0	7.6	16.0

* u.a./metric ton

Figure 5a

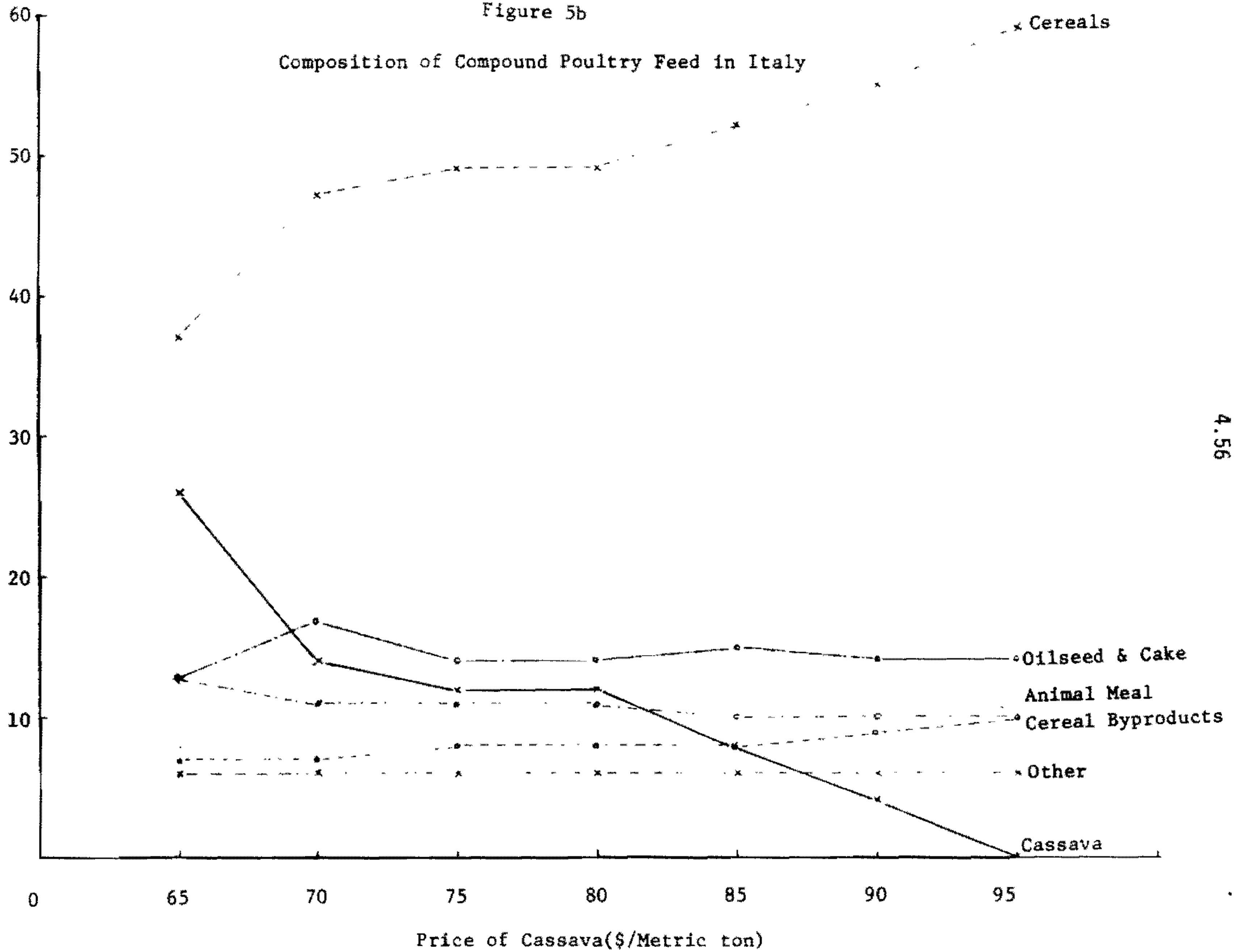
Composition of Compound Cattle Feed in Italy



Price of Cassava($/Metric ton)

Figure 5b

Composition of Compound Poultry Feed in Italy



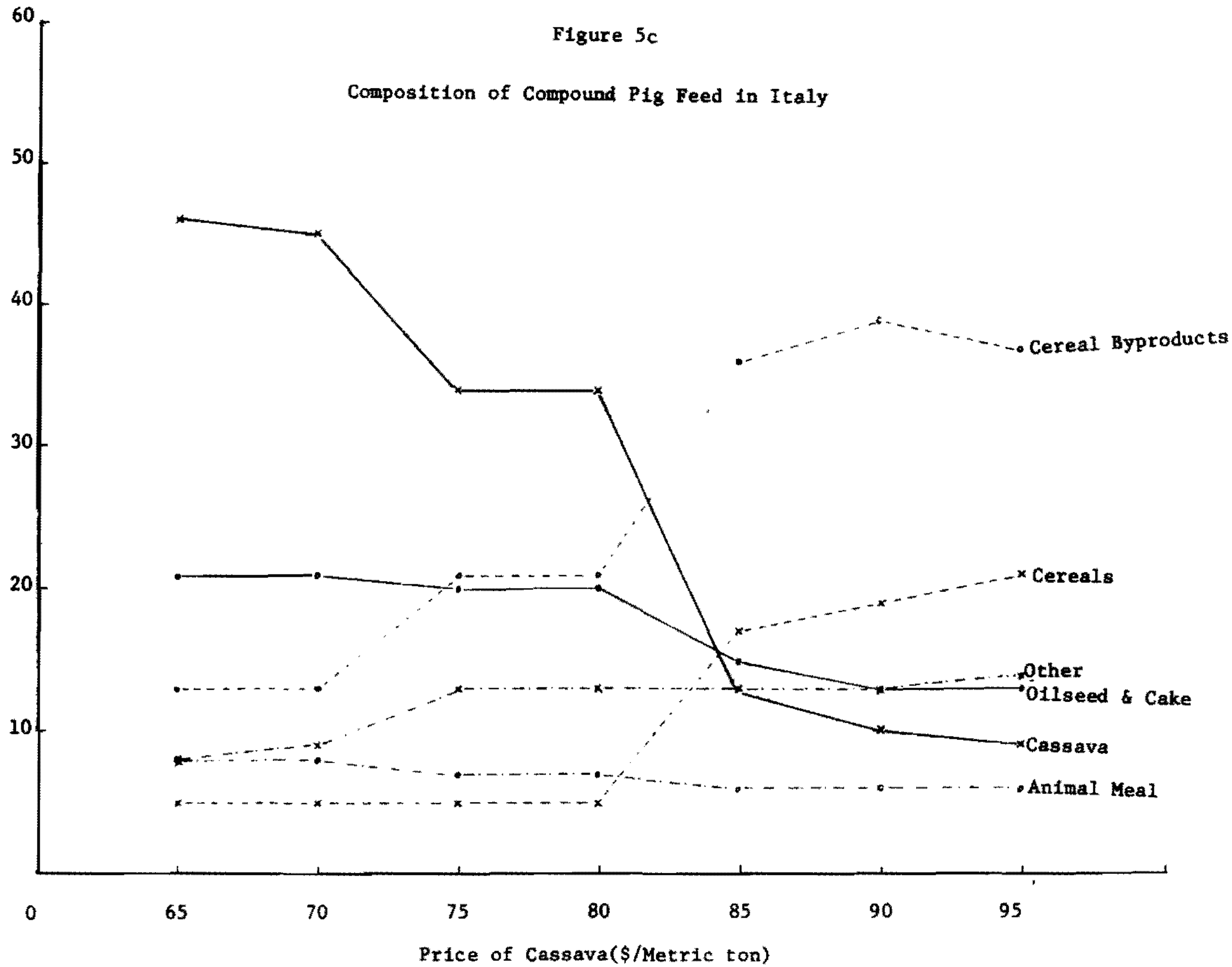


Figure 5c
Composition of Compound Pig Feed in Italy
60
50
40
30
20
10
0
65
70
75
80
85
90
95
Price of Cassava($/Metric ton)
Cereal Byproducts
Cereals
Other
Oilseed & Cake
Cassava
Animal Meal

Table 21

Projected Demand for Cassava in Italy 1980
(1000 Metric tons)

	Low L_1*	Low L**	High**
Cow	0.0	220.	220
Poultry	0.0	227.	227
Pig	117.	130.	130
Total	117.	577.	577

*Cassava price assumed to be $95.00/metric ton.

**Cassava price assumed to be $90.00/metric ton.

since expected price changes are outside past observations. Thus the conclusions of this section must be qualified by the possibility that the future may differ substantially from what best available information now suggests.

A priori, one would expect that compound feed consumption per livestock unit will not increase greatly in the 1970's, owing to already existing high rates of consumption. Estimates show that mixed feed consumption [5, Ch. 8] is more important in the United Kingdom than in the EEC as a whole, and that consumption of compound dairy rations is greater than in any EEC country. However, it is expected that a proportion of compound dairy feeds consumed will be replaced by bulk feeds once CAP becomes effective in the United Kingdom [5, p. 8-5]. Nevertheless, growth in demand for compound feeds will be primarily determined by expansion of livestock numbers. Hence, the greatest increase in consumption of compound feeds is expected to occur for pig feed, while consumption of compound dairy rations is expected to decrease. Two sets of projections of compound feed utilisation are available [4,5]. Ferris et al, project that by 1980 cattle utilisation of compound feed will decrease by 7%; pig utilisation will increase by 119% to 124%; and poultry utilisation by 108%*. Extrapolation of Sturgess' and Reeves' 1977/78 projections of concentrate consumption of 1980/81** suggests that cattle utilisation will decrease by 10%; pig utilisation will increase by 134%, and poultry utilisation will increase by 109% [5, p. 8-5], over the 1969/70 feeding rates.

Both sets of projections are based on farm-mixed and commercially-mixed compound feeds, with the latter accounting for approximately 55% of compound feeds. Sturgess and Reeves assume that compounder:farm mixer

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*The calculations are based on Ferris's Case III, that the United Kingdom joins the EEC in 1972 and has a five-year transition period; and Case IV, as Case II plus annual growth rate of 3.4% and annual inflation rate of 5% of [4, p. 35]

**Projected 1972/73 to 1977/78 changes were converted to compound rates which were then used to project 1980/81 values.

rations will not change, and argue that "farm mixers who grow their own cereals will generally not use energy sources other than cereals" [5, p. 9-2]. Thus, for the purposes of this study, it is assumed that only feeds compounded commercially will use cassava. This assumption probably understates the potential market for cassava, because much farm-mixed poultry feed is done on a sufficiently large scale to warrant the use of cheaper, unconventional feed ingredients. Nevertheless, since the use of cassava is untried in the United Kingdom it seems best to rely on conservative estimates of future demand.

Ferris et al., and Sturgess' and Reeves' projections were therefore deflated to provide estimates of commercially compounded feeds. The deflators used were for dairy feed (68%), beef feed (23%), pig feed (49%), poultry feed (61%), and layer feed (61%). By this procedure it was estimated that the demand for commercial compound feeds will increase by approximately 103% by 1980 (Table 22).

Evaluation of least-cost feed rations required estimating feed ingredient prices once CAP is fully effective. Price predictions made by Sturgess and Reeves [5] and Cambell [17] were combined and used in the objective function of the least-cost matrix. Ration constraints were based on information provided in the aforementioned two studies*.

The rations considered for the United Kingdom differ slightly from those used in the analysis of the original six and reflect conditions peculiar to the United Kingdom, the greatest difference being for dairy rations which are more varied than those previously evaluated (expressing a higher dependency on dairy rations in the United Kingdom than in the rest of the EEC). Pig and poultry rations resemble EEC rations.

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*Ian Sturgess kindly provided the author with additional information and details regarding the United Kingdom compound animal feed market.

Table 22

Projected use of Commercially Compounded
Feeds in the United Kingdom 1980
(1000 Metric tons)

Type of Feed	1969/70	1980/81	Index(1969/70 = 100)
Dairy	3383	2533	75
Beef	500	500	100
Pig	2360	3171	134
Layer	2635	2712	103
Poultry	1010	1253	124
TOTAL	9888	10169	103

Source: I.M. Sturgess and R. Reeves, The Potential Market for British Cereals, Agricultural Adjustment Unit, University of Newcastle, Newcastle upon Tyne, 1972.

The evaluation of the least-cost rations suggests, not surprisingly, that cereal content in compound feeds given EEC prices will be low and that cassava content will be high (Table 23). The results indicate that no cereals will be consumed in cattle feeds, and that cassava will constitute more than 40% of this ration. Broiler feeds, on the other hand, will contain more than 35% cereals and cassava, while pig rations indicate cassava content above 50%.

Long run cassava price changes induce the same general effects (Figures 6a, 6b and 6c) as in the original six. The previously indicated complementarity between cassava and oilseed and cake in cattle rations is not clearly demonstrated. The results indicate that cassava will not be used in cattle or dairy rations if cassava price is greater than $90.00/metric ton, while on the other hand cassava content in pig feeds is predicted to be greater than 25% at this price.

Least-cost feed rations are again combined with projected consumption of commercially produced compound feeds (Table 22) to derive estimates of the demand for cassava in the 1980 (Table 24). It is assumed that predicted 1980 prices or price relativities prevail; that cassava is utilised within the constrained and unconstrained levels (with a technical maximum of 50%); and that port and country compounders use equal amounts of cassava*. This latter assumption is not held to be accurate by all British compounders. Nevertheless, Campbell [17] found that cassava will be used to its constraint level by both country and port compounders.

The projected demand for cassava indicates that the United Kingdom could, by 1980, rank as high as third in terms of cassava utilisation.

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*Differences in consumption patterns between country and port compounders could be important since it is anticipated that 50% of compounding will occur in future at country locations. This inland shift of compounding was mentioned to the author by commercial feed manufacturers and Simon Harris of the Economics Division of the United Kingdom Ministry of Agricultural Fisheries and Feed, August 1972.

Table 23

Composition of Animal Feed in the United Kingdom
(percent)

Type Feed	Dairy 3.5 gallons	Dairy 4.0 gallons	Beef Fattening	Grazing Cake	Layer Medium Energy	Poultry Grower	Broiler Rearing	Broiler Finishing	Pig Growing	Pig Fattening
Cost*	$77.84	$71.83	$69.90	$67.91	$82.95	$79.15	$107.86	$104.91	$74.07	$71.16
Cereals	-	-	-	-	-	-	40.3	35.6	-	-
Cereal Byproducts	15.0	10.0	12.7	10.5	15.0	15.0	12.5	12.5	10.0	10.0
Oilcake & Seeds	30.3	23.6	12.5	13.5	10.5	12.5	14.6	10.3	24.0	16.7
Animal Meal	5.0	5.0	5.0	5.0	13.0	12.2	16.3	16.5	6.0	5.5
Cassava	40.0	47.5	42.2	40.6	54.1	59.7	12.4	21.3	53.9	57.7
Other	10.0	13.9	27.6	20.4	7.4	0.6	3.9	3.8	6.1	10.1

*u.a./metric ton.

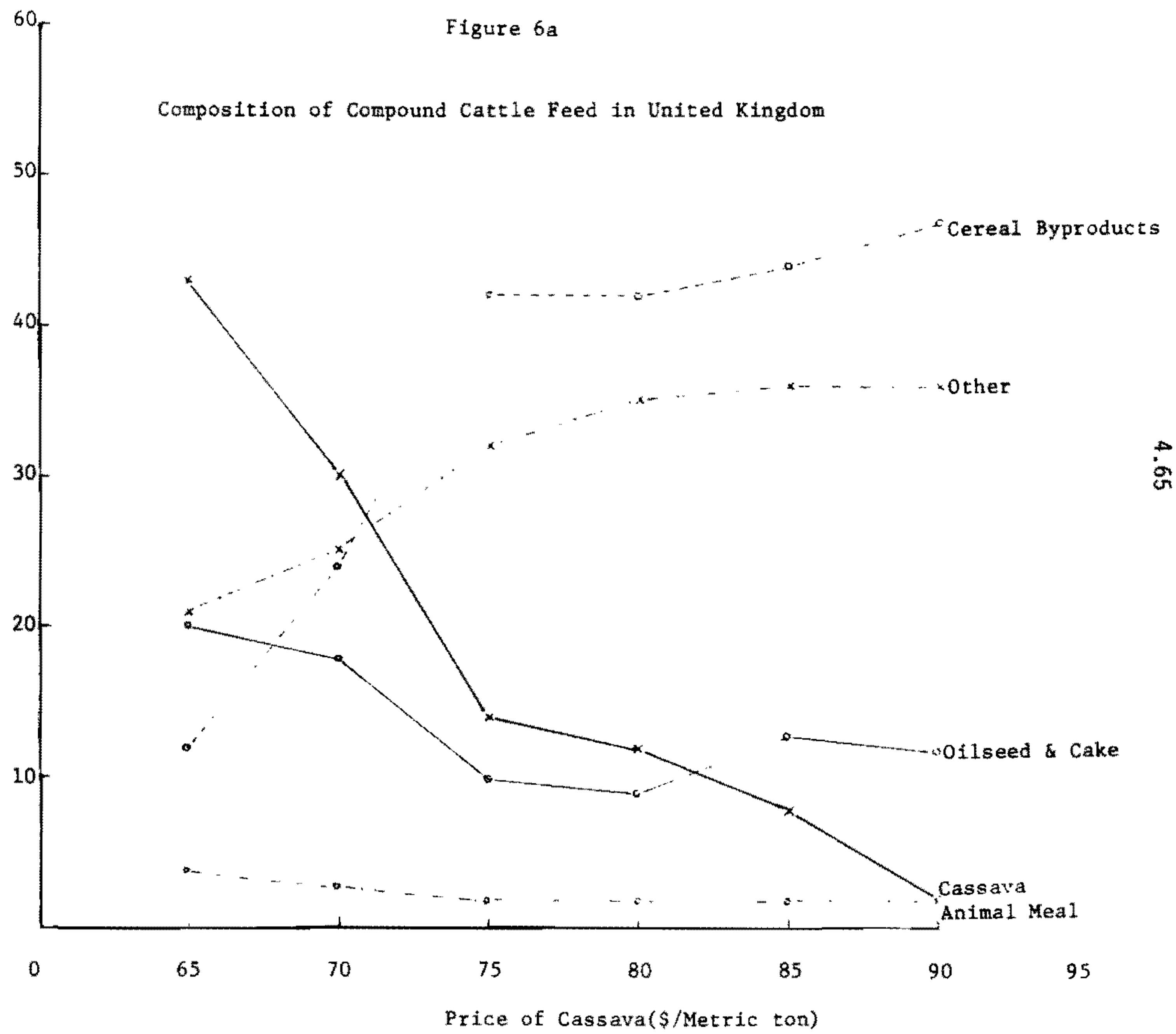
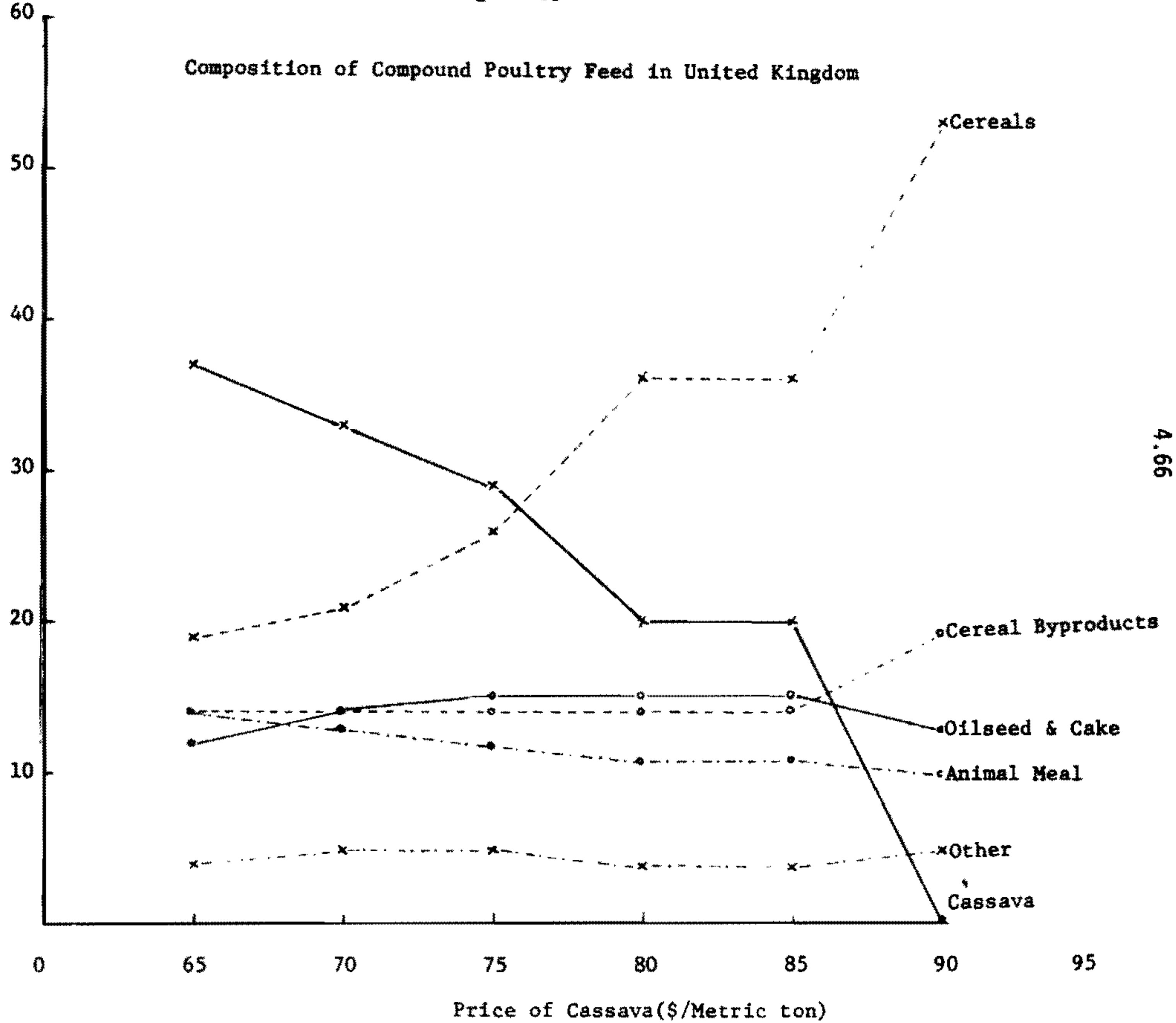


Figure 6a
Composition of Compound Cattle Feed in United Kingdom
60
50
40
30
20
10
0
65
70
75
80
85
90
95
Cereal Byproducts
Other
Oilseed & Cake
Cassava
Animal Meal
Price of Cassava($/Metric ton)

Figure 6b



Composition of Compound Poultry Feed in United Kingdom
60
50
40
30
20
10
0
65
70
75
80
85
90
95
Cereals
Cereal Byproducts
Oilseed & Cake
Animal Meal
Other
Cassava
Price of Cassava($/Metric ton)

Figure 6c

Composition of Compound Pig Feed in United Kingdom

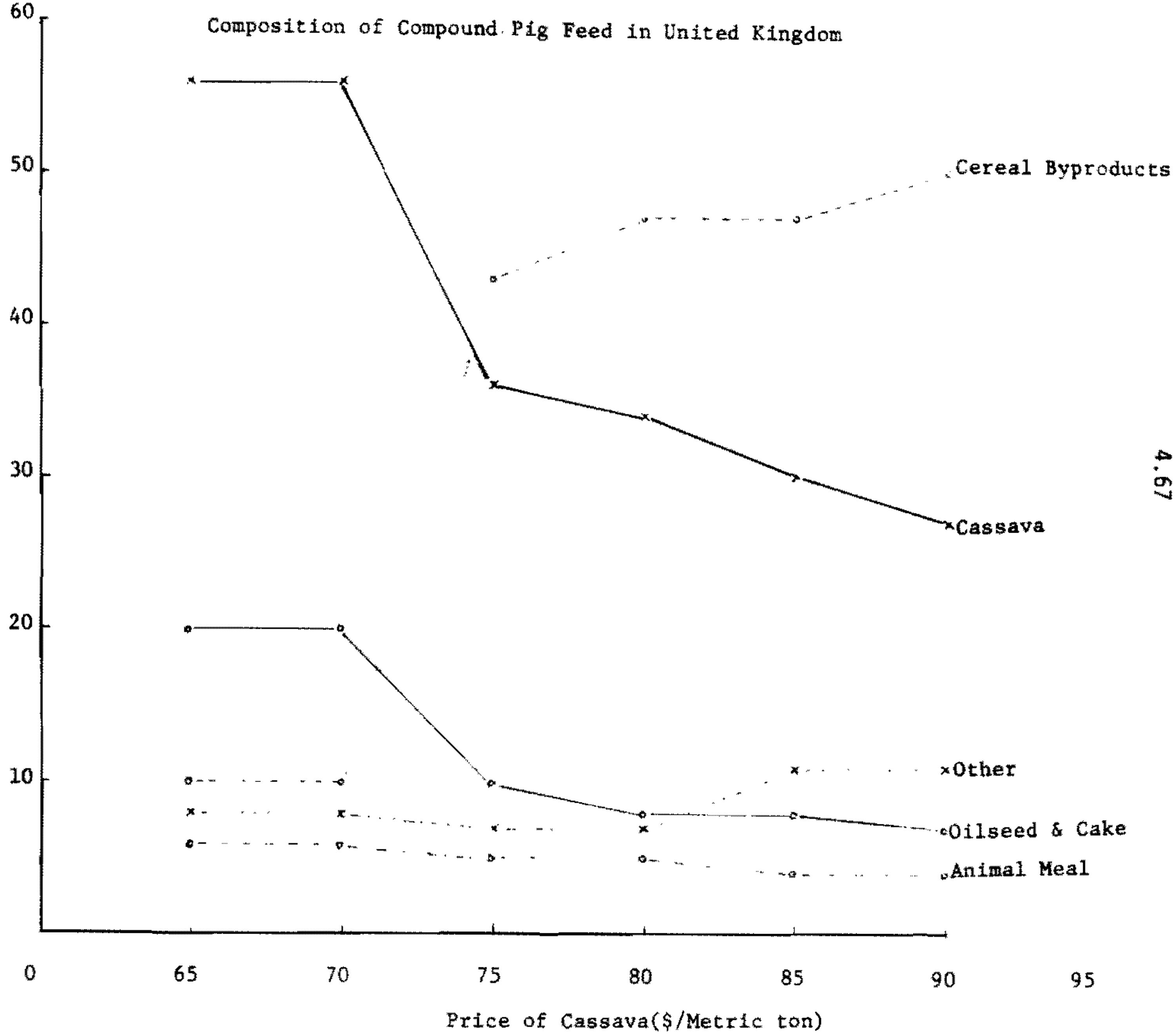


Table 24

Projected Demand for Cassava*
in the United Kingdom 1980
(1000 Metric tons)

	Low	High
Cows	91	91
Poultry	0	0
Pigs	381	856
TOTAL	472	947

*Cassava price assumed to be $90.00/metric ton

Utilisation, however, is expected to be near the smaller estimate since it will require time for compounders to become confident in the applicability of cassava.

United Kingdom Transition Period and the Demand for Cassava

It is obvious that projected demand for cassava will develop differently for the United Kingdom than for the original six, because price changes in the former will be greater than those in the latter countries. Thus, feed rations were evaluated for a set of transition prices for the years 1973, 1974, 1975, 1976, 1977 and 1978. The prices (Appendix E, Table E.4) were derived from a study conducted by Ellis [11]. The estimated rations* (Table 25) suggest not only that cassava could be used as early as 1974 in cow and pig feeds, but that it will be used at levels in excess of current maximums in pig feeds. Poultry rations are predicted to commence utilisation in 1975.

The results presented in Table 25 clearly show the expected pattern of change in United Kingdom compound feeds; cereal content of compound feeds will decrease,perhaps to disappear in cattle feeds after 1975; cassava and oilseed and cake content will increase; other ingredients will generally increase; and the cost of compound feeds will increase by 113% to 124% by 1978.

Denmark

The consumption of compound feeds in Denmark is less than that of the United Kingdom, Netherlands, Germany, Belgium, France and perhaps Italy. Danish compound feeding rates are relatively high with dependency in pig meat production being greater than in any of the previously analysed countries. As a result of these relatively high consumption rates, future demand for compound feeds will depend primarily on future livestock

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*The reader will note that the average rations presented in Table 25 and Figures 6a, 6b and 6c differ slightly owing to the fact that Ellis' transition prices had slightly different relativities than those used in the original Linear Programming Matrix.

Table 25

Average Composition of Animal Feed Rations
During United Kingdom Transition Period 1973 to 1978

Type of Ration	1973	1974	1975	1976	1977	1978
Cattle						
Cost*	67.15	70.97	72.71	73.73	74.83	76.28
Cereal	55.9	29.7	-	-	-	-
Cereal By-products	16.7	32.3	30.0	30.0	19.3	7.5
Oilseed & Cake	7.3	9.3	16.3	15.7	20.0	22.4
Animal Meal	3.2	2.4	2.9	2.6	2.9	4.5
Cassava	0.0	5.7	26.9	26.2	35.9	43.3
Other	16.9	20.5	23.9	25.5	21.9	22.3
Poultry						
Cost*	82.80	86.53	90.34	94.65	96.94	102.71
Cereal	68.9	64.5	49.6	43.9	37.5	18.0
Cereal By-products	5.2	8.7	8.7	8.7	11.3	11.2
Oilseed & Cake	13.9	13.7	15.8	21.3	22.7	23.5
Animal Meal	9.5	9.1	9.7	7.8	7.5	9.7
Cassava	-	-	13.4	14.0	16.3	32.6
Other	2.5	3.9	2.8	4.3	4.7	5.0
Pig						
Cost*	68.16	72.62	75.15	77.55	79.73	82.48
Cereal	69.7	42.7	18.2	16.3	13.1	4.6
Cereal By-products	15.4	21.9	30.0	30.0	22.5	30.3
Oilseed & Cake	7.1	8.0	12.4	12.1	15.0	15.7
Animal Meal	5.1	5.3	4.7	4.6	4.3	5.2
Cassava	-	20.6	30.9	30.9	36.3	37.4
Other	2.5	1.5	3.8	6.1	8.8	6.8

*u.a./metric ton

numbers, except in dairy feeds where a substantial increase in use of compound feeds is predicted [4, p. 151]. It is assumed that between 1967 and 1980 consumption of compound feed for cows will have increased by 53%; for pigs by 56%; and for poultry by 4%. It is calculated therefore that total 1980 consumption of compound feeds will be 7,907 thousand metric tons, of which 33% of cattle feed, 88% of pig feed, and 79% of poultry feed are assumed to be commercially mixed*.

As in the previous case, only commercially compounded feed is assumed to use cassava. Thus the amount of feed which will utilise cassava is estimated to be (in thousand metric tons):

Cattle feed	753
Poultry feed	437
Pig feed	4461
TOTAL	5651

Because similar levels of technology prevail in Denmark and the United Kingdom, the least-cost rations derived for the latter country are applied to the Danish situation. Combining the feed rations derived from Figures 6a, b and c with the above estimates of Danish compound feeds which could utilise cassava produces the predictions of Danish demand for cassava in 1980 (Table 26).

4.4 Summary of Projected Demand for Cassava in the EEC

The analyses of compound feed utilisation in the EEC reveal that the 1980 demand for cassava may be from 246% to 634% greater than the 1970 demand. In order of importance the maximum consumption levels are (thousand metric tons):

*These are 1971 percentages [2, p. 79] which, lacking information to the contrary, are assumed to apply in the future.

Table 26

Projected Demand for Cassava*
in Denmark 1980
(1000 metric tons)

	Low	High
Cows	23	23
Poultry	0	0
Pigs	535	1204
Total	558	1227

*Cassava price assumed to be $90.00/metric ton.

	Low	High
Netherlands	1020	2380
France	157	1950
Denmark	558	1227
Germany	677	1161
United Kingdom	472	947
Belgium	472	725
Italy	117	577
TOTAL	3473	8967

The accuracy of these projections depends on the reliability of

- projected 1980 consumption of compound feeds*;
- percentage of compound feeds utilising cassava;
- price relativities among ingredients;
- least-cost feed rations as a reflection of the types of feed formulas which will be consumed.

Of these assumptions the price relativity assumption is the most crucial. Two points must be considered in this regard: First, regional prices will undoubtedly differ from national averages. Whether these differences will be sufficient to alter formulation dramatically is difficult to predict. It was illustrated in Figures 1 through 6 that in many instances cassava content would exceed existing maximums for a wide range of prices, thereby suggesting that, for minimum projections at least, regional price differences will not result in marked changes in feed formuli.

Second, the EEC could alter agricultural policies in such a way as to adversely affect cassava imports. Three specific policies which could

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*These projections depending in turn upon 1980 projections of demand for livestock products, production of livestock, and feeding rates of compound feeds.

produce such an effect are:

1) decreases of cereal prices;
2) introduction of variable levies on cassava;
3) introduction of variable levies on oilseed and cake.

The first option, often discredited by North Americans, has been shown to be possible [18]. The second option, while possible, seems unlikely because: a) the EEC has committed itself to assisting LDCs, and the importation of cassava is an obvious means of fulfilling this commitment; and b) imported cassava enables commercial compounders to keep feed prices low, thereby holding down livestock production costs* (in the extreme, the removal of cassava from feed rations would increase Dutch feed costs by more than $10.00/metric ton in Broiler Finisher feeds). and finally, the third option, introduction of a variable levy on oilseed and cake, although again possible, is not desirable because it would increase the cost of compound feeds.* Furthermore, the major exporter of oilseed and cake, the United States, would certainly contest any policy which adversely affects the market for oilseed and cake.

Such changes, should they occur, are not expected to be announced before the end of the forthcoming trade liberalisation talks in Geneva in 1975. In any case, full implementation of policy changes would require several years, thereby affecting demand for cassava only in the latter years of the 'seventies.

Thus, the tentative conclusion is that demand for cassava will be relatively secure until 1980. The post-1980 demand for cassava is less definite. Quite possibly the CAP of the 'eighties will differ substantially from the present CAP. Furthermore, new sources of protein, and perhaps

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*If, however, cheap manufactured single cell protein became available, a levy on vegetable protein could have no effect on cost of compound feeds. It is suggested in the ITC Oilcake Study [2] that single cell protein will not be economically attractive before 1980. There are, however, two single cell protein plants now in operation in Italy with a capacity well in excess of 100,000 tons, while BP in France has a history of working with petro-protein.

energy, could affect the ingredients used in compound feeds.

Exporters can look forward to a growing demand for cassava if it can be supplied in sufficient quantity, required quality, and correct price. One expects that quality requirements will become stricter and more rigidly enforced. The important standards will be -

Moisture: less than 13 or 14%
Starch content: greater than 70 or 75%
Fibre content: less than 5%
Foreign material (vegetable and mineral): less than 3%

The cif price of cassava over the past few years has varied from approximately \$65.00/metric tons to \$78.00/metric ton. For the purposes of this study, end-user prices of \$90.00 to \$95.00/metric ton have been assumed. This is the price range which the exporter must meet. Thus, the implication for exporting countries is that production and processing cost must be in the range of \$16.00 to \$22.00/metric ton of fresh roots (Table 27), (on the basis of a 2.5 - 3:1 conversion ratio of roots to ton of chips or pellets).

In the future, a major proportion of cassava trade will be in the form of pellets because of ease of handling* and lower transportation cost. Quality of pellets will be subject to constant testing for two specific reasons:

1) to insure that pellets do not contain cassava waste. If so, pellets must then be imported under Brussels Tariff Nomenclature 11.06, which is subject to a 11% duty; and

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*Compounders will undoubtedly require better physical quality of pellets. Empirical observation indicates that the breakdown of some pellet shipments is undesirably high, such that the delivered shipment constitutes a high proportion of flour and dust and a low proportion of pellets. It was suggested that some German compounders continue to use chips because they are not so dusty. Many Dutch compounders, however, do not have this option because their equipment is not suited to handling chips.

Table 27

Estimates of Cost Targets for Cassava Exports

Cost Item	Low	High
Pellets to End-user	$90.00	$95.00
Pellets cif Rotterdam*	70.00	75.00
Less Transportation cost**	20.00	20.00
Technical coefficient roots to pellets***	3:1	2.5:1
Cost for processing and roots	16.67	22.00

*Shipping costs from Rotterdam assumed to be in the order of $20.00/ton.

**An average of Thai charter and conference shipping rates.

***The first technical coefficient is an estimate of the Brazilian average, while the second is an estimate of the Thai average.

2) to insure that foreign material content is not above 3%.

The exporter and potential exporter must bear these multiple factors in mind when evaluating the potential of the market with reference to his particular operation. If the exporter anticipates that quantity, quality, and price requirements can be met, he may ship to Europe with some assurance that the market of the 'seventies will require the product, demand being expected to experience accelerated growth after 1975 when the United Kingdom and Denmark become consumers of cassava. However, the exporter who cannot supply Europe before the late 'seventies or early 'eighties would, at that point in time, be entering a very uncertain market.

4.5 Other Aspects

The preceding analyses ignored quality as a factor influencing demand for cassava. This section briefly examines the possible consequence of altering cassava quality -- specifically, the effects of altering protein, starch and metabolisable energy content. The procedure is analogous to that of changing price, namely a particular quality attribute is altered by a finite among and the least-cost formula is re-estimated. The procedure is iterated until the desired number of possibilities have been accounted for. Because of the similarities of the country-by-country results, the results of cassava quality changes are assessed only for Dutch rations. It is assumed that the findings are generally applicable to all EEC countries.

The first quality factor to be altered was cassava crude protein content, changed from 2.2% to 6.2%. Changes within this range were found to have little impact on the composition of feed rations in general or on the content of cassava specifically. However, one interesting result was that all pig feeds, except sow feeds, increased in cost. The reason that a higher protein content cassava increases the cost of compounding pig feeds is related to the fact that pig feeds have a maximum protein limit. As cassava protein level is increased, the previously unimportant upper protein maximum is invoked. Theoretically, this more constrained, cost-minimising problem produces a more costly feed than the less constrained problem. Practically, the active upper limit on protein causes cassava protein and oilseed and cake protein to compete rather than capitalising on the complementarity between oilseed and cake protein and cassava energy. This additional competition is expensive, as indicated by the increased cost of the pig feed rations. The greatest increase in cost is $1.61/metric ton for pig 0 to 30 kg feeds. Accompanying this cost change is an increase of cereal by-product content by 17% to 28%, a decrease of oilseed and cake from 24% to 19% and a decrease of cassava from 33% to 27%.

