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THE INTENSITY AND INTERDEPENDENCE OF GROSS RETURN AND FACTORS OF PRODUCTION IN AGRICULTURE

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BY

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Preface

This study was conducted at the Agricultural Economics Research Institute and the Institute of Economics of Helsinki University in 1969. Following its completion, its authors now wish to express their thanks to the persons who made their own contribution to this study. Timo Pekkonen, student of mathematics, is responsible for statistical data analysis and computer programs. Mr. Heikki Järvelä and Mr. Juhani Ikonen have in many ways helped prepare the material for computer analysis. The study was translated by Mr. Jarmo Jaakola. To all the aforementioned persons as well as the institute staff, we want to express our thanks. Also, our thanks go to the National Research Council for Agriculture and Forestry and the Kyösti Haataja Foundation for granting funds whereby part of this study has been financed.

Helsinki, October, 1969

Authors

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Introduction

The purpose of this study is to examine the size, variations and interdependence of agricultural production and the factors influencing it in terms of the information obtained from bookkeeping farms in South Finland. Examined in the study are of ordinary mean values of various factors, the information obtained from them and efforts are made to estimate production functions on the basis of the material gained from bookkeeping farms. This is done in order to give a picture of the impact of different production factors, inputs, on the volume of production and farm management in general. The results obtained can be used later on in connection with various conclusions with regard to the profitability of different inputs used in agriculture. Giving an impetus to the study has been a partial transfer of bookkeeping farm results to punched cards in 1968, facilitating a fairly extensive use of bookkeeping results in computer programs. For this reason, it has been possible to measure the applicability and drawbacks of punched card material plus provide hints as to how material analysis should be developed in order to serve research and practical needs in the best possible manner.

Because there are considerable differences in agricultural production between the farms with respect to the production branch involved (cf. f.ex. SUOMELA 1952, TORVELA 1966), there are justifiable grounds for grouping the farms in terms of their size and the current production line in this examination of the use of various production factors and the dispersal of various factors. The same grouping has been used in that part of the study which is concerned with an examination of the impact of various factors on return with the help of production functions. Because the material consists only of farms located in South Finland, the production lines exhibit greater differences than the national average since the possibilities for diversified production elsewhere in the country are smaller than in its southern part. The period covered by this study is fiscal 1967 and the region South Finland (cf. A Study of Agricultural Profitability in Fiscal 1967).

In 1967, a total of 618 farms took part in the profitability survey as shown below. The table also shows average farm size and average forest land size.

Arable land, hectares	Number of farms	Arable land, average, hectares	Forest land, average, hectares
Under 10	115	7.46	18.70
10-20	226	14.67	31.50
20-30	115	24.64	52.40
30-50	109	37.99	90.30
50-	53	68.29	126.20
Total/Average	618	23.89	51.50

The average size of arable land on the bookkeeping farms in South Finland - nearly 24 hectares - clearly exceeds the national average which is now about 9 hectares. Farms in South Finland are also generally smaller than those regularly involved in bookkeeping. Also, the bookkeeping farms exhibit a greater cultivation intensity than what is the average. No exact studies on this score have been conducted recently but according to some investigations (cf. f.ex. SUOMELA 1958), return and cost entries on the bookkeeping farms were 20 per cent higher than the national average in the early 1950s. Of course, this must be taken into consideration in any examination or generalization of the results of this study.

Although this study is concentrated on an analysis of agricultural production, forestry is often closely related to farm income and the return yielded by the farm. It is to be noted that apart from agricultural production proper, the smaller farms have nearly 20 hectares of forest land while the corresponding figure for the bigger farms in some 100 hectares or more. In part, this affects the use of human labor and other aspects of agriculture.

This study is not directly concerned with an examination of forestry except in some instances in connection with an examination of the farmer's labor input. Also, income from by-enterprises outside the farm is examined only as regards human labor.

This study is based on the aforementioned 615 farms. Results from 3 bookkeeping farms were so defective that they were excluded. The farms are grouped into 3 categories in terms of the size of arable land: 115 farms of less than 10 hectares of arable land, 226 farms of 10 to 20 hectares of arable land and 274 farms of more than 20 hectares of arable land. Because the intensity analysis of certain factors has been performed in terms of production lines, the number of farms in each group would have been too small if the farms had been divided into more than 3 categories.

The categorization of the farms in terms of different production lines is based on the formation of gross return (cf. also Torvela 1966, p. 53). The farms are divided into 2 main groups. Included among domestic animal-oriented farms are those on which animal husbandry return has been more than 50 per cent of gross return. This group has been divided into subdivisions with farms on which animal husbandry return is more than 80 per cent and 50 to 79.9 per cent forming separate subdivisions. In addition, farms on which pig husbandry return has been more than 20 per cent of gross return have been examined separately. Plant cultivation-oriented farms are divided into 2 groups. One group consists of farms on which the return yielded by sugar beet cultivation has been more than 20 per cent of gross return. As regards differences in production lines, it is to be noted that because of diversified agricultural production, the number of completely and clearly specialized farms is small and for this reason, the line separating various production lines from each other is not always very clear.

The early part of this study is concerned with a detailed examination of the level of and variations in return and production factors with the help of arithmetic mean values. Also, efforts have been made to examine just to what extent interesting information is contained in the said mean values.

Variations in the input intensity level, examined in the early part of this study, must be large enough to facilitate a successful production function analysis because that makes parameter estimates as reliable as possible. Another prerequisite is that a correct production function model is found. This requires, to begin with, the disclosure of all factors influencing return. Attemts have been made in the present study to solve this problem, among other things, with the help of factor analysis. A factor analysis may be applied to a preparatory analysis in an examination of the interdependence of various factors and, above all, of the existence of such factors as affect the return but are not usually measured. Factor analyses are used quite extensively in psychology, for instance. In agriculture, factor analysis has been used in the examination of the effect of human factors, for instance (cf. f.ex. TAURIAINEN 1966, VAINIO-MATTILA 1966).

The latter part of this study consists of a production function analysis. In this connection, the applicability of the transcendental type of function used here to the problem under examination has been studied and its variations have been expressed by different parameter values. The production functions are estimated by using, in the first phase, all the variables given by factor analysis and logical deduction as explanatory variables. A so-called selective regression analysis has been applied in the second phase. This selects from a given number of variables those whose coefficients are statistically significant. Of course, the number of coefficients thereby depends on how significant the coefficients have to be.

The results of the production function analysis may be applied f.ex. in an examination of just how profitably the use of various production factors and the entire production have been arranged in each farm category. Other interesting things, even theoretical, may also be revealed by the estimated models, such as maximum return in terms of each production factor. The last-mentioned special analysis is, however, so extensive and multi-faceted as to require a separate study. This study is confined to an examination of the points referred to earlier.

I. THE INTENSITY AND VARIATION OF CERTAIN FACTORS ON THE FARMS EXAMINED IN THIS STUDY

1. Variations in return

A. Variations in gross return

Gross return in agriculture[1] per hectare of arable land[2] was 1,452 marks in fiscal 1967 in South Finland. On the average, smaller farms exhibited the greatest intensity as shown, for instance, by the fact that gross return on farms of less than 10 hectares of arable land was 2 035 marks per hectare and averaged 1 525 marks on farms of 10 to 20 hectares. By the some token, gross return on farms of more than 20 hectares average 1 374 marks (Table 1).

Table 1. Variations in gross return between farms of different sizes

Arable land	Average gross return marks/hectare	Gross return minimum marks/hectare	Gross return maximum marks/hectare
Under 10 hectares	2 035	413	7 759
10-20 "	1 525	591	3 500
20- "	1 374	608	3 764
Average	1 452		

Worth particular attention as far as gross return is concerned is the extent of the dispersal of results. In the use of bookkeeping results for various purposes, it is a fairly common practice to examine just the mean values of relatively large groups only in spite of the dispersity of results. In most cases, the groups are formed on the basis of the size of arable land. If the grouping is detailed

[1] As regards the methods whereby gross return in agriculture is calculated, see the following studies: PIHKALA, RURIK 1943 and MÄKI, ANTTI 1953.

[2] The size of arable land is given in terms of adjusted hectares (cf. Investigations on the Profitability of Agriculture in Finland. Business Year 1967, p. 12).

enough, it is clear that the farms examined are nearly equal in terms of their size. However, the dispersity of results between various farms is so marked - largely due to variations in intensity, the production line involved etc. - that a mean value does not alone describe with adequate accuracy the factor. It is to be noted, however, that gross return per hectare of arable land on farms of less than 10 hectares ranged from 413 marks to 7 759 marks. In case the classification of farms in terms of their size only is considered adequate, variations in gross return, for instance, between various farms are so sharp that no far-reaching conclusions can be drawn, on the strength of the mean values, about the return and its formation.

Despite the fact that in the following examination, the farms are divided into different groups in terms of the production line involved, there are considerable variations in the formation of production between the groups. Average gross return rates in the various groups are as shown in Table 2.

As regards the intensity, it may be noted that in terms of gross return per hectare of arable land, the farms specialized in growing sugar beet were the most intensive ones. Upon an examination of gropland use, it may be noted that these farms grew the beet on a fairly large scale. On farms of less than 10 hectares, for instance, nearly 60 per cent of arable land was under sugar beet cultivation. By the same token, the figure on farms of 10 to 20 hectares and on farms of more than 20 hectares averaged about 20 per cent.

If production intensity is assessed solely on the basis of gross return per hectare, farms specialized in animal husbandry show the most extensive cultivation. The fact that a farm has specialized in milk production does not generally increase the return. On the other hand, farms specialized to a large extent in pig husbandry indicate that this move has clearly increased the intensity as expressed in pecuniary terms.

Table 2. Variations in gross return between farms representing different lines of production

	Animal husbandry-oriented			Plant cultivation-oriented		Average
	Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	Total
Farms of less than 10 hectares						
Number of farms	49	36	17	2	11	115
Gross return, marks/hectare	1 753	2 096	2 221	3 802	2 491	2 035
Ratio	86	103	109	187	122	100
Dispersal $s_{\bar{x}}$	596	978	1 773	55	2 038	1 168
				range = 413 - 7 759		
Farms of 10 to 20 hectares						
Number of farms	79	78	45	7	17	226
Gross return, marks/hectare	1 462	1 401	1 837	2 252	1 256	1 525
Ratio	96	92	120	148	82	100
Dispersal $s_{\bar{x}}$	400	442	830	456	476	572
				range = 591 - 3 500		
Farms of more than 20 hectares						
Number of farms	31	86	51	8	98	274
Gross return, marks/hectare	1 188	1 364	1 753	1 768	1 211	1 374
Ratio	86	99	128	129	88	100
Dispersal $s_{\bar{x}}$	416	442	777	345	371	536
				range = 608 - 3 764		

B. Return of animal husbandry and its formation

Although the farms examined here represent different production lines as mentioned in this study, we may, however, take note of the relatively great importance of milk production in a number of other groups than those specialized in milk production (Table 3). This is because specialization has obviously occurred in many individual cases through an increase in the cultivation of a special product without an essential decrease in milk production. It is to be noted, however, that differences are found between farms of different sizes. Farms specialized in pig husbandry have clearly cut back milk production, a fact particularly in evidence on small farms. On the other hand, farms of less than 10 hectares growing sugar beet have produced fairly large quantities of milk. It is natural, then, that the additional amount of feed arising from sugar beet culture, particularly on small farms, makes possible intensive milk production. It may be noted here that on farms of less than 10 hectares which have specialized in sugar beet culture, dairy husbandry has yielded an average of 1 000 marks per hectare. The corresponding figure on farms of 10 to 20 hectares has averaged 436 marks and on farms of more than 20 hectares 260 marks per hectare.