For cow and poultry feeds, for which no maximum protein limit is invoked, there is little change in feed formuli. Therefore, with the exception of pig feeds, it appears that changing the amount of crude protein in cassava has little effect and that what results do occur are not necessarily desirable from the point of view of exporters, who could lose earnings.

Altering energy content of cassava has more marked effects than protein changes. In the case of increased starch or metabolisable energy content, the utilisation of cassava increases and the cost of compound animal feeds decreases. As metabolisable energy increased from 2910 calories/kg. to 3310 calories/kg, cassava content increased from 17.9% to 28.2%*; cereal content decreased from 37.4% to 25.0%; and compound feed costs decreased by $3.88/metric ton.

Improvement of total digestible nutrient content revealed no clear pattern of demand change. In some instances, cassava content decreased while greater amounts of cereal by-products or 'other' feed ingredients

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*The increase of cassava energy content strengthens the complementary relation between cassava and oilseed and cake.

were used as fillers. In other instances, cassava percentages in pig feeds increased while cereal by-products decreased.

It may be concluded that, in general, the improvement of cassava energy attributes could expand the demand for cassava. Furthermore, a cassava product with higher energy content will be more impervious to price changes. In fact, price of cassava could be raised if energy content were higher without adversely affecting demand for cassava.

Although it is possible that the suggested quality alterations may be wrought by improvements of processing, it is likely that such alterations will depend largely on varietal selection. This possibility of genetically improving starch, metabolisable energy and total digestible nutrient content should be evaluated by CIAT. Additionally, attention must be paid to emerging LDC compound feed industries, which, unlike their EEC counterparts, may desire higher protein content cassava. For domestic purposes, it may be more economical to fortify cassava than to improve genetically its protein content.

In summary, the indications are that growth in demand for cassava can be affected by changes of price and/or quality. The astute cassava exporting nation may influence favourably the demand for its product by controlling price and quality. Conversely, a country may lose its market if quality or price are unattractive.

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Chapter V

RECONCILIATION

> I would willingly say that forecasting would be an absurd enterprise were it not inevitable. We have to make wagers about the future; we have no choice in the matter.
>
> Bertrand de Jouvenel

The three preceding chapters have presented the results of the analyses of potential 1980 demand for and supply of cassava. The projections of supply and demand are now compared in order to derive indicators of possible imbalances which might be expected if production trends continue. Because demand data are more accurate and readily available than production data, it is presumed that demand projections are more reliable than supply projections, and focus is therefore on the former. The approach of reconciliation is to derive from 1980 demand estimates a measure of required supply. The latter is then compared with extrapolated supply trends to determine if supply will match apparent demand.

The markets for cassava, ranked in terms of their ability to capture supply, are: human food market (the obvious exception being the export market for Thailand); other domestic markets; and export markets. Given this ranking, it is assumed that if supply of cassava is insufficient to meet domestic demand, export markets will be the first to suffer. Bearing this in mind, the projections of total demand for and supply of cassava are considered.

5.1 <u>1980 Demand for Cassava</u>

The demand projections for cassava as a human food (Chapter II) must be altered for reconciliation purposes, owing to the inconsistency of FAO and Brazilian figures. FAO estimates of 1980 Brazilian human demand are less than the 1970 consumption level -- despite the fact that there is little indication that total consumption of cassava in Brazil will decrease during the 'seventies. The problem may be one of data and/or definition. FAO projections of 1980 Brazilian cassava demand may relate to the demand for processed cassava, primarily farinha de mandioca, while Brazilian statistics relate to demand for cassava in fresh root units. Or, it is possible that FAO projections may relate only to *mandioca mansa*. Because the extent to which either of these possibilities adequately explain the difference between the two sets of data could not be determined, it was considered necessary to estimate cassava consumption functions using the Brazilian data. Statistically, the best fitting function (Equation 1) indicates that the income demand elasticity for cassava is 2.65 (at evaluated man values).

$$D_{Bc} = -74.9 + 1785/Y_B + 14\ Y_B \qquad R^2 = .87 \qquad \ldots (1)$$

where D_{Bc} = Brazilian demand for cassava;

Y_B = Brazilian income; terms in parentheses are t-values.

The projection of 1980 Brazilian demand, based on Equation 1, is 13,990 thousand metric tons. The FAO projection is 7436 thousand metric tons. Using the former estimate to assess Latin American and world human demand for cassava alters the original FAO projections to 17,393 and 78,054 thousand metric tons, respectively.

Brazil is also reported to use substantial amounts of cassava in livestock feeding. Thus, an accurate assessment of domestic demand for cassava requires a prediction of 1980 cassava demand for animal feeding. Food Balance Sheet [1] data indicate that 47% of Brazilian cassava production is so used. However, as is noted in Chapter VI, this figure could be an overstatement. For purposes of the study, therefore, it was decided that only 22% of production (the share of cassava production in Santa Caterina and Rio Grande do Sul, states utilising cassava as an animal feed) would be used for animal feeds*. The resulting estimates of cassava utilisation in animal feeding in Brazil are thus 8961 and 11,143 thousand metric tons, depending upon which production projection is used (Appendix A). These figures, combined with the 1980 human demand estimates of Chapter II, provide the following projections of 1980 cassava demand in producing countries (1000 metric tons):

	Low	High
Latin America	26,353	29,036
Africa	34,727	35,444
Far East	21,154	21,318
World Total	82,234	85,798

Projected demands for industrial cassava starch, presented in Chapter II, are given in final product terms. For the purpose of reconsiliation, however, it is necessary to convert the projections to fresh root terms. The starch conversion coefficient is taken to be 1 ton of starch = 4.49 tons of roots**. The 1980 demand for industrial cassava starch in fresh root terms is thus (in 1000 metric tons):

	Low	High
United States	184	1527
Canada	90	94
Japan	225	225
Total	499	1845

* This measure must be taken as a proxy measure for future Brazilian animal feed demand for cassava because, more likely than not, it will be demand rather than supply considerations which will determine 1980 animal consumption levels of cassava.

** This is reported to be the root:starch conversion ratio during the hot season in Thailand. The average conversion ratio is 5.29, while the technologically feasible ratio is approximately 3.5 tons of roots to 1 ton of starch.

The projected demand for cassava as an animal feed (Chapter III), converted to fresh root terms at a ratio of 1 ton of pellets = 2.5 tons of roots, is (in 1000 metric tons):

	Low	High
Netherlands	2550	5950
France	393	4875
Denmark	1395	3067
Germany	1692	2902
United Kingdom	1180	2367
Belgium-Luxembourg	292	1443
EEC Total	8682	22417

The total world demand for cassava in 1980 is projected to be between 91,415 and 110,060 thousand metric tons, a 145 to 174% increase in demand for cassava.

The following section considers the question: if past trends persist, will supply of cassava in 1980 be sufficient to meet projected demand?

5.2 Reconciliation of Cassava Supply and Demand Projections

1980 regional supply of cassava, extrapolated from past trends, is predicted to be of the following order:

	Low	High
Latin America	48,052	60,491
Africa	37,107	37,207
Far East	26,357	29,592
Total*	111,516	127,290

* Using aggregated world data, 1980 world supplies of cassava are estimated to be between 110,581 thousand metric tons and 119,163 thousand metric tons.

Comparison of 1980 supply and demand projections (Table 1) reveals

- . that the EEC market can account for as much as 20% of world demand for cassava;
- . that human demand can account for 78% to 90% of world demand;
- . that industrial starch demand will account for less than 1% of world demand for cassava;
- . that supply of and human demand for cassava in Africa are nearly equal with supply exceeding demand by less than 7%.
- . that supply of cassava in Latin America and the Far East substantially exceeds human demand;
- . that given high demand projections and low supply forecasts, the world markets for cassava would appear to be near equilibrium, supply exceeding demand by only 1%.

5.3 Reliability and Implications of Reconciliation

While the analyses of this study have attempted to estimate lower and upper limits for demand for and supply of cassava by 1980, the reasonableness of these limits must still be assessed.

The 1980 projections of human demand for cassava imply an annual growth in world demand of between 2 and 3%. Because this rate closely approximates population growth rate (the prime factor in determining the human demand for cassava), it is deduced that the rate of change conforms to *a priori* expectations. However, this does not imply that the magnitudes of the projections are necessarily correct. It was assumed that projected demand for cassava was in fresh root terms. If some projections relate to processed cassava, however, then the 1980 demand estimates are incorrect. For example, if in actual fact 10% of projected human demand relates to processed cassava, the 1980 figure will understate demand by approximately 15% (21,000 thousand metric tons). Such an error is great enough to alter the Minimum Difference Reconciliation (Table 1) from a position of near equilibrium to one of insufficient supply.

Table 1

Reconciliation of Supply and Demand Projections for 1980
(1000 metric tons)

	Demand	Supply	Difference between Demand and Supply
Minimum Differences			
Latin America (Human)	29,036	48,052	19,016
Africa (Human)	35,444	37,107	1,663
Far East (Human)	21,318	26,357	5,039
Europe (Animal)	22,417	-	-22,417
North America (Starch)	1,621	-	- 1,621
Japan (Starch)	225	-	- 225
Total	110,061	111,516	1,455
Maximum Differences			
Latin America (Human)	26,353	60,491	34,138
Africa (Human)	34,727	37,207	2,480
Far East (Human)	21,154	29,592	8,438
Europe (Animal)	8,682	-	- 8,682
North America (Starch)	274	-	- 274
Japan (Starch)	225	-	- 255
Total	90,415	127,290	35,845

The industrial starch demand projections imply an increase which is less than that experienced during the 'sixties. It could be argued that the 1980 estimates are conservative. However, non-economic factors, such as quality or new requirements or political policies, could adversely affect the demand for cassava industrial starch. Countering this argument are the facts that cassava starch constitutes a relatively small proportion of starch consumed, providing little incentive to interfere with the market, and that Japanese demand for starch could grow very rapidly if internal price support policies were altered. Even so, it would appear that foreseeable changes in the demand for cassava starch will be small relative to total demand.

The 1980 projections of the European demand for cassava cover a wide range. The uncertainties associated with estimates of future prices, cassava limits in feeds, and spread of cassava utilisation in the United Kingdom and Denmark require that the projections of 1980 demand be diverse. The upper prediction is unlikely to be surpassed unless total demand for compound feeds increases more rapidly than this study assumes, but the lower prediction should be exceeded, barring drastic changes in CAP* and/or cost of cassava. It is therefore assumed that the deviations in the demand for cassava as an animal feed will occur within the range defined by the upper and lower estimates.

The supply estimates, which are again extrapolations of past trends, indicate future changes in the absence of new forces. If, however, changes of price, cost, policy, etc. occur, the trend projections will be incorrect. A 1% decrease in 1980 supply would result in the Minimum Differences Reconciliation (Table 1) estimate being negative (demand for cassava would exceed supply).

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* If policies are introduced which interfere with cassava imports, then the lower estimate may become zero very quickly.

In summary, both the predictions of human demand for and supply of cassava are crucial in the determination of whether supply and demand will be in equilibrium or if one will exceed the other. Because human demand for cassava may be underestimated, it is possible that there could be insufficient supply to meet the export demand for cassava. On the other hand, it is not to be expected that the Maximum Difference Reconcilication of 36 million tons will occur, because it is unlikely that the production would be allowed to exceed demand by so much.

It should be realised that the positive differences between supply and demand are a reflection of large cassava surpluses in Brazil, Paraguay, India, Thailand and Uganda (Chapter II, Table 13), and it is these countries which will be in the best supply position to export cassava. The total surpluses of these countries (approximately 29 million metric tons) are sufficient to exceed the predicted minimum size of the market. *Ergo propter hoc*, if this predicted surplus is converted to animal feed, and if EEC demand for cassava does not approach the maximum limits, there may be little scope for other countries to export cassava to Europe. That some of these surplus countries* will export cassava has been indicated by individuals involved with the trade. Thus, only the traditional domestic markets can be considered to be assured for most producing countries.

5.4 Conclusions (Not Findings)

There are many intangibles associated with the future demand for cassava. By definition, these are unquantifiable. Nevertheless, these factors can be interpreted as indicating certain potentialities. The overriding impression is that cassava and cassava products will be used in larger quantities in the future. Domestic demands are almost certainly expected to emerge for cassava in the 'seventies. General livestock

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* Thailand, Brazil and India are known to be considering increasing or beginning shipments of cassava to Europe. Combined export targets of Thailand and Brazil in fresh root terms exceed 6 million tons.

and industrial production trends suggest that there could be an increasing need for cassava products. As countries in the Cassava Belt further increase industrial and livestock production, they will create demands which can be satisfied by utilisation of cassava. These countries may choose to rely on this domestic input -- or they may prefer to import inputs such as maize and maize starch. The choice, however, should be made with the full knowledge of the possible uses of cassava products.

The security of the European market for cassava in the 'eighties is questionable. First, cassava exporting countries must be wary of the fact that inflation in their country could exceed that of importing countries, thereby making cassava (if its price inflates) relatively more expensive than competing goods. Second, changes in CAP, which will certainly occur by the 'eighties, could affect the demand for cassava. However, exporters of cassava as a compound animal feed ingredient may be hopeful of Japan's becoming a major consumer of cassava.

If barriers to cassava imports to Japan are removed, and cassava is attractively priced, the Japanese could import in excess of a million tons of pellets, thus indicating that at the Minimum Difference Reconciliation (Table 1) level, there would be insufficient supplies to meet projected Japanese demand. Even if enough cassava is available, the opening of a Japanese market for cassava could disrupt current trade patterns. The possible rationalisation of cassava exporting (Pacific countries exporting to Japan and Atlantic countries exporting to Europe) could actually result in a loss of markets if rationalisation is not orderly, viz., if Thailand suddenly diverted all exports to Japan and no new supplies were forthcoming for Europe, European compounders would be forced to change to other energy sources, resulting in a perhaps irreversible loss of this market to cassava-producing countries. Thus, it is imperative that the exporter or potential exporter understand the markets involved and the types of changes which could occur. Failure to do so could result in loss of actual or potential trade.

References Chapter V

1) Food Balance Sheets 1964-66, Food and Agricultural Organisations of the United Nations, Rome, 1971.

Part II

CASE STUDIES OF BRAZIL AND THAILAND

Chapter VI

CASSAVA (MANDIOCA) IN BRAZIL*

> A mandioca é uma planta de cultura multisecular que se adapta a quase todas as regiões do Brasil. Sua cultura pouco exigente oferece grandes fecilidades, Não obstente, sua evolução agricola e industrial tem estado praticamente estacionária. Planta das mais rústicas produzindo até nos solos pobres e resistindo satisfatoriamente ás oscilacões climáticas, é cultura das mais recomendá veis para uma exploracão ampla e racional estando, inclusive, destinada a ocupar lugar de destaque entre as mais promissoras a solucão de grave problema alimentar nos trópicos.
>
> Prof. Alino Matta Santana

This Chapter considers primarily the supply of and demand for cassava in the post-1960 period, and perforce begs the question of sectoral balance between Industry and Agriculture. Furthermore, no attempt is made to exhaustively examine the merits of different agricultural sectors. Instead, an attempt is made to derive from a positive analysis of the evolution of the supply of and demand for cassava the possible future role of the crop in Brazil. Indicated developments are evaluated in terms of emerging research programmes which may affect future supply of or demand for cassava.** In the main the analysis is descriptive, with quantitative estimations being drawn primarily from secondary sources.

6.1 The Context

Brazil (Figure 1), the fifth largest country in the world in areal terms, has a population of 93,565,000 (1970) [1] and a Gross Domestic Product of US $32,482 million [2]. Excluding centrally planned countries,

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*Rafael Orlando Diaz, CIAT Economist who travelled to Brazil with the author, deserves credit for compiling a major proportion of the data in this Chapter.

**Current attributes and research programmes must be taken to mean those which are known to the author.

Figure 1. Brazil

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Brazil ranks tenth in total Gross National Product but much lower in terms of per capita GDP. This ranking is an improvement over its 1958 position, which was fourteenth.

Not surprisingly, with its large land base, Brazilian agriculture contributes 19.8% of GDP [2] and accounts for 72% of export earnings [4]. The history of agriculture as an export earner has been checkered.

> With one crop after another (Brazil) has had a leading position, only to lose it when other countries improved their competitive position while Brazil stayed at the same level. This was the case in its early history with sugar, with rubber, and with cocoa; and it appears that the same thing is happening with coffee. [3, p. 102].

On the other hand, Brazil has moved from a position of relative obscurity to become the fifth largest exporter of maize, second largest exporter of soybean cake and meal [4], and is slowly approaching self-sufficiency in wheat produciton* after importing a high of 2.6 million tons in 1968 [4]. Brazil is also the sixth largest producer of sweet potatoes and yams; the third largest producer of soybeans; the second largest producer of maize, sugar cane, oranges and pineapples; and the largest producer of bananas, coffee, dry beans, and cassava (Table 1) [1]. Whilst Brazil ranks high in the production of some temperate (developed country) crops, its agriculture is similar to that of many developing countries (viz., a large number of small holding, and a small proportion of GNP (19.8% [2]) generated in relation to agricultural labour force, 44% [1]). Apart from coffee, Brazilian agricultural production has displayed steady growth (Table 2), but this growth is primarily the result of increased agricultural acreage (Table 3) rather than increased yield. Apparently, Brazilian agriculture has not benefited from the adoption of new technology or the "Green Revolution".

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*Discounting the 1972-73 wheat failure, which is expected to be 1.5 million tons below expected production.

Table 1

Ranking of Countries by Production of Selected Crops. 1971 Levels

Crop	1st	2nd	3rd
Soybeans	USA (31,823)*	China(Mainland) (11,500)	Brazil (2,218)
Maize	USA (140,733)	Brazil (14,360)	USSR (11,500)
Sugar Cane	India (128,769)	Brazil (79,753)	Pakistan (31,977)
Oranges	USA (7,841)	Brazil (3,400)	Japan (3,000)
Pineapples**	USA (831)	Brazil (424	Malaysia (353)
Bananas**	Brazil (6,396)	India (3,300)	Equador (3,000)
Coffee	Brazil (16,655)	Colombia (5,200)	Ivory Coast (2,400)
Dry Beans	Brazil (2,430)	India (2,090)	China(Mainland) (1,400)
Cassava	Brazil (30,258)	Zaire (10,500)	Indonesia (10,042)

Source: Production Yearbook, Food and Agriculture Organization of the United Nations.

*Units 1000 Metric Tons.

**1970 Levels.

Table 2

Principal Crops - Quantity Produced (Tons)

Year	Cotton	Brazil Nuts	Rice	Banana (1)	Potatoes	Cashew	Coffee and Cocoa (2)
1947	1,050,653	53,497	2,596,374	127,467	575,387	119,056	1,894,978
1948	968,436	138,961	2,554,334	136,291	585,310	96,910	2,074,930
1949	1,199,907	135,702	2,720,159	147,696	747,764	133,376	2,136,566
1950	1,190,909	118,192	3,217,690	162,874	707,159	152,902	2,142,874
1951	995,534	150,892	3,182,080	169,632	721,747	121,199	2,160,378
1952	1,504,439	145,001	2,931,110	185,167	735,402	113,558	2,250,812
1953	1,110,507	146,499	3,072,374	185,062	814,705	136,970	2,221,212
1954	1,166,457	168,002	3,366,838	198,200	815,001	162,947	2,073,974
1955	1,281,110	185,856	3,737,471	204,275	898,184	157,921	2,739,518
1956	1,193,878	180,911	3,488,777	224,035	1,003,098	161,093	1,958,556
1957	1,177,369	191,621	4,072,051	233,270	998,993	164,556	2,818,608
1958	1,144,664	308,268	3,829,295	229,753	1,016,548	164,186	3,391,710
1959	1,399,494	357,403	4,101,447	244,261	1,024,708	177,834	4,396,844
1960	1,609,275	408,410	4,794,810	256,339	1,112,640	163,223	4,169,586
1961	1,828,475	584,432	5,392,477	271,446	1,080,310	155,901	4,905,594
1962	1,902,335	647,811	5,556,834	300,660	1,133,860	140,363	3,637,979
1963	1,956,895	603,840	5,740,065	313,106	1,167,774	143,495	2,980,129
1964	1,770,288	469,671	6,344,931	338,206	1,263,812	153,685	1,185,509
1965	1,986,313	742,686	7,579,649	348,522	1,245,857	160,823	4,588,095
1966	1,865,430	894,902	5,801,814	355,867	1,328,734	170,363	2,405,737
1967	1,692,066	750,741	6,791,990	402,780	1,466,521	194,692	3,014,991
1968	1,999,465	753,905	6,652,388	421,857	1,606,473	149,338	2,115,404
1969	2,110,775	753,863	6,394,285	463,324	1,506,500	211,162	2,567,014
1970	1,954,993	928,073	7,553,083	492,900	1,583,465	197,061	1,509,520
1971	2,152,779	894,369	7,111,123	523,532	1,433,815	211,892	3,590,807

(1) - 1,000 cachos.

(2) - A partir de 1961 e até 1967, dados retificados na fonte.

Table 2 (continued)

Principal Crops - Quantity Produced (Tons)

Sugar Cane	Beans	Soybeans	Leaf Tobacco	Oranges	Cassava	Sorghum	Wheat
28,989,901	1,046,234		110,889	5,310,228	11,844,510	5,502,548	359,363
30,892,577	1,132,610		117,627	6,129,180	12,454,823	5,607,477	405,135
30,928,755	1,256,848		114,504	5,974,846	12,615,735	5,448,879	437,506
32,670,814	1,248,138		107,950	6,015,129	12,532,482	6,023,549	532,351
33,652,508	1,237,662		117,932	6,181,678	11,917,560	6,218,030	423,646
36,041,132	1,151,708	77,881	106,307	6,116,426	12,809,263	5,906,916	689,500
38,336,721	1,386,600	88,226	132,135	6,177,462	13,441,421	5,984,284	771,692
40,301,966	1,544,228	117,321	146,738	6,384,209	14,492,961	6,788,994	871,333
40,946,305	1,474,985	106,884	148,205	6,501,670	14,863,193	6,689,930	1,101,315
43,975,743	1,379,327	114,938	143,529	6,869,852	15,316,002	6,999,329	854,971
47,703,359	1,582,017	121,501	140,027	7,244,476	15,442,747	7,763,439	781,143
50,020,121	1,453,613	130,893	143,922	7,457,794	15,353,604	7,370,089	583,999
53,512,330	1,549,644	151,574	151,479	7,993,153	16,575,121	7,786,739	610,884
56,926,882	1,730,795	205,744	161,426	8,359,854	17,613,213	8,671,952	713,124
59,377,397	1,744,561	271,488	167,839	8,808,842	18,058,378	9,036,237	544,858
62,534,516	1,708,983	345,175	187,040	9,254,518	19,843,422	9,587,285	705,619
63,722,895	1,942,963	322,915	206,806	10,532,360	22,248,644	10,418,267	392,363
66,398,978	1,950,683	304,897	210,427	10,274,799	24,355,602	9,408,043	643,004
75,852,866	2,289,796	523,176	248,182	11,427,622	24,992,579	12,111,921	585,384
75,787,512	2,148,100	594,975	228,284	11,766,563	24,710,041	11,371,455	614,657
77,086,529	2,547,577	715,606	242,817	12,523,280	27,268,193	12,824,500	629,301
76,610,500	2,419,677	654,476	258,019	13,586,728	29,203,229	12,813,638	856,170
75,247,090	2,199,974	1,056,607	250,224	14,434,057	30,073,943	12,693,435	1,373,691
79,752,936	2,211,449	1,508,540	244,000	15,497,198	29,464,275	14,216,009	1,844,263
79,595,157	2,499,832	1,977,097		16,693,559	30,258,215	14,306,812	2,132,309

Table 3

Principal Crops -- Area of Cultivation (Hectares)

Year	Cotton	Brazil Nuts	Rice	Banana	Potatoes	Cashew	Coffee Cocoa
1947	2,470,091	51,652	1,650,989	90,983	116,521	257,885	2,414,648
1948	2,307,585	141,920	1,661,601	95,632	128,068	260,786	2,463,996
1949	2,497,295	136,177	1,758,246	100,082	154,856	258,024	2,537,851
1950	2,689,185	127,428	1,964,158	110,126	147,739	275,970	2,663,117
1951	2,486,699	141,161	1,967,225	115,792	149,518	291,383	2,738,180
1952	3,035,481	141,059	1,872,728	128,452	152,032	284,396	2,823,003
1953	2,587,366	137,145	2,072,335	136,446	163,047	340,462	2,918,919
1954	2,487,265	139,275	2,425,277	141,280	165,265	352,924	3,004,585
1955	2,617,086	166,306	2,511,689	155,567	178,614	368,297	3,265,541
1956	2,663,025	163,479	2,554,853	161,749	185,314	375,915	3,411,651
1957	2,770,653	169,470	2,490,167	164,222	189,603	386,676	3,672,325
1958	2,706,343	228,002	2,514,490	165,854	191,952	460,917	4,077,920
1959	2,745,592	255,223	2,682,879	174,520	187,889	466,209	4,296,645
1960	2,930,361	291,025	2,965,684	184,530	198,772	470,806	4,419,537
1961	3,233,779	436,381	3,174,037	193,815	191,255	474,270	4,691,706
1962	3,456,857	476,461	3,349,810	208,699	196,198	464,762	4,420,315
1963	3,553,746	422,876	3,721,800	231,290	199,788	469,644	4,081,758
1964	3,764,597	429,837	4,182,361	227,700	208,674	487,136	3,845,944
1965	4,004,444	540,627	4,618,898	238,600	202,257	482,317	3,511,079
1966	3,897,709	643,580	4,004,850	249,972	199,308	455,866	3,057,470
1967	3,719,805	693,863	4,291,147	255,634	217,423	473,078	2,791,650
1968	3,902,238	606,434	4,458,952	268,476	226,728	432,691	2,622,885
1969	4,194,676	613,332	4,620,699	273,113	221,049	437,637	2,570,899
1970	4,298,573	669,688	4,979,165	277,744	214,155	443,916	2,402,993
1971	4,459,626	672,007	5,042,330	279,968	206,702	441,872	2,583,546

Table 3 (continued)

Sugar Cane	Beans	Leaf Tobacco	Soybeans	Oranges	Cassava	Sorghum	Wheat
772,853	1,583,723	134,211		77,916	911,285	4,323,052	391,555
818,608	1,650,007	143,877		76,024	913,022	4,346,544	536,334
796,687	1,790,966	145,447		80,656	941,309	4,516,540	630,102
828,182	1,807,956	141,931		77,018	957,493	4,681,827	652,453
874,341	1,787,465	159,811		77,095	964,337	4,749,951	724,875
919,780	1,838,392	154,378	60,029	76,449	1,015,327	4,864,079	809,579
990,872	1,995,136	168,400	62,975	76,856	1,061,915	5,119,609	910,414
1,027,409	2,199,055	183,627	68,116	76,115	1,101,898	5,528,338	1,081,397
1,072,902	2,228,539	196,084	73,931	77,738	1,149,123	5,623,134	1,196,063
1,124,083	2,257,260	179,526	80,804	85,290	1,178,150	5,997,876	885,573
1,172,413	2,323,473	178,982	97,447	87,813	1,193,411	6,095,085	1,153,517
1,208,134	2,124,493	181,321	107,043	98,286	1,225,818	5,790,350	1,446,334
1,291,073	2,378,774	190,981	114,098	106,398	1,239,366	6,189,107	1,185,661
1,339,933	2,560,281	213,203	171,440	112,241	1,342,403	6,681,165	1,141,015
1,366,640	2,580,567	227,656	240,919	118,750	1,381,331	6,885,740	1,022,234
1,466,619	2,716,257	232,297	313,640	125,823	1,476,206	7,347,881	743,458
1,509,011	2,982,436	250,402	339,796	138,737	1,617,810	7,957,633	793,494
1,519,491	3,130,562	250,505	359,622	143,793	1,715,857	8,105,894	733,597
1,705,081	3,272,525	273,849	431,834	150,257	1,749,960	8,771,318	766,640
1,635,503	3,324,592	264,967	490,687	165,361	1,779,806	8,703,169	716,981
1,680,763	3,650,568	260,768	612,115	166,660	1,914,439	9,274,321	830,869
1,686,727	3,663,301	275,654	721,913	173,170	1,998,197	9,584,386	970,128
1,672,101	3,633,264	258,128	906,073	183,057	2,029,373	9,653,757	1,407,115
1,725,121	3,484,778	245,207	1,318,809	202,037	2,024,557	9,858,108	1,895,249
1,691,681	3,743,110	--	1,589,064	215,750	2,040,692	10,708,816	2,260,935

This conclusion, however, is curiously contradicted by data on fertiliser application per hectare which has expanded rapidly since 1963 (Table 4). This contradiction is not easily interpreted. Perhaps the use of principal crop rather than total agricultural acreage biases the figures upward, but it does seem logical that fertiliser would be applied first to principal crops. Or, perhaps initial data on fertiliser consumption may have been low, but this in itself cannot account for apparent annual increases in fertiliser application. Finally, it is possible that new lands brought into production (or areas not dropped from production) are of poorer quality and therefore require higher levels of fertiliser application*. Although this last does not provide a complete explanation of the rather slow growth rate of crop yields, it does suggest that once the factors inhibiting increases of crop yields are identified and overcome, Brazilian crop production could explode.

The following sections analyze the post-1960 role of cassava in Brazil, and suggest possible future roles.

6.2 Cassava Production

Cassava is produced in all regions of Brazil**, with the North and Northeast accounting for 33% of production and the South for 35% (Table 5). The states producing more than 1 million tons of roots in 1970 were: Bahia, Rio Grande do Sul, Santa Catarina, Paraná, Maranhão, Minas Gerais, Ceará, São Paulo, Pernambuco and Goiás.

Generally production is increasing in all states***. Fitting of the simple supply function, Equation 1 (production regressed on cassava

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*At the time of writing the author was not able to ascertain the validity of this statement.

**There are five regions: North (Acre, Amazonas, Pará); Northeast (Maranhão, Paulí, Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas); East (Sergipe, Bahia, Minas Gerais, Espirito Santo, Rio de Janeiro); Central West (Mato Grosso, Goiás); and South (São Paulo, Paraná, Santa Catarina, Rio Grande do Sul).

*** The clear exception is Amapá.

Table 4

Fertiliser Consumption 1961/62 -- 1970/71

	1961/62-1965/66	1966/67	1967/68	1968/69	1969/70	1970/71
Nitrogen*	578	711	1064	1443	1644	2759
Phosphate	860	916	1660	2141	2366	3753
Potash	800	933	1369	1843	2003	3067
Principal Crop Acreage**	30,720	26,971	31,592	32,674	34,040	36,181
Nitrogen/Acre***	1.9	2.6	3.4	4.4	4.8	7.6
Phosphate/Acre	2.8	3.4	5.3	6.6	6.9	10.4
Potash/Acre	2.6	3.5	4.3	5.6	5.9	8.5

Source: Table 3 and Production Yearbook, FAO.

*Units 100 Metric Tons.

**1000 hectares.

***kg/ha

Table 5

Cassava Production by States

States	1961	1962	1963	1964	1965
BAHIA	2355751.	2082145.	2318597.	2563324.	2819756.
RIO GRANDE DO SUL	2228032.	2522524.	2658072.	2837448.	2767332.
SANTA CATARINA	1837789.	1866014.	2017472.	2202675.	2226537.
PARANA	447175.	551382.	845181.	2051355.	2107691.
MARANHAO	891777.	1084291.	1290721.	1224240.	1330604.
MINAS GERAIS	1636406.	1705027.	1690366.	1806927.	1864498.
CEARA	910406.	939647.	1059401.	1074764.	1076585.
SAO PAULO	1310010.	1477829.	2104374.	2145585.	2445007.
PERNAMBUCO	1193113.	1691955.	1623245.	1607388.	1445491.
GOIAS	801447.	864790.	1004225.	1105354.	1263801.
ESPIRITO SANTO	427990.	436100.	538400.	528350.	493300.
PARA	546441.	667602.	966243.	1062510.	964514.
SERGIPE	676067.	693036.	854663.	781243.	872459.
MATTO GROSSO	465848.	583098.	562016.	448306.	478408.
PARAIBA	562388.	632962.	625166.	616808.	597056.
PIAVI	439498.	540455.	701637.	664220.	673754.
RIO DE JANEIRO	422521.	426234.	425094.	446737.	439794.
AMAZONAS	99167.	226815.	169640.	209890.	223672.
ALAGOAS	463467.	490837.	523379.	484936.	456510.
RIO GRANDE DO N.	217207.	235240.	215574.	198066.	236847.
ACRE	74934.	86321.	79589.	81674.	79839.
AMAPA	38854.	34087.	30557.	24770.	22143.
GUANABARA	3740.	15520.	15120.	15400.	15920.
RONDONIA	8045.	8905.	8964.	9284.	11754.
RORAIMA	0.	0.	12075.	12950.	15725.
DISTRITO FEDERAL	300.	400.	900.	6368.	13570.
BRASIL	1805837.	1964342.	2224864.	2435560.	2499257.

Table 5 (continued)

State	1966	1967	1968	1969	1970
BAHIA	2961691.	3374166.	3898567.	4056588.	4013920.
RIO GRANDE DO SUL	3200478.	3351689.	3426436.	3622176.	3607767.
SANTA CATARINA	2438129.	2553442.	2832020.	2936226.	3017231.
PARANA	1663779.	2004696.	1953300.	1851235.	2118782.
MARANHAO	1588506.	1776046.	1743798.	2112673.	2075162.
MINAS GERAIS	1917883.	2045146.	2086562.	2023257.	2004119.
CEARA	1120182.	1368799.	1907722.	2163508.	1866606.
SAO PAULO	2026951.	1883629.	2032384.	2020247.	1827383.
PERNAMBUCO	1195981.	1529750.	1597743.	1756198.	1644323.
GOIAS	1314883.	1311918.	1288880.	1219582.	1155230.
ESPIRITO SANTO	534440.	572070.	606190.	693100.	877710.
PARA	634302.	749849.	880143.	949384.	832092.
SERGIPE	784803.	813026.	819595.	762802.	782963.
MATTO GROSSO	492175.	504648.	607402.	676889.	711466.
PARAIBA	577985.	695474.	623471.	535449.	545206.
PIAVI	591069.	714890.	737568.	720227.	542047.
RIO DE JANEIRO	459754.	460130.	446951.	475596.	536042.
AMAZONAS	264766.	372426.	496957.	434328.	423823.
ALAGOAS	466838.	474662.	505755.	502191.	379523.
RIO GRANDE DO N.	326080.	555557.	556375.	399345.	348481.
ACRE	78779.	82874.	84604.	90544.	97984.
AMAPA	19036.	17004.	16144.	15916.	15186.
GUANABARA	16184.	16320.	15720.	15460.	14880.
RONDONIA	11927.	11137.	11250.	12585.	12670.
RORAIMA	10000.	11025.	10500.	10500.	11880.
DISTRITO FEDERAL	13440.	17820.	17852.	17820.	1800.
BRASIL	2471004.	2726819.	2920322.	3007394.	2946427.

Source: Anuario Estadistico do Brasil, 1962/1971, IBGE prices), reveals that the influence of selling price of cassava varies between regions.

$$Q_{ci} = \alpha_i + \beta_i P_{ci} + u_i \qquad \ldots(1)$$

where Q_c = quantity of cassava produced; and P_c = selling price of cassava and i = i^{th} state.

The resulting regressions (Table 6) generally conform to a priori expectations that price increases will be accompanied by supply increases (e.g., a positive β). Only three states, Paraiba, Alagoas, and Amapa, indicate perverse relationships. Apart from Paraná, the supply functions of the seven largest cassava producing states are statistically significant. However, the general results are disappointing to the degree that the supply functions of other large producing states (more than 1 million tons) Paraná, Sao Paulo, Pernambuco and Goias, are statistically insignificant. Nevertheless, the twenty seven supply models indicate that Brazilian cassava producers respond positively to price changes. In economic terms the supply schedules are inelastic as indicated by the .17 supply elasticity calculated from the Brazilian function*. In other words, nearly a 6% price change is required to induce a 1% change in production. Thus the encouragement of cassava production through price policies would, if these supply models are representative, appear to be expensive, relative to the gains in production.

The above supply models quite clearly cannot account explicitly for regionally different production practices, wage rates (opportunity costs), and resources. While the development of such models would be useful in assaying the future for cassava, appropriate data were not available at the time of this study.

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*The general supply elasticity for Equation 1 is $\eta s = \frac{Pci}{Qci}$.
For evaluation of the Brazilian supply elasticity ηs is evaluated assuming average values of P_{ci} and Q_{ci} (viz. ηs = (2,302,051) (.18)/(2,459,164)).

Table 6

Cassava Price Response Functions by States

State	α	β*	R^2	State	α	β	R^2
Bahia	2,193,063	52,536,677 (5,829,049)	.91	Matto Grosso	463,247	2,959,902 (856,223)	.6
Rio Grand do Sul	2,469,067	22,583,939 (2,713,808)	.90	Paraiba	622,557	-677,073 (644,345)	.1
Santa Catarina	1,857,657	39,274,918 (3,486,803)	.94	Piaui	607,806	1,608,967 (2,336,079)	.0
Parana	1,113,271	22,512,060 (10,160,877)	.38	Rio de Janeiro	421,950	1,284,613 (362,846)	.6
Maranhao	1,069,337	35,738,779 (4,278,276	.90	Amazonas	118,583	18,097,616 (2,448,708)	.8
				Alagoas	500,485	-954,375 (446,253)	.3
Minas Gerais	1,700,678	8,900,560 (1,510,748)	.81	Rio Grande do N.	167,174	5,689,821 (1,397,662)	.6
Ceara	804,614	36,201,308 (4,460,409)	.89	Acre	78,074	134,874 (28,604)	.7
Sao Paulo	1,850,556	4,379,370 (8,494,664)	.03	Amapa	36,985	-333,544 (27,390,857)	.9
Pernambuco	1,455,290	2,773,273 (3,059,887)	.09	Guanabara	11,943	32,605 (21,329)	.2
Goias	1,061,246	3,426,680 (2,548,680)	.18	Rondonia	9,430	61,986 (16,729)	.6
Espirito Santo	415,446	10,263,223 (2,004,608)	.78	Roraima	6,069	50,841 (29,640)	.2
Para	794,690	2,441,333 (5,262,717)	.03	Districto Fed.	-2,042	314,927 (104,132)	.5
Sergipe	761,583	887,870 (1,129,252)	.07	Brazil	2,080,149	2,302,051 (443,315)	.7

*Values in brackets are standard errors

Source: Anuario Estadistico do Brasil, 1962/1971, IBGE

However, regional studies of cassava production and marketing are available, and these provide a useful basis for furthering one's understanding of the factors influencing cassava supply functions.

Data collected by SUDENE* and Banco do Nordeste do Brasil [6,7,8,9] (Table 7) indicate that labour input varies from a low of 50 man-days per hectare for Rainfall Zone 3 to 165.4 man days per hectare in Sergipe. This latter figure results from relatively large labour cultivation input.

A University of Georgia research team, using average labour requirements and wages, and adding estimates of rent and interest charges, calculated per hectare cost of cassava production to be CR$488.7** (Table 8). Clearly, labour costs constitute the major share of production costs (79%).

As previously noted, the use of average wage rates to cost labour is not appropriate if opportunity costs of labour are low. Thus, the above estimate of production cost may be overstated, but the amount of overestimation is not determined. The values presented in Table 8 are used in the following calculations:

Assuming average yield of 11.5 tons/hectare and a price of CR$0.10 per kilogram [5, p. 52], the cassava producer can expect to make CR$662. per hectare over variable costs. In the Northeast this return is greater than the net returns on corn or beans returns.

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*SUDENE is the acronym for Superintendencia de Desenvolvimento do Nordeste (Superintendency for Development of the Northeast).

** At CR$6 to $1 this cost is translated to $81.45/hectare.

Table 7

Labour Input in Cassava Production in The Northeast

	ALAGOAS (10.7 tons)	MARANHAO (10 tons)	SERGIPE (13.9 tons)	AVERAGE (11.5 tons)
Land Preparation	39	22	25.6	28.9
Planting	10	15	24.3	16.3
Cultivation	34	20	100.0	51.3
Harvest	13	12	15.5	13.5
TOTAL:	96	69	165.4	110.0

	ZONE 1 (More than 750mm Rainfall)		Zone 2 (500-750mm Rainfall)		Zone 3 (Less than 500mm Rainfall)	
	Mean	(Range)	Mean	(Range)	Mean	(Range)
Land Preparation	17	(9-25)	20	(12-28)	13	(7-19)
Planting	33	(20-47)	31	(17-45)	13	(7-20)
Cultivation	27	(17-37)	18	(11-25)	10	(5-15)
Harvest	16	(10-22)	21	(10-32)	14	(9-19)
TOTAL:	93		90		50	
Yield per hectare in tons	9.6	(5.1-14.1)	10.8	(7.6-14.1)	10.2	(7.3-13.2)

Source: Feasibility of manioc production in Northeast Brazil. Brazil. University of Georgia. 1971. pp.44,45.

Table 8

Production Costs Per Hectare of Cassava, N.E. Brazil, 1971

ITEM	Man days (Average Northeast)	Cost - Cr$
Land Preparation	28.9	101.1
Planting	16.3	57.1
Cultivation	51.3	179.6
Harvest	13.5	47.3
Land rent or equivalent/hectare	-	45.0
Interest charges*		58.6
TOTAL CHARGES	-	488.7
Cost per Ton (11.5 tons/he) (Cr$)		42.5
Cost per Kilogram (centavos)		4.25

*Land preparation and planting charged for 18 months at 13%, cultivation cost computed for 12 months, land rent computed for an average of 9 months.

Source: Feasibility of manioc production in Northeast Brazil. Brazil. University of Georgia, 1971, pp. 46.

Expansion of the discussion of cassava production practices requires, at the minimum, data on cassava response to fertiliser and production costs and returns of other crops normally grown in conjunction with cassava. Such data were not available. Suffice it to say that the simple supply function analysis reveals that cassava production is responsive to price changes and that the returns to cassava production are competitive with other crops. The conclusion to be drawn at this point, therefore, is that cassava production is economically attractive, and that any policy which increases cassava prices will result in increased supplies.

6.3 Human Utilisation of Cassava

Cassava as a human food is extremely important in the Brazilian diet, on average accounting for 11% of total caloric intake and 13% of vegetable calories [11]. As expected, substantial deviation from this rate exists among regions and income levels [12] (Table 9). The highest dependency on cassava (38% of calories) is associated with families living in the rural areas of the Northeast and in the income range of Cr$ 150 to 249, whilst lowest dependency (1% of calories) is associated with families living in urban centres of the South with incomes over Cr$ 2500. Table 9 includes findings which, if correct, contradict expectations - namely, that the relative consumption of fresh cassava is greatest in the rural areas of the South, not the Northeast, whilst highest relative consumption of cassava flour is in the Northeast (both urban and rural areas). However, the expectation that rural areas consume more cassava than urban areas is confirmed.

Attempts to measure the income demand elasticity* for various

*The data presented in Appendix F, Table F1, were used to derive the income demand function.

$$D_{cyk} = \alpha + \beta Y_y \qquad k = 1,2$$

where D_{cyk} = per capita demand for cassava at income level y;
Y_y = average income of income level y; and k = 1 for fresh cassava
or k = 2 for cassava flour. D_{cyk} and Y_y are in log or linear terms.
In order to fit these functions it was assumed that the income of each income range was at its mean level with highest income arbitarily assumed to be Cr$2750.

Table 9

<u>% of Calories Consumed Derived From Fresh Cassava and Cassava Flour</u>

Urban — Brazil	Fresh Cassava	Cassava Flour	East	Fresh Cassava	Cassava Flour
Under 100*	0.196	7.426	Under 100*	0.430	6.893
100 to 149	0.283	7.387	100 to 149	0.583	7.071
150 to 249	0.372	6.109	150 to 249	0.510	5.723
250 to 349	0.435	5.324	250 to 349	0.610	5.601
350 to 499	0.446	4.718	350 to 499	0.599	5.320
500 to 799	0.433	3.655	500 to 799	0.625	4.509
800 to 1199	0.448	3.038	800 to 1199	0.692	4.015
1200 to 2499	0.461	2.584	1200 to 2499	0.772	2.865
Over 2500	0.386	2.053	Over 2500	0.730	2.715

Northeast	Fresh Cassava	Cassava Flour	South	Fresh Cassava	Cassava Flour
Under 100*	0.086	17.560	Under 100*	0.072	2.926
100 to 149	0.076	16.050	100 to 149	0.168	3.058
150 to 249	0.100	12.847	150 to 249	0.405	2.462
250 to 349	0.052	10.381	250 to 349	0.521	1.771
350 to 499	0.150	8.714	350 to 499	0.483	1.786
500 to 799	0.211	6.998	500 to 799	0.446	1.020
800 to 1199	0.011	4.908	800 to 1199	0.529	0.898
1200 to 2499	0.057	4.479	1200 to 2499	0.455	0.875
Over 2500	0.000	3.071	Over 2500	0.334	0.687

Rural — Brazil	Fresh Cassava	Cassava Flour	East	Fresh Cassava	Cassava Flour
Under 100*	4.775	17.462	Under 100*	4.549	15.438
100 to 149	3.220	17.981	100 to 149	3.315	14.976
150 to 249	3.691	17.536	150 to 249	2.374	14.275
250 to 349	4.473	13.825	250 to 349	2.411	9.901
350 to 499	3.013	13.341	350 to 499	1.740	13.608
500 to 799	3.909	12.384	500 to 799	3.610	8.438
800 to 1199	3.216	13.542	800 to 1199	4.658	9.711
1200 to 2499	2.703	8.996	1200 to 2499	1.546	7.443
Over 2500	1.548	10.465	Over 2500	1.175	3.671

Northeast	Fresh Cassava	Cassava Flour	South	Fresh Cassava	Cassava Flour
Under 100*	1.248	34.411	Under 100*	7.464	6.587
100 to 149	1.171	36.492	100 to 149	4.590	6.920
150 to 249	2.469	35.546	150 to 249	6.183	3.373
250 to 349	2.047	33.638	250 to 349	8.597	4.311
350 to 499	1.099	25.829	350 to 499	5.957	2.472
500 to 799	3.023	26,024	500 to 799	4.930	3.324
800 to 1199	0.759	26.148	800 to 1199	4.878	5.484
1200 to 2499	1.073	18.031	1200 to 2499	4.909	3.115
Over 2500	0.000	29.361	Over 2500	3.092	4.398

*New Cruzeiros: Annual Family Income.

Source : <u>Food Consumption in Brazil: Family Budget Surveys in the Early 1960's</u>, Fundacao Gatulio Vargas, Rio de Janeiro, November, 1970 income categories and regions met with partial success. Aggregate urban income demand functions for fresh cassava and cassava flour were statistically significant, as shown below*:

$$D_{cy1} = 1.74 + \underset{(.00028)}{.00095}\, Y_y \qquad R^2 = .62 \qquad \ldots(2)$$

$$D_{cy2} = 12.02 - \underset{(.00037)}{.00166}\, Y_y \qquad R^2 = .74 \qquad \ldots(3)$$

The elasticities are 1.36 and -.06, respectively. The rather surprising implication is that there is a positive income demand elasticity for freash cassava, but not for cassava flour in urban areas. Indications for rural areas are the opposite, (Appendix F, Table F.2,), but the equations are not statistically significant. Regional disaggregation supports these findings.

If the implications of these equations, as indicated by the signs of the elasticities (Table 10), are considered valid and applicable to the contemporary situation, it suggests that as income increases

1) demand for fresh cassava will increase in urban areas;
2) demand for fresh cassava will decrease in rural areas;
3) demand for cassava flour will decrease in urban areas; and
4) demand for cassava flour will increase in rural areas.

The net effect of these changes on total demand for cassava cannot be precisely estimated, but an attempt will be made to suggest the direction of the net effect. The factors which determine future demand for cassava will be original consumption levels, income and population growth, changes in the urban-rural population proportions, and income demand elasticities. Products with positive income demand elasticities will experience demand increases greater than population growth, but if the income demand elasticity is negative the demand will not increase as rapidly as population (given sufficiently large income increases or negative elasticities, the

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* Values in parentheses are standard errors.

Table 10

Signs of Income Demand Elasticities for Fresh Cassava and Farinha de Mandioca for Different Regions of Brazil

	Fresh Cassava	Farinha de Mandioca
Urban Regions		
Brazil	+	-
Northeast	-	-
East	+	-
South	+	-
Rural Regions		
Brazil	-	+
Northeast	-	+
East	-	-
South	-	+

Source: Regression Results, Appendix F.

total demand could decrease). Thus in urban areas total consumption of fresh cassava will increase by more than population growth, while consumption of cassava flour will not grow as quickly or may remain relatively constant. In rural areas total consumption of fresh cassava may remain relatively constant, while consumption of flour will increase by more than the growth of population. Rural-urban migration will (if migrants adopt urban habits) accentuate the growing demand for fresh roots in urban centres, further decreasing rural demand; retard the decreasing demand for cassava flour in urban areas; and lessen demand for cassava flour in rural areas.

The net effect of the hypothesised set of conditions are that total consumption of cassava will increase; that consumption of fresh roots will decrease when migration is considered; and that consumption of *farinha de mandioca* may remain constant or may even increase.

Consideration must be given, however, to factors which were not operative in the foregoing analysis. One such factor is the development of protein-fortified *farinha de mandioca*. The National Food Commission (CNA), Institute of Food Technology, Centre of Agricultural Technology and Food (CTAA), Granfino Ltd., Bank of Brazil and the United States Agency for International Development (USAID) are presently collaborating on research related to fortified *farinha de mandioca*. Cassava flour was selected for fortification because

- it is a widely accepted product at all income levels;
- it is a basic food in rural areas and has high per capita consumption in many urban areas;
- it is relatively simple to fortify;
- it is more readily available throughout the year than are rice, corn and bean products. [14, p. 1]

The first phase of the fortification programme involved the evaluation of the acceptability of three possible protein sources: 1) soy protein isolate (SPI) plus methionine or calcium caseinate; 2) calcium caseinate; and 3) fish protein concentrate. The second phase entails testing the market-acceptability of the fortified cassava flour in the Greater Rio area. A study of fortifying agents has concluded that the first fortification method is the most attractive, because of its cost, and because soy protein isolate is produced domestically.

In accordance with the above recommendation, the largest distributor and reprocessor of cassava flour in the greater Rio de Janeiro area agreed to fortify a proportion of its sales. It was possible to fortify only 'roasted' *farinha de mandioca*, because SPI discolours the standard, unroasted product. Unfortunately, roasted *farinha de mandioca* is more expensive than plain *farinha de mandioca* and presumably is not consumed as much by lower income groups who are in greatest need of protein. Nevertheless, a fortified roasted *farinha de mandioca* could improve the protein intake of a substantial proportion of the population.

Evaluation of the market acceptability of the fortified product is not complete. However, a limited survey* of low and middle income consumers of the new 7% protein product found that

. 27% of the families used for *purão* (mush) and 75% for *farofa;*
. 86% said that they would buy it;
. 45% of the families noticed a difference.

Of the last group

. 60% thought that it was better over all;
. 10% thought that odor was better;
. 50% thought that the colour was worse;
. 20% thought that it tasted better;
. 20% thought that it tasted worse.

The survey was not designed for extrapolation purposes, but USAID consider the initial findings encouraging for the future of fortified *farinha de mandioca.*

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*Information kindly provided by USAID, Rio de Janeiro, December 1972.

The USAID fortification programme has expanded as a result of 1) a contract signed with the Federal Government regarding co-operation in the fortification of cassava flour, and 2) co-operation of selected Recife *farinha de mandioca* firms who will test-market fortified cassava flour. The programme has also benefited from the introduction of a new protein source, soy grits, which are preferable to SPI because the former is thermally treated to destroy anti-tretic fractions, and can be granulated to any size to make it indistinguishable from *farinha de mandioca.*

Thus, information on this new product should be available within the next few years. Such information may make it possible to alter presently projected trends in per capita consumption of cassava. In any event, the development of an available and acceptable fortified cassava product should reduce the protien deficiency existing in parts of the country. In short, the development of the fortification programme should prove extremely interesting and should be closely observed.

6.4 Other Domestic Uses of Cassava

Whilst cassava starch could be used by numerous industries in Brazil it apparently is not. Brazil, being a major producer of maize, an estimated 60% of industrial starch used derives from maize. However, increased production and use of cassava starch, thereby releasing maize for potentially more productive uses, could possibly prove economically advantageous. The expansion of cassava starch production could be inhibited by two factors: a) cassava starch manufacturers are small and are only concerned with local markets and b) resistance on the part of Brazil's largest maize starch producer against any attempt to expand starch production at the expense of maize starch. Data on the relative economic merits of cassava and maize starch were not available, but it is known that the average price for cassava in 1970 was Cr$ 2.85/50kg., while that for maize was Cr$ 11.06/60kg. for 1970/71 [15]. Superficially, it seems that the possibility of producing more cassava starch warrants further exploration.

Another domestic market for cassava is the animal feed market which, as shown in Table 11, utilises a substantial proportion of total cassava production. The figures in Table 11 indicate that during the 1964-68 period 63% of cassava production was used for animal feed, and that the proportion is increasing. This percentage is greater than FAO estimates (47% of production used for animal feed [11]). Both figures appear to be inconsistent with the general assessment that virtually all cassava fed to animals is in Rio Grande do Sul and Santa Catarina (22% of Brazilian production). The consensus is that most cassava fed to animals is fed fresh and that virtually none of the cassava is used as an energy source in compound animal feeds. At present there is very little production of compound animal feed no doubt because of the extensive nature of livestock production. But livestock production is rapidly expanding (Table 12), and it appears that production is becomeing more intensive. Thus, it might be expected that use of compound feeds will increase. In this event, there could be a growing market for cassava in this area. The future size of this market has not been projected, owing to a lack of data. Suffice it to say that cassava utilisation is not expected to decrease in the future, and that in fact the demand for cassava will increase at least at the same rate as livestock.

6.5 Export Markets for Brazilian Cassava

Brazil has exported cassava as flour, meal, starch, tapioca, and chips, but over the years the most important exports in quantity and value terms have been cassava flour and chips (Tables 13 and 14). The high point (119,870 tons valued at $6,144,000) reached in 1965 has not been duplicated - in fact, it appears that exports have generally declined since that date. The important export markets, while varying through time, have been Germany, United States, and Belgium-Luxembourg (Table 15). This table reveals that the demand for specific cassava products differs from one country to another. The United States and Canada are the main markets for Brazilian cassava starch and tapioca, while Germany and

Table 11

Brazil's Utilisation of Cassava. 1964-68

Animal Feed

Commodities	Years	Animal	Residue	Trans-formation	Total
Sweet Mandioca	1964	3,950,953	987,738	-	4,938,697
	1965	4,237,314	1,059,329	-	5,926,643
	1966	4,238,095	1,059,524	-	5,297,619
	1967	4,523,038	1,130,759	-	5,653,797
	1968	4,724,571	1,181,143	-	5,905,714
Mandioca Brava	1964	-	1,474,822	9,570,542	11,018,369
	1965	-	1,439,929	9,464,668	10,904,597
	1966	-	1,411,480	9,335,604	10,747,084
	1967	-	1,596,060	10,714,740	12,310,800
	1968	-	1,739,180	11,261,854	13,001,034

Source: Brasil. Ministerio da Agricultura. Mandioca. Productos Esenciais. 1972. Vol. II.

Table 12

Beef and Veal, Mutton and Lamb, and Pork Production.
(1000 Metric Tons)

	Beef + Veal	Mutton + Lamb	Pork	Total
1948-1952	1092	32	351	1475
1961-1965	1404	48	574	2026
1967	1506	52	668	2226
1968	1694	57	718	2469
1969	1826	56	719	2601
1970	1900F	56F	735F	2691
1971	1900F	57F	740F	2697

Source: Production Yearbook, Food and Agriculture Organization of the United Nations, 1971.

Table 13

Brazilian Exports of Cassava Products. 1960 - 1971
Quantity (Tons).

Years	Flour*	Meal	Starch	Tapioca	Chips	Total
1960	28,333	2,508	35,258	846	-	66,945
1961	11,429	5,381	16,555	1,217	-	34,582
1962	527	1,692	8,507	1,197	-	11,923
1963	524	6,825	2,814	914	-	11,077
1964	36,030	9,487	17,522	1,200	3,203	64,239
1965	23,514	21,561	31,911	1,083	41,801	119,870
1966	24,270	19,583	16,088	1,084	27,052	88,077
1967	81	13,932	5,558	1,025	711	20,637
1968	754	7,887	7,172	1,013		16,826
1969	46,598	9,611	10,354	837	38,135	105,535
1970	34,236	8,690	12,835	990	24,672	72,733
1971	12,980	2,167	7,557	1,014	9,069	23,063

Source: Discussions with Banco do Brasil, S.A.

*Headings from left to right, *farinha de mandioca, farinha de raspa de mandioca, fecula de mandioca, tapioca, raspa de mandioca.*

Table 14

Value of Brazilian Exports of Cassava Products. 1960 - 1971
Thousands of US Dollars.

Years	Flour	Meal	Starch	Tapioca	Chips	Total
1960	1,184	140	2,675	129	-	4,128
1961	504	299	1,338	199	-	2,340
1962	66	94	781	196	-	1,137
1963	58	256	295	171	-	780
1964	1,387	380	1,149	204	-	3,243
1965	982	974	2,122	189	1,877	6,144
1966	1,159	1,029	1,393	-	1,318	4,899
1967	9	839	558	-	41	1,406
1968	79	510	648	-	-	1,237
1969	2,015	476	863	-	1,630	3,354
1970	1,729	521	1,049	212	1,254	2,999
1971	536	152	773	223	477	1,453

Source: Discussions with Banco do Brasil, S.A.

Table 15

Brazilian Exports of Cassava Products by Country of Destination, 1964-1971.

Product	Country	Tons	$/M.Ton
	1 9 6 4		
Cassava Roots	Germany	3203	125
Flour	Germany	35036	1305
	U.S.A.	18	2
	Portugal	74	6
	Uruguay	902	74
		36030	1387
Chips	Germany	7605	298
	Belgium-Luxembourg	150	6
	Canada	54	1
	U.S.A.	1678	74
Starch	Germany	700	43
	Canada	496	32
	U.S.A.	15971	1043
	France	40	3
	Guatemala	20	1
	Italy	6	1
	Netherlands	179	12
	U.K.	110	8
Tapioca	Belgium-Luxembourg	15	2
	Canada	102	19
	Spain	135	23
	U.S.A.	918	153
	Portugal	5	1
	Switzerland	20	4
	Uruguay	6	1

Table 15 (continued)

Product	Country	Tons	$/M.Ton
	1 9 6 5		
Cassava	Germany	36670	1646
	Hungary	944	46
	Netherlands	2036	84
	Switzerland	2150	101
Flour	Germany	23088	953
	U.S.A.	40	4
	Italy	1	-
	Portugal	25	2
	Uruguay	359	23
Chips	Germany	1954	86
	Canada	1941	89
	U.S.A.	15667	705
	Switzerland	2000	94
Starch	Germany	8300	332
	Canada	432	30
	Denmark	250	14
	U.S.A.	22287	1706
	Netherlands	142	11
	Peru	500	29
Tapioca	Belgium-Luxembourg	36	6
	Canada	65	12
	Spain	129	22
	U.S.A.	805	139
	Mexico	22	4
	Portugal	7	1
	Switzerland	20	4

Table 15 (continued)

Product	Country	Tons	$/M.Ton
	1 9 6 7		
Cassava	Germany	267	15
	U.S.A.	167	10
	Netherlands	287	16
Flour	Germany	-	-
	Bolivia	-	-
	U.S.A.	22	3
	Portugal	29	3
	Uruguay	28	3
Chips	Belgium-Luxembourg	100	6
	Canada	1090	66
	U.S.A.	12531	753
	France	5	-
	Netherlands	200	12
	U.K.	5	-
Starch	Germany	200	20
	Canada	160	16
	U.S.A.	5108	513
	Netherlands	90	9
Tapioca	Canada	107	22
	Spain	74	13
	U.S.A.	823	172
	Mexico	11	3
	Switzerland	10	8
	1 9 6 8		
Flour	Germany	-	-
	U.S.A.	43	5
	Portugal	48	3
	Uruguay	668	70

Table 15 (continued)

Product	Country	Tons	$/M.Ton
Chips	Canada	2612	165
	U.S.A.	5275	344
Starch	Germany	200	19
	Canada	800	68
	U.S.A.	5818	523
	Netherlands	131	12
	Portugal	10	1
	U.K.	213	24
Sagu	Canada	23	3
	U.S.A.	18	3
	Portugal	1	-
Tapioca	Canada	155	31
	Spain	5	1
	U.S.A.	841	175
	Portugal	7	2
	Switzerland	5	1
	1 9 6 9		
Cassava	Germany	33213	1417
	Belgium-Luxembourg	100	4
	U.S.A.	1000	46
	France	100	3
	Netherlands	3612	154
	Paraguay	100	4
Flour	Germany	9530	397
	Belgium-Luxembourg	36518	1570
	U.S.A.	46	5
	Portugal	29	3
	Uruguay	474	40

Table 15 (continued)

Product	Country	Tons	$/M.Ton
Chips	Germany	549	23
	Belgium-Luxembourg	1000	50
	Canada	1919	94
	U.S.A.	6043	304
	Netherlands	100	4
Starch	Argentina	625	47
	Canada	2809	243
	U.S.A.	6792	562
	Netherlands	128	10
Sagu	Canada	60	9
	U.S.A.	32	4
	Mexico	11	2
Tapioca	Canada	134	27
	U.S.A.	685	144
	Mexico	13	2
	Switzerland	5	1
	1 9 7 0		
Cassava	Germany	17631	918
	Belgium-Luxembourg	1525	79
	Netherlands	5516	258
Meal (farinha de raspa)	Germany	1467	87
	Canada	2675	160
	U.S.A.	4547	272
Flour (farinha de mandioca)	Belgium-Luxembourg	24922	1154
	U.S.A.	59	6
	Portugal	35	2
	Uruguay	531	48

Table 15 (continued)

Product	Country	Tons	$/M.Ton
Starch (amido e feculas)	Germany	99	8
	Belgium-Luxembourg	500	33
	Canada	835	70
	U.S.A.	11183	920
	Netherlands	218	18
Tapioca	Canada	131	27
	Spain	9	1
	U.S.A.	839	182
	Portugal	5	1
	Switzerland	6	1
	1 9 7 1		
Meal (farinha de raspa)	Belgium-Luxembourg	464	25
	Canada	485	34
	U.S.A.	1218	91
Flour (farinha de mandioca)	Belgium-Luxembourg	9189	481
	U.S.A.	1021	88
	France	1	-
	Netherlands	500	25
	Portugal	30	3
	Uruguay	72	7
Chips	Germany	5873	305
	Belgium-Luxembourg	2681	146
	Netherlands	515	25
Tapioca	U.S.A.	829	184
	Canada	137	30
	Switzerland	35	7
	Mexico	8	1
	Portugal	5	1

Table 15 (continued)

Product	Country	Tons	$/M.Ton
Starch	U.S.A.	6033	613
	Canada	1115	112
	Netherlands	396	45
	Spain	6	2
	South Africa	4	1

Source: IBGE, Anuario Comercio Exterior (various issues) collected data by: University of Georgia. Feasibility of Manioc Production in N.E. Brazil, August 1971 and EZ/CIAT/COLOMBIA. 1973.

Note: The figures reported in this table are rounded to the nearest thousands of dollars. For example, 1.6 thousand dollars appears as 2 thousand dollars.

and Belgium-Luxembourg are the main markets for cassava chips and flour. The eratic nature of exports is perhaps indicative of Brazil's inability to respond to the export potential for cassava. Reinforcing this contention is the fact that both the North American starch (Chapter III) and the EEC flour and chip market (Chapter IV) have been growing while Brazilian exports have exhibited no clear trend. In part, this failure reflects the facts that

1) exports come primarily from the south of Brazil (Table 16), thus drawing on only a proportion of Brasilian production capacity;

2) export prices, except for tapioca and starch, are lower than domestic prices (Table 17) (viz., *farinha de mandioca* costs approximately $115/metric ton while fob export price may be half this value). The extra quality control required for the tapioca and starch markets no doubt means that returns from these two export markets are not much higher than the less-demanding domestic markets;

3) cassava exports have not consistently met minimum quality standards.

The latter point may be overcome by the implementation of export standards approved by the National Council of External Trade in 1971 (Table 18). Adherance to these standards should stimulate export demand for Brazilian cassava.

6.6 Summary

The evidence presented in this chapter suggests that the role of cassava in Brazil is similar to the pattern common in many LDCs, namely, that cassava production is required to meet home food requirements before other domestic demands (in this instance, primarily animal feed demands). The residual is then exported.

The aggregate analysis of Brazil (see Chapter II) indicates that the human demand for and supply of cassava will continue to increase during the 'seventies. The more disaggregated approach supports these findings in principle, although the present analysis indicates that

Table 16

Cassava Exports by Port of Embarkation

Port of Embarkation	Chips Quantity	Chips Value	Starch Quantity	Starch Value	Tapioca Quantity	Tapioca Value
1960-Santos(SP)	2,508	140,000	4,537	318,140		
-Rio de Janeiro(GB)			1	81		
-Itajaí(SC)			28,792	2,220,180	840	128,067
-Laguna(SC)			1,927	137,048		
-Pôrto Alegre(RS)					6	1,047
1961-Santos(SP)	5,052	281,000	2,664	205,636		
-São Paulo(SP)	329	18,000				
-Itajaí(SC)			13,456	1,095,393	1,211	198,216
-Laguna(SC)			436	36,565		
-Pôrto Alegre(RS)					6	1,089
1962-Santos(SP)	754	41,909	1,334	106,331	113	19,927
-Itajaí(SC)	938	52,178	7,173	675,146	1,083	176,098
1963-Santos(SP)	6,134	216,349	323	33,388	19	3,627
-Itajaí(SC)	691	39,559	2,485	260,814	815	152,432
-Livramento(RS)			5	590		
-Paranaguá(PR)					79	14,974
1964-Salvador(BA)	1,000	39,200				
-Santos(SP)	7,276	289,354			11	2,337
-Itajaí(SC)	1,210	51,256	16,509	1,082,057		
-Outros			1,014	66,489	1,150	195,340
-Paranaguá(PR)					39	6,550

Table 16 (continued)

Port of Embarkation	Chips		Starch		Tapioca	
	Quantity	Value	Quantity	Value	Quantity	Value
1965-Salvador(BA)	120	6,000				
-Santos(SP)	20,941	942,890	2,064	144,700		
-Itajaí(SC)	500	25,553	21,377	1,632,661	879	152,418
-Laguna(SC)			8,300	332,000		
-Outros			170	12,445	204	36,743
1966-Santos(SP)	18,738	985,575	260	22,852		
-Itajaí(SC)	308	15,573	15,828	1,369,768	898	171,406
-Laguna(SC)	538	27,810				
-Outros					260	45,912
1967-Santos(SP)	12,415	747,309	20	2,646		
-Itajaí(SC)	1,517	91,456	5,483	550,188	946	195,248
-Paranaguá(PR)			55	5,604	67	13,592
-Pôrto Alegre(RS)					11	2,818
1968-Santos(SP)	7,887	509,825	283	28,342	7	1,621
-Itajaí(SC)			6,610	589,321	929	192,567
-Parnaiba(PI)			213	23,587		
-Paranaguá(PR)			65	6,549	78	15,815

SOURCE: Banco do Brasil S.A.

Table 17

Average Price of Cassava Exports (US$/Metric Ton:FOB)

Derivados	1966	1967	1968	1969	1970	1971
Meal	52,54	60,22	64,66	49,52	59,95	70,09
Flour	47,75	112,50+	104,77+	43,24	47,47	54,19
Chips	48,72	57,11	-	42,75	51,66	52,64
Starch	86,58	100,40	90,35	83,34	81,90	102,30
Tapioca	187,40	207,00	207,10	209,08	215,95	221,05

+ Includes edible farinha de mandioca.

Table 18

Cassava Export Standards

Characteristics and Limits	Starch 1			Tapioca 2				Chips 3		Meal 4	
Classes				Granules		Artificial Sago					
Types	1 or A	2 or B	3 or C	1	2	1	2	1	2	1	2
Starch-minimum%	84,0	82,0	80,0					75,0	70,0	71,0	70,0
Mesh Size (mm) (%)	0,105 99,0	0,105 99,0	0,105 99,0							0,160 99,0	0,160 99,0
Moisture-maximum%	14,0	14,0	14,0	15,0	15,0	15,0	15,0	13,0	14,0	13,0	14,0
Breaking point	58° a 83° C	58° a 83° C	58° a 83° C								
Coloration	9A1 10A1 11A1	9A1 10A1 11A1 12A1 13A1	9A1 10A1 11A1 12A1 12B1 13A1	white to creamy gray	white to light gray	white to ash	ashy to cream to yellowish and yellow			10A1 10A2 10B1 10B2 11A1 11A2 11A3 11B1 11B2 11B3 11C1 11C2 11C3	10A1 10A2 10B1 10B2 11A1 11A2 11A3 11B1 11B2 11B3 11C1 11C2 11C3 13A1 13A2 13B1 13B2

Table 18 (continued)

Characteristics and Limits	Starch 1			Tapioca 2				Chips 3		Meal 4	
Viscosity	good	regu-lar	poor	(Granules)		(Artificial Sago)					
Acid factor content	4,5	4,5	6,0								
pH	4,5 a 6,5	4,5 a 6,5	4,0 a 6,5								
Acidity(ml % in solution of NaOH N/1)								2,0	2,5	2,0	2,5
Ash/Powder-maximum %	0,12	0,5	1,0	0,2	0,5	0,2	0,5	2,0	3,0	2,0	2,0
Pulp-ml	0,5	2,5	3,5							40.0	45,0
Odor				Distinctive		Distinctive		Distinctive			
Foreign material or impurities-maximum %				0,0	0,0	0,0	0,0	1,0	2,0	0,5	1,0
Length (cm)								5,0	5,0		

Source: Farinha de Mandioca e Prodcutors Amilaceos, CACEX publication, 1972.

growth in demand will be primarily for cassava flour, if migrational patterns are accounted for, rather than for fresh cassava. *Prima facie*, by 1980 Brazil will have plentiful supplies to meet additional domestic demands or to export*.

1980 domestic demand for cassava is expected to be 13,990 thousand metric tons for food and an average of 10,052 thousand metric tons for animal feed**. The 1980 supply of cassava is expected to range from 40,733 thousand metric tons to 50,653 thousand metric tons. These projections suggest that by 1980 Brazil could have from 16,691 to 26,611 thousand metric tons available for domestic or export purposes. If this quantity were all exported as pellets, Brazil could theoretically export from 6,676 to 10,644 thousand metric tons***, with an approximate fob value of $367,180,000 to $585,420,000. From the demand point of view, it would appear that Brazil could capture (if not glut) a substantial proportion of EEC demand for cassava. From the supply standpoint, Brazil must evaluate her export potential in terms of competition between cassava export earnings and opportunity costs of cassava production as opposed to production of other crops. Moreover, exportation implies not only availability of supplies but the necessary transportation and port infrastructure, which is notably lacking in cassava-growing regions of the North and Northeast. On this point, the Brazilian case differs substantially from the Thai situation -- the Brazilian decision to export requiring state and/or federal support for infrastructure development.

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Chapter VII

CASSAVA IN THAILAND

> There's no doubt about it. Thailand is at the top of the Tapioca Tree. And it's gonna take a lot to shake her out of it.
>
> Bill Manson, 1972.

Agriculture in Thailand has undergone two major changes in the latter half of this century. First, agriculture, historically the pre-eminent industry in the Thai economy (Table 1), has declined in terms of GDP. Today it accounts for only 30% of GDP (but employs 76% of the labour force (Table 2), reflecting the persistence of low-wage, labour-intensive conditions). Second, since the mid-'fifties , efforts to diversify have transformed the former rice monoculture into a nearly self-sufficient agricultural economy (Thailand's main imports now being cotton, tobacco, wheat and wheat flour).

7.1 Cassava Production and Export

In the wake of the diversification drive, the crops to experience the greatest increases in production have been cassava, maize and kenaf, with cassava exhibiting the greatest increase of all (Tables 3 and 4). Growth in cassava production clearly reflects both the rapid development of the EEC export market (note the sudden and substantial increase after 1959 (Table 5)) and high returns to cassava cultivation (Table 6). Of fifteen major crops, cassava, in terms of returns per unit area, ranks after kapok, tobacco and coconut. Moreover, because the cost of cassava production is relatively low, the crop, in terms of returns over cost per unit land, may rank even higher.

The Thai cassava processing industry has also responded rapidly to changing market conditions (Table 5), probably the most spectacular

TABLE 1

Gross Domestic Products by Industrial Origin
(million baht)

	1966 Value	1966 %	1967 Value	1967 %	1968 Value	1968 %	1969 Value	1969 %	1970 Value	1970 %
Agriculture	37,320	36.8	34,890	32.4	36,760	31.4	41,680	31.9	40,050	29.6
Mining and Quarrying	1,950	1.9	2,060	1.9	2,110	1.8	2,470	1.9	2,960	2.2
Manufacturing	13,910	13.7	16,040	14.9	17,550	15.0	19,190	14.7	20,210	14.9
Construction	6,180	6.1	7,400	6.9	8,190	7.0	8,620	6.6	9,420	7.0
Electricity and Water Supply	890	0.9	1,080	1.0	1,300	1.1	1,560	1.2	1,850	1.4
Transportation and Communication	6,330	6.2	6,810	6.3	7,320	6.2	7,960	6.1	8,490	6.3
Trade	16,740	16.5	18,710	17.4	20,290	17.3	22,890	17.5	23,260	17.2
Banking, Insurance and Real Estate	2,820	2.8	3,440	3.2	4,060	3.5	4,820	3.7	5,600	4.1
Ownership of Dwellings	2,230	2.2	2,340	2.2	2,470	2.1	2,560	2.0	2,710	2.0
Public Administration and Defence	3,810	3.8	4,290	4.0	4,990	4.3	5,570	4.3	6,310	4.7
Other Services	9,240	9.1	10,660	9.9	12,090	10.3	13,310	10.2	14,470	10.7
GDP	101,430	100.0	107,720	100.0	117,140	100.0	130,610	100.0	135,320	100.0

Source: National Accounts Division, National Economic Development Board.

TABLE 2

Employment Trend in Thailand* by Sectors

Sector	1954[1] Num.	%	1960[2] Num.	%	1966[3] Num.	%	1971[4] Num.	%
griculture, Forestry, Hunting and Fishing	8,971,600	88	10,341,857	82	11,618,752	80	12,675,498	76
ining and Quarrying	19,200	...	28,443	...	41,486	...	51,322	...
anufacturing	212,520	2	454,807	4	689,134	5	982,143	6
onstruction	28,440	...	68,260	1	110,687	1	164,247	1
lectricity, Gas, Water and Sanitary Services	4,680	...	15,454	...	33,249	...	57,548	...
ommerce	463,240	5	744,424	6	1,027,574	7	1,368,792	8
ransport, Storage and Communications	84,520	1	164,142	1	228,949	2	324,818	2
ervices	393,080	4	643,595	5	804,304	6	1,139,818	7
thers	23,400	...	220,275	2	-		-	
otal Number of Persons Employed	10,200,680	100	12,681,257	100	14,554,135	100	16,764,198	100

ources: 1. 1954 Demographic and Economic Survey

2. 1960 Population Census

3. & 4. Estimate of Manpower Planning Division, NEDB.

Relates to persons aged 15 years and over.