Farms particularly specialized in meat production are not included in this study. The return yielded by cattle husbandry indicates the return coming, apart from milk production, from the sale and consumption of beef on the farm.

As regards pig husbandry, it may be noted that farms of less than 10 hectares of arable land have been run most intensively. On these farms, pig husbandry yielded an average of 1 035 marks, on farms of 10 to 20 hectares 784 marks and on farms of more than 20 hectares 816 marks per hectare. Table 3 also shows the number of farms with no pig husbandry.

Because of the relatively small number of farms specialized in poultry keeping, the material examined in this study does not provide a representative picture of this branch of production. It is to be noted, however, that some measure of poultry husbandry, in most cases chicken husbandry, is practiced on a minor scale along with agricultural production. Of the 115 farms of less than 10 hectares, 54 or about one-half have reported no income from poultry keeping. Of the 226 farms of 10 to 20 hectares, 105 have reported no income from poultry keeping and of the 274 farms of more than 20 hectares, 118 have reported no income from poultry keeping.

Apart from the average figures for various production items, Table 3 also shows the corresponding standard deviations. Also, it shows the range of each item and the number of observations with a zero value in each category[1]. A similar practice has been followed in other contexts as well.

C. Return of plant cultivation and its formation

The formation of the return yielded by plant cultivation has been examined on the basis of the yield gained from growing bread grains, wheat and rye, potato and sugar beet (cf. Table 5). As regards bread grain culture, it has been of relatively minor significance and has been practiced on a relatively minor-scale on the farms examined in this study, particularly on the small farms (Table 4).

The extent of bread grain, rye and spring wheat, culture has average 5.5 per cent on farms of less than 10 hectares. In this connection, arable land under bread grain cultivation also includes land used for growing rye and spring wheat. Farm land set aside for

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1) n_o = the frequency of zero values in the entire group

Vv = the range in the entire group, the smallest value $\neq 0$ inside brackets

s_x = standard deviation

Table 3. Animal husbandry return, its formation and variations on farms representing different lines of production

		Animal husbandry-oriented			Plant cultivation-oriented		Average
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		Farms of less than 10 hectares					
		1.	2.	3.	4.	5.	6.
Cattle	marks/hectare	255	195	188	117	62	206
	s_x	133	115	124	134	92	133
			n_o = 7	Vv = 0 - (1) - 654			
Milk production	marks/hectare	1 034	932	613	1 000	161	856
	s_x	356	436	354	346	349	460
			n_o = 8	Vv = 0 - (45) - 1 898			
Pigs	marks/hectare	58	89	1 035	54	301	235
	s_x	70	139	1 353	76	887	672
			n_o = 44	Vv = 0 - (17) - 2 968			
Poultry	marks/hectare	167	285	27	0	46	169
	s_x	359	779	101	0	129	503
			n_o = 54	Vv = 0 - (1) - 3 930			
Animal husbandry return, total	marks/hectare	1 552	1 525	1 889	1 172	575	1 493
	s_x	557	753	1 566	401	889	910
			n_o = 3	Vv = 0 - (191) - 3 930			

		1.	2.	3.	4.	5.	6.
Farms of 10 to 20 hectares							
Cattle	marks/hectare	200	170	155	170	63	162
	s_x	92	90	78	157	83	99
				n_o = 5	Vv = 0 - (1) - 266		
Milk production	marks/hectare	902	648	528	436	125	667
	s_x	250	236	354	348	166	343
				n_o = 10	Vv = 0 - (185) - 1 538		
Pigs	marks/hectare	88	48	784	166	1	209
	s_x	102	73	465	204	5	364
				n_o = 81	Vv = 0 - (8) - 1 342		
Poultry	marks/hectare	90	77	78	24	44	78
	s_x	260	245	428	58	79	284
				n_o = 105	Vv = 0 - (1) - 1 462		
Animal husbandry return, total	marks/hectare	1 299	956	1 517	798	248	1 129
	s_x	366	305	680	407	231	538
				n_o = 3	Vv = 0 - (128) - 3 125		
Farms of more than 20 hectares							
Cattle	marks/hectare	163	140	82	82	52	99
	s_x	110	68	62	63	62	82
				n_o = 24	Vv = 0 - (6) - 217		
Milk production	marks/hectare	664	597	380	206	135	388
	s_x	252	258	260	231	179	315
				n_o = 46	Vv = 0 - (12) - 2 023		
Pigs	marks/hectare	55	64	816	109	72	207
	s_x	63	87	792	275	185	466
				n_o = 114	Vv = 0 - (2) - 1 870		
Poultry	marks/hectare	133	76	29	49	37	59
	s_x	463	246	112	130	100	223
				n_o = 118	Vv = 0 - (1) - 737		
Animal husbandry	marks/hectare	1 028	889	1 312	447	303	761
	s_x	376	317	730	328	275	568
				n_o = 18	Vv = 0 - (6) - 2 400		

growing winter wheat which has been of some significance on a number of farms, has not been taken into consideration. The size of cropland under bread grain culture was, in relative terms, largest on farms not growing sugar beet. On these farms, arable land under rye and spring wheat cultivation totalled 11.3 per cent of the total. On farms of 10 to 20 hectares, the size of arable land under bread grain culture has average 11.4 per cent of the total. On plant culture farms proper in this category, it has totalled 38.1 per cent. Also, on farms specialized in growing sugar beet and those on which the return yielded by animal husbandry has amounted to 50 to 80 per cent of the gross return, it has average 13 to 14 per cent. Also, on plant culture farms of more than 20 hectares, the size of arable land under bread grain cultivation has averaged more than 30 per cent of the total. Also, farms of a major size specialized in growing sugar beet have grown bread grain on lands representing more than 20 per cent of the total.