TABLE 3

Production of Principal Crops by Groups, 1953-1970
(1,000 Metric Tons)

Year	Upland food crops	Oilseeds	Fiber crops	Rubber	Tobacco (Virginia)	All crops except rice	Rice (1)	All crops
1953	1,944	964.7	39.5	98.1	11.5	3,057.8	8,239	11,296.8
1954	2,574	1,278.3	30.9	119.6	10.0	4,012.8	5,709	9,721.8
1955	2,844	1,376.9	34.8	133.3	6.3	4,395.3	7,334	11,729.3
1956	4,137	1,475.2	49.3	136.7	6.9	5,805.1	8,297	14,102.1
1957	4,489	1,505.8	181.6	142.0	7.0	6,325.4	5,570	11,895.4
1958	4,728	1,338.3	174.9	149.6	8.8	6,399.6	7,053	13,452.6
1959	6,434	1,102.0	207.8	161.0	8.0	7,912.8	6,770	14,682.8
1960	7,208	1,279.2	355.0	171.8	8.8	9,022.8	7,834	16,856.8
1961	6,349	1,231.3	350.5	186.1	8.7	8,125.6	8,177	16,302.6
1962	5,950	1,300.0	234.5	195.4	8.6	7,688.5	9,279	16,967.5
1963	7,818	1,361.8	349.8	198.3	8.6	9,736.5	10,029	19,765.5
1964	7,676	1,300.2	449.5	210.6	8.9	9,645.2	9,558	19,203.2
1965	7,101	1,369.6	686.5	217.4	7.6	9,382.1	9,198	18,580.1
1966	6,975	1,388.6	853.1	218.1	7.8	9,442.6	11,975	21,417.6
1967	8,026	1,387.2	605.6	219.3	8.3	10,246.4	9,595	19,841.4
1968	10,182	988.1	538.5	257.8	8.2	11,974.6	10,771	22,745.6
1969	10,840	949.1	513.9	281.8	9.3	12,594.1	13,410	26,004.1
1970	12,150	982.2	510.7	287.2	9.6	13,940.0	13,270	27,210.0

(1) From area planted in specified year.

Source: <u>Agricultural Statistics of Thailand</u>

TABLE 4

Index of Production of Selected Crops

	Maize	Cassava	Kenaf	All crops except rice	All crops
1950-53	100	100	100	100	100
1954	150	107	63	165	101
1955	165	98	76	181	121
1956	279	352	131	239	146
1957	332	373	137	260	123
1958	451	434	229	263	139
1959	768	2,461	386	325	152
1960	1,319	2,777	1,400	371	174
1961	1,450	3,923	1,848	334	169
1962	1,612	4,720	1,038	316	175
1963	2,080	4,798	1,635	400	204
1964	2,267	3,539	2,341	397	199
1965	2,475	3,352	4,086	386	192
1966	2,720	4,300	5,115	388	222
1967	3,188	4,686	3,257	421	205
1968	3,656	5,934	2,440	492	235
1969	4,121	6,998	2,883	518	269
1970	4,727	7,798	2,941	573	281

Source: Agricultural Statistics of Thailand, 1970.

TABLE 5

Export of Cassava Products (1953-1970)

Year	Cassava root		Cassava flour		Cassava Pellets	
	tons	1,000 baht	tons	1,000 baht	tons	1,000 baht
1953	985	727	21,939	36,312	-	-
1954	1,054	767	29,733	58,524	-	-
1955	909	750	29,359	52,864	-	-
1956	673	545	56,482	94,603	-	-
1957	286	217	76,990	127,237	-	-
1958	2,063	1,870	124,708	177,383	-	-
1959	208	34	149,248	193,646	3,735	3,190
1960	2,957	2,611	241,424	270,447	-	-
1961	8,405	6,921	416,022	427,930	-	-
1962	12,670	10,143	378,240	403,690	-	-
1963	93,422	76,324	311,304	346,711	-	-
1964	339,418	252,420	353,760	370,082	-	-
1965	400,526	315,241	220,923	283,293	-	-
1966	359,817	277,222	220,765	283,272	-	-
1967	337,307	236,414	373,515	445,228	-	-
1968	323,209	223,558	532,416	529,876	-	-
1969	56,394	42,839	148,939	204,310	752,751	616,863
1970	8,111	7,317	148,681	211,200	1,163,985	999,393
1971	2,500	2,500	151,352	253,400	963,895	976,100
1972(Jan-July)	n.a	n.a	79,598	133,000	717,554	795,000
Extrapolated 1972	n.a	n.a	(136,453)	(278,000)	(1,230,093)	(1,362,857)

TABLE 5 (continued)

Year	Cassava waste		Saga flour and pearl		Total	
	tons	1,000 baht	tons	1,000 baht	tons	1,000 baht
1953	17,362	8,771	3,747	5,672	44,033	51,482
1954	22,249	11,288	1,683	2,701	54,719	73,280
1955	23,854	15,551	1,595	2,736	55,717	71,90
1956	28,276	17,005	1,547	2,619	86,973	114,772
1957	21,053	9,224	446	884	98,775	137,562
1958	24,475	12,012	380	799	151,626	192,064
1959	44,574	29,511	619	1,225	227,895	227,606
1960	24,988	14,006	363	733	269,732	287,797
1961	18,568	10,805	372	714	443,367	446,370
1962	9,586	8,501	292	626	400,788	422,960
1963	22,391	15,146	326	664	427,443	438,845
1964	45,520	29,745	162	269	738,698	652,100
1965	97,811	77,212	182	342	719,260	675,600
1966	107,858	83,206	163	347	688,439	643,700
1967	70,238	43,280	297	613	781,059	724,900
1968	33,082	19,493	147	297	888,707	772,900
1969	16,905	12,011	152	302	974,940	876,000
1970	5,906	4,870	182	446	1,326,683	1,222,800
1971	4,151	4,200	n.a	n.a	1,121,898	1,237,700
1972(Jan-July)	n.a	n.a	n.a	n.a	805,239	935,000
Extrapolated 1972	n.a	n.a	n.a	n.a	(1,380,410)	(1,602,857)

TABLE 6

Value of Output per Rai* of Selected Crops
(Baht)

Product	58-60	65-67
Maize	269	325
Mungbeans	370	414
Cassava	713	611
Rice	169	291
Sugarcane	596	606
Castorbeans	523	321
Groundnuts	437	507
Sesame	618	533
Soybeans	350	363
Coconuts	1,249	757
Cotton	486	501
Kapok	1,663	1,452
Kenaf	1,531	569
Rubber	637	377
Tobacco	976	917

Source: Omero Sabatoni, The Agricultural Economy of Thailand, USDA, Foreign 321, January, 1972.

*2.5 rai = 1 acre; 6.25 rai = 1 hectare.

adjustment being the virtual replacement in two years of cassava chips and waste by pellets. Growth in cassava exports has elevated its export earnings to fifth position (Table 7). The extent of exports would most probably have been impossible if cassava constituted an important part of the Thai diet. The Thai farmer plants cassava solely as a cash crop -- in all other countries cassava is generally cultivated as a local food crop.

Prior to the mid-'fifties , cassava exports consisted primarily of starch to the United States. Three people and one event are credited with the initiation of cassava exports to Europe. In 1956, Messrs. Erich Funke, R. Schaller and Overseas Barter (sic) introduced Thai cassava products to the European animal feed market. This introduction combined fortuitously with a freight war between Thai and French shipping lines, which had the effect of reducing shipping costs to Europe by roughly a third of the normal price (140 shillings per long ton) [1]. Initial shipments of cassava feeds were in the form of cassava waste (meal) from starch manufacturing. In 1958, cassava meal came to be produced directly from roots, the invention of the cassava chipper and the importation of a German hammer mill permitting this breakthrough. By 1963, export of cassava chips exceeded those of meal, and in 1965, cassava exports to Europe earned more than total starch exports. In 1967, starch earnings rose above earnings from Europe, but the introduction of cassava pellets in 1969 swung the balance (perhaps permanently) back in favour of the European animal feed market.

Production of pellets in 1967/68 was initiated primarily by German interests which invested a reported 20 million baht into the first pelleting plant. Pellets were immediately accepted by the European market because of their superior nutrient and physical properties (pellets are less dusty than meal, their greater density makes them cheaper to ship, and they are more readily worked by bulk handling facilities).

It did not take long for processors to appreciate that the future of cassava lay in the form of the pellet. There are now a reported 300 pelletising machines [2, p. 37] in 90 plants [3, p. 9] in Thailand.

Pellets are defined as 'native' and 'branded'. To a large extent this distinction also reflects a difference in quality. Branded pellets, constituting 30 to 40% of exports and primarily produced by large, commercial* firms, are generally considered to possess better quality. However, this should not be taken to imply that all native pellets are of low quality**.

Poor quality of product has been a common complaint on the parts of Thailand's European customers. The main criticism are that

- minimum starch content is not met;
- maximum sand and foreign matter content is exceeded;
- maximum moisture content is exceeded;
- bacteria and mold content is too high.
- pellets are of poor, friable consistency.

Failure to provide a better product rests first with the fact that, despite poor quality, the market for cassava has not decreased. German and Dutch importers have combined complaints with increased demand and steady price for the products. Only Belgium has cancelled Thai imports, preferring since 1969 to use the more sporadic but higher quality products of Indonesia, Africa and the People's Republic of China [2, p. 40].

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*Formerly, 'commercial' was synonymous with foreign-owned plants. To-day, however, the largest single production unit is Thai-owned. The producers of branded pellets are Peter Cremer (2 plants), Khrone (2 plants), Thai Wah (2 plants), Trakulkam (1 plant), and Tradex (1 plant).

**The author visited one native plant whose product is rated as being one of the top two in quality.

TABLE 7

Quantity and Value of Major Exports
Volume: Metric tons
Value: Million Baht

Period	Rice		Maize		Rubber		Tin †	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1961	1,575,998	3,598	567,236	597	184,598	2,130	18,104	617
1962	1,271,023	3,240	472,405	502	194,180	2,111	19,841	685
1963	1,417,673	3,424	744,046	828	186,887	1,903	22,003	741
1964	1,896,258	4,389	1,115,041	1,346	216,993	2,060	22,339	962
1965	1,895,223	4,334	804,380	969	210,854	1,999	20,503	1,166
1966	1,507,550	4,001	1,218,537	1,520	202,535	1,861	18,898	1,316
1967	1,482,272	4,653	1,090,762	1,355	211,118	1,574	27,107	1,822
1968	1,068,185	3,775	1,480,841	1,556	252,220	1,816	24,017	1,510
1969	1,023,064	2,945	1,476,106	1,674	276,381	2,664	23,431	1,631
1970	1,063,616	2,516	1,371,474	1,857	275,610	2,232	22,246	1,618
1971*	1,661,840	2,901	1,829,878	2,251	307,873	1,901	21,703	1,561
1971								
Jan.-Mar.**	305,910	634	713,051	997	82,262	542	5,535	392
Apr.-Jun.**	323,813	595	70,158	98	61,859	403	5,157	374
Jul.-Sept.*	446,182	793	187,474	237	87,528	530	5,334	383
Oct.-Dec.*	585,935	879	859,195	919	76,224	426	5,677	412
1972*								
January	179,417	330	242,391	243	23,859	136	1,524	113
February	131,785	236	188,600	204	27,975	161	1,880	141
March	198,388	369	269,711	285	33,570	194	2,743	213
Jan.-Mar.	509,590	935	700,702	732	85,404	491	6,147	467
April	151,532	283	174,677	184	17,209	101	2,083	165
May	192,310	355	130,218	138	30,214	175	1,433	112
June	108,191	310	50,745	60	21,886	123	1,178	91
Apr.-Jun.	452,033	948	355,640	382	69,309	399	4,694	368
July	209,108	395	33,937	42	34,891	196	1,778	135

TABLE 7 (continued)

Period	Cassava		Kenaf and Jute		Teak and Woods	
	Volume	Value	Volume	Value	Cu.M.	Value
1961	443,376	446	143,477	626	135,279	321
1962	400,788	423	237,898	579	104,617	232
1963	427,443	439	125,753	358	118,161	216
1964	738,859	653	162,095	495	130,367	269
1965	719,442	676	316,986	1,102	117,380	279
1966	688,603	644	473,269	1,614	98,514	295
1967	781,357	726	317,112	866	66,319	244
1968	888,854	772	289,478	674	64,735	218
1969	975,091	876	255,978	780	62,133	216
1970	1,326,865	1,223	257,663	719	61,830	206
1971*	1,112,466	1,229	270,977	933	85,457	269
1971						
Jan.-Mar.**	313,065	342	71,707	225	16,702	53
Apr.-Jun.**	235,723	262	66,640	236	19,633	66
Jul.-Sept.*	192,849	219	30,867	101	23,991	71
Oct.-Dec.*	370,829	406	101,763	371	25,131	79
1972*						
January	117,628	129	50,759	219	5,188	19
February	125,849	142	28,469	122	8,640	25
March	128,395	137	36,974	162	6,161	24
Jan.-Mar.	371,872	408	116,202	503	19,989	68
April	80,435	96	27,061	126	7,256	30
May	174,446	198	4,813	25	7,601	29
June	90,661	131	3,705	18	7,839	27
Apr.-Jun.	345,542	425	35,579	169	22,746	86
July	84,825	102	417	2	8,746	26

Source: Department of Customs

† 1960-1964 tin concentrates only; 1965-1967 tin concentrate and tin metal combined; from 1968 tin metal only.

*Preliminary figures.

**Revised figures.

Second, and perhaps more important, the low market margins on chips in Thailand make it economical to chip cassava only if the final product weight is supplemented with sand and other foreign matter. Moreover, export standards* have not been rigorously enforced by licensed inspectors or employees of the Office of Commodity Standards, acquisition of a quality certificate depending in many cases more on sub rosa payments than on quality of product. This year, in an effort to enforce export standards, the Thai Minister of Commerce, Prasit Kanchanawat, announced that importers of Thai cassava products could appoint their own surveyors to insure that shipments from Thailand met established standards. It is anticipated that this change will improve the quality of Thai exports and may eventually lead to higher prices for Thai cassava products**.

Assuming that Thai cassava exports achieve the desired quality level, what is the export potential for cassava? In recent years, root production has expanded by more than 10% per annum, owing primarily to increased acreage diverted to cultivation. If this growth rate is projected through the 'seventies , production in 1980 will be 8,886,000 metric tons***, or 2.59 times greater than the 1970 level. However, processors and exporters believe that by 1980 their root supply will only be sufficient to allow them to export two million tons of processed cassava, principally in pellet form. In fresh root units, this represents a production of only five million tons. Therefore, those most closely connected with the trade suggest that the growth rate of cassava production will not be maintained at the 10% level but will decrease in the 'seventies .

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*The export standards are: minimum starch 60%; maximum fibre 5%; maximum sand 3%; maximum moisture 14% (14.3% for period 1/6-30/9).

**Mathot claims that Thai cassava products receive from 1 to 4 Dutch guilders/ 100 kg. less than their nutritiional value because of lack of proper quality control [3,p.2].

***This projection is about equal to that derived from the log-log time trend model (production regressed on time), and more than that derived from the linear time trend model. (Appendix A, Table A.2), 8,987,000 tons and 3,317,000 tons, respectively.

In any event, because of present production practices, an increase in cassava production is inevitably associated with a proportionate increase in land devoted to cassava. However, the current Five Year Agricultural Plan encourages expanding cassava production through higher yields without expansion of acreage. If this goal is to be realised, there clearly must be a break with prevailing production practices.*

Such a break will certainly require not only applied research on cultivation practices but effective dissemination of research findings. Perhaps the most obvious and important area of need is fertiliser application. Field trials, conducted by the Division of Agricultural Chemistry since 1954, have reported an optimum fertiliser application level for cassava of 8-8-4 (N, P_2O_5, K_2O) at 100 kg/rai (625 kg/ha).** A more recent study, conducted in 1970 by FAO/UNDP, found fertiliser application to be economic for Thai cassava cultivation over a wide range of applications, with maximum profit occurring at levels of N 75.6 kg/ha, P_2O_5 15.7 kg/ha, and K_2O 30.3 kg/ha on sattahip soils [8, p. 74]. The results of these reports have remained largely academic, however, and have not found expression in application by cassaver growers.

Non-adoption may be accounted for by several factors. First, use of fertiliser requires a radical change of attitude on the parts of Thai farmers. Second, government efforts to disseminate results and stimulate uptake appear to have been inadequate. Third, despite its technical appropriateness, fertiliser utilisation may involve a liquidity problem -- the farmer may not be able to afford fertiliser when needed. And finally, marginal returns to fertiliser applications are visibly greater for such crops as chilies, tomatoes and other vegetables.

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*The consensus of individuals with whom the author spoke is that, on the one hand, production practices will not change readily, and that, on the other, government cannot easily restrict expanding cassava acreage.

** 6.25 rai = 1 hectare; 2.5 rai = 1 acre.

Limited research has also been conducted on spacing, intercropping, chemical weed control and other aspects of production, but little that can be applied has emerged from these studies. The request of the Thai Tapioca Trade Association to the Department of Agriculture to conduct research on varietal selection, production methods and fertiliser response has also failed to produce tangible results [5]. The Association's observation that research efforts have been primarily concerned with theoretical and not applied research does seem appropriate.

7.2 Economics of Cassava Production and Processing

Information on the economics of Thai production and processing is of great interest because of Thailand's pre-eminence in the world trade of cassava. Such information may not only be useful in establishing a world standard but may also indicate areas where Thailand can further improve efficiency. For these reasons, this section draws heavily upon data reported in a survey conducted in 1972 by the Thai Department of Agriculture on all aspects of cassava production, processing and trade (Table 8).

The survey* is a massive work, comprising data gathered from a 25% random sample of handlers and exporters, a 50% sample of factories and processors, and a 10% sample of producer families on a two village per district basis. In all, 35% of the districts in Thailand's nine cassava growing provinces were surveyed. (These provinces lie primarily in the cassava agro-economic zones [10], indicated by cross-hatching (Figure1). The eastern zone is the traditional region of cassava production, with Cholburi recognised as the oldest cassava growing region in the country. The western zone is a relatively new area of cassava production).**

Producer farms average 53.7 rai, with 47% of land in cassava, 17% in rice, 13% in upland crops, 5% in vegetable, 2% in buildings, and 16% devoted to other uses. The farmers interviewed were highly market

*The survey was directed by Mr. Thawee, Economist, Department of Agriculture, who kindly gave his time to discuss details of the survey with the author. This section draws largely from this conversation.

**The survey in addition covers Chantburi, and Nakornrajsima, not shown in Figure 1, and excludes Kanchanaburi.

Figure 1. Thailand: Cassava Agro-Economic Zones

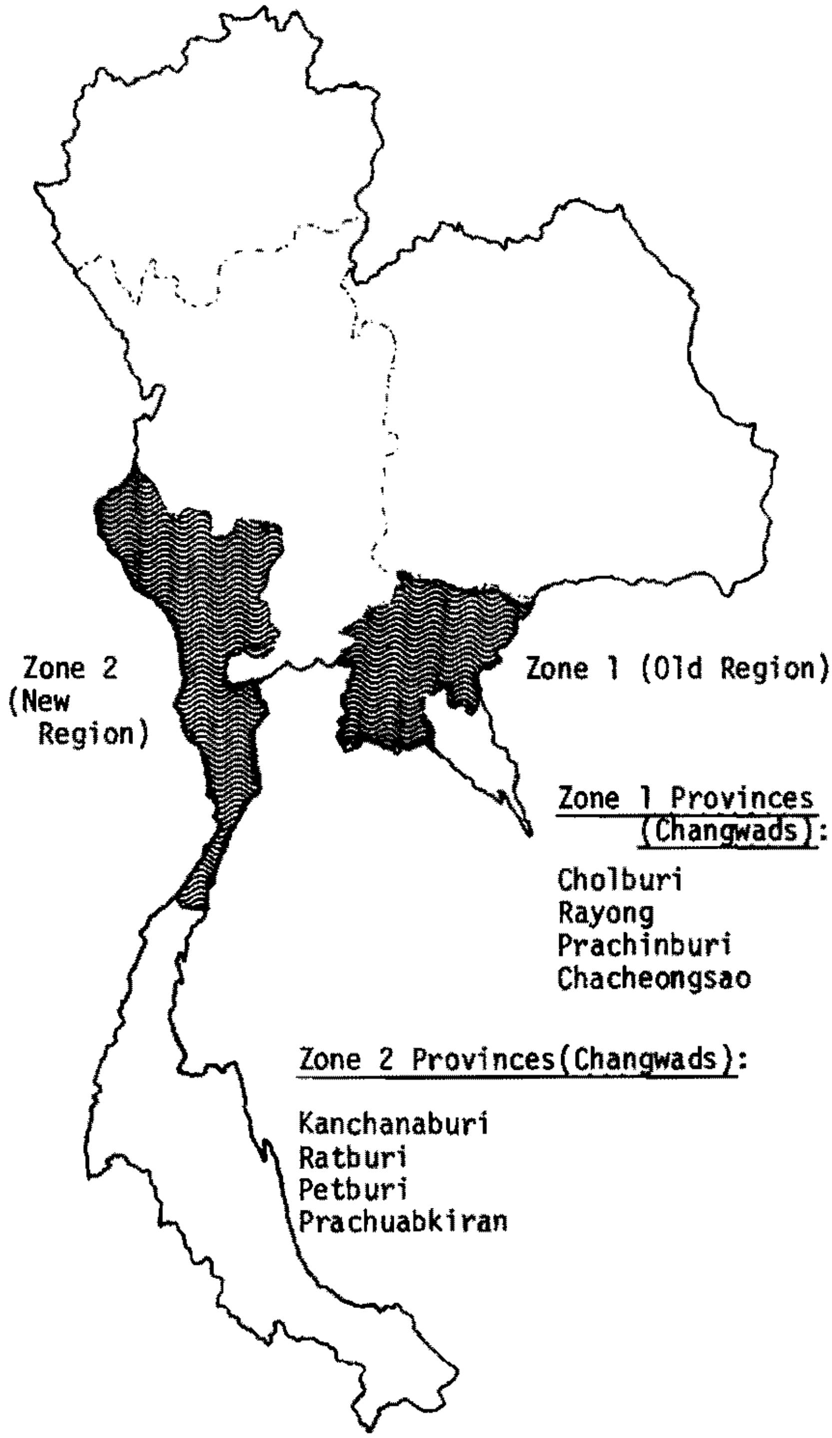

TABLE 8

Composition of Survey of Cassava Producers, Processors, and Traders.

		Factory				Wholesale			
Province	Farmers	Starch	Chip	Pellet	Sago	Root Chips	Starch & Pearls	Retailers	Export
Cholburi	84	38	12	17	4	8	12	21	-
Rayong	25	8	55	7	-	5	6	10	-
Chantburi	14	-	2	-	-	-	3	7	-
Nakornrajsima	22	2	5	-	-	-	3	15	-
Prachinburi	29	-	2	-	-	5	2	13	-
Chachoengsao	58	1	7	2	-	-	1	10	-
Ratburi	46	-	2	-	-	-	2	9	-
Petburi	10	1	2	-	-	-	2	10	-
Prachuabkirikan	23	-	3	-	-	-	1	6	-
Bangkok(?)	-	-	-	-	-	-	10	8	10
Total Number	311	50	90	28	4	18	42	109	10

oriented, with 91.5% of total production being sold, 4.7% going to labour perquisites, and 3.8% held in credit.

The average capacity (potential/realised) of the processing plants were: chip plants 16 tons per day/9 tons per day; pellet plants 21 tons per day/14 tons per day; sago plants 4 tons per day/3 tons per day; and starch plants 32 tons per day/21 tons per day.

The market structure for cassava involves a movement of 91% of crop sold from farmer to handler/transporter, to factory, to wholesaler, and finally to retailer or exporter. 5.1% of sales involve partnership arrangements and 2.3% involve companies. Only 16.8% of handlers deal exclusively in cassava, the remainder dealing in numerous crops.

Production costs vary according to acreage devoted to cassava (Table 9) and region (Table 10). Of these two parameters, region appears to be the most important, with late-comers to production exhibiting relatively lower production costs and higher yields. Ratburi and Prachabkirikan, the provinces with the lowest production costs (287Bh/rai and 318Bh/rai, respectively), are both new producer areas. Production costs for Petburi, also a new cassava growing province, are 25Bh/rai below the average (408Bh/rai)* for all farms surveyed. All three provinces rank among the highest in terms of yield. On the other hand, the province with the longest history of cassava production, Cholburi, has the highest production costs and lowest yields. Obviously, production cost is highly associated with yield, and yield, in turn, is largely a function of soil condition. In old regions, cassava has succeeded rice or other crops on already depleted soil. Higher yields in new provinces clearly reflect better soil conditions. It should be stated, however, that cassava yields of 4 to 5 tons/rai on newly cleared land are reported to diminish to 2.5 to 3 tons/rai within

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*At a current exchange of 20 Bh = $1.00 U.S., this average is equivalent to a production cost of $127.50/ha.

TABLE 9

Cost of Production for Different Acreages of Cassava
(per rai and per Kg)

	Cost /rai	Cost/Kg	Kg/rai
Under 6.00 rai	462.84	0.22	2,068.29
6.00 - 10.99	445.19	0.24	1,831.01
11.00 - 15.99	403.43	0.21	1,965.76
16.00 - 20.99	395.10	0.22	1,739.53
21.00 - 25.99	386.05	0.21	1,806.03
26.00 - 30.99	373.43	0.18	2,062.84
31.00 - 35.99	381.90	0.19	1,964.83
36.00 - 40.99	397.82	0.19	2,048.62
41.00 - 45.99	386.44	0.19	1,984.67
46.00 - 50.99	422.24	0.22	1,926.36
51.00 - upward	392.93	0.20	1,892.51
Average	407.99	0.21	1,929.98

TABLE 10

Provincial Cost of Production
(per rai & per Kg)

Province	Cost/rai	Cost/Kg	Kg/rai
Cholburi	457.58	0.31	1,456.51
Rayong	437.55	0.18	2,489.97
Chantburi	430.02	0.16	2,705.12
Nakornrajsima	447.86	0.26	1,722.22
Prachinburi	351.76	0.18	1,855.65
Chachoengsao	375.19	0.22	1,718.46
Ratburi	286.70	0.12	2,384.14
Petburi	382.49	0.17	2,236.36
Prachuabkirikan	317.53	0.14	2,249.92
Average	407.99	0.21	1,929.98

3 years.* Thus, lower costs in new regions may also be a consequence of better production practices and higher levels of technology compared with old established provinces.

From Table 9 it would appear that cassava is profitable at all levels of production (viz., maximum cost/Kg is 24 Baht while minimum price is 26 Baht),a fact which is fully appreciated by farmers and which no doubt explains the steady increase of production. Rather surprisingly, however, production costs on very large plantations are nearly as great as on very small plantations, with critical size occurring at the 26 to 31 rai level. Costs generally decrease up to this point and increase beyond it. Labour is clearly the crucial input. As indicated in Table 10 labour costs/rai are lowest for the 26 to 31 rai category, and it is suggested here that this is because that size may be the optimum scale of enterprise for the family labour unit. Beyond this level, hired labour is required. Finally, if the calculated gross returns are valid, net returns (184 Baht/rai) for this size plantation are greater than for any other category (Table 11).

The following discussion of the price structure of the cassava marketing chain draws on survey data to indicate how the margin between farmer selling price for fresh roots and the final FOB Bangkok price is shared among the various participants in the chain. The reader is referred throughout to Table 12 and reminded that all prices shown apply to 1972, the year of the survey.

Surveyed farmer selling price for poor to good quality (low to high starch content) roots ranges from .26 to .30Bh/kg. Average production cost in terms of kilogram of roots is calculated as .21Bh,

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*The question of cassava as a soil depletor has been discussed in Chapter II. It is iterated that production practice, not the crop *per se*, is largely responsible for soil depletion.

TABLE 11

Input Costs for Different Sized Plantations. (Baht/rai)

	Size of Plantation (rai)											
	Under 6.00	6.00-10.99	11.00-15.99	16.00-20.99	21.00-25.99	26.00-30.99	31.00-35.99	36.00-40.99	41.00-45.99	46.00-50.99	51.00-Upward	Average
Labour Cost	216.09	255.76	235.64	220.88	222.45	204.97	228.76	241.97	244.33	251.74	242.27	228.73
(%)	(46.70)	(57.45)	(58.40)	(55.90)	(57.62)	(54.88)	(59.90)	(60.82)	(63.26)	(59.62)	(61.66)	(56.06)
Land Preparation	52.03	65.23	67.53	67.80	52.75	67.09	80.84	92.14	93.88	80.15	72.33	70.40
(%)	(11.24)	(14.65)	(16.74)	(17.16)	(13.66)	(17.96)	(21.16)	(23.16)	(24.29)	(18.98)	(18.41)	(17.26)
Planting	28.82	32.16	30.67	25.75	30.93	21.37	22.90	19.54	25.95	25.50	39.52	26.19
(%)	(6.23)	(7.22)	(7.60)	(6.25)	(8.01)	(5.72)	(6.00)	(4.91)	(6.71)	(6.03)	(00.06)	(6.42)
Cultivating	69.26	100.35	89.01	81.21	93.49	64.69	66.76	63.10	71.19	85.49	71.88	77.24
(%)	(14.95)	(22.54)	(22.06)	(20.55)	(24.21)	(17.32)	(17.48)	(15.80)	(18.42)	(20.24)	(18.29)	(18.93)
Harvesting	66.18	58.02	48.43	46.12	45.28	51.82	58.25	67.19	53.87	60.60	58.54	54.90
(%)	(14.27)	(13.03)	(12.00)	(11.67)	(11.72)	(13.87)	(15.32)	(16.88)	(13.94)	(14.35)	(14.90)	(13.46)
*	17.31	13.76	12.29	9.06	9.66	11.16	5.07	9.53	5.88	8.40	6.24	8.77
(%)	(3.74)	(3.09)	(3.04)	(2.29)	(2.50)	(2.98)	(1.32)	(2.39)	(1.52)	(1.98)	(1.59)	(2.15)

* Heading Missing

TABLE 11 (continued)

	Under 6.00	6.00-10.99	11.00-15.99	16.00-20.99	21.00-25.99	26.00-30.99	31.00-35.99	36.00-40.99	41.00-45.99	46.00-50.99	51.00-Upward	Average
Pesticide Cost	13.20	-	-	-	-	-	-	-	-	-	7.56	8.50
(%)	(2.85)	-	-	-	-	-	-	-	-	-	(1.92)	(2.08)
Fertilizer Cost	65.12	46.67	40.05	26.25	37.15	31.67	28.06	15.75	19.52	22.79	25.61	39.80
(%)	(14.07)	(10.48)	(9.92)	(6.64)	(9.62)	(8.48)	(7.34)	(3.95)	(5.05)	(5.39)	(6.52)	(9.76)
Transportation Cost	52.88	42.75	41.50	62.36	43.27	55.00	52.19	58.46	54.67	63.63	39.83	47.28
(%)	(11.43)	(9.60)	(10.28)	(15.78)	(11.20)	(14.72)	(13.67)	(14.69)	(14.15)	(15.06)	(10.13)	(11.59)
Constant Cost	98.14	86.25	73.95	76.55	73.52	70.62	67.82	72.11	62.04	75.68	71.42	74.91
(%)	(21.20)	(19.37)	(18.38)	(19.37)	(19.04)	(18.91)	(17.76)	(18.21)	(16.05)	(17.92)	(18.17)	(18.36)
Total Input Cost	462.74	445.19	403.43	395.10	386.05	373.43	381.90	397.82	386.44	422.24	392.93	407.99
(%)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Estimate Gross Returns*	558	494	530	469	487	557	530	553	536	520	511	521
Estimate Net Returns*	95	49	127	74	101	184	149	155	150	98	119	113

*Returns estimated as average yield times .27 Baht/Kg (average price for good quality roots). Net returns = gross returns minus total input costs. Calculations made by author.

giving the Thai cassava grower a net return of .06 Bh/Kg (or $35/ha). Surveyed handler/transporter selling price to chipping plants ranges from .28 to .34 Bh/kg, and the average chipping plant selling price to higher level processors is approximately .75 Bh/kg, or .31 Bh/kg in fresh root terms.* Thus, it appears that only if lower quality roots are purchased and/or if the chipper subsumes the handling/transport function can he realise a profit. For the chipper buying from a middleman, clearly the extremely slim margin between purchase and re-sale price is a great incentive for him to dilute his product with other exotic ingredients (corn cobs, rice husks, sand, etc.).

The flour (starch) manufacturer also operates within a fairly small margin, and it is probable that returns on cassava waste are largely responsible for making his operation economic. Wholesalers, retailers and exporters of starch, however, appear to make a more substantial profit on their activities.

Tapioca-sago production and sale do not appear to be viable operations. The figures may be misleading, however, because tapioca production is in many instances performed in conjunction with and may be complementary to starch production. It is possible, therefore, that the astute starch-tapioca producer may schedule production to optimise returns for given price relativities in the various markets.

Small-scale, native pellet manufacturers do not clear much above their purchase cost of chips. Actual pellet selling price (.77 to .86 Bh/kg) expressed in terms of root units ranges from .30 to .34 Bh/kg. Obviously, the profitability of this operation depends greatly on chip price -- the lower the price of chips, the greater the profits to pellets.

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*This selling price would appear to be high, because in early 1973 commercial pelleters were paying .48 to .50 Baht/ton. It is possible that these prices differ by some form of transportation cost.

TABLE 12

Selling Price of Cassava and Cassava Products
(actual prices and prices in fresh root units, Baht/kg)

Seller (Product)	Rural Dealers Lower	Rural Dealers Upper	Rural Dealers Average	Rural Dealers Actual	Urban Dealers Lower	Urban Dealers Upper	Urban Dealers Average	Urban Dealers Actual
Farmer (Roots)	.26	.30	.27	.27				
Merchant (Transportation)	.28	.33	.28	.28	.31	.34	.32	.32
Chippers (Chips*)	.31	.31	.31	.71	.31	.34	.31	.71
Flour (Starch)	.29	.30		1.58	.29	.31		1.64
(Waste)			.10	.53			.10	.53
Flour Wholesaler (Transportation)	.37	.39		2.01				2.38
Flour Retailer					.45	.52		2.49
Exporter (Flour)	.39	.40		2.06				
Pelleters (Pellets)	.30	.33	.31	.78	.31	.34	.32	.81
Exporter (Pellets)	.56	.64	.57	1.44				
Tapioca-Sago	.12	.13	.12	1.06	.13	.14	.13	1.15
Sago Wholesalers (Transportation)	.23	.26	.24	2.12				
Sago Retailer					.29	.31	.29	2.56

*Technical coefficients: 2.26 tons roots = 1 ton chips.
2.53 tons roots = 1 ton pellets.
5.29 tons roots = 1 ton flour
8.83 tons roots = 1 ton sago

It does appear however, that production cost* are low (chips.05Bh/kg; flour .08Bh/kg; pellets.06Bh/kg; and sago .06Bh/kg), and therefore profits may be obtainable on what appears to be very small margins.

The greatest marginal share clearly belongs to the pellet exporter, whose sellina price in root units ranges from .56 to .64Bh/kg, giving an average fob Bangkok price of 1,440Bh/metric ton (or $72.00/metric ton).**

The participant (excluding retailers, wholesalers and exporters of starch) with the next most profitable operation appears to be the cassava producer. In between, extremely low profit margins produce conditions which can be best described as a fragile ecological balance between entrepreneurs. The response of these entrepreneurs has been to favour the use of lower quality chips and the practice of product adulteration.

At first glance pellet manufacturing appears to be potentially the most profitable operation, starch and tapioca the most vulnerable, and chipping the economic bottleneck. A change in price relativities up the line resulting in reduced share for the exporter or large processor-exporter could insure profitability at all levels of processing. Barring this, however, it seems likely that production of starch and tapioca will decrease relative to production of pellets.

With respect to pellet manufacturing, however, the following qualification should be made. It is the opinion of some representatives of commercial processing plants that the purchase price of chips will increase in future. The chipper, despite his rather precarious position in the domestic cassava marketing chain, nonetheless provides a service

*These cost estimates are taken to be variable costs.

**This figure also appears to be high, because commercial pelleters-exporters claim that fob price is approximately $60.00/metric ton.

to both small and large pelleters which neither wishes or is easily able to subsume.* Commercial firms, whose greater volume enables them to undertake profitably wholesale and export activities**, can and apparently, will tolerate higher chip prices in return for better quality. Smaller pelleters, however, will have greater difficulty in meeting increased chip prices because they may not necessarily be able to command higher purchase prices from exporters for their product. Thus, it appears that the small pelleter will prove less viable than the chipper, and that in future a greater proportion of pellets may be expected to be produced in larger, commercial plants.

7.3 Further Considerations

A brief glance at the price structures of other would-be suppliers to the European animal feed market indicates that Thai pellets are not in fact appreciably cheaper in terms of fob prices.*** The real competitiveness of the Thai product rests on two main attributes:

1. Volume and consistency of supply: Thailand's ability to fulfill large European consignments regularly is possibly the most significant factor in the development not only of Thai production capacities but of the international market for cassava itself. The sheer volume, moreover, of Thai exports enables exporters to charter ships which result in substantial reduction in costs (e.g., September 1971 conference rates for

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*Operators of large native and commercial pelleting plants told the author that they did not want to get involved with drying roots. It was suggested that the small scale chippers were more efficient than any alternative the pelleting plants could provide.

**It is the author's observation that pellet production should be of the order of 40,000 tons per year in order to subsume profitably the final wholesale activities.

***As indicated by the Ministry of Agriculture survey fob price can be as high as $72.00/metric ton, (large pelleter-exporters claim fob price of approximately $60.00/ton), which is still more than the Brazilian costs of $47.17/ton fob for chips, [12,p.67], or the pellet price of $56./ton to $60./tons included in the budgets of several investment proposals for establishing pelleting plants.

pellets in bulk were $19/ton while charter rate was $14/ton[11,p.20])*.

2. Entrepreneurship: Thailand's pelleting industry benefited in the first instance from foreign investment and stimulation. That events should have so combined when they did in Thailand and not somewhere else is perhaps an historical accident. The development of the industry over the past few years, however, owes little to chance and much to the capabilities of Thailand's large and small entrepreneurs. In aggregate, the Thai cassava industry has exhibited great market sensitivity and commendable pragmatism with respect to optimisation of available capabilities**and responsiveness in terms of price and quantity. Particularly to be commended are Thailand's small and medium operators whose flexibility and astuteness have permitted them to function under conditions of small margins and high risk which operators in many other parts of the world would consider unacceptable.

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*The advantages of volume exporting is reflected in the fact that shipping costs from Indonesia were approximately $10/ton more than shipping costs from Thailand.

**For example, in regard to chip drying, Thai processors, large and small, seem to be willing to rely on two natural endowments: sunshine and plentiful labour. By contrast, other would-be exporters (also well provisioned in those two inputs) favour installation of relatively expensive mechanical drying devices.

References Chapter VII

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Part III

RESEARCH RECOMMENDATIONS

Chapter VIII

RESEARCH RECOMMENDATIONS

The *raison d'être* of this study, as conceived by IDRC and CIAT, is to derive economically based priorities for research in cassava. From the start it was apparent that any comprehensive statement on research priorities should be preceded by a quantitative and qualitative survey of on-going or completed work, not only to provide building blocks for future research activities but to point up areas of research needs. Ideally, such a research directory would classify research by type and region to facilitate flows of information between individuals, organisations, institutions and countries*, as well as to avoid duplication of work.** Unfortunately, such a directory does not appear to exist, and its compilation is clearly beyond the scope of this study. Therefore, the first recommendation forwarded by this report is that a comprehensive survey of past and present cassava research, classified by type and region, be undertaken.