As regards the extent of sugar beet culture, it is to be noted that on farms of less than 10 hectares, sugar beet has been grown on lands representing an average of 4.4 per cent of the total of arable land under cultivation. On farms of 10 to 20 hectares and on farms of more than 20 hectares, it has average 2 to 3 per cent. It is to be noted that on the farms of more than 10 hectares mentioned here and specialized in growing sugar beet, about 22 per cent of available arable land has been under sugar beet cultivation. On 2 farms of less than 10 hectares growing sugar beet, the size of arable land under sugar beet culture has totalled nearly 60 per cent. Generally, smaller farms have grown sugar beet on a relatively large scale. On farms of more than 10 hectares of arable land representing other production lines, sugar beet has been grown on lands amounting to 2 to 3 per cent of the total.

Table 4. Land under bread grain and sugar beet cultivation on farms representing different lines of production[1).]

	Animal husbandry-oriented			Plant cultivation-oriented		Average
	Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
Farms of less than 10 hectares						
Land under rye cultivation, %	1.5 (4.8)	1.3 (6.6)	0.8 (3.5)	0 (0)	3.2 (11.8)	1.5 (5.8)
Land under spring wheat cultivation, %	3.6 (7.1)	4.4 (7.6)	2.2 (9.2)	0 (0)	8.1 (22.8)	4.0 (8.6)
Land under sugar beet cultivation, %	0.9 (1.5)	6.2 (9.0)	3.1 (13.1)	58.7(58.7)	5.7 (15.6)	4.4 (11.6)
Arable land, hectares	7.3	7.6	8.4	8.2	6.0	7.5
Farms of 10 to 20 hectares						
Land under rye cultivation, %	1.9 (4.7)	4.6 (8.0)	2.8 (6.4)	0 (0)	3.4 (9.7)	3.1 (6.8)
Land under spring wheat cultivation, %	3.6 (6.3)	8.9(13.1)	4.6 (8.6)	13.7(24.0)	34.7(39.3)	8.3 (13.3)
Land under sugar beet cultivation, %	1.0 (4.6)	3.3 (6.3)	2.2 (10.8)	22.7(22.7)	0.5 (2.9)	2.7 (7.8)
Arable land, hectares	14.0	15.0	14.9	15.7	15.0	14.7
Farms of more than 20 hectares						
Land under rye cultivation, %	2.9 (4.9)	4.9 (8.2)	4.4 (9.0)	2.6 (6.8)	6.7 (10.3)	5.1 (8.8)
Land under spring wheat cultivation, %	4.5 (6.9)	12.6(15.9)	7.8 (13.3)	19.4(22.2)	27.5 (29.9)	16.3 (20.6)
Land under sugar beet cultivation, %	0.4 (2.8)	2.4 (6.4)	2.1 (6.7)	21.7(21.7)	0.7 (4.2)	2.1 (7.4)
Arable land, hectares	29	36	34	34	45	38

[1)] The percentages figure inside brackets indicates the mean value of land use on the farms growing the plant in question. The actual percentage figure indicates the extent of cultivation on all farms.

Indicated, inside brackets, in Table 4 is also the percentage figure showing cropland use on farms growing the plant in question in general. These actual percentage figures are, of course, higher and indicate the extent of plant cultivation in terms of mean values derived from the farms growing the plant in question.

In this connection, cropland use has not been examined in its entirety. With a view to different production line comparisons, the extent of bread grain and sugar beet culture was felt to clarify the economy of farms representing different production lines. It is clear that the extent to which other plants, e.g. potato, feed grain and hay, are cultivated and how pasture lands are arranged, affect in many ways the manner in which the economy of a farm is planned, but they have not been examined separately in this study.

Table 5 indicates the size of arable land in each category. No actual differences in farm size within a category seem to exist except one: in the more than 20 hectares category, plant cultivation farms not specialized in growing sugar beet, the average size is clearly above the mean value. It seems natural, therefore, that the mechanization needed in growing bread grain is becoming possible on larger farms, affecting the choice of a production line.

Table 5 shows the formation of the return resulting from plant culture on farms representing different production lines. It seems natural that in pecuniary terms, the biggest return has been registered on farms specialized in growing sugar beet. On farms of less than 10 hectares, the return has average 2 408 marks per hectare of arable land and on farms of 10 to 20 hectares growing sugar beet 1 395 marks and on farms of more than 20 hectares 1 265 marks. What has been said before indicates that there are only two farms of less than 10 hectares specialized in growing sugar beet. In the other categories, their number is 7 to 8.

Because in the calculation of gross return in agriculture, only the yield - also as regards individual products - which is made up of sales or transfer outside agriculture is taken into consideration, grains, for instance, do not include that part of the return which has been used for animal feed. Feed is included in the return only as the so-called final product in the form of animal products. This is clearly in evidence in the case of potatoes, since included in the gross return obtained from potato culture are only potato sales and the estimated consumption in households. On the other hand, potatoes used for feed are included in the return yielded by animal husbandry. Also, as regards the sugar beet, the return consists only of beet sales according to the methodology used in this study. The top yield is reflected in the return only in the form of different animal products. The standard variations in the mean values of different groups included in Table 5 also show the variations in the return derived from plant cultivation between individual farms.

2. Variations in cost

A. Variations in different items of production expenses

Production expenses in agriculture refer to the sacrifices, in monetary terms, made to achieve the gross return. Production expenses include all production costs except interest claim on capital[1].

Production expenses on the farms examined in this study averaged 1 132 marks per hectare of arable land in fiscal 1967. Also, costs per hectare of arable land were, on the average, higher on smaller farms than on the larger ones. The difference partly stems from the fact that an increase in the use of production factors has been necessary in order to achieve a fairly high return. Part of the high fixed costs stem exclusively from the small size of the production unit. Production expenses on farms of less than 10 hectares have average 1 981 marks, on farms of 10 to 20 hectares 1 344 marks and on farms of more than 20 hectares 1 019 marks per hectare. Variations in production expenses and their different components on farms of roughly equal size have been highly significant.

[1] As regards the method whereby business costs are calculated, see the studies referred to in connection with gross return.

Table 5. Plant cultivation return, its formation and variations on farms representing different lines of production

		Animal husbandry-oriented			Plant cultivation-oriented		Average
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		1.	2.	3.	4.	5.	6.
				Farms of less than 10 hectares			
Wheat	marks/hectare	21	53	14	0	136	41
	s_x	31	74	27	0	296	106
				n_o = 62	Vv = 0 - (1) - 836		
Rye	marks/hectare	13	15	3	0	34	14
	s_x	26	35	6	0	92	38
				n_o = 87	Vv = 0 - (1) - 304		
Potato	marks/hectare	39	62	45	7	282	70
	s_x	38	70	52	11	479	166
				n_o = 3	Vv = 0 - (9) - 1 480		
Sugar beet	marks/hectare	18	196	76	2 388	138	135
	s_x	44	185	229	245	212	346
				n_o = 71	Vv = 0 - (25) - 2 562		
Plant cultivation return, total	marks/hectare	144	493	255	2 408	1 623	451
	s_x	83	254	247	251	1 017	607
				n_o = 0	Vv = 9 - 3 145		

		1.	2.	3.	4.	5.	6.
				Farms of 10 to 20 hectares			
Wheat	marks/hectare	33	112	58	213	608	114
	s_x	41	133	99	225	470	218
				n_o = 67	Vv = 0 - (2) - 1 727		
Rye	marks/hectare	14	47	23	0.1	32	28
	s_x	26	66	39	0.2	52	49
				n_o = 130	Vv = 0 - (1) - 271		
Potato	marks/hectare	26	49	59	88	98	48
	s_x	28	75	167	171	246	115
				n_o = 4	Vv = 0 - (1) - 802		
Sugar beet	marks/hectare	22	104	67	853	16	85
	s_x	53	190	187	239	38	205
				n_o = 17	Vv = 0 - (11) - 1 414		
Plant cultivation return, total	marks/hectare	145	426	303	1 395	931	371
	s_x	74	208	310	428	354	354
				n_o = 0	Vv = 24 - 1 960		
				Farms of more than 20 hectares			
Wheat	marks/hectare	37	187	133	305	462	262
	s_x	48	145	166	159	263	249
				n_o = 20	Vv = 0 - (4) - 975		
Rye	marks/hectare	24	47	41	20	80	55
	s_x	35	62	59	38	93	74
				n_o = 106	Vv = 0 - (1) - 384		
Potato	marks/hectare	16	23	38	9	17	22
	s_x	11	39	145	13	51	73
				n_o = 20	Vv = 0 - (1) - 111		
Sugar beet	marks/hectare	9	76	71	710	20	66
	s_x	30	176	161	326	62	178
				n_o = 194	Vv = 0 - (18) - 1 124		
Plant cultivation return, total	marks/hectare	154	465	427	1 265	899	601
	s_x	75	190	282	271	274	366
				n_o = 0	Vv = 9 - 1 538		

Costs of purchased supplies which represent an average of one-third of the total production expenses have averaged 562 marks on farms of less than 10 hectares, 362 marks on farms of 10 to 20 hectares and 361 marks on farms of more than 20 hectares. Costs of purchased supplies in the said groups have varied as shown in Table 6.

Table 6. Variations in costs of purchased supplies

Arable land	Average costs of purchased supplies marks/hectare	Costs of purchased supplies minimum marks/hectare	maximum marks/hectare
Under 10 hectares	562	59	2 709
10-20 "	362	100	1 173
20- "	361	111	1 651
Average	374		

The most important components of costs of purchased supplies are purchased feed, purchased fertilizers, purchased seeds, pesticides, electricity bills and liquid fuels. It is clear that the use of these materials essentially depends on the organization and intensity of the farm business. Tables 7a, 7b and 7c show variations in these material-cost components on farms of different farms-size categories and of different production line categories. The figures showing the dispersal of results indicate, among other things, that purchased feed has been used most on farms specialized in pig husbandry and, in general, on farms on which animal husbandry has been of relatively major importance. Purchased fertilizers, again, have been used most on farms specialized in growing sugar beet and, in general, on farms placing major emphasis on plant cultivation. The dispersal of results with regard to the use of materials has been substantial between different farms.