A general bibliography, presently being compiled at CIAT, should go a long way, when completed, toward realising this recommendation, but even this bibliography may fail to include a sizeable body of information which is unpublished or of limited circulation. In these cases,

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* For example, results of pre-World II Dutch selection trials conducted in Indonesia are generally thought to have been destroyed. Yet Dr. M.M. Flach has informed the author that almost all of the reports of this research activity are available in the University of Wägeningen archives.

** Such a directory will help to avoid intra-regional redundancies as well. For example, in Malaysia, both NISIR (National Institute of Scientific and Industrial Research) and the Ministry of Agriculture's Crop Promotion Division are working on development of small-scale cassava chipping and pelleting machinery. The disadvantages of duplication in this case are not readily apparent, since the resulting machinery is quite different. However, it is possible that joint effort could have produced a machine that is perhaps even superior to the first two.

the individual cassava researcher must be the main instrument for chanelling obscure data to a wider audience. Possibly, systemmatic collection of this hidden wealth of information can be undertaken in cooperation with CIAT in an effort to encourage, centralise and facilitate the collection and use of cassava research data.

The following other recommendations are forwarded:

Breeding

The study reveals that the demand for cassava, present and future, is a demand for carbohydrate. Therefore, selection and breeding which improves starch yield per tuber, per unit land, and per unit time is highly desirable.

- It should be recognized that the three cassava markets require different types of starch. The human market may require high amylopectin and low amylose starch, while the relative content of amylose and amylopectin is not so important for animals. Amylose content of cassava may be more important in starch manyfacturing. It is recommended, therefore, that selection and breeding work screen varieties according to the properties demanded by the different markets.

- The properties of different cassava varieties at different stages of maturity should be explored. Tuber properties which should be specifically examined are: protein and starch content, composition and digestibility; vitamin availability and suitability for digestion; viscosity, gelling and other starch properties; pest, virus, and bacteria resistence; drought and flood tolerance; adaptability to different soils; HCN content; and yield.

- This study recommends that breeding for a high protein cassava be given low priority. Protein content of cassava is unimportant in starch and animal feed manufacture. In some circumstances, high protein content is a disadvantage -- protein is considered a waste product in starch manufacture, and in European animal feed rations with maximum protein constraints, a high protein cassava (say, 6 to 10%) could actually inhibit use of cassava in the formula. However, if cassava is used in LDC feed compounding, price relativities might be such as to make a high protein cassava desirable. This possibility requires further investigation. Where the human market is concerned, high cassava consumption coupled with regional protein deficiency and poor protein distribution within the family unit suggests that a higher protein cassava protein could be beneficial. However, in terms of essential amino acids, cassava protein is not of high quality, and there seems to be little evidence to show that an increase in crude protein results in an improvement of cassava protein quality. On the other hand, cassava may be efficient as a protein carrier or growth medium when fortified or used as a substrate. These aspects should receive continued attention.

Cultivation

- The great part of cassava cultivation is presently and presumably to a large extent will continue to be small scale. Two aspects should receive attention: a) selection of improved varieties which will grow under small-scale, traditional production conditions; and b) development of appropriate cultivation methods designed to support the use of improved but perhaps less hardy varieties.

- Labour saving or production increasing machinery that is compatible with small-scale production should be developed. All aspects of cassava production could benefit from improved tools.

- On the other hand, estate cultivation will likely become more common in future -- many would-be exporters base their export potential on estate production, while in some places large-scale cultivation already occurs as an adjunct to intensive poultry systems. Thus, techniques and machinery suitable to large-scale production are also required. Harvesting machinery is one area of particular need.

- Development of space-economising harvesting, storage and handling methods will release valuable land to other uses. Cheap storage methods, by permitting more consistently available supply, could enable existing cassava processing plants to more fully realise production capacities (or, alternatively, existing production could be generated by smaller plants).

- Research is required on intercropping. For example, field work might show that a less leafy variety is best suited for intercropping (that is, tuber yield may decrease with thinly leafed varieties, but yield of intercalated crops could increase, with a net effect of gain in production). Studies of cassava intercropped with rubber and oil palm are available, but information on intercropping with legumes or cereals does not appear to be available.

- The notion of cassava as a soil depletor should be examined, as must be the counter-argument that soil depletion is a consequence of poor production methods and consequent leeching. If the latter contention proves to be correct, development of improved production practices is obviously necessary.

- The economics of cassava production must be understood in regional contexts. For example, while the advantages of fertiliser application may be amply demonstrable for cassava production in general, regional variability of availability and cost of fertiliser and relative marginal returns to application may preclude its use in some areas and to certain size groups of farmers.

- The results of varietal and cultivation research should not reduce the usefulness of cassava as a risk aversion crop. Thus, higher yielding varieties which are more susceptible to complete failure should not be encouraged at small-scale or subsistence levels.

Processing

- Rapid transformation of roots to a less perishable state through drying, soaking and/or fermenting is critical to the production of many cassava products. Further study is needed in the drying of sliced or chipped roots. Initial CIAT findings are that cassava's α solar absorption coefficient is low and that ambient temperature and air circulation are the most important factors in drying. This finding calls for confirmation in numerous environments. Furthermore, cassava's low α value (provided this can be preserved under treatment) suggests a possible use for cassava in solar reflecting paint.

- Processing of chips and pellets requires research at the small-scale farm-cooperative level and the large-scale commercial level. The latter is fairly well researched, but methods for optimum pre-heating before pelleting or post-pelleting cooling do not seem to be available -- perhaps this information is kept at limited circulation for commercial reasons. Research on small-scale pelleting machines must be done with a view to market requirements, viz., density and friability of pellets. Furthermore, research should be undertaken on the comparative advantages of different chip size and form. The cassava bar (measuring 1x1x5 centimetres), presently under consideration at CIAT, for example, could replace the pellet if the former can be shown to have the physical properties required by the market and to be manufacturable at a competitive price.

- Research in the use of cassava as an animal feed in LDCs through compounding or micro-biological process seems justifiable and appropriate. Although it was not possible in the course of this study to assess quantitatively the scope for using mixed or complete feeds in LDC livestock production, it does appear that cassava could play an important part in the future livestock production of LDCs if the availability of appropriate products accompanies the emergence of that market.

- Research on the production of cassava starch and modified cassava starches is required. This work should be conducted in the context of the needs of external markets as well as existing and emerging domestic starch markets. As cassava-producing LDCs expand their industrial base and experience greater requirements for starch,development in this area may be important in obviating importation of foreign starches.

- Research on new humanly consumed cassava foods (flours, breads, cakes, baby foods) should continue with a view to market acceptability, viz., if white bread is not normally consumed in a given region, it is not apparent that the development of a white cassava bread will be a successful innovation, as seems to have been the case in parts of West Africa.

Marketing

- Cassava products are not unique and can be replaced by other commodities when economic or political reasons demand. For exporters, therefore, a global marketing research service which monitors developments in the industrial starch and animal feed markets seem necessary. Such a service, in the form of periodical publications, could provide information on marketing trends which will enable LDCs to plan investments.

- Greater information is required in producer countries on the domestic markets for cassava. There is a need to bring producers, processors and consumers together to promote flows of information and to coordinate development of potential markets. It should be pointed out in this context that the adoption of technologies from developed countries is often taken to be synonymous with use of developed country inputs. It is important for producers and processors to realise under what conditions an indigenously produced input, such as cassava, can do the job equally well.

Systems

- The results of research on breeding, cultivation, processing and marketing should be brought together into a 'cassava system'. Analysis of this system will point up research bottlenecks and weaknesses. Moreover, the creation of such a system will enable the appropriateness of research results to be judged and will promote the smooth introduction of new findings into the system.

In summary, the major research need, as determined by this study, is that of applied research into cassava breeding, cultivation, processing and marketing. Since demand for cassava appears to be growing at a rate faster than supply, it must be concluded that the greatest immediate returns are to be derived from research which enables increased supply of cassava and cassava products.

The development of the European animal feed market has been largely responsible for promoting cassava from the category of a subsistence to a diversification crop. The present export market has shown cassava to be a flexible and desirable commodity which will play an important role in the agriculture and industry of LDCs for some time to come. Enthusiasm over cassava as an earner of foreign exchange must be tempered, however, by the fact that the EEC animal feed market is less certain than the markets for traditional LDC agricultural exports. For this reason, it could be wrong to commit substantial resources to a long-run cassava export scheme. Nevertheless, the promotion of cassava for short-run foreign exchange earnings will be profitable. The concurrent development of expertise in all phases of the 'cassava system' will, moreover, have long-run pay-offs closer to home in terms of domestic application, particularly where home markets come to equal or exceed in importance foreign demand. In this sense, the present export market has given a new perspective to cassava, and has brought attention to bear not on what cassava is not, but on what it is and what it can become.

APPENDICES

Appendix A

SUMMARY OF CASSAVA PRODUCTION TIME TREND MODELS AND CASSAVA PRODUCTION PROJECTIONS

Table A.1

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

ARGENTINA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	242.40	2.464	0.421000	5.49	0.009	0.409000
ACREAGE	18.60	0.397	0.681000	2.93	0.018	0.661000
YIELD	128.90	-1.044	0.765000	4.66	-0.009	0.765000

BOLIVIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	44.47	10.690	0.857000	4.09	0.086	0.375000
ACREAGE	0.12	0.983	0.930000	0.97	0.121	0.934000
YIELD	215.80	-5.396	0.958000	5.41	-0.034	0.945000

BRAZIL

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	13833.00	1094.000	0.970000	9.56	0.051	0.973000
ACREAGE	1075.00	64.470	0.972000	7.02	0.041	0.973000
YIELD	127.90	1.307	0.928000	4.85	0.010	0.926000

COLUMBIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	1776.00	-42.430	0.301000	7.47	-0.032	0.316000
ACREAGE	273.60	-7.900	0.449000	5.65	-0.041	0.502000
YIELD	61.75	0.700	0.227000	4.15	0.018	0.178000

ECUADOR

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	111.70	17.900	0.902000	5.01	0.062	0.901000
ACREAGE	14.58	1.622	0.907000	2.86	0.054	0.912000
YIELD	83.04	0.974	0.508000	4.42	0.011	0.499000

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

PARAGUAY

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	561.50	73.900	0.78	6.39	0.070	0.55
ACREAGE	48.01	4.561	0.92	4.00	0.051	0.92
YIELD	146.00	-0.214	0.20	4.98	-0.001	0.20

PERU

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	287.30	15.230	0.85	5.67	0.040	0.85
ACREAGE	25.69	1.262	0.61	3.17	0.044	0.67
YIELD	123.60	-0.636	0.19	4.80	-0.004	0.15

VENEZULA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	228.40	7.526	0.75	5.41	0.030	0.75
ACREAGE	33.50	0.028	0.02	3.48	0.002	0.04
YIELD	80.61	1.536	0.24	4.23	0.028	0.37

CEYLON

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	172.10	14.620	0.84	5.16	0.056	0.83
ACREAGE	46.56	0.943	0.35	3.81	0.019	0.40
YIELD	42.08	1.563	0.50	3.65	0.038	0.57

TAIWAN

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	123.90	12.990	0.94	4.89	0.061	0.94
ACREAGE	10.94	0.681	0.94	2.42	0.044	0.93
YIELD	116.50	2.169	0.75	4.76	0.016	0.76

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

INDIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	860.50	247.900	0.91	7.20	0.083	0.92
ACREAGE	218.00	7.258	0.80	5.41	0.025	0.80
YIELD	53.18	5.822	0.89	4.10	0.057	0.88

INDONESIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	10984.00	17.160	0.10	9.30	0.002	0.12
ACREAGE	1318.00	14.900	0.54	7.18	0.011	0.56
YIELD	83.42	-0.729	0.80	4.42	-0.009	0.80

W.MALAYSIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	202.30	9.091	0.79	5.37	0.030	0.79
ACREAGE	13.20	0.436	0.57	2.59	0.026	0.59
YIELD	160.30	0.816	0.18	5.08	0.004	0.16

PHILIPPNES

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	419.90	7.407	0.35	5.99	0.020	0.42
ACREAGE	76.73	0.877	0.40	4.32	0.012	0.45
YIELD	53.29	0.447	0.32	3.97	0.008	0.35

THAILAND

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	491.90	113.000	0.85	6.08	0.121	0.85
ACREAGE	33.44	7.494	0.90	3.46	0.114	0.87
YIELD	145.90	0.278	0.05	4.93	0.007	0.17

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

VIET NAM N.

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	920.60	-14.130	0.64	6.83	-0.018	0.64
ACREAGE	109.80	-0.591	0.17	4.67	-0.004	0.11
YIELD	86.85	-1.127	0.68	4.47	-0.015	0.69

VIET NAM R.

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	242.60	1.631	0.12	5.43	0.011	0.20
ACREAGE	42.80	-0.432	0.25	3.74	-0.010	0.23
YIELD	53.66	1.374	0.72	3.99	0.021	0.71

ANGOLA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	1001.00	40.230	0.97	6.96	0.028	0.97
ACREAGE	99.77	1.409	0.96	4.61	0.012	0.96
YIELD	103.50	1.950	0.91	4.65	0.016	0.91

BURUNDI

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	133.40	78.160	0.81	6.12	0.068	0.83
ACREAGE	-31.35	10.970	0.70	3.41	0.091	0.68
YIELD	141.50	-2.148	0.32	5.01	-0.023	0.39

CAMEROON

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	504.20	32.150	0.83	6.27	0.041	0.83
ACREAGE	38.04	10.340	0.88	4.01	0.085	0.91
YIELD	93.28	-2.935	0.90	4.56	-0.043	0.91

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

CENTR.AF.REP

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	947.30	5.455	0.52	6.86	0.005	0.52
ACREAGE	194.70	0.545	0.52	5.27	0.003	0.52
YIELD	48.74	0.130	0.52	3.89	0.003	0.52

CHAD

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	41.53	0.654	0.15	3.60	0.022	0.24
ACREAGE	-1.34	1.336	0.87	0.97	0.138	0.81
YIELD	84.96	-3.933	0.73	4.53	-0.079	0.76

COMORO ISH

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	-19.86	7.955	0.88	2.53	0.142	0.87
ACREAGE	6.16	1.382	0.89	2.27	0.069	0.88
YIELD	7.53	2.038	0.85	2.54	0.075	0.85

CONGO BRAZZ

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	1119.00	-49.550	0.84	7.19	-0.081	0.82
ACREAGE	169.40	-4.636	0.72	5.16	-0.036	0.70
YIELD	71.23	-2.160	0.87	4.34	-0.045	0.86

CONGO REP

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	6857.00	51.510	0.22	8.83	0.006	0.18
ACREAGE	629.20	0.266	0.02	6.44	0.000	0.00
YIELD	109.30	0.712	0.28	4.70	0.005	0.26

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

DAHOMEY

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	1166.00	-12.490	0.30	7.07	-0.014	0.32
ACREAGE	234.60	-5.843	0.70	5.52	-0.036	0.70
YIELD	47.31	1.239	0.73	3.86	0.022	0.73

EQUAT GUINEA

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	35.92	0.445	0.81	3.59	0.011	0.81
ACREAGE	11.32	0.227	0.41	2.44	0.016	0.40
YIELD	31.93	-0.188	0.22	3.46	-0.006	0.21

GABON

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	130.10	0.655	0.14	4.87	0.004	0.13
ACREAGE	33.55	1.913	0.89	3.56	0.039	0.88
YIELD	37.69	-1.095	0.63	3.61	-0.035	0.59

GHANA

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	649.60	69.830	0.81	6.61	0.054	0.85
ACREAGE	52.25	9.603	0.87	4.11	0.080	0.85
YIELD	122.70	-2.701	0.63	4.80	-0.026	0.60

GUINEA

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	369.20	7.031	0.80	5.91	0.017	0.79
ACREAGE	41.60	-0.898	0.44	3.65	-0.019	0.39
YIELD	106.50	3.378	0.54	4.56	0.036	0.55

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

IVORY COAST

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	851.70	-18.360	0.36	6.71	-0.025	0.35
ACREAGE	158.70	2.195	0.32	5.05	0.014	0.36
YIELD	52.49	-1.494	0.55	3.97	-0.038	0.52

KENYA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	575.20	3.000	0.85	6.36	0.005	0.85
ACREAGE	85.93	0.436	0.89	4.45	0.005	0.89
YIELD	67.58	-0.044	0.49	4.21	-0.001	0.49

LIBERIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	420.90	-2.784	0.59	6.04	-0.007	0.60
ACREAGE	62.24	-0.248	0.45	4.13	-0.004	0.45
YIELD	67.81	-0.209	0.81	4.22	-0.003	0.81

MADAGASCAR

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	608.90	29.160	0.78	6.48	0.031	0.79
ACREAGE	216.20	1.971	0.16	5.35	0.009	0.18
YIELD	28.65	1.155	0.40	3.43	0.022	0.32

MALI

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	170.80	1.033	0.16	5.14	0.004	0.13
ACREAGE	14.65	-0.263	0.49	2.67	-0.020	0.48
YIELD	120.60	3.197	0.76	4.79	0.023	0.73

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

NIGER

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	50.11	10.000	0.97	4.21	0.075	0.96
ACREAGE	8.40	1.219	0.94	2.37	0.062	0.96
YIELD	63.61	0.856	0.40	4.13	0.014	0.44

NIGERIA

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	7420.00	-19.000	0.16	8.90	-0.002	0.11
ACREAGE	749.40	29.810	0.71	6.57	0.036	0.74
YIELD	106.80	-3.459	0.74	4.63	-0.038	0.73

SENEGAL

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	139.60	4.359	0.44	4.97	0.022	0.44
ACREAGE	31.90	1.386	0.46	3.51	0.028	0.46
YIELD	43.20	-0.251	0.35	3.76	-0.006	0.36

SIERRA LEONE

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	49.02	1.145	0.96	3.90	0.020	0.96
ACREAGE	18.75	0.167	0.91	2.93	0.008	0.91
YIELD	26.67	0.305	0.93	3.28	0.011	0.93

SUDAN

	LINEAR EQUATIONS			LOGARITHMIC EQUATIONS		
	CONSTANT	TIME COEFF.	R2	CONSTANT	TIME COEFF.	R2
PRODUCTION	99.66	2.518	0.98	4.63	0.020	0.99
ACREAGE	15.48	0.154	0.85	2.74	0.009	0.85
YIELD	65.86	0.763	0.86	4.19	0.010	0.85

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

RWANDA

	LINEAR EQUATIONS CONSTANT	LINEAR EQUATIONS TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	LOGARITHMIC EQUATIONS TIME COEFF.	R2
PRODUCTION	-97.98	26.560	0.91	3.50	0.149	0.81
ACREAGE	-9.64	2.552	0.94	1.12	0.152	0.85
YIELD	110.70	-0.406	0.10	4.70	-0.004	0.10

TANZANIA

	LINEAR EQUATIONS CONSTANT	LINEAR EQUATIONS TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	LOGARITHMIC EQUATIONS TIME COEFF.	R2
PRODUCTION	803.80	37.190	0.83	6.77	0.029	0.85
ACREAGE	258.50	1.545	0.78	5.56	0.006	0.78
YIELD	32.52	1.065	0.80	3.53	0.023	0.81

TOGO

	LINEAR EQUATIONS CONSTANT	LINEAR EQUATIONS TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	LOGARITHMIC EQUATIONS TIME COEFF.	R2
PRODUCTION	366.60	57.390	0.90	6.07	0.073	0.87
ACREAGE	59.48	6.773	0.91	4.19	0.062	0.89
YIELD	65.39	0.783	0.59	4.18	0.011	0.58

UGANDA

	LINEAR EQUATIONS CONSTANT	LINEAR EQUATIONS TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	LOGARITHMIC EQUATIONS TIME COEFF.	R2
PRODUCTION	287.40	129.700	0.94	6.52	0.081	0.92
ACREAGE	379.60	-8.318	0.40	5.94	-0.027	0.42
YIELD	-5.69	6.240	0.89	2.89	0.108	0.89

ZAMBIA

	LINEAR EQUATIONS CONSTANT	LINEAR EQUATIONS TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	LOGARITHMIC EQUATIONS TIME COEFF.	R2
PRODUCTION	152.40	0.036	0.02	5.03	0.000	0.00
ACREAGE	32.88	1.118	0.70	3.53	0.025	0.71
YIELD	44.38	-0.931	0.83	3.82	-0.027	0.83

COEFFICIENTS OF PRODUCTION ACREAGE AND YIELD TIME TREND REGRESSIONS

LAT.AMERICA

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	16327.00	1269.000	0.97	9.75	0.050	0.97
ACREAGE	1482.00	76.070	0.96	7.32	0.038	0.95
YIELD	113.90	1.446	0.93	4.74	0.012	0.93

FAR EAST

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	13472.00	515.400	0.95	9.51	0.031	0.94
ACREAGE	1717.00	48.720	0.89	7.45	0.025	0.89
YIELD	78.70	0.561	0.79	4.37	0.007	0.79

AFRICA

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	28500.00	344.300	0.61	10.26	0.011	0.60
ACREAGE	3434.00	109.700	0.96	8.15	0.026	0.95
YIELD	81.21	-1.058	0.65	4.39	-0.014	0.64

WORLD

	LINEAR EQUATIONS CONSTANT	TIME COEFF.	R2	LOGARITHMIC EQUATIONS CONSTANT	TIME COEFF.	R2
PRODUCTION	59806.00	2031.000	0.97	11.01	0.027	0.98
ACREAGE	6786.00	227.400	0.98	8.83	0.028	0.97
YIELD	88.55	-0.007	0.01	4.48	-0.000	0.01

Table A.2

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

ARGENTINA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	279.	25.	113.	278.	24.	113.
1971	282.	25.	112.	281.	25.	112.
1972	284.	25.	111.	283.	25.	111.
1973	287.	26.	110.	286.	26.	110.
1974	289.	26.	109.	288.	26.	109.
1975	292.	27.	108.	291.	27.	108.
1976	294.	27.	107.	294.	27.	107.
1977	297.	27.	106.	296.	28.	107.
1978	299.	28.	105.	299.	28.	106.
1979	302.	28.	104.	302.	29.	105.
1980	304.	29.	103.	304.	29.	104.
1981	306.	29.	102.	307.	30.	103.
1982	309.	29.	101.	310.	30.	102.
1983	311.	30.	100.	313.	31.	101.
1984	314.	30.	99.	316.	31.	100.
1985	316.	31.	98.	319.	32.	99.

BOLIVIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	205.	15.	135.	218.	16.	135.
1971	215.	16.	129.	238.	18.	131.
1972	226.	17.	124.	260.	21.	126.
1973	237.	18.	119.	283.	23.	122.
1974	248.	19.	113.	309.	26.	118.
1975	258.	20.	108.	337.	30.	114.
1976	269.	21.	102.	367.	33.	110.
1977	280.	22.	97.	400.	38.	107.
1978	290.	23.	92.	436.	43.	103.
1979	301.	24.	86.	476.	48.	100.
1980	312.	25.	81.	519.	54.	97.
1981	322.	26.	76.	565.	61.	93.
1982	333.	27.	70.	616.	69.	90.
1983	344.	28.	65.	672.	78.	87.
1984	354.	29.	59.	733.	88.	84.
1985	365.	30.	54.	799.	99.	82.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

BRAZIL

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	29793.	2042.	147.	30505.	2077.	147.
1971	30887.	2107.	148.	32092.	2165.	148.
1972	31981.	2171.	150.	33761.	2256.	150.
1973	33075.	2235.	151.	35517.	2352.	151.
1974	34169.	2300.	152.	37365.	2451.	153.
1975	35263.	2364.	153.	39309.	2554.	154.
1976	36357.	2429.	155.	41353.	2662.	156.
1977	37451.	2493.	156.	43504.	2775.	157.
1978	38545.	2558.	157.	45767.	2892.	159.
1979	39639.	2622.	159.	48148.	3014.	160.
1980	40733.	2687.	160.	50653.	3142.	162.
1981	41827.	2751.	161.	53288.	3274.	163.
1982	42921.	2816.	163.	56059.	3413.	165.
1983	44015.	2880.	164.	58976.	3557.	166.
1984	45109.	2945.	165.	62043.	3707.	168.
1985	46203.	3009.	167.	65271.	3864.	170.

COLUMBIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1140.	155.	72.	1093.	153.	71.
1971	1097.	147.	73.	1058.	147.	71.
1972	1055.	139.	74.	1025.	141.	72.
1973	1012.	131.	74.	993.	135.	73.
1974	970.	123.	75.	962.	130.	73.
1975	927.	116.	76.	932.	124.	74.
1976	885.	108.	76.	902.	119.	74.
1977	843.	100.	77.	874.	114.	75.
1978	800.	92.	78.	846.	110.	75.
1979	758.	84.	79.	820.	105.	76.
1980	715.	76.	79.	794.	101.	77.
1981	673.	68.	80.	769.	97.	77.
1982	630.	60.	81.	745.	93.	78.
1983	588.	52.	81.	722.	89.	78.
1984	546.	44.	82.	699.	86.	79.
1985	503.	37.	83.	677.	82.	80.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

ECUADOR

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	380.	39.	98.	380.	39.	98.
1971	398.	41.	99.	404.	41.	99.
1972	416.	42.	100.	430.	43.	100.
1973	434.	44.	101.	458.	46.	101.
1974	452.	45.	102.	487.	48.	102.
1975	470.	47.	103.	518.	51.	103.
1976	488.	49.	103.	551.	54.	104.
1977	505.	50.	104.	587.	57.	105.
1978	523.	52.	105.	624.	60.	106.
1979	541.	54.	106.	664.	63.	107.
1980	559.	55.	107.	707.	67.	108.
1981	577.	57.	108.	752.	70.	110.
1982	595.	58.	109.	800.	74.	111.
1983	613.	60.	110.	851.	78.	112.
1984	631.	62.	111.	906.	83.	113.
1985	649.	63.	112.	964.	87.	114.

PARAGUAY

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1670.	116.	143.	1698.	118.	143.
1971	1744.	121.	143.	1820.	124.	142.
1972	1818.	126.	142.	1952.	131.	142.
1973	1892.	130.	142.	2093.	137.	142.
1974	1966.	135.	142.	2244.	145.	142.
1975	2039.	139.	142.	2406.	152.	142.
1976	2113.	144.	142.	2579.	160.	141.
1977	2187.	148.	141.	2766.	169.	141.
1978	2261.	153.	141.	2965.	177.	141.
1979	2335.	157.	141.	3180.	187.	141.
1980	2409.	162.	141.	3409.	197.	141.
1981	2483.	167.	140.	3655.	207.	140.
1982	2557.	171.	140.	3919.	218.	140.
1983	2631.	176.	140.	4203.	229.	140.
1984	2705.	180.	140.	4506.	241.	140.
1985	2778.	185.	140.	4831.	254.	140.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

PERU

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	516.	45.	114.	528.	46.	114.
1971	531.	46.	113.	549.	48.	113.
1972	546.	47.	113.	572.	51.	113.
1973	561.	48.	112.	595.	53.	112.
1974	577.	50.	112.	619.	55.	112.
1975	592.	51.	111.	644.	58.	111.
1976	607.	52.	110.	671.	60.	111.
1977	622.	53.	110.	698.	63.	110.
1978	638.	55.	109.	727.	66.	110.
1979	653.	56.	108.	756.	69.	109.
1980	668.	57.	108.	787.	72.	109.
1981	683.	59.	107.	819.	75.	108.
1982	699.	60.	106.	853.	79.	108.
1983	714.	61.	106.	888.	82.	107.
1984	729.	62.	105.	924.	86.	107.
1985	744.	64.	105.	962.	90.	106.

VENEZULA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	341.	34.	104.	348.	33.	105.
1971	349.	34.	105.	358.	33.	108.
1972	356.	34.	107.	369.	33.	111.
1973	364.	34.	108.	380.	34.	114.
1974	371.	34.	110.	391.	34.	118.
1975	379.	34.	111.	403.	34.	121.
1976	386.	34.	113.	415.	34.	125.
1977	394.	34.	114.	428.	34.	128.
1978	401.	34.	116.	440.	34.	132.
1979	409.	34.	117.	454.	34.	135.
1980	417.	34.	119.	467.	34.	139.
1981	424.	34.	121.	481.	34.	143.
1982	432.	34.	122.	496.	34.	147.
1983	439.	34.	124.	510.	34.	152.
1984	447.	34.	125.	526.	34.	156.
1985	454.	34.	127.	541.	34.	160.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

CEYLON

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	391.	61.	66.	406.	60.	68.
1971	406.	62.	67.	429.	61.	70.
1972	421.	63.	69.	454.	62.	73.
1973	435.	64.	70.	480.	64.	76.
1974	450.	64.	72.	508.	65.	79.
1975	464.	65.	73.	537.	66.	82.
1976	479.	66.	75.	568.	67.	85.
1977	494.	67.	76.	601.	69.	88.
1978	508.	68.	78.	635.	70.	91.
1979	523.	69.	80.	672.	71.	95.
1980	538.	70.	81.	711.	73.	98.
1981	552.	71.	83.	752.	74.	102.
1982	567.	72.	84.	795.	75.	106.
1983	581.	73.	86.	841.	77.	110.
1984	596.	74.	87.	890.	78.	114.
1985	611.	75.	89.	941.	80.	119.

TAIWAN

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	319.	21.	149.	332.	22.	149.
1971	332.	22.	151.	353.	23.	151.
1972	345.	23.	153.	376.	24.	154.
1973	358.	23.	156.	399.	25.	156.
1974	371.	24.	158.	425.	26.	159.
1975	384.	25.	160.	451.	27.	162.
1976	397.	25.	162.	480.	28.	164.
1977	410.	26.	164.	510.	29.	167.
1978	423.	27.	166.	542.	31.	170.
1979	436.	27.	169.	577.	32.	172.
1980	449.	28.	171.	613.	34.	175.
1981	462.	29.	173.	652.	35.	178.
1982	475.	29.	175.	693.	37.	181.
1983	488.	30.	177.	737.	38.	184.
1984	501.	31.	179.	783.	40.	187.
1985	514.	31.	182.	833.	42.	190.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

INDIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	4579.	327.	141.	4618.	325.	142.
1971	4827.	334.	146.	5016.	333.	150.
1972	5075.	341.	152.	5448.	341.	159.
1973	5323.	349.	158.	5918.	349.	168.
1974	5571.	356.	164.	6428.	358.	178.
1975	5818.	363.	170.	6981.	367.	189.
1976	6066.	370.	175.	7583.	376.	200.
1977	6314.	378.	181.	8236.	386.	212.
1978	6562.	385.	187.	8946.	395.	224.
1979	6810.	392.	193.	9717.	405.	237.
1980	7058.	399.	199.	10554.	415.	251.
1981	7306.	407.	205.	11463.	426.	266.
1982	7554.	414.	210.	12451.	436.	281.
1983	7802.	421.	216.	13524.	447.	298.
1984	8050.	428.	222.	14689.	459.	316.
1985	8297.	436.	228.	15955.	470.	334.

INDONESIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	11241.	1541.	72.	11233.	1546.	73.
1971	11259.	1556.	72.	11254.	1563.	72.
1972	11276.	1571.	71.	11275.	1580.	71.
1973	11293.	1586.	70.	11295.	1598.	71.
1974	11310.	1601.	70.	11316.	1615.	70.
1975	11327.	1616.	69.	11337.	1633.	69.
1976	11344.	1631.	68.	11358.	1651.	69.
1977	11362.	1646.	67.	11379.	1670.	68.
1978	11379.	1661.	67.	11400.	1688.	67.
1979	11396.	1676.	66.	11421.	1707.	67.
1980	11413.	1690.	65.	11442.	1726.	66.
1981	11430.	1705.	64.	11463.	1745.	65.
1982	11447.	1720.	64.	11484.	1764.	65.
1983	11464.	1735.	63.	11505.	1784.	64.
1984	11482.	1750.	62.	11527.	1804.	64.
1985	11499.	1765.	62.	11548.	1824.	63.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

W.MALAYSIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	339.	20.	173.	339.	20.	172.
1971	348.	20.	173.	349.	20.	172.
1972	357.	21.	174.	360.	21.	173.
1973	366.	21.	175.	371.	21.	174.
1974	375.	21.	176.	382.	22.	174.
1975	384.	22.	177.	394.	23.	175.
1976	393.	22.	177.	406.	23.	176.
1977	402.	23.	178.	419.	24.	176.
1978	411.	23.	179.	432.	24.	177.
1979	420.	24.	180.	445.	25.	178.
1980	430.	24.	181.	459.	26.	179.
1981	439.	25.	182.	473.	26.	179.
1982	448.	25.	182.	487.	27.	180.
1983	457.	25.	183.	502.	28.	181.
1984	466.	26.	184.	518.	29.	181.
1985	475.	26.	185.	534.	29.	182.

PHILIPPNES

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	531.	90.	60.	536.	91.	60.
1971	538.	91.	60.	547.	92.	60.
1972	546.	92.	61.	558.	93.	61.
1973	553.	93.	61.	569.	94.	61.
1974	561.	93.	62.	580.	95.	62.
1975	568.	94.	62.	591.	96.	62.
1976	575.	95.	63.	603.	98.	63.
1977	583.	96.	63.	615.	99.	64.
1978	590.	97.	64.	627.	100.	64.
1979	598.	98.	64.	640.	101.	65.
1980	605.	99.	64.	652.	103.	65.
1981	612.	100.	65.	665.	104.	66.
1982	620.	100.	65.	678.	105.	66.
1983	627.	101.	66.	692.	107.	67.
1984	635.	102.	66.	705.	108.	67.
1985	642.	103.	67.	719.	109.	68.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

THAILAND

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	2187.	146.	150.	2682.	176.	152.
1971	2300.	153.	150.	3027.	197.	153.
1972	2413.	161.	151.	3416.	221.	154.
1973	2526.	168.	151.	3855.	248.	155.
1974	2639.	176.	151.	4351.	278.	156.
1975	2752.	183.	151.	4910.	312.	157.
1976	2865.	191.	152.	5541.	349.	158.
1977	2978.	198.	152.	6253.	392.	160.
1978	3091.	206.	152.	7056.	439.	161.
1979	3204.	213.	153.	7963.	492.	162.
1980	3317.	221.	153.	8987.	551.	163.
1981	3430.	228.	153.	10142.	618.	164.
1982	3543.	236.	153.	11445.	693.	165.
1983	3656.	243.	154.	12916.	777.	166.
1984	3769.	251.	154.	14576.	870.	167.
1985	3882.	258.	154.	16449.	976.	168.

VIET NAM N.

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	709.	101.	70.	709.	101.	70.
1971	695.	100.	69.	696.	101.	69.
1972	680.	100.	68.	684.	100.	68.
1973	666.	99.	67.	672.	100.	67.
1974	652.	99.	65.	660.	100.	66.
1975	638.	98.	64.	648.	99.	65.
1976	624.	97.	63.	636.	99.	64.
1977	610.	97.	62.	625.	99.	63.
1978	596.	96.	61.	614.	98.	62.
1979	581.	96.	60.	603.	98.	61.
1980	567.	95.	59.	592.	97.	61.
1981	553.	94.	58.	582.	97.	60.
1982	539.	94.	56.	571.	97.	59.
1983	525.	93.	55.	561.	96.	58.
1984	511.	93.	54.	551.	96.	57.
1985	497.	92.	53.	541.	96.	56.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

VIET NAM R.

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	267.	36.	74.	268.	36.	74.
1971	269.	36.	76.	271.	36.	76.
1972	270.	35.	77.	274.	35.	78.
1973	272.	35.	78.	277.	35.	79.
1974	274.	35.	80.	280.	35.	81.
1975	275.	34.	81.	283.	34.	83.
1976	277.	34.	83.	286.	34.	84.
1977	278.	33.	84.	289.	34.	86.
1978	280.	33.	85.	292.	33.	88.
1979	282.	32.	87.	295.	33.	90.
1980	283.	32.	88.	298.	33.	92.
1981	285.	32.	89.	302.	32.	94.
1982	287.	31.	91.	305.	32.	96.
1983	288.	31.	92.	308.	32.	98.
1984	290.	30.	94.	311.	31.	100.
1985	292.	30.	95.	315.	31.	102.

ANGOLA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1604.	121.	133.	1608.	121.	133.
1971	1645.	122.	135.	1654.	122.	135.
1972	1685.	124.	137.	1702.	124.	137.
1973	1725.	125.	139.	1750.	125.	139.
1974	1765.	127.	141.	1800.	127.	142.
1975	1806.	128.	142.	1852.	129.	144.
1976	1846.	129.	144.	1905.	130.	146.
1977	1886.	131.	146.	1959.	132.	148.
1978	1926.	132.	148.	2015.	133.	151.
1979	1967.	134.	150.	2073.	135.	153.
1980	2007.	135.	152.	2132.	137.	156.
1981	2047.	136.	154.	2193.	138.	158.
1982	2087.	138.	156.	2256.	140.	161.
1983	2127.	139.	158.	2321.	142.	163.
1984	2168.	141.	160.	2387.	143.	166.
1985	2208.	142.	162.	2455.	145.	168.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

BURUNDI

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1306.	133.	109.	1271.	120.	106.
1971	1384.	144.	107.	1361.	131.	104.
1972	1462.	155.	105.	1457.	144.	101.
1973	1540.	166.	103.	1560.	158.	99.
1974	1618.	177.	101.	1670.	173.	97.
1975	1697.	188.	99.	1788.	189.	95.
1976	1775.	199.	96.	1914.	207.	92.
1977	1853.	210.	94.	2049.	227.	90.
1978	1931.	221.	92.	2194.	249.	88.
1979	2009.	232.	90.	2349.	273.	86.
1980	2087.	243.	88.	2515.	299.	84.
1981	2166.	254.	86.	2693.	328.	82.
1982	2244.	265.	84.	2883.	359.	80.
1983	2322.	276.	81.	3086.	393.	79.
1984	2400.	287.	79.	3304.	431.	77.
1985	2478.	298.	77.	3538.	472.	75.