Table 7a. Costs of purchased supplies, its formation and variations on farms representing different lines of production

		Animal husbandry-oriented			Plant cultivation-oriented		All farms of less than 10 hectares
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		Farms of less than 10 hectares					
Purchased feed	marks/hectare	318	331	535	125	166	336
	s_x	308	470	1 034	33	375	529
				n_o = 3	Vv = 0 - (6) - 2 411		
Purchased fertilizers	marks/hectare	111	156	146	600	212	149
	s_x	45	88	106	99	158	108
				n_o = 0	Vv = 11 - 260		
Purchased seeds	marks/hectare	22	31	27	11	52	28
	s_x	20	26	29	14	48	28
				n_o = 9	Vv = 0 - (1) - 136		
Pesticides	marks/hectare	3	10	3	50	27	8
	s_x	3	17	4	8	38	17
				n_o = 27	Vv = 0 - (1) - 114		
Electricity rates	marks/hectare	14	16	24	9	15	16
	s_x	8	8	17	4	18	11
				n_o = 1	Vv = 0 - (1) - 76		
Fuels	marks/hectare	19	13	20	10	17	17
	s_x	12	9	16	6	26	14
				n_o = 5	Vv = 0 - (2) - 41		
Materials, total	marks/hectare	495	567	764	822	490	562
	s_x	329	544	1 138	150	474	590
				n_o = 0	Vv = 59 - 2 709		

Table 7b. Costs of purchased supplies, its formation and variations of farms representing different lines of production

		Animal husbandry-oriented			Plant cultivation-oriented		All farms of 10 to 20 hectares
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugan beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		Farms of 10 to 20 hectares					
Purchased feed	marks/hectare	178	127	311	144	23	174
	s_x	188	118	359	112	27	221
				n_o = 1	Vv = 0 - (11) - 968		
Purchased fertilizers	marks/hectare	104	131	140	281	129	128
	s_x	52	60	72	89	42	67
				n_o = 0	Vv = 30 - 348		
Purchased seeds	marks/hectare	21	21	25	23	24	22
	s_x	21	21	23	33	30	22
				n_o = 25	Vv = 0 - (1) - 115		
Pesticides	marks/hectare	3	6	6	23	14	6
	s_x	4	7	6	17	14	8
				n_o = 40	Vv = 0 - (1) - 48		
Electricity rates	marks/hectare	14	13	19	10	11	14
	s_x	7	8	12	6	10	9
				n_o = 3	Vv = 0 - (2) - 37		
Fuels	marks/hectare	13	11	14	7	9	12
	s_x	9	7	13	4	19	10
				n_o = 10	Vv = 0 - (1) - 18		
Materials, total	marks/hectare	340	315	521	496	212	362
	s_x	225	166	423	206	68	268
				n_o = 0	Vv = 100 - 1 173		

Table 7c. Costs of purchased supplies, its formation and variations on farms representing different lines of production.

		Animal husbandry-oriented			Plant cultivation-oriented		All farms of more than 20 hectares
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
Farms of more than 20 hectares							
Purchased feed	marks/hectare	175	127	389	94	54	154
	s_x	241	137	640	89	79	322
				n_o = 20	Vv = 0 - (1) - 707		
Purchased fertilizers	marks/hectare	89	138	149	269	152	144
	s_x	47	70	62	76	54	67
				n_o = 0	Vv = 30 - 427		
Purchased seeds	marks/hectare	14	20	19	41	25	22
	s_x	19	18	21	48	28	24
				n_o = 22	Vv = 0 - (1) - 153		
Pesticides	marks/hectare	3	10	10	40	13	11
	s_x	3	9	8	28	10	11
				n_o = 8	Vv = 0 - (1) - 47		
Electricity rates	marks/hectare	15	17	21	22	13	16
	s_x	6	11	14	15	9	11
				n_o = 2	Vv = 0 - (4) - 37		
Fuels	marks/hectare	11	11	14	11	10	11
	s_x	6	9	12	11	8	9
				n_o = 10	Vv = 0 - (1) - 50		
Materials, total	marks/hectare	313	329	605	480	269	361
	s_x	247	201	663	108	117	347
				n_o = 0	Vv = 111 - 1 651		

Costs arising from the use of human labor on all the farms average in 1967 nearly 50 per cent of the total production expenses. Labor costs per hectare of arable land on farms of less than 10 hectares were nearly fourfold compared with farms of more than 20 hectares (Table 8). Variations in labour costs between farms of similar size were substantial.

Table 8. Variations in labor costs

Arable land	Average labor costs	Labor costs minimum marks/hectare	Labor costs maximum marks/hectare
Under 10 hectares	1 096	512	3 011
10-20 "	676	48	1 748
20- "	385	60	740
Average	680		

Variations in the other components of production expenses, such as animal husbandry expenditure, machinery and equipment costs, building and land improvement costs as well as the so-called other costs in different production lines and different size categories are shown in Tables 9a, 9b and 9c. As for the calculation of various cost units, see the Study of Agricultural Profitability in Finland in 1967.

Table 9a. Production expenses and the major cost items

		Animal husbandry-oriented			Plant cultivation-oriented		All farms of less than 10 hectares
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		Farms of less than 10 hectares					
Materials, total	marks/hectare	495	567	764	822	490	562
	s_x	329	544	1 138	150	474	590
				n_o = 0	Vv = 59 - 2 709		
Animal husbandry costs, total	marks/hectare	35	27	50	44	5	32
	s_x	21	22	47	26	8	28
				n_o = 6	Vv = 0 - (1) - 76		
Labor costs, total	marks/hectare	1 114	1 145	984	1 430	964	1 096
	s_x	368	408	338	332	775	429
				n_o = 0	Vv = 512 - 3 011		
Machinery and equipment costs, total	marks/hectare	140	193	177	484	303	184
	s_x	82	124	79	56	140	118
				n_o = 0	Vv = 23 - 318		
Building costs	marks/hectare	72	75	82	75	100	77
	s_x	41	39	45	18	41	41
				n_o = 0	Vv = 13 - 147		
Land improvement costs. total	marks/hectare	5	11	7	0	10	8
	s_x	8	18	8	0	11	12
				n_o = 45	Vv = 0 - (1) - 45		
Other costs, total	marks/hectare	43	61	61	195	103	60
	s_x	25	51	48	166	121	59
				n_o = 0	Vv = 3 - 292		
Production expenses, total	marks/hectare	1 904	2 079	2 125	2 213	1 975	2 019

Table 9b. Production expenses and the major cost items

		Animal husbandry-oriented			Plant cultivation-oriented		All farms of 10 to 20 hectares
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		Farms 10 to 20 hectares					
Materials, total	marks/hectare	340	315	521	496	212	362
	s_x	225	166	423	206	68	268
				n_o = 0	Vv = 100 - 1 173		
Animal husbandry costs, total	marks/hectare	31	23	38	17	4	27
	s_x	18	15	28	20	5	21
				n_o = 9	Vv = 0-(3) - 80		
Labor costs, total	marks/hectare	754	673	683	634	323	676
	s_x	197	237	221	248	215	243
				n_o = 0	Vv = 48 - 1 748		
Machinery and equipment costs, total	marks/hectare	149	167	199	245	206	173
	s_x	56	69	81	88	109	76
				n_o = 0	Vv = 53 - 445		
Building costs	marks/hectare	55	50	62	43	52	54
	s_x	27	28	33	13	23	28
				n_o = 0	Vv = 11 - 157		
Land improvement costs, total	marks/hectare	6	7	6	9	7	6
	s_x	6	7	4	6	6	6
				n_o = 46	Vv = 0 - (1) - 16		
Other costs, total	marks/hectare	36	42	48	98	54	44
	s_x	23	34	34	65	28	33
				n_o = 0	Vv = 9 - 271		
Production expenses, total	marks/hectare	1 371	1 277	1 557	1 542	858	1 342

Table 9c. Production expenses and the major cost items

		Animal husbandry-oriented			Plant cultivation-oriented		All farms of more than 20 hectares
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		Farms of more than 20 hectares					
Materials, total	marks/hectare	313	329	605	480	269	361
	s_x	247	201	663	108	117	347
				n_o = 0	Vv = 111 - 1 651		
Animal husbandry costs, total	marks/hectare	30	22	28	13	6	18
	s_x	17	12	21	12	8	17
				n_o = 20	Vv = 0 - (4) - 81		
Labor costs, total	marks/hectare	489	461	461	478	239	385
	s_x	138	139	167	183	112	175
				n_o =0	Vv = 60 - 740		
Machinery and equipment costs, total	marks/hectare	141	170	181	279	161	168
	s_x	38	60	52	57	44	54
				n_o = 0	Vv = 80 - 306		
Building costs	marks/hectare	47	44	58	42	36	44
	s_x	27	23	31	22	17	24
				n_o = 0	Vv = 11 - 111		
Land improvement costs, total	marks/hectare	5	7	8	10	8	7
	s_x	5	6	7	7	5	6
				n_o = 9	Vv = 0 - (1) - 25		
Other costs, total	marks/hectare	33	35	35	60	36	36
	s_x	23	22	19	42	24	23
				n_o = 0	Vv = 7 - 127		
Production expenses, total	marks/hectare	1058	1 068	1 376	1 362	755	1 019

B. Variations in the use of labor in agriculture

a. Human labor

In agricultural bookkeeping, regular farm work includes the normal work necessitated by plant cultivation, care for domestic animals, harvest processing and various activities required to turn the products into a proper shape for sale, the maintenance of machinery and equipment plus various forms of transportation work. On the other hand, work in forestry, work done outside the farm, household work and investment work are not included in regular farm work. Table 10 indicates regular farm work and its average variations on farms representing different production lines.

As regards regular farm work, labor necessitated by plant cultivation on farms of less than 10 hectares has averaged 187 hours per hectare of arable land, 113 hours on farms of 10 to 20 hectares and 69 hours on farms of more than 20 hectares. Also, the average labor input in animal husbandry in per-hectare terms has been clearly greater on small farms than on the bigger ones. As regards labor input on farms representing different production lines, no clear differences are visible in the volume of plant cultivation work on small farms (of less than 10 hectares). However, on farms engaged to a fairly substantial degree in pig husbandry, the volume of plant cultivation work is markedly lower than in the other groups. In agriculture, the use of human labor depends on the availability of farm machinery and a number of factors other than the production line in question. The volume of plant cultivation work on farms growing bread and coarse grains, sugar beet, potato etc. essentially depends on the size of arable land under cultivation and the mechanization of the farm. On the larger farms, on the other hand, mechanization has already proceeded quite far as evidenced by the labor input figures. On the larger farms (of more than 20 hectares), plant cultivation work in per-hectare terms has, obviously due to the intensity of feed cultivation, been roughly on the same level as on the farms specialized in growing sugar beet, i.e. 75 to 80 hours per hectare. On these larger farms, generally specialized in plant cultivation, the volume of plant cultivation work is clearly lower than on farms of equal size but representing a different production line.

Table 10. Use of human labor and its variations in regular farm work on farms representing different lines of production