CAMEROON

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	986.	193.	49.	988.	197.	50.
1971	1019.	203.	46.	1030.	214.	48.
1972	1051.	214.	43.	1073.	233.	46.
1973	1083.	224.	40.	1119.	254.	44.
1974	1115.	234.	38.	1166.	276.	42.
1975	1147.	245.	35.	1216.	300.	40.
1976	1179.	255.	32.	1267.	327.	39.
1977	1211.	266.	29.	1321.	356.	37.
1978	1244.	276.	26.	1377.	387.	36.
1979	1276.	286.	23.	1435.	422.	34.
1980	1308.	297.	20.	1496.	459.	33.
1981	1340.	307.	17.	1559.	499.	31.
1982	1372.	317.	14.	1625.	543.	30.
1983	1404.	328.	11.	1694.	591.	29.
1984	1437.	338.	8.	1766.	644.	27.
1985	1469.	348.	5.	1841.	701.	26.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

CENTR.AF.REP

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1029.	203.	51.	1029.	203.	51.
1971	1035.	203.	51.	1034.	203.	51.
1972	1040.	204.	51.	1039.	204.	51.
1973	1045.	205.	51.	1045.	205.	51.
1974	1051.	205.	51.	1050.	205.	51.
1975	1056.	206.	51.	1056.	206.	51.
1976	1062.	206.	51.	1061.	206.	51.
1977	1067.	207.	52.	1067.	207.	52.
1978	1073.	207.	52.	1072.	207.	52.
1979	1078.	208.	52.	1078.	208.	52.
1980	1084.	208.	52.	1084.	208.	52.
1981	1089.	209.	52.	1089.	209.	52.
1982	1095.	209.	52.	1095.	210.	52.
1983	1100.	210.	52.	1101.	210.	52.
1984	1105.	211.	53.	1106.	211.	52.
1985	1111.	211.	53.	1112.	211.	53.

CHAD

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	51.	19.	26.	51.	21.	29.
1971	52.	20.	22.	52.	24.	26.
1972	53.	21.	18.	53.	27.	24.
1973	53.	23.	14.	55.	31.	23.
1974	54.	24.	10.	56.	36.	21.
1975	55.	25.	6.	57.	41.	19.
1976	55.	27.	2.	58.	47.	18.
1977	56.	28.	-2.	60.	54.	17.
1978	57.	29.	-5.	61.	62.	15.
1979	57.	31.	-9.	62.	72.	14.
1980	58.	32.	-13.	64.	82.	13.
1981	59.	33.	-17.	65.	94.	12.
1982	59.	35.	-21.	66.	108.	11.
1983	60.	36.	-25.	68.	124.	10.
1984	61.	37.	-29.	69.	143.	10.
1985	61.	39.	-33.	71.	164.	9.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

COMORO ISH

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	99.	27.	38.	106.	27.	39.
1971	107.	28.	40.	123.	29.	42.
1972	115.	30.	42.	141.	31.	45.
1973	123.	31.	44.	163.	34.	49.
1974	131.	32.	46.	188.	36.	53.
1975	139.	34.	48.	217.	39.	57.
1976	147.	35.	50.	250.	41.	61.
1977	155.	37.	52.	288.	44.	66.
1978	163.	38.	54.	332.	48.	71.
1979	171.	39.	56.	383.	51.	76.
1980	179.	41.	58.	442.	55.	82.
1981	187.	42.	61.	510.	59.	89.
1982	195.	43.	63.	588.	63.	96.
1983	203.	45.	65.	678.	67.	103.
1984	211.	46.	67.	782.	72.	111.
1985	219.	48.	69.	901.	77.	120.

CONGO BRAZZ

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	376.	100.	39.	396.	101.	39.
1971	326.	95.	37.	365.	97.	37.
1972	277.	91.	35.	337.	94.	36.
1973	227.	86.	32.	311.	91.	34.
1974	178.	81.	30.	287.	87.	33.
1975	128.	77.	28.	264.	84.	31.
1976	78.	72.	26.	244.	81.	30.
1977	29.	67.	24.	225.	78.	29.
1978	-21.	63.	22.	208.	76.	27.
1979	-70.	58.	19.	192.	73.	26.
1980	-120.	54.	17.	177.	70.	25.
1981	-169.	49.	15.	163.	68.	24.
1982	-219.	44.	13.	150.	65.	23.
1983	-268.	40.	11.	139.	63.	22.
1984	-318.	35.	9.	128.	61.	21.
1985	-367.	30.	6.	118.	59.	20.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

CONGO REP

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	7630.	633.	120.	7470.	629.	119.
1971	7681.	633.	121.	7512.	629.	119.
1972	7733.	634.	121.	7554.	629.	120.
1973	7784.	634.	122.	7596.	629.	121.
1974	7836.	634.	123.	7639.	629.	121.
1975	7887.	635.	124.	7681.	629.	122.
1976	7939.	635.	124.	7724.	629.	123.
1977	7990.	635.	125.	7768.	629.	123.
1978	8042.	635.	126.	7811.	629.	124.
1979	8093.	636.	126.	7855.	629.	125.
1980	8145.	636.	127.	7899.	629.	125.
1981	8196.	636.	128.	7943.	629.	126.
1982	8248.	636.	129.	7987.	629.	127.
1983	8299.	637.	129.	8032.	629.	127.
1984	8351.	637.	130.	8077.	630.	128.
1985	8402.	637.	131.	8122.	630.	129.

DAHOMEY

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	979.	147.	66.	961.	144.	66.
1971	966.	141.	67.	948.	139.	68.
1972	954.	135.	68.	935.	134.	69.
1973	941.	129.	70.	922.	129.	71.
1974	929.	124.	71.	910.	125.	73.
1975	916.	118.	72.	898.	120.	74.
1976	904.	112.	73.	886.	116.	76.
1977	891.	106.	75.	874.	112.	78.
1978	879.	100.	76.	862.	108.	79.
1979	866.	94.	77.	850.	104.	81.
1980	854.	89.	78.	839.	100.	83.
1981	841.	83.	80.	828.	97.	85.
1982	829.	77.	81.	816.	93.	87.
1983	816.	71.	82.	805.	90.	89.
1984	804.	65.	83.	795.	87.	91.
1985	791.	59.	84.	784.	84.	93.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

EQUAT GUINEA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	43.	15.	29.	43.	15.	29.
1971	43.	15.	29.	43.	15.	29.
1972	43.	15.	29.	43.	15.	29.
1973	44.	15.	29.	44.	15.	28.
1974	44.	16.	28.	44.	16.	28.
1975	45.	16.	28.	45.	16.	28.
1976	45.	16.	28.	45.	16.	28.
1977	46.	16.	28.	46.	16.	28.
1978	46.	17.	28.	46.	17.	28.
1979	47.	17.	27.	47.	17.	27.
1980	47.	17.	27.	47.	17.	27.
1981	48.	17.	27.	48.	17.	27.
1982	48.	17.	27.	48.	18.	27.
1983	48.	18.	27.	49.	18.	27.
1984	49.	18.	26.	49.	18.	27.
1985	49.	18.	26.	50.	19.	26.

GABON

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	140.	62.	21.	139.	63.	22.
1971	141.	64.	20.	139.	66.	21.
1972	141.	66.	19.	140.	68.	20.
1973	142.	68.	18.	140.	71.	20.
1974	143.	70.	17.	141.	74.	19.
1975	143.	72.	16.	141.	77.	18.
1976	144.	74.	15.	142.	80.	18.
1977	145.	76.	14.	143.	83.	17.
1978	145.	78.	13.	143.	86.	17.
1979	146.	79.	11.	144.	89.	16.
1980	146.	81.	10.	144.	93.	15.
1981	147.	83.	9.	145.	97.	15.
1982	148.	85.	8.	146.	100.	14.
1983	148.	87.	7.	146.	104.	14.
1984	149.	89.	6.	147.	108.	13.
1985	150.	91.	5.	147.	113.	13.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

GHANA

YEAR	LINEAR FUNCTION PROD	AREA	YIELD	LOG FUNCTION PROD	AREA	YIELD
1970	1697.	196.	82.	1684.	204.	83.
1971	1767.	206.	79.	1778.	221.	80.
1972	1837.	216.	77.	1877.	240.	78.
1973	1907.	225.	74.	1982.	260.	76.
1974	1976.	235.	71.	2093.	282.	74.
1975	2046.	244.	69.	2211.	305.	73.
1976	2116.	254.	66.	2334.	331.	71.
1977	2186.	264.	63.	2465.	358.	69.
1978	2256.	273.	61.	2603.	388.	67.
1979	2326.	283.	58.	2748.	421.	66.
1980	2395.	292.	55.	2902.	456.	64.
1981	2465.	302.	52.	3065.	494.	62.
1982	2535.	312.	50.	3236.	536.	61.
1983	2605.	321.	47.	3417.	580.	59.
1984	2675.	331.	44.	3609.	629.	58.
1985	2744.	340.	42.	3810.	682.	56.

GUINEA

YEAR	LINEAR FUNCTION PROD	AREA	YIELD	LOG FUNCTION PROD	AREA	YIELD
1970	475.	28.	157.	476.	29.	164.
1971	482.	27.	161.	485.	29.	169.
1972	489.	26.	164.	493.	28.	176.
1973	496.	25.	167.	501.	28.	182.
1974	503.	25.	171.	510.	27.	189.
1975	510.	24.	174.	518.	27.	195.
1976	517.	23.	177.	527.	26.	203.
1977	524.	22.	181.	536.	26.	210.
1978	531.	21.	184.	545.	25.	217.
1979	538.	20.	188.	554.	25.	225.
1980	545.	19.	191.	564.	24.	234.
1981	552.	18.	194.	573.	24.	242.
1982	559.	17.	198.	583.	23.	251.
1983	566.	16.	201.	593.	23.	260.
1984	573.	16.	204.	603.	22.	269.
1985	580.	15.	208.	613.	22.	279.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

IVORY COAST

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	576.	192.	30.	565.	191.	30.
1971	558.	194.	29.	551.	194.	29.
1972	540.	196.	27.	537.	197.	28.
1973	521.	198.	26.	524.	199.	27.
1974	503.	200.	24.	511.	202.	26.
1975	485.	203.	23.	498.	205.	25.
1976	466.	205.	21.	486.	208.	24.
1977	448.	207.	20.	474.	210.	23.
1978	429.	209.	18.	462.	213.	22.
1979	411.	211.	17.	451.	216.	21.
1980	393.	214.	15.	440.	219.	20.
1981	374.	216.	14.	429.	222.	20.
1982	356.	218.	12.	418.	225.	19.
1983	338.	220.	11.	408.	228.	18.
1984	319.	222.	9.	398.	231.	17.
1985	301.	225.	8.	388.	235.	17.

KENYA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	620.	92.	67.	620.	92.	67.
1971	623.	93.	67.	623.	93.	67.
1972	626.	93.	67.	626.	93.	67.
1973	629.	94.	67.	629.	94.	67.
1974	632.	94.	67.	632.	94.	67.
1975	635.	95.	67.	635.	95.	67.
1976	638.	95.	67.	638.	95.	67.
1977	641.	96.	67.	642.	96.	67.
1978	644.	96.	67.	645.	96.	67.
1979	647.	96.	67.	648.	97.	66.
1980	650.	97.	66.	651.	97.	66.
1981	653.	97.	66.	654.	97.	66.
1982	656.	98.	66.	657.	98.	66.
1983	659.	98.	66.	661.	98.	66.
1984	662.	99.	66.	664.	99.	66.
1985	665.	99.	66.	667.	99.	66.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

LIBERIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	379.	59.	65.	379.	58.	65.
1971	376.	58.	64.	376.	58.	64.
1972	374.	58.	64.	373.	58.	64.
1973	371.	58.	64.	371.	58.	64.
1974	368.	58.	64.	368.	57.	64.
1975	365.	57.	64.	365.	57.	64.
1976	362.	57.	63.	363.	57.	63.
1977	360.	57.	63.	360.	57.	63.
1978	357.	57.	63.	358.	57.	63.
1979	354.	56.	63.	355.	56.	63.
1980	351.	56.	63.	353.	56.	63.
1981	349.	56.	62.	350.	56.	62.
1982	346.	56.	62.	348.	56.	62.
1983	343.	55.	62.	345.	55.	62.
1984	340.	55.	62.	343.	55.	62.
1985	337.	55.	62.	340.	55.	62.

MADAGASCAR

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1046.	246.	46.	1038.	242.	43.
1971	1075.	248.	47.	1071.	244.	44.
1972	1105.	250.	48.	1104.	246.	45.
1973	1134.	252.	49.	1139.	249.	46.
1974	1163.	254.	51.	1175.	251.	47.
1975	1192.	256.	52.	1212.	253.	48.
1976	1221.	258.	53.	1251.	256.	49.
1977	1250.	260.	54.	1290.	258.	50.
1978	1280.	262.	55.	1331.	260.	51.
1979	1309.	264.	56.	1373.	263.	52.
1980	1338.	265.	58.	1417.	265.	54.
1981	1367.	267.	59.	1461.	268.	55.
1982	1396.	269.	60.	1508.	270.	56.
1983	1425.	271.	61.	1555.	272.	57.
1984	1455.	273.	62.	1604.	275.	58.
1985	1484.	275.	63.	1655.	278.	60.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

MALI

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	186.	11.	169.	183.	11.	170.
1971	187.	10.	172.	184.	11.	174.
1972	188.	10.	175.	185.	10.	178.
1973	189.	10.	178.	186.	10.	183.
1974	190.	10.	181.	187.	10.	187.
1975	191.	9.	185.	187.	10.	191.
1976	192.	9.	188.	188.	10.	196.
1977	194.	9.	191.	189.	9.	200.
1978	195.	9.	194.	190.	9.	205.
1979	196.	8.	197.	191.	9.	210.
1980	197.	8.	201.	191.	9.	215.
1981	198.	8.	204.	192.	9.	220.
1982	199.	8.	207.	193.	9.	225.
1983	200.	7.	210.	194.	8.	230.
1984	201.	7.	213.	195.	8.	236.
1985	202.	7.	217.	196.	8.	241.

NIGER

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	200.	27.	76.	209.	27.	77.
1971	210.	28.	77.	226.	29.	78.
1972	220.	29.	78.	243.	31.	79.
1973	230.	30.	79.	262.	33.	80.
1974	240.	32.	80.	283.	35.	81.
1975	250.	33.	81.	305.	37.	83.
1976	260.	34.	82.	329.	39.	84.
1977	270.	35.	82.	355.	42.	85.
1978	280.	36.	83.	383.	44.	86.
1979	290.	38.	84.	413.	47.	87.
1980	300.	39.	85.	445.	50.	88.
1981	310.	40.	86.	480.	53.	90.
1982	320.	41.	87.	517.	57.	91.
1983	330.	43.	88.	558.	60.	92.
1984	340.	44.	88.	601.	64.	94.
1985	350.	45.	89.	649.	68.	95.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

NIGERIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	7135.	1197.	55.	7146.	1231.	58.
1971	7116.	1226.	51.	7134.	1277.	56.
1972	7097.	1256.	48.	7121.	1323.	54.
1973	7078.	1286.	45.	7109.	1372.	52.
1974	7059.	1316.	41.	7096.	1422.	50.
1975	7040.	1346.	38.	7083.	1475.	48.
1976	7021.	1375.	34.	7071.	1529.	46.
1977	7002.	1405.	31.	7058.	1585.	44.
1978	6983.	1435.	27.	7046.	1643.	43.
1979	6964.	1465.	24.	7033.	1703.	41.
1980	6945.	1495.	20.	7021.	1766.	40.
1981	6926.	1524.	17.	7008.	1831.	38.
1982	6907.	1554.	13.	6996.	1898.	37.
1983	6888.	1584.	10.	6983.	1968.	35.
1984	6869.	1614.	6.	6971.	2040.	34.
1985	6850.	1644.	3.	6959.	2115.	33.

SENEGAL

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	205.	53.	39.	201.	51.	39.
1971	209.	54.	39.	205.	53.	39.
1972	214.	55.	39.	210.	54.	39.
1973	218.	57.	39.	214.	56.	39.
1974	222.	58.	38.	219.	57.	38.
1975	227.	60.	38.	224.	59.	38.
1976	231.	61.	38.	229.	61.	38.
1977	235.	62.	38.	234.	62.	38.
1978	240.	64.	37.	239.	64.	37.
1979	244.	65.	37.	245.	66.	37.
1980	249.	67.	37.	250.	68.	37.
1981	253.	68.	37.	256.	70.	37.
1982	257.	69.	36.	262.	72.	37.
1983	262.	71.	36.	268.	74.	36.
1984	266.	72.	36.	274.	76.	36.
1985	270.	73.	36.	280.	78.	36.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

SIERRA LEONE

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	66.	21.	31.	67.	21.	31.
1971	67.	21.	32.	68.	21.	32.
1972	68.	22.	32.	69.	22.	32.
1973	70.	22.	32.	71.	22.	32.
1974	71.	22.	32.	72.	22.	33.
1975	72.	22.	33.	74.	22.	33.
1976	73.	22.	33.	75.	22.	33.
1977	74.	22.	33.	77.	23.	34.
1978	75.	23.	34.	78.	23.	34.
1979	76.	23.	34.	80.	23.	34.
1980	78.	23.	34.	81.	23.	35.
1981	79.	23.	35.	83.	23.	35.
1982	80.	23.	35.	85.	24.	35.
1983	81.	23.	35.	86.	24.	36.
1984	82.	24.	36.	88.	24.	36.
1985	83.	24.	36.	90.	24.	37.

SUDAN

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	137.	18.	77.	138.	18.	77.
1971	140.	18.	78.	140.	18.	78.
1972	142.	18.	79.	143.	18.	79.
1973	145.	18.	80.	146.	18.	80.
1974	148.	18.	80.	149.	18.	81.
1975	150.	19.	81.	152.	19.	81.
1976	153.	19.	82.	155.	19.	82.
1977	155.	19.	83.	158.	19.	83.
1978	158.	19.	83.	161.	19.	84.
1979	160.	19.	84.	164.	19.	85.
1980	163.	19.	85.	168.	19.	86.
1981	165.	19.	86.	171.	20.	87.
1982	168.	20.	86.	174.	20.	87.
1983	170.	20.	87.	178.	20.	88.
1984	173.	20.	88.	181.	20.	89.
1985	175.	20.	89.	185.	20.	90.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

RWANDA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	300.	29.	105.	313.	30.	104.
1971	327.	31.	104.	363.	35.	104.
1972	354.	34.	104.	422.	41.	103.
1973	380.	36.	103.	490.	48.	103.
1974	407.	39.	103.	569.	55.	102.
1975	433.	41.	103.	661.	65.	102.
1976	460.	44.	102.	767.	75.	102.
1977	486.	47.	102.	891.	87.	101.
1978	513.	49.	101.	1034.	102.	101.
1979	539.	52.	101.	1201.	119.	101.
1980	566.	54.	101.	1394.	138.	100.
1981	593.	57.	100.	1619.	161.	100.
1982	619.	59.	100.	1880.	187.	99.
1983	646.	62.	99.	2182.	218.	99.
1984	672.	64.	99.	2534.	254.	99.
1985	699.	67.	99.	2942.	296.	98.

TANZANIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1362.	282.	48.	1355.	282.	48.
1971	1399.	283.	50.	1395.	283.	49.
1972	1436.	285.	51.	1437.	285.	51.
1973	1473.	286.	52.	1480.	286.	52.
1974	1510.	288.	53.	1523.	288.	53.
1975	1548.	289.	54.	1569.	290.	54.
1976	1585.	291.	55.	1615.	291.	56.
1977	1622.	292.	56.	1663.	293.	57.
1978	1659.	294.	57.	1713.	294.	58.
1979	1696.	296.	58.	1763.	296.	59.
1980	1734.	297.	59.	1816.	298.	61.
1981	1771.	299.	60.	1870.	299.	62.
1982	1808.	300.	61.	1925.	301.	64.
1983	1845.	302.	62.	1982.	303.	65.
1984	1882.	303.	63.	2041.	304.	67.
1985	1919.	305.	64.	2102.	306.	68.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

TOGO

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	1227.	161.	77.	1296.	168.	77.
1971	1285.	168.	78.	1395.	179.	78.
1972	1342.	175.	79.	1501.	190.	79.
1973	1400.	181.	79.	1615.	203.	80.
1974	1457.	188.	80.	1737.	216.	81.
1975	1514.	195.	81.	1869.	230.	82.
1976	1572.	202.	82.	2012.	244.	83.
1977	1629.	208.	83.	2164.	260.	84.
1978	1687.	215.	83.	2329.	277.	84.
1979	1744.	222.	84.	2506.	294.	85.
1980	1801.	229.	85.	2697.	313.	86.
1981	1859.	236.	86.	2902.	333.	87.
1982	1916.	242.	87.	3122.	355.	88.
1983	1974.	249.	87.	3360.	378.	89.
1984	2031.	256.	88.	3615.	402.	90.
1985	2088.	263.	89.	3890.	428.	91.

UGANDA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	2233.	255.	88.	2285.	253.	90.
1971	2363.	247.	94.	2478.	246.	101.
1972	2492.	238.	100.	2687.	240.	112.
1973	2622.	230.	107.	2914.	233.	125.
1974	2752.	222.	113.	3160.	227.	139.
1975	2881.	213.	119.	3427.	221.	155.
1976	3011.	205.	125.	3716.	215.	172.
1977	3141.	197.	132.	4030.	209.	192.
1978	3270.	188.	138.	4370.	204.	214.
1979	3400.	180.	144.	4739.	198.	238.
1980	3530.	172.	150.	5138.	193.	265.
1981	3660.	163.	157.	5572.	188.	295.
1982	3789.	155.	163.	6042.	183.	329.
1983	3919.	147.	169.	6552.	178.	366.
1984	4049.	138.	175.	7105.	173.	408.
1985	4178.	130.	182.	7705.	169.	454.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

ZAMBIA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	153.	50.	30.	153.	50.	30.
1971	153.	51.	29.	153.	51.	30.
1972	153.	52.	29.	153.	52.	29.
1973	153.	53.	28.	153.	54.	28.
1974	153.	54.	27.	153.	55.	27.
1975	153.	55.	26.	153.	56.	27.
1976	153.	56.	25.	153.	58.	26.
1977	153.	57.	24.	153.	59.	25.
1978	153.	59.	23.	153.	61.	25.
1979	153.	60.	22.	153.	62.	24.
1980	153.	61.	21.	153.	64.	23.
1981	153.	62.	20.	153.	66.	23.
1982	153.	63.	19.	153.	67.	22.
1983	153.	64.	18.	153.	69.	21.
1984	153.	65.	17.	153.	71.	21.
1985	153.	66.	16.	153.	73.	20.

LAT.AMERICA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	35362.	2623.	136.	36583.	2681.	136.
1971	36631.	2699.	137.	38470.	2785.	137.
1972	37900.	2775.	138.	40454.	2892.	139.
1973	39169.	2851.	140.	42541.	3004.	140.
1974	40438.	2927.	141.	44735.	3120.	142.
1975	41707.	3003.	143.	47042.	3241.	144.
1976	42976.	3079.	144.	49468.	3366.	145.
1977	44245.	3156.	146.	52020.	3496.	147.
1978	45514.	3232.	147.	54703.	3631.	149.
1979	46783.	3308.	149.	57524.	3772.	151.
1980	48052.	3384.	150.	60491.	3918.	152.
1981	49321.	3460.	151.	63611.	4069.	154.
1982	50590.	3536.	153.	66892.	4226.	156.
1983	51859.	3612.	154.	70342.	4390.	158.
1984	53128.	3688.	156.	73970.	4560.	159.
1985	54397.	3764.	157.	77785.	4736.	161.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

FAR EAST

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	21203.	2448.	87.	21650.	2486.	87.
1971	21718.	2497.	88.	22337.	2548.	88.
1972	22234.	2545.	88.	23046.	2612.	88.
1973	22749.	2594.	89.	23778.	2677.	89.
1974	23265.	2643.	89.	24532.	2744.	89.
1975	23780.	2691.	90.	25311.	2813.	90.
1976	24295.	2740.	90.	26115.	2883.	91.
1977	24811.	2789.	91.	26944.	2955.	91.
1978	25326.	2838.	92.	27799.	3029.	92.
1979	25842.	2886.	92.	28681.	3105.	93.
1980	26357.	2935.	93.	29592.	3183.	93.
1981	26872.	2984.	93.	30531.	3262.	94.
1982	27388.	3032.	94.	31500.	3344.	94.
1983	27903.	3081.	94.	32500.	3428.	95.
1984	28419.	3130.	95.	33532.	3513.	96.
1985	28934.	3179.	96.	34596.	3601.	96.

AFRICA

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	33664.	5079.	65.	33475.	5142.	66.
1971	34009.	5189.	64.	33831.	5279.	65.
1972	34353.	5299.	63.	34190.	5421.	64.
1973	34697.	5409.	62.	34553.	5566.	63.
1974	35042.	5518.	61.	34920.	5715.	62.
1975	35386.	5628.	60.	35292.	5868.	61.
1976	35730.	5738.	59.	35667.	6025.	60.
1977	36075.	5847.	58.	36046.	6186.	60.
1978	36419.	5957.	57.	36429.	6351.	59.
1979	36763.	6067.	56.	36816.	6521.	58.
1980	37107.	6176.	55.	37207.	6696.	57.
1981	37452.	6286.	54.	37602.	6875.	56.
1982	37796.	6396.	53.	38002.	7059.	56.
1983	38140.	6506.	52.	38406.	7248.	55.
1984	38485.	6615.	51.	38814.	7442.	54.
1985	38829.	6725.	49.	39226.	7641.	53.

PROJECTIONS OF PRODUCTION ACREAGE AND YIELD FOR 1970 TO 1985

WORLD

YEAR	LINEAR FUNCTION			LOG FUNCTION		
	PROD	AREA	YIELD	PROD	AREA	YIELD
1970	90271.	10197.	88.	90849.	10359.	88.
1971	92302.	10424.	88.	93347.	10650.	88.
1972	94333.	10652.	88.	95914.	10950.	88.
1973	96364.	10879.	88.	98552.	11257.	88.
1974	98395.	11107.	88.	101262.	11574.	88.
1975	100426.	11334.	88.	104047.	11899.	88.
1976	102457.	11561.	88.	106909.	12233.	88.
1977	104488.	11789.	88.	109849.	12577.	88.
1978	106519.	12016.	88.	112870.	12930.	88.
1979	108550.	12244.	88.	115974.	13294.	88.
1980	110581.	12471.	88.	119163.	13667.	88.
1981	112612.	12698.	88.	122440.	14051.	88.
1982	114643.	12926.	88.	125808.	14446.	88.
1983	116674.	13153.	88.	129268.	14852.	88.
1984	118705.	13381.	88.	132823.	15269.	88.
1985	120736.	13608.	88.	136475.	15698.	88.

Appendix B

BRIEF LIST OF KNOWN CASSAVA RESEARCH PROGRAMMES

Appendix B, listing on-going research projects, awaits the completion of the Indian Cassava Report. It is therefore not included in this preliminary draft, but will be presented in the final version.

Appendix C

UNITED STATES INDUSTRIAL STARCH STANDARDS

Appendix C

Some United States Industrial Starch Standards for Cassava Starch

Some common standards for tapioca starch are:

Paper Manufacturing

Moisture Content: 12.5% average; 13.5% maximum
Ash Content: 0.2% maximum
Speck Count (no. per sq. inch): 15 maximum
Viscosity (Brabender Units): 300-900
Pulp: .25 cc/50 grams
ph: 6.5 - 7.0 (6.7 desired)
Cleanliness: FDA approved

Food Manufacturing

1) Moisture: 12.5% maximum
Ash content: 0.15% maximum
Speck Count: 8 maximum
Viscosity Peak: 600
Pulp: 0.1cc/50 grams
ph: 5.5 - 7.5
acid factor: 2.6 maximum
Cleanliness: FDA approved

2) Moisture: 11-14%
Ash Content: .30% maximum
Speck Count: 5 maximum
Viscosity Peak: 350-450
at 92.5°C: 280-400
Pulp: .5 cc/50 grams
ph: 5.0-6.5
Acid Factor: 1.75-2.5
Cleanliness: FDA approved

Appendix D

LINEAR PROGRAMMING MATRIX USED IN ESTIMATING EEC LEAST-COST FEED RATIONS

TABLE D.1

LINEAR PROGRAMMING MATRIX USED FOR LEAST COST FEED RATIONS, OF NETHERLANDS, GERMANY, FRANCE, ITALY, BELGIUM-LUXEMBOURG. FORMAT THAT OF IBM MPSX

```
NAME          EECOTH
ROWS
 G S.E.
 G M.E.
 G TON
 G PROT.MIN
 L PROT.MAX
 G CR.FAT
 L CR.FIB
 G LYSINE
 G METH
 G METH+CYS
 G CAL.MIN.
 L CAL.MAX.
 G PHOSUP
 L BARLEY
 L WHEAT
 L MAIZE
 L LINSEED
 L SOYBEAN
 L M.GLUTIN
 L COTTMEAL
 L LINDMEAL
 L GRNUTEXP
 L WH.MIDD
 L WH.BRAN
 L BEETPULP
 L BREWGRAN
 L CITRPULP
 L RICEBRAN
 L FISHMEAL
 L OYSTSHEL
 L MEATBONE
 L MOLASSES
 L TALLOW
 L RAPE
 L CASSAVA
 L S.TON
 G MINMAIZ
 G MINGRLUC
 G MINFISH
 G MINMAZGL
 G MINBATLY
 N P.GER
 N P.FRA
 N P.BEL
 N P.ITA
 N P.CASBEL
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CEREALS

SORGHUM	S.E.	75.5000	M.E.	3240.0000
SORGHUM	TDN	1.1700	PROT.MIN	10.2000
SORGHUM	PROT.MAX	10.2000	CR.FAT	3.2000
SORGHUM	CR.FIB	2.0000	LYSINE	0.2300
SORGHUM	METH	0.1700	METH+CYS	0.3500
SORGHUM	CAL.MIN.	0.0200	CAL.MAX.	0.0200
SORGHUM	PHOSOP	0.2500	M.TON	1.0000
SORGHUM	P.GER	0.0970	P.FRA	0.0870
SORGHUM	P.BEL	0.0930	P.ITA	0.0960
BARLEY	S.E.	70.6000	M.E.	2690.0000
BARLEY	TDN	1.0400	PROT.MIN	10.9000
BARLEY	PROT.MAX	10.9000	CR.FAT	2.0000
BARLEY	CR.FIB	5.1000	LYSINE	0.3900
BARLEY	METH	0.1800	METH+CYS	0.4300
BARLEY	CAL.MIN.	0.0700	CAL.MAX.	0.0700
BARLEY	PHOSOP	0.3600	BARLEY	1.0000
BARLEY	M.TON	1.0000	MINBATLY	1.0000
BARLEY	P.GER	0.0990	P.FRA	0.0890
BARLEY	P.BEL	0.0960	P.ITA	0.0970
WHEAT	S.E.	76.2000	M.E.	3020.0000
WHEAT	TDN	1.1100	PROT.MIN	11.5000
WHEAT	PROT.MAX	11.5000	CR.FAT	1.7000
WHEAT	CR.FIB	2.1000	LYSINE	0.3300
WHEAT	METH	0.1900	METH+CYS	0.4600
WHEAT	CAL.MIN.	0.0500	CAL.MAX.	0.0500
WHEAT	PHOSOP	0.3800	WHEAT	1.0000
WHEAT	M.TON	1.0000	P.GER	0.1120
WHEAT	P.FRA	0.1000	P.BEL	0.1090
WHEAT	P.ITA	0.1180		
MAIZE	S.E.	80.6000	M.E.	3360.0000
MAIZE	TDN	1.1700	PROT.MIN	9.1000
MAIZE	PROT.MAX	9.1000	CR.FAT	4.2000
MAIZE	CR.FIB	2.4000	LYSINE	0.2700
MAIZE	METH	0.2000	METH+CYS	0.4200
MAIZE	CAL.MIN.	0.0200	CAL.MAX.	0.0200
MAIZE	PHOSOP	0.3000	MAIZE	1.0000
MAIZE	M.TON	1.0000	MINMAIZ	1.0000
MAIZE	P.GER	0.1000	P.FRA	0.0760
MAIZE	P.BEL	0.0950	P.ITA	0.0840
LINSEED	S.E.	127.3000	TDN	1.7200
LINSEED	PROT.MIN	21.5000	PROT.MAX	21.5000
LINSEED	CR.FAT	34.2000	CR.FIB	7.3000
LINSEED	LYSINE	0.7700	METH	0.4300
LINSEED	METH+CYS	0.6300	CAL.MIN.	0.2300
LINSEED	CAL.MAX.	0.2300	PHOSOP	0.6600
LINSEED	LINOSEED	1.0000	M.TON	1.0000
LINSEED	P.GER	0.1310	P.FRA	0.1310
LINSEED	P.BEL	0.1310	P.ITA	0.1310

SOYBEAN	S.E.	97.9000	M.E.	2900.0000
SOYBEAN	TDN	1.3600	PROT.MIN	36.6000
SOYBEAN	PROT.MAX	36.6000	CR.FAT	18.3000
SOYBEAN	CR.FIB	6.0000	LYSINE	2.2600
SOYBEAN	METH	0.5100	METH+CYS	1.0600
SOYBEAN	CAL.MIN.	0.2900	CAL.MAX.	0.2900
SOYBEAN	PHOSOP	0.6200	SOYBEAN	1.0000
SOYBEAN	M.TON	1.0000	P.GER	0.1470
SOYBEAN	P.FRA	0.1470	P.BEL	0.1470
SOYBEAN	P.ITA	0.1470		
M.GLUTTN	S.E.	64.7900	M.E.	1900.0000
M.GLUTTN	TDN	0.9000	PROT.MIN	22.6000
M.GLUTTN	PROT.MAX	22.6000	CR.FAT	3.9000
M.GLUTTN	CR.FIB	3.2000	LYSINE	0.7200
M.GLUTTN	METH	0.4300	METH+CYS	0.9500
M.GLUTTN	CAL.MIN.	0.1400	CAL.MAX.	0.1400
M.GLUTTN	PHOSOP	0.5500	M.GLUTTN	1.0000
M.GLUTTN	M.TON	1.0000	MINMAZGL	1.0000
M.GLUTTN	P.GER	0.0790	P.FRA	0.0790
M.GLUTTN	P.BEL	0.0790	P.ITA	0.0790
COTTMEAL	S.E.	62.0000	M.E.	2030.0000
COTTMEAL	TDN	0.9600	PROT.MIN	41.3000
COTTMEAL	PROT.MAX	41.3000	CR.FAT	5.6000
COTTMEAL	CR.FIB	11.5000	LYSINE	1.5600
COTTMEAL	METH	0.6600	METH+CYS	1.3600
COTTMEAL	CAL.MIN.	0.2000	CAL.MAX.	0.2000
COTTMEAL	PHOSOP	1.1500	COTTMEAL	1.0000
COTTMEAL	M.TON	1.0000	P.GER	0.1020
COTTMEAL	P.FRA	0.1020	P.BEL	0.1020
COTTMEAL	P.ITA	0.1020		
LINSEXP	S.E.	68.9000	M.E.	1600.0000
LINSEXP	TDN	1.0000	PROT.MIN	33.4000
LINSEXP	PROT.MAX	33.4000	CR.FAT	6.3000
LINSEXP	CR.FIB	9.0000	LYSINE	1.2300
LINSEXP	METH	0.6600	METH+CYS	1.3000
LINSEXP	CAL.MIN.	0.3300	CAL.MAX.	0.3300
LINSEXP	PHOSOP	0.8000	LINOMEAL	1.0000
LINSEXP	M.TON	1.0000	P.GER	0.0950
LINSEXP	P.FRA	0.0950	P.BEL	0.0950
LINSEXP	P.ITA	0.0950		
GRNUTEXP	S.E.	78.1000	M.E.	2630.0000
GRNUTEXP	TDN	1.1300	PROT.MIN	49.8000
GRNUTEXP	PROT.MAX	49.8000	CR.FAT	7.0000
GRNUTEXP	CR.FIB	5.3000	LYSINE	1.6400
GRNUTEXP	METH	0.5400	METH+CYS	1.1900
GRNUTEXP	CAL.MIN.	0.1400	CAL.MAX.	0.1400
GRNUTEXP	PHOSOP	0.6400	GRNUTEXP	1.0000
GRNUTEXP	M.TON	1.0000	P.GER	0.1310
GRNUTEXP	P.FRA	0.1310	P.BEL	0.1310
GRNUTEXP	P.ITA	0.1310		

WH.MIDDL	S.E.	64.6000	M.E.	2060.0000
WH.MIDDL	TON	0.9400	PROT.MIN	16.3000
WH.MIDDL	PROT.MAX	16.3000	CR.FAT	4.3000
WH.MIDDL	CR.FIB	7.5000	LYSINE	0.6500
WH.MIDDL	METH	0.2600	METH+CYS	0.6200
WH.MIDDL	CAL.MIN.	0.1000	CAL.MAX.	0.1000
WH.MIDDL	PHOSOP	0.9000	WH.MIDD	1.0000
WH.MIDDL	M.TON	1.0000	P.GER	0.0760
WH.MIDDL	P.FRA	0.0690	P.BEL	0.0730
WH.MIDDL	P.ITA	0.0760		
WH.BRAN	S.E.	56.5000	M.E.	1800.0000
WH.BRAN	TON	1.1000	PROT.MIN	15.8000
WH.BRAN	PROT.MAX	15.8000	CR.FAT	4.3000
WH.BRAN	CR.FIB	9.0000	LYSINE	0.6300
WH.BRAN	METH	0.2500	METH+CYS	0.6000
WH.BRAN	CAL.MIN.	0.1000	CAL.MAX.	0.1000
WH.BRAN	PHOSOP	1.2600	WH.BRAN	1.0000
WH.BRAN	M.TON	1.0000	P.GER	0.0840
WH.BRAN	P.FRA	0.0760	P.BEL	0.0810
WH.BRAN	P.ITA	0.0840		
BEETPULP	S.E.	67.1000	TON	0.9400
BEETPULP	PROT.MIN	8.2000	PROT.MAX	8.2000
BEETPULP	CR.FIB	7.8000	LYSINE	0.4600
BEETPULP	METH	0.1300	METH+CYS	0.2400
BEETPULP	CAL.MIN.	0.6800	CAL.MAX.	0.6800
BEETPULP	PHOSOP	0.0700	BEETPULP	1.0000
BEETPULP	M.TON	1.0000	P.GER	0.0710
BEETPULP	P.FRA	0.0710	P.BEL	0.0710
BEETPULP	P.ITA	0.0710		
BR.GRAN	S.E.	70.0000	M.E.	2866.0000
BR.GRAN	TON	0.9800	PROT.MIN	27.0000
BR.GRAN	PROT.MAX	27.0000	CR.FAT	9.0000
BR.GRAN	CR.FIB	5.0000	LYSINE	0.9000
BR.GRAN	METH	0.4000	METH+CYS	0.6200
BR.GRAN	CAL.MIN.	3.7500	CAL.MAX.	3.7500
BR.GRAN	PHOSOP	0.9800	BREWGRAN	1.0000
BR.GRAN	M.TON	1.0000	P.GER	0.0840
BR.GRAN	P.FRA	0.0760	P.BEL	0.0810
BR.GRAN	P.ITA	0.0840		
CITRPULP	S.E.	65.2000	TON	0.9000
CITRPULP	PROT.MIN	6.2000	PROT.MAX	6.2000
CITRPULP	CR.FAT	3.3000	CR.FIB	12.9000
CITRPULP	LYSINE	0.2100	METH	0.0800
CITRPULP	METH+CYS	0.2000	CAL.MIN.	1.9000
CITRPULP	CAL.MAX.	1.9000	PHOSOP	0.1000
CITRPULP	CITRPULP	1.0000	M.TON	1.0000
CITRPULP	P.GER	0.0630	P.FRA	0.0630
CITRPULP	P.BEL	0.0630	P.ITA	0.0630

RICEBRAN	S.E.	89.9000	M.E.	3270.0000
RICEBRAN	TON	1.3300	PROT.MIN	13.3000
RICEBRAN	PROT.MAX	13.3000	CR.FAT	14.8000
RICEBRAN	CR.FIB	5.7000	LYSINE	0.6200
RICEBRAN	METH	0.2600	METH+CYS	0.5300
RICEBRAN	CAL.MIN.	0.0400	CAL.MAX.	0.0400
RICEBRAN	PHOSOP	1.1000	RICEBRAN	1.0000
RICEBRAN	M.TON	1.0000	P.GER	0.0670
RICEBRAN	P.FRA	0.0600	P.BEL	0.0640
RICEBRAN	P.ITA	0.0660		
FISHMEAL	S.E.	70.9000	M.E.	2910.0000
FISHMEAL	TON	0.9900	PROT.MIN	66.3000
FISHMEAL	PROT.MAX	66.3000	CR.FAT	8.1000
FISHMEAL	LYSINE	4.9100	METH	1.9200
FISHMEAL	METH+CYS	2.5800	CAL.MIN.	4.2000
FISHMEAL	CAL.MAX.	4.2000	PHOSOP	2.7500
FISHMEAL	FISHMEAL	1.0000	M.TON	1.0000
FISHMEAL	MINFISH	1.0000	P.GER	0.1910
FISHMEAL	P.FRA	0.1910	P.BEL	0.1910
FISHMEAL	P.ITA	0.1910		
OYSTSHEL	CR.FAT	0.5000	CAL.MIN.	38.0000
OYSTSHEL	CAL.MAX.	38.0000	OYSTSHEL	1.0000
OYSTSHEL	M.TON	1.0000	P.GER	0.0270
OYSTSHEL	P.FRA	0.0270	P.BEL	0.0270
OYSTSHEL	P.ITA	0.0270		
MEATBONE	S.E.	63.0000	M.E.	2425.0000
MEATBONE	TON	0.7600	PROT.MIN	50.0000
MEATBONE	PROT.MAX	50.0000	CR.FAT	10.0000
MEATBONE	LYSINE	2.8000	METH	0.6500
MEATBONE	METH+CYS	1.2000	CAL.MIN.	10.0000
MEATBONE	CAL.MAX.	10.0000	PHOSOP	4.8000
MEATBONE	MEATBONE	1.0000	M.TON	1.0000
MEATBONE	P.GER	0.1030	P.FRA	0.1030
MEATBONE	P.BEL	0.1030	P.ITA	0.1030
MOLASSES	S.E.	42.7000	M.E.	2140.0000
MOLASSES	TON	0.7600	PROT.MIN	3.4000
MOLASSES	PROT.MAX	3.4000	CR.FIB	0.2000
MOLASSES	CAL.MIN.	0.3400	CAL.MAX.	0.3400
MOLASSES	PHOSOP	0.0500	MOLASSES	1.0000
MOLASSES	M.TON	1.0000	P.GER	0.0480
MOLASSES	P.FRA	0.0480	P.BEL	0.0480
MOLASSES	P.ITA	0.0480		
TALLOW	S.E.	283.5999	M.E.	6850.0000
TALLOW	TON	4.0100	CR.FAT	99.5000
TALLOW	TALLOW	1.0000	M.TON	1.0000
TALLOW	P.GER	0.1990	P.FRA	0.1990
TALLOW	P.BEL	0.1990	P.ITA	0.1990

RAPEEXT	S.E.	52.6000	M.E.	1690.0000
RAPEEXT	TON	0.7900	PROT.MIN	35.3000
RAPEEXT	PROT.MAX	35.3000	CR.FAT	1.8000
RAPEEXT	CR.FIB	12.7000	LYSINE	2.0500
RAPEEXT	METH	0.7400	METH+CYS	1.3000
RAPEEXT	CAL.MIN.	0.6000	CAL.MAX.	0.6000
RAPEEXT	PHOSOP	1.1000	RAPE	1.0000
RAPEEXT	M.TON	1.0000	P.GER	0.0660
RAPEEXT	P.FRA	0.0660	P.BEL	0.0660
RAPEEXT	P.ITA	0.0660		
CASSAVA	S.E.	74.0000	M.E.	2910.0000
CASSAVA	TON	1.1100	PROT.MIN	2.2000
CASSAVA	PROT.MAX	2.2000	CR.FAT	0.5000
CASSAVA	CR.FIB	3.0000	LYSINE	0.1100
CASSAVA	METH	0.0400	METH+CYS	0.0700
CASSAVA	CAL.MIN.	0.1100	CAL.MAX.	0.1100
CASSAVA	PHOSOP	0.0900	CASSAVA	1.0000
CASSAVA	M.TON	1.0000	P.GER	0.0620
CASSAVA	P.FRA	0.0620	P.BEL	0.0620
CASSAVA	P.ITA	0.0620	P.CASDEL	0.0050
GRASMEAL	S.E.	49.8000	M.E.	940.0000
GRASMEAL	TON	0.7000	PROT.MIN	16.1000
GRASMEAL	PROT.MAX	16.1000	CR.FAT	3.5000
GRASMEAL	CR.FIB	22.4000	LYSINE	0.7600
GRASMEAL	METH	0.2400	METH+CYS	0.4200
GRASMEAL	CAL.MIN.	0.5800	CAL.MAX.	0.5800
GRASMEAL	PHOSOP	0.3400	M.TON	1.0000
GRASMEAL	MINGRLUC	1.0000	P.GER	0.0730
GRASMEAL	P.FRA	0.0730	P.BEL	0.0730
GRASMEAL	P.ITA	0.0730		
ALFAMEAL	S.E.	33.8000	M.E.	890.0000
ALFAMEAL	TON	0.5000	PROT.MIN	17.0000
ALFAMEAL	PROT.MAX	17.0000	CR.FAT	2.3000
ALFAMEAL	CR.FIB	27.6000	LYSINE	0.8000
ALFAMEAL	METH	0.2600	METH+CYS	0.4500
ALFAMEAL	CAL.MIN.	1.7000	CAL.MAX.	1.7000
ALFAMEAL	PHOSOP	0.2500	M.TON	1.0000
ALFAMEAL	MINGRLUC	1.0000	P.GER	0.0650
ALFAMEAL	P.FRA	0.0650	P.BEL	0.0650
ALFAMEAL	P.ITA	0.0650		
SOYBMEAL	S.E.	70.0000	M.E.	1980.0000
SOYBMEAL	TON	0.9600	PROT.MIN	42.3000
SOYBMEAL	PROT.MAX	42.3000	CR.FAT	2.0000
SOYBMEAL	CR.FIB	8.1000	LYSINE	2.6200
SOYBMEAL	METH	0.5900	METH+CYS	1.2300
SOYBMEAL	CAL.MIN.	0.3000	CAL.MAX.	0.3000
SOYBMEAL	PHOSOP	0.7000	M.TON	1.0000
SOYBMEAL	P.GER	0.1030	P.FRA	0.1030
SOYBMEAL	P.BEL	0.1030	P.ITA	0.1030
SUNFMEAL	S.E.	54.7000	M.E.	1790.0000
SUNFMEAL	TON	0.9800	PROT.MIN	44.3000
SUNFMEAL	PROT.MAX	44.3000	CR.FAT	1.3000
SUNFMEAL	CR.FIB	14.4000	LYSINE	1.5000
SUNFMEAL	METH	0.9700	METH+CYS	1.7200
SUNFMEAL	CAL.MIN.	0.4000	CAL.MAX.	0.4000
SUNFMEAL	PHOSOP	0.9000	M.TON	1.0000
SUNFMEAL	P.GER	0.0870	P.FRA	0.0870
SUNFMEAL	P.BEL	0.0870	P.ITA	0.0870

D.7

OATS	S.E.	64.8000	M.E.	2580.0000
OATS	TDN	0.9200	PROT.MIN	10.4000
OATS	PROT.MAX	10.4000	CR.FAT	4.9000
OATS	CR.FIB	10.4000	LYSINE	0.3700
OATS	METH	0.1500	METH+CYS	0.4100
OATS	CAL.MIN.	0.1000	CAL.MAX.	0.1000
OATS	PHOSOP	0.3500	M.TON	1.0000
OATS	P.GER	0.0950	P.FRA	0.0890
OATS	P.BEL	0.1030	P.ITA	0.1040

RHS

COW.STAN	S.E.	66000.0000	M.E.	0.0
COW.STAN	TDN	0.0	PROT.MIN	16000.0000
COW.STAN	PROT.MAX	30000.0000	CR.FAT	3000.0000
COW.STAN	CR.FIB	7000.0000	LYSINE	0.0
COW.STAN	METH	0.0	METH+CYS	0.0
COW.STAN	CAL.MIN.	800.0000	CAL.MAX.	1100.0000
COW.STAN	PHOSCP	650.0000	BARLEY	100.0000
COW.STAN	WHEAT	200.0000	MAIZE	200.0000
COW.STAN	LINOSEED	200.0000	SOYBEAN	200.0000
COW.STAN	M.GLUTTN	250.0000	COTTMEAL	150.0000
COW.STAN	LINOMEAL	200.0000	GRNUTEXP	80.0000
COW.STAN	WH.MIDD	200.0000	WH.BRAN	200.0000
COW.STAN	BEETPULP	200.0000	BREWGRAN	50.0000
COW.STAN	CITRPULP	200.0000	RICEBRAN	100.0000
COW.STAN	FISHMEAL	50.0000	OYSTSHEL	0.0
COW.STAN	MEATBONE	50.0000	MOLASSES	150.0000
COW.STAN	TALLOW	20.0000	RAPE	100.0000
COW.STAN	CASSAVA	200.0000	M.TDN	1000.0000
COW.STAN	MINMAIZ	0.0	MINGRLUC	0.0
COW.STAN	MINFISH	0.0	MINMAZGL	0.0
COW.STAN	MINBATLY	0.0	P.GER	0.0
COW.STAN	P.FRA	0.0	P.BEL	0.0
COW.STAN	P.ITA	0.0		
COW.CALF	S.E.	64000.0000	M.E.	0.0
COW.CALF	TDN	0.0	PROT.MIN	22000.0000
COW.CALF	PROT.MAX	40000.0000	CR.FAT	4000.0000
COW.CALF	CR.FIB	7000.0000	LYSINE	0.0
COW.CALF	METH	0.0	METH+CYS	0.0
COW.CALF	CAL.MIN.	650.0000	CAL.MAX.	1200.0000
COW.CALF	PHOSCP	800.0000	BARLEY	100.0000
COW.CALF	WHEAT	200.0000	MAIZE	200.0000
COW.CALF	LINOSEED	200.0000	SOYBEAN	200.0000
COW.CALF	M.GLUTTN	250.0000	COTTMEAL	150.0000
COW.CALF	LINOMEAL	200.0000	GRNUTEXP	80.0000
COW.CALF	WH.MIDD	200.0000	WH.BRAN	200.0000
COW.CALF	BEETPULP	200.0000	BREWGRAN	50.0000
COW.CALF	CITRPULP	200.0000	RICEBRAN	100.0000
COW.CALF	FISHMEAL	50.0000	OYSTSHEL	0.0
COW.CALF	MEATBONE	50.0000	MOLASSES	150.0000
COW.CALF	TALLOW	20.0000	RAPE	100.0000
COW.CALF	CASSAVA	200.0000	M.TDN	1000.0000
COW.CALF	MINMAIZ	0.0	MINGRLUC	0.0
COW.CALF	MINFISH	0.0	MINMAZGL	0.0
COW.CALF	MINBATLY	0.0	P.GER	0.0
COW.CALF	P.FRA	0.0	P.BEL	0.0
COW.CALF	P.ITA	0.0		

LAY.MED	S.E.	0.0	M.E.	2800000.0000
LAY.MED	TON	0.0	PROT.MIN	15000.0000
LAY.MED	PROT.MAX	25000.0000	CR.FAT	2000.0000
LAY.MED	CR.FIB	6000.0000	LYSINE	650.0000
LAY.MED	METH	320.0000	METH+CYS	600.0000
LAY.MED	CAL.MIN.	3000.0000	CAL.MAX.	3200.0000
LAY.MED	PHOSOP	450.0000	BARLEY	1000.0000
LAY.MED	WHEAT	100.0000	MAIZE	1000.0000
LAY.MED	LINDSEED	1000.0000	SOYBEAN	1000.0000
LAY.MED	M.GLUTTN	70.0000	COTTMEAL	0.0
LAY.MED	LINDMEAL	1000.0000	GRNUTEXP	50.0000
LAY.MED	WH.MIDD	100.0000	WH.BRAN	150.0000
LAY.MED	BEETPULP	50.0000	BREWGRAN	50.0000
LAY.MED	CITRPULP	0.0	RICEBRAN	30.0000
LAY.MED	FISHMEAL	50.0000	OYSTSHEL	50.0000
LAY.MED	MEATBONE	70.0000	MOLASSES	30.0000
LAY.MED	TALLOW	30.0000	RAPE	50.0000
LAY.MED	CASSAVA	100.0000	M.TON	1000.0000
LAY.MED	MINMAIZ	250.0000	MINGRLUC	30.0000
LAY.MED	MINFISH	20.0000	MINMAZGL	0.0
LAY.MED	MINBATLY	0.0	P.GER	0.0
LAY.MED	P.FRA	0.0	P.BEL	0.0
LAY.MED	P.ITA	0.0		
PROULGRW	S.E.	0.0	M.E.	3200000.0000
PROULGRW	TON	0.0	PROT.MIN	20000.0000
PROULGRW	PROT.MAX	24000.0000	CR.FAT	2500.0000
PROULGRW	CR.FIB	5500.0000	LYSINE	1150.0000
PROULGRW	METH	430.0000	METH+CYS	820.0000
PROULGRW	CAL.MIN.	1000.0000	CAL.MAX.	1150.0000
PROULGRW	PHOSOP	500.0000	BARLEY	450.0000
PROULGRW	WHEAT	300.0000	MAIZE	400.0000
PROULGRW	LINDSEED	1000.0000	SOYBEAN	1000.0000
PROULGRW	M.GLUTTN	100.0000	COTTMEAL	0.0
PROULGRW	LINDMEAL	1000.0000	GRNUTEXP	70.0000
PROULGRW	WH.MIDD	250.0000	WH.BRAN	250.0000
PROULGRW	BEETPULP	0.0	BREWGRAN	50.0000
PROULGRW	CITRPULP	0.0	RICEBRAN	30.0000
PROULGRW	FISHMEAL	200.0000	OYSTSHEL	50.0000
PROULGRW	MEATBONE	70.0000	MOLASSES	20.0000
PROULGRW	TALLOW	30.0000	RAPE	50.0000
PROULGRW	CASSAVA	0.0	M.TON	1000.0000
PROULGRW	MINMAIZ	0.0	MINGRLUC	0.0
PROULGRW	MINFISH	20.0000	MINMAZGL	0.0
PROULGRW	MINBATLY	0.0	P.GER	0.0
PROULGRW	P.FRA	0.0	P.BEL	0.0
PROULGRW	P.ITA	0.0		

BROILRER	S.E.	0.0	M.E.	2800000.0000
BROILRER	TON	0.0	PROT.MIN	0.0
BROILRER	PROT.MAX	23000.0000	CR.FAT	4000.0000
BROILRER	CR.FIB	5000.0000	LYSINE	1050.0000
BROILRER	METH	400.0000	METH+CYS	750.0000
BROILRER	CAL.MIN.	950.0000	CAL.MAX.	1150.0000
BROILRER	PHOSCP	450.0000	BARLEY	250.0000
BROILRER	WHEAT	200.0000	MAIZE	400.0000
BROILRER	LINDSEED	1000.0000	SOYBEAN	100.0000
BROILRER	M.GLUTTN	50.0000	COTTMEAL	0.0
BROILRER	LINDMEAL	1000.0000	GRNUTEXP	50.0000
BROILRER	WH.MIDD	100.0000	WH.BRAN	100.0000
BROILRER	BEETPULP	0.0	BREWGRAN	30.0000
BROILRER	CITRPULP	0.0	RICEBRAN	0.0
BROILRER	FISHMEAL	200.0000	OYSTSHEL	0.0
BROILRER	MEATBONE	50.0000	MOLASSES	20.0000
BROILRER	TALLOW	40.0000	RAPE	50.0000
BROILRER	CASSAVA	50.0000	M.TON	1000.0000
BROILRER	MINMAIZ	0.0	MINGRLUC	30.0000
BROILRER	MINFISH	20.0000	MINMAZGL	0.0
BROILRER	MINBATLY	0.0	P.GER	0.0
BROILRER	P.FRA	0.0	P.BEL	0.0
BROILRER	P.ITA	0.0		
BROILFIN	S.E.	0.0	M.E.	2800000.0000
BROILFIN	TON	0.0	PROT.MIN	0.0
BROILFIN	PROT.MAX	19500.0000	CR.FAT	5000.0000
BROILFIN	CR.FIB	5000.0000	LYSINE	840.0000
BROILFIN	METH	320.0000	METH+CYS	600.0000
BROILFIN	CAL.MIN.	800.0000	CAL.MAX.	1000.0000
BROILFIN	PHOSOP	420.0000	BARLEY	250.0000
BROILFIN	WHEAT	200.0000	MAIZE	400.0000
BROILFIN	LINDSEED	1000.0000	SOYBEAN	70.0000
BROILFIN	M.GLUTTN	100.0000	COTTMEAL	0.0
BROILFIN	LINDMEAL	1000.0000	GRNUTEXP	50.0000
BROILFIN	WH.MIDD	100.0000	WH.BRAN	150.0000
BROILFIN	BEETPULP	0.0	BREWGRAN	30.0000
BROILFIN	CITRPULP	0.0	RICEBRAN	50.0000
BROILFIN	FISHMEAL	200.0000	OYSTSHEL	0.0
BROILFIN	MEATBONE	50.0000	MOLASSES	30.0000
BROILFIN	TALLOW	40.0000	RAPE	50.0000
BROILFIN	CASSAVA	100.0000	M.TON	1000.0000
BROILFIN	MINMAIZ	0.0	MINGRLUC	30.0000
BROILFIN	MINFISH	0.0	MINMAZGL	0.0
BROILFIN	MINBATLY	0.0	P.GER	0.0
BROILFIN	P.FRA	0.0	P.BEL	0.0
BROILFIN	P.ITA	0.0		

PIGSTART	S.E.	0.0	M.E.	0.0
PIGSTART	TON	1070.0000	PROT.MIN	0.0
PIGSTART	PROT.MAX	19500.0000	CR.FAT	2500.0000
PIGSTART	CR.FIB	6000.0000	LYSINE	940.0000
PIGSTART	METH	0.0	METH+CYS	600.0000
PIGSTART	CAL.MIN.	800.0000	CAL.MAX.	1000.0000
PIGSTART	PHOSUP	650.0000	BARLEY	100.0000
PIGSTART	WHEAT	300.0000	MAIZE	300.0000
PIGSTART	LINDSEED	1000.0000	SOYBEAN	1000.0000
PIGSTART	M.GLUTTN	200.0000	COTTMEAL	0.0
PIGSTART	LINOMEAL	1000.0000	GRNUTEXP	50.0000
PIGSTART	WH.MIDD	250.0000	WH.BRAN	250.0000
PIGSTART	BEETPULP	0.0	BREWGRAN	50.0000
PIGSTART	CITRPULP	50.0000	RICEBRAN	100.0000
PIGSTART	FISHMEAL	70.0000	OYSTSHEL	0.0
PIGSTART	MEATBONE	200.0000	MOLASSES	30.0000
PIGSTART	TALLOW	30.0000	RAPE	50.0000
PIGSTART	CASSAVA	50.0000	M.TON	1000.0000
PIGSTART	MINMAIZ	0.0	MINGRLUC	0.0
PIGSTART	MINFISH	0.0	MINMAZGL	100.0000
PIGSTART	MINBATLY	0.0	P.GER	0.0
PIGSTART	P.FRA	0.0	P.BEL	0.0
PIGSTART	P.ITA	0.0		
PIG-30KG	S.E.	0.0	M.E.	0.0
PIG-30KG	TON	1000.0000	PROT.MIN	0.0
PIG-30KG	PROT.MAX	18500.0000	CR.FAT	2500.0000
PIG-30KG	CR.FIB	6000.0000	LYSINE	900.0000
PIG-30KG	METH	0.0	METH+CYS	560.0000
PIG-30KG	CAL.MIN.	800.0000	CAL.MAX.	1000.0000
PIG-30KG	PHOSUP	650.0000	BARLEY	600.0000
PIG-30KG	WHEAT	350.0000	MAIZE	150.0000
PIG-30KG	LINDSEED	1000.0000	SOYBEAN	1000.0000
PIG-30KG	M.GLUTTN	70.0000	COTTMEAL	0.0
PIG-30KG	LINOMEAL	1000.0000	GRNUTEXP	50.0000
PIG-30KG	WH.MIDD	70.0000	WH.BRAN	70.0000
PIG-30KG	BEETPULP	0.0	BREWGRAN	50.0000
PIG-30KG	CITRPULP	50.0000	RICEBRAN	100.0000
PIG-30KG	FISHMEAL	70.0000	OYSTSHEL	0.0
PIG-30KG	MEATBONE	200.0000	MOLASSES	40.0000
PIG-30KG	TALLOW	30.0000	RAPE	50.0000
PIG-30KG	CASSAVA	100.0000	M.TON	1000.0000
PIG-30KG	MINMAIZ	0.0	MINGRLUC	0.0
PIG-30KG	MINFISH	0.0	MINMAZGL	0.0
PIG-30KG	MINBATLY	100.0000	P.GER	0.0
PIG-30KG	P.FRA	0.0	P.BEL	0.0
PIG-30KG	P.ITA	0.0		
PG30-100	S.E.	0.0	M.E.	0.0
PG30-100	TON	1030.0000	PROT.MIN	0.0
PG30-100	PROT.MAX	18000.0000	CR.FAT	2000.0000
PG30-100	CR.FIB	7000.0000	LYSINE	800.0000
PG30-100	METH	0.0	METH+CYS	520.0000
PG30-100	CAL.MIN.	800.0000	CAL.MAX.	1000.0000
PG30-100	PHOSUP	650.0000	BARLEY	600.0000
PG30-100	WHEAT	350.0000	MAIZE	100.0000

PG30-100	LINDSEED	1000.0000	SOYBEAN	1000.0000
PG30-100	M.GLUTTN	100.0000	COTTMEAL	0.0
PG30-100	LINDMEAL	1000.0000	GRNUTEXP	50.0000
PG30-100	WH.MIDD	70.0000	WH.BRAN	70.0000
PG30-100	BEETPULP	0.0	BREWGRAN	50.0000
PG30-100	CITRPULP	50.0000	RICEBRAN	100.0000
PG30-100	FISHMEAL	300.0000	OYSTSHEL	0.0
PG30-100	MEATBONE	200.0000	MOLASSES	50.0000
PG30-100	TALLOW	30.0000	RAPE	50.0000
PG30-100	CASSAVA	150.0000	M.TON	1000.0000
PG30-100	MINMAIZ	0.0	MINGRLUC	30.0000
PG30-100	MINFISH	0.0	MINMAZGL	0.0
PG30-100	MINBATLY	100.0000	P.GER	0.0
PG30-100	P.FRA	0.0	P.BEL	0.0
PG30-100	P.ITA	0.0		
SOWS	S.E.	0.0	M.E.	0.0
SOWS	TON	970.0000	PROT.MIN	0.0
SOWS	PROT.MAX	18000.0000	CR.FAT	2000.0000
SOWS	CR.FIB	7000.0000	LYSINE	800.0000
SOWS	METH	0.0	METH+CYS	520.0000
SOWS	CAL.MIN.	800.0000	CAL.MAX.	1200.0000
SOWS	PHOSUP	650.0000	BARLEY	600.0000
SOWS	WHEAT	350.0000	MAIZE	100.0000
SOWS	LINDSEED	1000.0000	SOYBEAN	1000.0000
SOWS	M.GLUTTN	100.0000	COTTMEAL	0.0
SOWS	LINDMEAL	1000.0000	GRNUTEXP	50.0000
SOWS	WH.MIDD	200.0000	WH.BRAN	200.0000
SOWS	BEETPULP	0.0	BREWGRAN	50.0000
SOWS	CITRPULP	50.0000	RICEBRAN	100.0000
SOWS	FISHMEAL	300.0000	OYSTSHEL	0.0
SOWS	MEATBONE	200.0000	MOLASSES	50.0000
SOWS	TALLOW	30.0000	RAPE	50.0000
SOWS	CASSAVA	70.0000	M.TON	1000.0000
SOWS	MINMAIZ	0.0	MINGRLUC	70.0000
SOWS	MINFISH	30.0000	MINMAZGL	0.0
SOWS	MINBATLY	0.0	P.GER	0.0
SOWS	P.FRA	0.0	P.BEL	0.0
SOWS	P.ITA	0.0		

CASSE	S.E.	2.0000	M.E.	0.0
CASSE	TON	0.0	PROT.MIN	0.0
CASSE	PROT.MAX	0.0	CR.FAT	0.0
CASSE	CR.FIB	0.0	LYSINE	0.0
CASSE	METH	0.0	METH+CYS	0.0
CASSE	CAL.MIN.	0.0	CAL.MAX.	0.0
CASSE	PHOSOP	0.0	BARLEY	0.0
CASSE	WHEAT	0.0	MAIZE	0.0
CASSE	LINOSEED	0.0	SOYBEAN	0.0
CASSE	M.GLUTTN	0.0	COTTMEAL	0.0
CASSE	LINOMEAL	0.0	GRNUTEXP	0.0
CASSE	WH.MIDD	0.0	WH.BRAN	0.0
CASSE	BEETPULP	0.0	BREWGRAN	0.0
CASSE	CITRPULP	0.0	RICEBRAN	0.0
CASSE	FISHMEAL	0.0	OYSTSHEL	0.0
CASSE	MEATBONE	0.0	MOLASSES	0.0
CASSE	TALLOW	0.0	RAPE	0.0
CASSE	CASSAVA	0.0	M.TON	0.0
CASSE	MINMAIZ	0.0	MINGRLUC	0.0
CASSE	MINFISH	0.0	MINMAZGL	0.0
CASSE	MINBATLY	0.0	P.GER	0.0
CASSE	P.FRA	0.0	P.BEL	0.0
CASSE	P.ITA	0.0		
CASME	S.E.	0.0	M.E.	50.0000
CASME	TON	0.0	PROT.MIN	0.0
CASME	PROT.MAX	0.0	CR.FAT	0.0
CASME	CR.FIB	0.0	LYSINE	0.0
CASME	METH	0.0	METH+CYS	0.0
CASME	CAL.MIN.	0.0	CAL.MAX.	0.0
CASME	PHOSOP	0.0	BARLEY	0.0
CASME	WHEAT	0.0	MAIZE	0.0
CASME	LINOSEED	0.0	SOYBEAN	0.0
CASME	M.GLUTTN	0.0	COTTMEAL	0.0
CASME	LINOMEAL	0.0	GRNUTEXP	0.0
CASME	WH.MIDD	0.0	WH.BRAN	0.0
CASME	BEETPULP	0.0	BREWGRAN	0.0
CASME	CITRPULP	0.0	RICEBRAN	0.0
CASME	FISHMEAL	0.0	OYSTSHEL	0.0
CASME	MEATBONE	0.0	MOLASSES	0.0
CASME	TALLOW	0.0	RAPE	0.0
CASME	CASSAVA	0.0	M.TON	0.0
CASME	MINMAIZ	0.0	MINGRLUC	0.0
CASME	MINFISH	0.0	MINMAZGL	0.0
CASME	MINBATLY	0.0	P.GER	0.0
CASME	P.FRA	0.0	P.BEL	0.0
CASME	P.ITA	0.0		

CASPROT	S.F.	0.0	M.E.	0.0
CASPROT	TDN	0.0	PROT.MIN	0.5000
CASPROT	PROT.MAX	0.5000	CR.FAT	0.0
CASPROT	CR.FIB	0.0	LYSINE	0.0
CASPROT	METH	0.0	METH+CYS	0.0
CASPROT	CAL.MIN.	0.0	CAL.MAX.	0.0
CASPROT	PHOSUP	0.0	BARLEY	0.0
CASPROT	WHEAT	0.0	MAIZE	0.0
CASPROT	LINOSEED	0.0	SOYBEAN	0.0
CASPROT	M.GLUTTN	0.0	COTTMEAL	0.0
CASPROT	LINOMEAL	0.0	GRNUTEXP	0.0
CASPROT	WH.MIDD	0.0	WH.BRAN	0.0
CASPROT	BEETPULP	0.0	BREWGRAN	0.0
CASPROT	CITRPULP	0.0	RICEBRAN	0.0
CASPROT	FISHMEAL	0.0	OYSTSHEL	0.0
CASPROT	MEATBONE	0.0	MOLASSES	0.0
CASPROT	TALLOW	0.0	RAPE	0.0
CASPROT	CASSAVA	0.0	M.TDN	0.0
CASPROT	MINMAIZ	0.0	MINGRLUC	0.0
CASPROT	MINFISH	0.0	MINMAZGL	0.0
CASPROT	MINBATLY	0.0	P.GER	0.0
CASPROT	P.FRA	0.0	P.BEL	0.0
CASPROT	P.ITA	0.0		
CASPLUS	S.F.	2.0000	M.E.	50.0000
CASPLUS	TDN	0.0200	PROT.MIN	0.5000
CASPLUS	PROT.MAX	0.5000	CR.FAT	0.0
CASPLUS	CR.FIB	0.0	LYSINE	0.0
CASPLUS	METH	0.0	METH+CYS	0.0
CASPLUS	CAL.MIN.	0.0	CAL.MAX.	0.0
CASPLUS	PHOSUP	0.0	BARLEY	0.0
CASPLUS	WHEAT	0.0	MAIZE	0.0
CASPLUS	LINOSEED	0.0	SOYBEAN	0.0
CASPLUS	M.GLUTTN	0.0	COTTMEAL	0.0
CASPLUS	LINOMEAL	0.0	GRNUTEXP	0.0
CASPLUS	WH.MIDD	0.0	WH.BRAN	0.0
CASPLUS	BEETPULP	0.0	BREWGRAN	0.0
CASPLUS	CITRPULP	0.0	RICEBRAN	0.0
CASPLUS	FISHMEAL	0.0	OYSTSHEL	0.0
CASPLUS	MEATBONE	0.0	MOLASSES	0.0
CASPLUS	TALLOW	0.0	RAPE	0.0
CASPLUS	CASSAVA	0.0	M.TDN	0.0
CASPLUS	MINMAIZ	0.0	MINGRLUC	0.0
CASPLUS	MINFISH	0.0	MINMAZGL	0.0
CASPLUS	MINBATLY	0.0	P.GER	0.0
CASPLUS	P.FRA	0.0	P.BEL	0.0
CASPLUS	P.ITA	0.0		

CASTON	S.E.	0.0	M.E.	0.0
CASTON	TDN	0.0200	PROT.MIN	0.5000
CASTON	PROT.MAX	0.5000	CR.FAT	0.0
CASTON	CR.FIB	0.0	LYSINE	0.0
CASTON	METH	0.0	METH+CYS	0.0
CASTON	CAL.MIN.	0.0	CAL.MAX.	0.0
CASTON	PHOSOP	0.0	BARLEY	0.0
CASTON	WHEAT	0.0	MAIZE	0.0
CASTON	LINDSEED	0.0	SOYBEAN	0.0
CASTON	M.GLUTEN	0.0	COTTMEAL	0.0
CASTON	LINDMEAL	0.0	GRNUTEXP	0.0
CASTON	WH.MIDD	0.0	WH.BRAN	0.0
CASTON	BEETPULP	0.0	BREWGRAN	0.0
CASTON	CITRPULP	0.0	RICEBRAN	0.0
CASTON	FISHMEAL	0.0	OYSTSHEL	0.0
CASTON	MEATBONE	0.0	MOLASSES	0.0
CASTON	TALLOW	0.0	RAPE	0.0
CASTON	CASSAVA	0.0	M.TON	0.0
CASTON	MINMAIZ	0.0	MINGRLUC	0.0
CASTON	MINFISH	0.0	MINMAZGL	0.0
CASTON	MINBATLY	0.0	P.GER	0.0
CASTON	P.FRA	0.0	P.BEL	0.0
CASTON	P.ITA	0.0		

ENDATA

Appendix E

LEAST-COST FEED RATIONS FOR VARYING CASSAVA PRICES, AND PRICE DATA

Table E.1

FEED RATIONS WITH VARIABLE CASSAVA PRICES

COW STANDARD

Price Increment*	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	69.53	71.62	73.29	73.99	74.55	75.08
Cereals	-	-	-	-	-	-
Cereal Byproducts	15.0	15.0	15.8	14.7	19.6	19.6
Oilseeds & Cakes	21.9	21.9	19.6	20.1	18.9	18.9
Animal Meal	5.0	5.0	5.0	5.0	4.1	4.1
Cassava	43.0	43.0	18.2	13.1	10.9	10.9
Other	15.0	15.0	41.1	46.8	46.1	46.1
GERMANY						
Cost	69.41	70.47	70.88	70.88	70.88	70.88
Cereals	-	-	-	-	-	-
Cereal Byproducts	12.0	41.8	38.0	38.0	38.0	38.3
Oilseeds & Cakes	23.4	10.0	10.0	10.0	10.0	10.0
Animal Meal	5.0	3.9	4.1	4.1	4.1	4.1
Cassava	28.3	9.5	0.2	0.2	0.2	-
Other	31.1	34.5	47.3	47.3	47.3	47.3
FRANCE						
Cost	66.34	66.34	66.34	66.34	66.34	67.47
Cereals	-	-	-	-	-	18.9
Cereal Byproducts	17.3	17.3	17.3	17.3	17.3	35.0
Oilseeds and Cakes	23.6	23.6	23.6	23.6	23.6	15.9
Animal Meal	4.0	4.0	4.0	4.0	4.0	1.5
Cassava	42.3	42.3	42.3	42.3	42.3	-
Other	12.7	12.7	12.7	12.7	12.7	28.6
BEL-LUX						
Cost	68.98	69.70	69.70	69.70	69.70	69.91
Cereals	-	-	-	-	-	-
Cereal Byproducts	20.4	46.9	46.9	46.9	46.9	43.9
Oilseeds & Cakes	21.0	10.0	10.0	10.0	10.0	10.0
Animal Meal	3.9	4.2	4.2	4.2	4.2	4.3
Cassava	21.1	5.2	5.2	5.2	5.2	-
Other	33.3	33.4	33.4	33.4	33.4	41.6
ITALY						
Cost	69.31	70.37	70.37	70.37	70.37	70.65
Cereals	-	-	-	-	-	10.2
Cereal Byproducts	12.0	41.8	41.8	41.8	41.8	38.5
Oilseeds & Cakes	23.4	10.0	10.0	10.0	10.0	10.0
Animal Meal	5.0	3.9	3.9	3.9	3.9	3.7
Cassava	28.3	9.5	9.5	9.5	9.5	-
Other	31.1	34.5	34.5	34.5	34.5	37.3

* +i = i x $5 + $65 = cassava price. Therefore +1 = cassava price of $70/metric ton.

Table E.1 (continued)

BEEF AND CALF

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	74.23	75.45	76.65	77.72	78.26	78.71
Cereals	-	-	-	-	-	-
Cereal Byproducts	16.3	16.3	16.6	15.0	15.0	15.0
Oilseeds & cakes	36.9	36.9	36.6	29.3	18.4	18.4
Animal Meal	5.0	5.0	5.0	5.0	5.0	5.0
Cassava	25.4	24.8	23.3	19.0	9.2	9.2
Other	16.2	16.7	18.2	31.5	52.2	52.2
GERMANY						
Cost	73.16	74.13	74.13	74.13	74.13	74.37
Cereals	-	-	-	-	-	-
Cereal Byproducts	20.8	40.0	40.0	40.0	40.0	59.5
Oilseeds & cakes	34.8	25.1	25.1	25.1	25.1	18.7
Animal Meal	5.0	5.0	5.0	5.0	5.0	5.0
Cassava	22.3	11.9	11.9	11.9	11.9	-
Other	16.8	17.8	17.8	17.8	17.8	16.5
FRANCE						
Cost	70.55	70.55	70.55	70.55	70.55	71.18
Cereals	- -	-	-	-	-	16.4
Cereal Byproducts	24.8	24.8	24.8	24.8	24.8	35.0
Oilseeds & cakes	34.2	34.2	34.2	34.2	34.2	28.8
Animal Meal	5.0	5.0	5.0	5.0	5.0	4.1
Cassava	21.7	21.7	21.7	21.7	21.7	-
Other	14.1	14.1	14.1	14.1	14.1	15.3
BEL-LUX						
Cost	72.60	72.60	72.60	72.60	72.60	73.33
Cereals	-	-	-	-	-	-
Cereal Byproducts	19.7	19.7	19.7	19.7	19.7	59.5
Oilseeds & cakes	35.8	35.8	35.8	35.8	35.8	18.8
Animal Meal	5.0	5.0	5.0	5.0	5.0	5.0
Cassava	22.7	22.7	22.7	22.7	22.7	-
Other	16.6	16.6	16.6	16.6	16.6	16.6
ITALY						
Cost	73.06	74.03	74.03	74.03	74.03	74.25
Cereals	-	-	-	-	-	11.4
Cereal Byproducts	20.8	40.0	40.0	40.0	40.0	40.0
Oilseeds & cakes	34.8	25.1	25.1	25.1	25.1	22.9
Animal Meal	5.0	5.0	5.0	5.0	5.0	5.0
Cassava	22.3	11.9	11.9	11.9	11.9	-
Other	16.8	17.8	17.8	17.8	17.8	20.4

Table E.1 (continued)

LAYER MEDIUM

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	95.03	96.13	97.24	98.35	99.22	100.04
Cereals	35.2	35.2	35.2	35.2	38.7	38.7
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cakes	13.9	13.9	13.9	13.9	13.3	13.3
Animal Meal	11.0	11.0	11.0	11.0	11.0	11.0
Cassava	22.8	22.8	22.8	22.8	16.9	16.9
Other	10.9	10.9	10.9	10.9	13.9	13.9
GERMANY						
Cost	89.17	90.15	90.90	90.90	90.90	91.20
Cereals	37.9	37.9	58.6	58.6	58.6	60.7
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	9.7
Oilseeds & cakes	14.6	14.6	10.2	10.2	10.2	9.1
Animal Meal	9.0	9.0	9.0	9.0	9.0	9.0
Cassava	19.4	19.4	3.0	3.0	3.0	-
Other	10.9	10.9	11.0	11.0	11.0	11.3
FRANCE						
Cost	75.89	75.89	75.89	75.89	75.89	75.89
Cereals	60.7	60.7	60.7	60.7	60.7	60.7
Cereal Byproducts	9.7	9.7	9.7	9.7	9.7	9.7
Oilseeds & cakes	9.1	9.1	9.1	99.1	9.1	9.1
Animal Meal	9.0	9.0	9.0	9.0	9.0	9.0
Cassava	-	-	-	-	-	-
Other	11.3	11.3	11.3	11.3	11.3	11.3
BEL-LUX						
Cost	87.04	87.58	87.73	87.73	87.73	87.88
Cereals	37.9	58.7	58.7	58.7	58.7	60.7
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	9.7
Oilseeds & cakes	14.6	10.2	10.2	10.2	10.2	9.1
Animal Meal	9.0	9.0	9.0	9.0	9.0	9.0
Cassava	19.4	3.0	3.0	3.0	3.0	-
Other	10.9	11.0	11.0	11.0	11.0	11.3
ITALY						
Cost	81.17	81.33	81.33	81.33	81.33	81.43
Cereals	58.7	58.7	58.7	58.7	58.7	61.5
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cakes	10.2	10.2	10.2	10.2	10.2	9.4
Animal Meal	9.0	9.0	9.0	9.0	9.0	8.8
Cassava	3.0	3.0	3.0	3.0	3.0	-
Other	11.0	11.0	11.0	11.0	11.0	12.0

Table E.1 (continued)

POULTRY GROWERS

Price Incremement	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	134.26	134.26	134.26	134.26	134.26	134.26
Cereals	59.8	59.8	59.8	59.8	59.8	59.8
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cakes	5.7	5.7	5.7	5.7	5.7	5.7
Animal meal	16.2	16.2	16.2	16.2	16.2	16.2
Cassava	-	-	-	-	-	-
Other	10.0	10.0	10.0	10.0	10.0	10.0
GERMANY						
Cost	112.02	112.02	112.02	112.02	112.02	112.15
Cereals	55.8	55.8	55.8	55.8	55.8	64.8
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cake	5.9	5.9	5.9	5.9	5.9	7.8
Animal Meal	17.3	17.3	17.3	17.3	17.3	16.3
Cassava	9.8	9.8	9.8	9.8	9.8	-
Other	3.0	3.0	3.0	3.0	3.0	3.0
FRANCE						
Cost	99.45	99.45	99.45	99.45	99.45	99.45
Cereals	64.8	64.8	64.8	64.8	64.8	64.8
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cake	7.8	7.8	7.8	7.8	7.8	7.8
Animal Meal	16.3	16.3	16.3	16.3	16.3	16.3
Cassava	-	-	-	-	-	-
Other	3.0	3.0	3.0	3.0	3.0	3.0
BEL-LUX						
Cost	108.91	108.91	108.91	108.91	108.91	108.91
Cereals	64.8	64.8	64.8	64.8	64.8	64.8
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cake	7.8	7.8	7.8	7.8	7.8	7.8
Animal Meal	16.3	16.3	16.3	16.3	16.3	16.3
Cassava	-	-	-	-	-	-
Other	3.0	3.0	3.0	3.0	3.0	3.0
ITALY						
Cost	105.43	105.43	105.43	105.43	105.43	105.47
Cereals	55.8	55.8	55.8	55.8	55.8	64.8
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cake	5.9	5.9	5.9	5.9	5.9	7.8
Animal Meal	17.3	17.3	17.3	17.3	17.3	16.3
Cassava	9.8	9.8	9.8	9.8	9.8	-
Other	3.0	3.0	3.0	3.0	3.0	3.0

Table E.1 (continued)

BROILER

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	103.34	105.37	107.40	109.07	110.36	111.27
Cereals	10.1	10.1	10.1	24.3	32.6	32.6
Cereal Byproducts	3.0	3.0	3.0	3.0	3.0	3.0
Oilseeds & cakes	16.8	16.8	16.8	20.6	23.7	23.7
Animal Meal	14.1	14.1	14.1	11.1	9.2	9.2
Cassava	41.7	41.7	41.7	26.7	18.7	18.7
Other	14.0	14.0	14.0	14.0	12.5	12.5
GERMANY						
Cost	94.12	95.87	97.42	98.09	98.09	98.27
Cereals	23.8	25.2	31.0	53.6	53.6	58.2
Cereal Byproducts	3.0	3.0	3.0	3.0	3.0	5.5
Oilseeds & cake	18.2	18.0	18.3	23.9	23.9	21.8
Animal Meal	14.3	14.2	13.6	9.0	9.0	9.2
Cassava	35.6	34.7	27.4	4.8	4.8	-
Other	4.9	4.6	6.4	5.4	5.4	5.0
FRANCE						
Cost	85.56	86.35	86.35	86.35	86.35	86.43
Cereals	40.0	55.1	55.1	55.1	55.1	58.2
Cereal Byproducts	3.0	3.0	3.0	3.0	3.0	5.5
Oilseeds & cake	19.6	23.5	23.5	23.5	23.5	21.8
Animal meal	12.0	9.0	9.0	9.0	9.0	9.2
Cassava	20.8	3.8	3.8	3.8	3.8	-
Other	4.2	5.2	5.2	5.2	5.2	5.0
BEL-LUX						
Cost	92.70	94.29	95.21	95.21	95.21	95.37
Cereals	28.8	32.8	55.1	55.1	55.1	58.2
Cereal Byproducts	3.0	3.0	3.0	3.0	3.0	5.5
Oilseeds & cake	16.8	17.5	23.5	23.5	23.5	21.8
Animal Meal	14.2	13.7	9.0	9.0	9.0	9.2
Cassava	33.1	29.1	3.8	3.8	3.8	-
Other	3.9	3.6	5.2	5.2	5.2	5.0
ITALY						
Cost	89.00	90.05	91.06	91.55	91.55	91.69
Cereals	40.0	40.0	40.0	55.1	55.1	58.2
Cereal Byproducts	3.0	3.0	3.0	3.0	3.0	5.5
Oilseeds & cake	19.6	19.6	20.2	23.5	23.5	21.8
Animal Meal	12.0	12.0	11.7	9.0	9.0	9.2
Cassava	20.8	20.8	18.9	3.8	3.8	-
Other	4.2	4.2	5.8	5.2	5.2	5.0

Table E.1 (continued)

BROILER FINISHERS

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	*89.86*	*92.38*	*94.90*	*97.17*	*98.81*	*100.42*
Cereals	-	-	-	10.4	18.1	20.0
Cereal Byproducts	8.0	8.0	8.0	8.0	8.0	8.0
Oilseeds & cakes	14.2	14.2	14.2	15.9	19.4	19.8
Animal Meal	10.3	10.3	10.3	8.7	6.5	6.2
Cassava	51.9	51.9	51.9	41.8	33.4	31.5
Other	14.8	14.8	14.8	15.0	14.3	14.3
GERMANY						
Cost	*85.55*	*87.85*	*89.92*	*91.40*	*91.98*	*92.00*
Cereals	13.1	15.5	20.1	33.5	50.7	53.0
Cereal Byproducts	8.0	8.0	8.0	8.6	18.0	18.0
Oilseeds & cake	15.5	15.4	15.7	20.7	16.4	16.2
Animal Meal	10.7	10.4	9.9	6.1	5.8	5.7
Cassava	47.6	44.5	38.4	23.5	2.3	-
Other	4.9	5.8	7.7	7.3	6.5	6.8
FRANCE						
Cost	*78.67*	*79.41*	*79.78*	*79.78*	*79.78*	*79.81*
Cereals	40.0	40.0	50.7	50.7	50.7	53.0
Cereal Byproducts	15.0	15.0	18.0	18.0	18.0	18.0
Oilseeds & cake	16.6	16.6	16.4	16.4	16.4	16.2
Animal Meal	6.6	6.6	5.8	5.8	5.8	5.7
Cassava	14.7	14.7	2.3	2.3	2.3	-
Other	6.9	6.9	6.5	6.5	6.5	6.8
BEL-LUX						
Cost	*84.60*	*86.75*	*88.29*	*88.89*	*88.89*	*88.94*
Cereals	14.8	20.1	33.5	50.7	50.7	53.0
Cereal Byproducts	8.0	8.0	8.6	18.0	18.0	18.0
Oilseeds & cake	15.6	15.7	20.7	16.4	16.4	16.2
Animal Meal	10.4	9.9	6.1	5.8	5.8	5.7
Cassava	45.7	38.4	23.5	2.3	2.3	-
Other	5.3	7.7	7.3	6.5	6.5	6.8
ITALY						
Cost	*82.44*	*83.58*	*84.35*	*85.11*	*85.42*	*85.42*
Cereals	33.7	40.0	40.0	40.0	51.8	53.0
Cereal Byproducts	8.0	12.7	12.7	12.7	18.0	18.0
Oilseeds & cake	20.7	18.8	18.8	18.8	16.2	16.2
Animal Meal	6.1	5.9	5.9	5.9	5.7	5.7
Cassava	23.8	15.2	15.2	15.2	1.2	-
Other	7.4	6.9	6.9	6.9	6.6	6.8

Table E.1 (continued)

PIG STARTERS

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	*83.42*	*85.43*	*87.44*	*89.24*	*90.79*	*92.22*
Cereals	-	-	-	-	-	-
Cereal Byproducts	20.0	20.0	20.0	34.5	34.5	45.0
Oilseeds & cakes	25.7	25.7	25.7	20.8	20.8	15.8
Animal Meal	8.2	8.2	8.2	8.3	8.3	8.5
Cassava	41.4	41.4	41.4	31.8	31.8	26.3
Other	4.4	4.4	4.4	4.3	4.3	4.1
GERMANY						
Cost	*78.10*	*80.17*	*82.08*	*83.28*	*84.26*	*85.18*
Cereals	-	-	-	-	-	-
Cereal Byproducts	20.0	20.0	20.0	45.0	50.0	53.2
Oilseeds & cakes	25.5	26.8	26.8	16.1	16.2	15.3
Animal Meal	6.2	5.3	5.3	7.7	6.2	6.4
Cassava	43.7	38.1	38.1	20.9	18.9	17.9
Other	4.2	9.5	9.5	10.0	8.5	6.9
FRANCE						
Cost	*77.33*	*78.36*	*78.70*	*78.86*	*78.95*	*79.04*
Cereals	-	8.8	19.2	30.0	30.0	30.0
Cereal Byproducts	40.2	52.9	43.0	34.3	34.3	34.3
Oilseeds & cakes	20.2	15.2	17.3	18.4	18.4	18.4
Animal Meal	4.5	6.6	5.7	5.8	5.8	5.8
Cassava	30.7	11.1	4.4	1.8	1.8	1.8
Other	4.1	5.1	10.1	9.4	9.4	9.4
BEL-LUX						
Cost	*77.80*	*79.87*	*81.15*	*82.09*	*82.98*	*83.81*
Cereals	-	-	-	-	-	2.5
Cereal Byproducts	20.0	20.0	50.0	53.2	55.6	55.5
Oilseeds & cakes	25.5	26.8	18.2	15.3	13.9	13.0
Animal Meal	6.2	5.3	4.4	6.4	7.5	8.6
Cassava	43.7	38.1	20.6	17.9	17.2	14.8
Other	4.2	9.5	6.5	6.9	5.4	5.4
ITALY						
Cost	*78.00*	*80.07*	*81.98*	*82.67*	*82.89*	*83.00*
Cereals	-	-	-	19.2	19.2	30.0
Cereal Byproducts	20.0	20.0	20.0	43.0	43.0	33.4
Oilseeds & cakes	25.5	26.8	26.8	17.3	17.3	18.5
Animal Meal	6.2	5.3	5.3	5.7	5.7	5.5
Cassava	43.7	38.1	38.1	4.4	4.4	1.0
Other	4.2	9.5	9.5	10.1	10.1	11.4

Table E.1 (continued)

PIG - 0 to 30 KG.

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	81.74	83.74	85.69	87.63	89.47	91.10
Cereals	10.0	10.0	10.0	10.0	10.0	10.0
Cereal Byproducts	5.4	10.0	10.0	10.0	17.0	17.0
Oilseeds & cakes	26.8	25.5	25.5	25.5	24.0	24.0
Animal meal	7.7	7.8	7.8	7.8	7.6	7.6
Cassava	43.3	40.0	40.0	40.0	33.4	33.4
Other	6.5	6.4	6.4	6.4	7.7	7.7
GERMANY						
Cost	77.58	79.35	80.84	82.27	83.53	84.64
Cereals	10.0	10.0	10.0	10.0	10.0	10.0
Cereal Byproducts	10.0	24.0	24.0	29.0	36.0	36.0
Oilseeds	23.3	17.9	17.9	18.3	16.9	17.0
Animal Meal	7.6	7.2	7.2	5.5	5.7	5.7
Cassava	40.8	29.6	29.6	26.6	22.1	22.1
Other	8.0	11.0	11.0	10.4	9.0	9.0
FRANCE						
Cost	75.47	76.97	77.70	78.23	78.75	79.26
Cereals	10.0	10.0	25.0	25.0	25.0	29.1
Cereal Byproducts	22.0	31.4	31.5	31.5	31.5	29.0
Oilseeds & cakes	20.7	18.0	16.8	16.8	16.8	17.1
Animal Meal	6.0	5.6	5.7	5.7	5.7	5.6
Cassava	33.6	25.0	10.4	10.4	10.4	8.0
Other	7.5	9.7	10.3	10.3	10.3	11.0
BEL-LUX						
Cost	76.88	78.54	79.98	81.25	82.36	83.43
Cereals	10.0	10.0	10.0	10.0	10.0	13.6
Cereal Byproducts	17.0	24.0	29.0	36.0	36.0	36.0
Oilseeds & cakes	20.8	17.9	18.3	16.9	16.9	16.7
Animal Meal	7.8	7.2	5.5	5.7	5.7	5.7
Cassava	36.4	29.6	26.6	22.1	22.1	18.5
Other	7.8	11.0	10.4	9.0	9.0	9.2
ITALY						
Cost	77.28	79.05	80.54	81.94	82.59	83.16
Cereals	10.0	10.0	10.0	22.3	25.0	25.0
Cereal Byproducts	10.0	24.0	24.0	29.0	27.7	31.4
Oilseeds & cakes	23.3	17.9	17.9	17.3	17.0	15.3
Animal Meal	7.6	7.2	7.2	5.5	5.9	7.4
Cassava	40.8	29.6	29.6	14.7	12.9	10.4
Other	8.0	11.0	11.0	10.9	11.2	10.3

Table E.1 (continued)

PIG 30 - 100 KG.

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	78.41	80.35	82.30	84.14	85.59	87.04
Cereals	10.0	10.0	10.0	10.0	10.0	10.0
Cereal Byproducts	10.0	10.0	10.0	17.0	17.0	17.0
Oilseeds & cakes	23.6	23.6	23.6	21.8	21.6	21.6
Animal Meal	8.0	8.0	8.0	7.2	7.2	7.2
Cassava	40.0	40.0	40.0	30.4	29.8	29.8
Other	8.1	8.1	8.1	13.3	14.2	14.2
GERMANY						
Cost	76.20	78.28	80.02	81.40	82.37	83.23
Cereals	10.0	10.0	10.0	10.0	10.0	10.0
Cereal Byproducts	10.0	10.0	10.0	29.0	39.0	39.0
Oilseeds & cakes	21.9	26.5	26.8	20.5	16.1	16.1
Animal Meal	5.8	4.7	4.9	3.4	3.5	3.5
Cassava	44.1	35.1	34.7	23.4	17.2	17.2
Other	8.0	13.4	13.2	13.4	14.0	14.0
FRANCE						
Cost	74.44	75.80	76.53	77.26	77.26	77.68
Cereals	10.0	20.0	20.0	20.0	20.0	29.8
Cereal Byproducts	18.9	29.0	29.0	29.0	29.0	37.8
Oilseeds & cakes	20.3	19.6	19.6	19.6	19.6	12.9
Animal Meal	4.0	3.2	3.2	3.2	3.2	3.1
Cassava	38.5	14.6	14.6	14.6	14.6	-
Other	8.0	13.4	13.4	13.4	13.4	16.1
BEL-LUX						
Cost	75.60	77.68	79.06	80.23	81.20	81.97
Cereals	10.0	10.0	10.0	10.0	10.0	24.1
Cereal Byproducts	10.0	10.0	29.0	29.0	39.0	39.0
Oilseeds & cakes	21.9	26.5	20.5	20.5	16.1	12.3
Animal Meal	5.8	4.7	3.4	3.4	3.5	3.6
Cassava	44.1	35.1	23.4	23.4	17.2	3.4
Other	8.0	13.4	13.4	13.4	14.0	17.3
ITALY						
Cost	75.90	77.98	79.72	80.91	81.49	81.89
Cereals	10.0	10.0	10.0	20.0	20.0	20.0
Cereal Byproducts	10.0	10.0	10.0	29.0	39.0	39.0
Oilseeds & cakes	21.9	26.5	26.8	19.6	14.6	12.8
Animal Meal	5.8	4.7	4.9	3.2	3.2	3.6
Cassava	44.1	35.1	34.7	14.6	8.5	7.7
Other	8.0	13.4	13.2	13.4	14.4	15.6

Table E.1 (continued)

SOWS

Price Increment	+1	+2	+3	+4	+5	+6
NETHERLANDS						
Cost	*76.78*	*79.45*	*81.91*	*84.17*	*86.26*	*87.98*
Cereals	-	-	-	-	-	-
Cereal Byproducts	1.6	1.6	10.0	13.5	15.0	35.0
Oilseeds & cakes	17.6	17.6	14.1	16.9	16.9	8.2
Animal Meal	10.4	10.4	10.4	8.8	8.3	9.0
Cassava	55.1	55.1	49.5	43.7	42.6	30.6
Other	15.0	15.0	15.7	17.0	16.9	16.9
GERMANY						
Cost	*74.00*	*76.02*	*77.70*	*79.12*	*80.30*	*81.47*
Cereals	-	-	-	-	-	-
Cereal Byproducts	10.0	30.9	30.9	45.0	46.4	46.4
Oilseeds & cakes	13.8	7.0	7.0	5.8	5.0	5.0
Animal Meal	10.4	10.2	10.2	7.9	8.0	8.0
Cassava	49.6	33.4	33.4	24.2	23.5	23.5
Other	16.0	18.2	18.2	16.9	16.9	16.9
FRANCE						
Cost	*72.19*	*73.74*	*74.75*	*75.58*	*75.58*	*75.91*
Cereals	-	-	10.0	10.0	10.0	21.3
Cereal Byproducts	35.0	39.2	42.9	42.9	42.9	50.0
Oilseeds & cakes	6.6	6.1	5.0	5.0	5.0	5.0
Animal Meal	8.9	8.5	8.3	8.3	8.3	6.6
Cassava	34.1	28.5	16.6	16.6	16.6	-
Other	15.0	17.4	17.0	17.0	17.0	17.0
BEL-LUX						
Cost	*73.43*	*75.12*	*76.71*	*78.03*	*79.20*	*80.11*
Cereals	-	-	-	-	-	16.0
Cereal Byproducts	30.0	30.9	36.8	46.4	46.4	51.1
Oilseeds & cakes	7.3	7.0	6.4	5.0	5.0	5.0
Animal Meal	10.3	10.2	8.4	8.0	8.0	6.4
Cassava	34.8	33.4	30.1	23.5	23.5	4.3
Other	17.3	18.2	17.9	16.9	16.9	17.0
ITALY						
Cost	*73.91*	*75.92*	*77.60*	*78.89*	*79.67*	*80.44*
Cereals	-	-	-	8.2	10.0	10.0
Cereal Byproducts	10.0	30.9	30.9	43.8	45.0	45.0
Oilseeds & cakes	13.8	7.0	7.0	5.0	5.0	5.0
Animal Meal	10.4	10.2	10.2	8.0	7.6	7.6
Cassava	49.6	33.4	33.4	17.8	15.3	15.3
Other	16.0	18.2	18.2	17.0	16.9	16.9

Table E.2

FEED RATIONS WITH VARIABLE CASSAVA PRICES: UNITED KINGDOM

Price Increment	0	1	2	3	4	5
DAIRY 3.5 GALLONS						
Cost	*74.33*	*76.65*	*78.48*	*79.48*	*80.22*	*80.32*
Cereals	-	-	-	-	-	11.7
Cereal Byproducts	15.0	15.0	45.0	47.9	43.5	47.7
Oilseeds & Cakes	30.3	30.3	15.6	14.6	19.3	14.4
Animal Meal	5.0	5.0	5.0	5.0	5.0	5.0
Cassava	39.9	39.9	22.7	20.5	14.3	-
Other	9.6	9.6	11.5	11.7	17.6	21.0
DAIRY 4.0 GALLONS						
Cost	*68.60*	*70.85*	*72.00*	*72.45*	*72.79*	*73.12*
Cereals	-	-	-	-	-	-
Cereal Byproducts	10.0	23.4	57.9	54.3	54.3	54.3
Oilseeds & Cakes	23.6	22.1	7.5	7.5	7.5	7.5
Animal Meal	5.0	2.1	2.5	2.6	2.6	2.6
Cassava	47.5	33.3	13.0	6.8	6.8	6.8
Other	13.6	18.8	18.9	28.5	28.5	28.5
BEEF FATTENING						
Cost	*66.76*	*68.10*	*68.63*	*68.69*	-	*68.72*
Cereals	-	-	-	-	-	-
Cereal Byproducts	12.6	35.0	36.4	36.4	36.4	38.4
Oilseeds & Cakes	13.4	10.2	7.5	7.5	7.5	7.5
Animal Meal	5.0	1.9	2.2	2.2	2.2	1.8
Cassava	42.2	13.7	1.4	1.4	1.4	-
Other	26.6	39.0	52.3	52.3	52.3	52.1
GRAZING CAKE						
Cost	*64.85*	*67.03*	*68.36*	*69.27*	*69.83*	*70.00*
Cereals	-	-	-	-	-	-
Oilseeds & Cake	13.5	10.2	7.5	7.5	7.5	7.5
Animal Meal	1.5	-	-	-	-	-
Cassava	40.6	33.9	18.9	18.9	8.6	-
Other	33.8	33.6	46.0	46.0	43.7	44.0
LAYER MEDIUM						
Cost	*79.21*	*81.89*	*84.06*	*85.86*	*87.49*	*87.92*
Cereals	-	7.2	11.3	24.7	24.7	55.2
Cereal Byproducts	15.0	15.0	15.0	15.0	15.0	15.0
Oilseeds & Cake	9.5	12.0	13.4	10.0	10.0	7.5
Animal Meal	12.9	12.0	10.9	11.4	11.4	9.2
Cassava	54.1	46.2	41.7	33.6	33.6	-
Other	8.3	7.3	7.5	5.0	5.0	12.8

Table E.2 (continued)

Price Increment	0	1	2	3	4	5
POULTRY GROWER						
Cost	*75.59*	*78.71*	*81.19*	*82.91*	*84.54*	*85.06*
Cereals	-	-	15.2	25.6	25.6	47.1
Cereal Byproducts	15.0	15.0	15.0	15.0	15.0	35.5
Oilseeds & Cake	12.5	19.7	22.0	20.2	20.2	12.6
Animal Meal	12.2	6.9	3.3	3.7	3.7	2.3
Cassava	59.7	54.5	40.6	33.5	33.5	-
Other	0.4	3.7	3.6	1.8	1.8	2.3
BROILER						
Cost	*103.00*	*103.73*	*104.33*	*104.83*	-	*104.93*
Cereals	40.3	40.3	40.3	47.8	47.8	54.1
Cereal Byproducts	12.5	12.5	12.5	12.5	12.5	12.5
Oilseeds & Cake	14.6	14.6	14.6	17.0	17.0	15.0
Animal Meal	16.3	16.3	16.3	15.1	15.1	15.1
Cassava	12.3	12.3	12.3	3.7	3.7	-
Other	3.7	3.7	3.7	3.7	3.7	2.6
BROILER FINISHING						
Cost	*100.18*	*101.24*	*102.22*	*103.07*	-	*103.08*
Cereals	35.6	36.4	37.0	44.6	44.6	54.4
Cereal Byproducts	12.5	12.5	12.5	12.5	12.5	12.5
Oilseeds & Cake	10.3	10.7	10.7	13.0	13.0	16.8
Animal Meal	16.4	16.1	16.2	15.0	15.0	12.4
Cassava	21.2	20.5	19.7	11.0	11.0	-
Other	3.7	3.7	3.7	3.7	3.7	3.7
PIG GROWER						
Cost	*70.73*	*73.78*	*75.75*	*77.29*	*78.69*	*80.03*
Cereals	-	-	-	-	-	-
Cereal Byproducts	10.0	10.0	40.0	47.7	50.0	50.0
Oilseeds & Cake	24.0	24.0	14.6	10.9	10.1	9.7
Animal Meal	6.0	6.0	4.6	4.7	4.4	4.6
Cassava	53.9	53.9	35.5	31.5	27.7	27.3
Other	5.8	5.8	5.1	5.0	7.6	8.2
PIG FATTENING						
Cost	*67.97*	*71.12*	*73.29*	*75.07*	*76.83*	*78.31*
Cereals	-	-	-	-	-	-
Cereal Byproducts	10.0	10.0	45.6	45.6	44.5	50.0
Oilseeds & Cake	16.7	16.7	5.0	5.0	5.0	5.0
Animal Meal	5.5	5.5	4.3	4.3	3.5	3.6
Cassava	57.7	57.7	36.7	36.7	32.6	28.1
Other	9.9	9.9	8.2	8.2	14.1	13.1

Table E.3

PRICES OF FEED INGREDIENTS IN EEC MEMBER COUNTRIES
$/METRIC TON, 1971

	France	Germany	Italy	Belgium-Luxembourg	Nether-Lands
Sorghum	87.50	97.01	96.06	93.21	95.11
Barley	89.42	99.45	97.17	96.19	98.42
Wheat	100.44	112.20	118.68	109.87	110.78
Maize	76.08	100.89	84.76	95.47	97.29
Linseed	131.55	131.55	131.55	131.55	131.55
Soybean	147.48	147.48	147.48	147.48	147.48
Maize Glutten	79.65	79.65	79.65	79.65	79.65
Cotton Meal	102.74	102.74	102.74	102.74	102.74
Linseed Exp	95.44	95.44	95.44	95.44	95.44
Groundnut	131.08	131.08	131.08	131.08	131.08
Wheat Middl	69.26	76.79	76.03	73.77	75.28
Wheat Bran	76.64	84.97	84.13	81.63	83.30
Beet Pulp	71.44	71.44	71.44	71.44	71.44
Brewers Grain	76.54	84.86	84.03	81.54	83.20
Citrus Pulp	63.88	63.88	63.88	63.88	63.88
Rice Bran	60.94	67.56	66.90	64.92	66.24
Fish Meal	191.47	191.47	191.47	191.47	191.47
Oyster Shell	27.28	27.28	27.28	27.28	27.28
Meat and Bone	103.92	103.92	103.92	103.92	103.92
Molasses	48.00	48.00	48.00	48.00	48.00
Tallow	199.15	199.15	199.15	199.15	199.15
Rape Ext	66.98	66.98	66.98	66.98	66.98
Cassava	65.00	65.00	65.00	65.00	65.00
Grassmeal	73.33	73.33	73.33	73.33	73.33
Alfalfa Meal	65.08	65.08	65.08	65.08	65.08
Soybean Meal	103.65	103.65	103.65	103.65	103.65
Sunflower	87.16	87.16	87.16	87.16	87.16
Oats	89.35	95.66	104.76	103.46	92.71

NOTE:

1. a) (Wheat, barley, oats and maize) - Market price in 1971 was obtained from the publication, "Background to the EEC Cereal Market, Home Grown Cereals Authority, Haymarket March 1972"; b) the price to the end user was available for Netherlands; c) from this, the price to the end user in other EEC member countries was obtained on a pro rata basis, on the assumption that the price relativities would be maintained.

2. (Sorghum, wheat middlings, wheat bran, brewers grain and rice bran) - a) An average of the price relativity of each of the member countries with respect to Netherlands was calculated; b) this was used to estimate the prices in the member countries from the prices given in Netherlands.

3. For the rest of the feed ingredients, the prices in other member countries were assumed to be the same as those prevailing in Netherlands.

Table E.4

ESTIMATED UNITED KINGDOM PRICES OF RAW MATERIALS
DURING TRANSITION TO EEC PRICES 1973-1978

(£/longton)

	(Feb) 1973		(Feb) 1974		(Feb) 1975	
	LOW	HIGH	LOW	HIGH	LOW	HIGH
Wheat	31.0	31.0	34.0	34.5	36.5	37.5
Denatured Wheat	25.0	25.0	28.0	28.5	30.5	31.5
Barley	26.0	26.0	28.5	29.5	31.0	32.0
Maize	28.5	28.5	31.0	31.0	33.5	34.0
Rye	24.0	24.0	27.5	27.5	31.0	32.0
Oats	27.0	27.0	29.5	29.5	32.0	32.5
Sorghum	27.5	27.5	30.0	30.5	33.0	33.5
Millet/Buckwheat	27.0	27.0	29.5	29.6	32.0	32.5
(European Maize)	24.5		27.0		30.0	
Soyabean Ext	53.5	54.5	51.5	53.5	50.5	53.5
Rapeseed Ext	34.0	35.0	33.0	34.0	32.0	34.0
Sunflower Ext	42.5	43.5	43.0	42.5	42.0	42.5
Groundnut Exp	52.5	53.5	50.5	52.5	50.0	52.5
Groundnut Ext	50.5	51.5	48.5	50.5	48.0	50.5
Cotton Exp	48.0	48.5	46.5	48.0	45.5	48.0
Cotton Ext	40.0	41.0	39.0	40.0	38.5	40.0
Linseed Exp	48.5	49.5	47.0	48.5	46.0	48.5
Coconut Exp	40.0	40.5	38.5	40.0	38.0	40.0
Fish Meal 65%	94.0	96.0	90.0	94.0	89.5	94.0
Meat Meal	56.0	57.0	54.0	56.0	53.5	56.0
Wheatbran	31.0	31.0	32.0	32.5	33.0	33.5
Wheat Middlings	28.0	29.0	29.5	30.0	30.5	30.5
Maize Meal	35.5	35.5	36.5	37.0	37.5	38.0
Pollard Pellets	29.0	29.0	30.0	30.5	31.0	31.5
Brewers Grains	33.0	33.0	34.0	34.5	35.0	35.5
Rolled Barley	30.0	30.0	32.5	33.5	35.0	36.0
Flaked Maize	35.5	35.5	38.0	38.0	40.5	41.0
Rice Bran	36.0	36.0	37.0	37.5	38.0	39.0
Rice Bran Ext	26.5	27.0	26.5	27.5	26.5	28.0
Beet Pulp	31.0	31.5	31.0	32.0	31.0	33.0
Maize Gluten Feed	36.0	36.5	36.0	37.0	36.0	38.0
Lucerne Meal	30.5	31.0	30.5	31.5	30.5	32.5
Grass Meal	29.0	29.5	29.0	30.0	29.0	31.0
Dried Peas	42.0	42.5	42.0	43.5	42.0	44.0
Citrus Pulp	27.0	27.5	27.0	28.0	27.0	28.5
Sliced Potatoes	24.0	24.5	24.0	25.0	24.0	25.5
Manioc	27.0	27.5	27.0	28.0	27.0	28.5

Table E.4 (continued)

	(Feb) 1976		(Feb) 1977		(Feb) 1978	
	LOW	HIGH	LOW	HIGH	LOW	HIGH
Wheat	39.0	41.0	42.0	44.5	48.5	53.0
Denatured Wheat	33.0	35.0	35.5	38.0	41.5	46.5
Barley	34.0	35.5	36.5	39.0	42.5	47.0
Maize	36.0	37.0	38.5	40.5	44.5	48.5
Rye	35.0	36.0	38.5	41.0	47.0	51.0
Oats	34.5	35.5	37.0	39.0	42.5	46.5
Sorghum	35.5	36.5	38.0	40.0	43.5	48.0
Millet/Buckwheat	35.0	36.0	37.5	39.0	43.0	47.0
(European Maize	32.0		35.0		40.0	
Soyabean Ext	49.5	53.5	48.5	53.5	48.5	54.5
Rapeseed Ext	31.5	34.0	31.0	34.0	31.0	35.0
Sunflower Ext	41.0	42.5	40.0	42.5	40.0	43.5
Groundnut Exp	47.0	50.5	46.0	50.5	46.0	51.5
Groundnut Ext	45.0	48.5	44.0	48.5	44.0	49.5
Cotton Exp	44.5	48.0	43.5	48.0	43.5	48.5
Cotton Ext	37.5	40.0	36.5	40.0	36.5	41.0
Linseed Exp	45.0	48.5	44.0	48.5	44.0	49.5
Coconut Exp	37.0	40.0	36.0	40.0	36.0	40.5
Fish Meal 65%	88.5	94.0	87.0	94.0	87.0	96.0
Meat Meal	52.0	56.0	51.0	56.0	51.0	57.0
Wheatbran	34.0	35.0	35.0	36.5	37.0	39.0
Wheat Middlings	31.0	32.0	32.0	33.5	34.0	36.0
Maize Meal	38.5	39.5	39.5	41.0	41.5	43.5
Pollard Pellets	32.0	32.0	33.0	34.5	35.0	37.0
Brewers Grains	36.0	36.0	37.0	38.5	39.0	41.0
Rolled Barley	38.0	39.5	40.5	43.0	44.5	51.0
Flaked Maize	43.0	44.0	45.5	47.5	51.5	55.5
Rice Bran	39.0	40.5	40.0	42.0	42.0	44.5
Rice Bran Ext	26.5	28.5	26.5	29.0	26.5	29.5
Beet Pulp	31.0	33.5	31.0	34.0	31.0	35.0
Maize Gluten Feed	36.0	38.5	36.0	39.0	36.0	40.0
Lucerne Meal	30.5	33.0	30.5	33.5	30.5	34.5
Grass Meal	29.0	31.5	29.0	32.0	29.0	33.0
Dried Peas	42.0	45.0	42.0	45.5	42.0	46.5
Citrus Pulp	27.0	29.5	27.0	30.0	27.0	31.0
Sliced Potatoes	24.0	26.0	24.0	26.5	24.0	27.0
Manioc	27.0	29.5	27.0	30.0	27.0	31.0

Appendix F

CROSS-SECTIONAL ANALYSIS OF CONSUMPTION OF CASSAVA IN BRAZIL

Table F.1

Brazilian Consumption Models, Cross Sectional Data
(Fresh Cassava)

	Linear Relationship				Logarithmic Relationship			
	α	β (t-value)	r^2	F-value	α	β (t-value)	r^2	F-value
Urban Areas								
- Brazil	1.73604	.00099 (3.48)	63.39	12.12	-1.955	0.45195 (6.27)	84.9	39.36
- Northeast	0.61535	-0.00013 (0.69)	6.31	0.47	3.68238	-0.8532 (1.43)	22.62	2.05
- East	2.31984	.00199 (7.39)	88.64	54.61	-1.4113	0.43611 (13.82)	96.46	190.9
- South	1.84703	.00069 (1.64)	27.70	2.68	-2.8355	0.57049 (3.39)	62.21	11.52
Rural Areas								
- Brazil	24.25976	-0.00152 (0.83)	8.9	0.68	3.13703	-0.00317 (0.05)	0.03	0.
- Northeast	10.25895	-0.00256 (1.25)	18.32	1.57	9.01852	-1.2934 (1.59)	26.55	2.53
- East	19.36012	-0.00124 (0.36)	1.85	0.13	2.88302	-0.00778 (0.06)	0.06	0.
- South	45.36469	-0.00062 (0.17)	0.4	0.03	3.70102	0.01409 (0.24)	0.81	0.06

Table F.1 (continued)

Brazilian Consumption Models, Cross Sectional Data
(Cassava Flour)

	Linear Relationship				Logarithmic Relationship			
	α	β (t-value)	r^2	F-value	α	β (t-value)	r^2	F-value
Urban Areas								
- Brazil	12.00853	- .00149 (4.31)	72.62	18.57	2.9635	-0.0974 (3.2)	59.44	10.26
- Northeast	25.07498	- .00411 (4.77)	76.46	22.74	3.95875	-0.1473 (3.96)	69.17	15.71
- East	11.53424	-0.00026 (0.48)	3.21	0.23	2.29849	0.01988 (0.52)	3.71	0.27
- South	4.63895	- .00102 (3.16)	58.79	9.98	2.76045	-0.2409 (5.02)	78.24	25.17
Rural Areas								
- Brazil	38.55973	0.00115 (0.46)	2.88	0.21	3.50996	0.02546 (0.54)	4.	0.29
- Northeast	66.36729	0.00576 (1.05)	13.63	1.1	3.88345	0.05938 (1.04)	13.37	1.08
- East	32.57811	-0.00516 (2.56)	48.3	6.54	3.96002	-0.10536 (1.47)	23.47	2.15
- South	13.09487	0.00249 (1.16)	16.15	1.35	2.31686	0.05451 (0.45)	2.79	0.2

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