		Animal husbandry-oriented			Plant cultivation-oriented		Average
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
			Farms of less than 10 hectares				
Plant cultivation work	hours/hectare	171	214	143	192	232	187
	s_x	77	101	69	46	213	106
				$n_o = 0$	Vv = 28 - 812		
Animal husbandry work	hours/hectare	302	266	264	274	102	265
	s_x	103	94	101	30	127	115
				$n_o = 3$	Vv = 0 - (6) - 678		
Other agricultural work	hours/hectare	23	17	21	31	48	23
	s_x	32	27	20	5	49	32
				$n_o = 6$	Vv = 0 - (1) - 160		
			Farms of 10 to 20 hectares				
Plant cultivation work	hours/hectare	122	120	101	122	65	113
	s_x	55	65	43	58	49	58
				$n_o = 0$	Vv = 16 - 384		
Animal husbandry work	hours/hectare	200	159	179	116	57	168
	s_x	55	57	73	64	50	70
				$n_o = 1$	Vv = 0 - (6) - 277		
Other agricultural work	hours/hectare	12	8	13	7	7	10
	s_x	16	9	20	5	10	14
				$n_o = 18$	Vv = 0 - (1) - 87		
			Farms of more than 20 hectares				
Plant cultivation work	hours/hectare	82	79	74	80	52	69
	s_x	36	33	39	23	22	33
				$n_o = 0$	Vv = 19 - 151		
Animal husbandry work	hours/hectare	115	108	112	57	36	82
	s_x	33	37	42	45	33	50
				$n_o = 20$	Vv = 0 - (3) - 169		
Other agricultural work	hours/hectare	6	7	7	5	6	6
	s_x	10	8	7	3	7	8
				$n_o = 16$	Vv = 0 - (1) - 19		

It is natural that the labor input in animal husbandry on farms predominantly engaged in plant cultivation is lower than on farms specialized in animal husbandry. If different groups of farms practicing animal husbandry are compared with each other, it will be found that on the farms specialized in pig production, particularly on farms of less than 10 hectares, the labor input in animal husbandry in per-hectare terms is on the same level as on the farms specialized in milk production - or on a lower level.

As regards the use of human labor, one may draw the conclusion that the average per-hectare input is affected more by the size of the production unit than the production line involved. It is clear that there has been no way of examining here purely different production lines or different degrees of mechanization. Furthermore, one may note that on farms predominantly engaged in plant cultivation, particularly those specialized in growing grains, the labor input is clearly lower than in the other groups.

b. Tractor and horse work

In the application of the factor analysis, the use of a tractor or a horse in farm work has also been examined as factors. Tractors and horses have been used in regular farm work on the farms included in this study as follows:

	Farms of less than 10 hectares	Farms of 10 to 20 hectares	Farms of more than 20 hectares
Horse work, hours/hectare	25	11	3
Tractor work, - " -	24	24	22

Affecting significantly the mean values is also the fact whether a tractor or a horse has been employed. It may be noted here that of the 115 farms of less than 10 hectares, 71 have relied on horse work. In this category, there is only one farm with no tractor work at all. Of the 226 farms of 10 to 20 hectares, 142 have used a horse in agricultural work. In this category, tractor work is found on every farm. In the third category consisting of 274 farms of more than 20 hectares, all have employed a tractor and 120 have also used a horse.

3. Yield levels

In order to figure out harvest levels for different farm categories, rye, spring wheat and sugar beet yields per hectare and the average feed unit harvest per hectare were calculated. Also calculated was the average milk production of cows.

As regards differences in harvest between different categories of farms, the average feed unit harvest on farms of various sizes was roughly the same. Among the farms representing different production lines, those specialized in growing sugar beet have reported the highest average feed unit yield. Also,farms engaged in pig husbandry with farms of less than 10 hectares excluded have registered feed unit harvests above the average.

As regards bread grain yields, wheat harvest in per-hectare terms, particularly on the large farms, has exceeded the yield levels of other farms of equal size. The material contained in this study suggests that the average sugar beet yield on the farms specialized in growing sugar beet has been higher than in other groups. Similarly, harvest levels on small farms specialized in growing sugar beet have been higher than on the larger ones.

The average yield of cows on farms of more than 20 hectares has been 4 632 kilos or somewhat more than on smaller farms. Also, on farms with specialized production, such as those growing sugar beet or engaged in pig husbandry, the average yield of cows is higher than in the other groups. Generally, specialized farms are also in other ways intensively cultivated. It is interesting to note that the lowest average yield per cow is registered on farms most specialized in cattle husbandry and in animal husbandry in general. Table 11 also shows the number of farms in each group represented by the figures for average harvest and production. In this connection, it has been impossible to obtain quantitative figures on beef production or the average production of pigs and poultry.

Table 11. Hectare yields of some plants, average feed-unit yield and average production of cows in 1967.

		Animal husbandry-oriented			Plant cultivation-oriented		Average
		Animal husbandry return 80 % or more	Animal husbandry return 50-79.9 %	Pig husbandry return 20 % or more	Sugar beet cultivation return 20 % or more	Sugar beet cultivation return under 20 %	
		1.	2.	3.	4.	5.	6.
		Farms of less than 10 hectares					
Rye,	kilos/hectare	2 085	2 648	2 128	-	1 880	2 206
	s_x	579	744	676	-	703	663
	n	15	7	4	-	3	29
Spring wheat,	kilos/hectare	1 974	1 989	2 302	-	2 629	2 052
	s_x	505	762	1 238	-	181	676
	n	25	21	4	-	4	54
Sugar beet,	kilos/hectare	17 800	28 600	21 700	25 300	30 900	26 500
	s_x	5 676	8 374	2 831	796	14 611	9 266
	n	8	25	4	2	4	43
Feed unit yield/hectare		2 650	3 141	3 086	8 744	3 204	3 020
	s_x	605	829	1 000	425	1 326	1 141
	n	49	36	17	2	11	115
Milk production, kilos/cow		4 176	4 449	4 641	5 038	(5 842)	4 387
	s_x	893	1 009	1 407	547	0	1 025
	n	32	23	10	2	1	68

		1.	2.	3.	4.	5.	6.
Farms 10 to 20 hectares							
Rye,	kilos/hectare	1 831	2 059	1 677	-	1 831	1 901
	s_x	727	694	576	-	418	679
	n	32	45	20	-	6	103
Spring wheat,	kilos/hectare	1 917	2 074	2 063	2 546	2 203	2 050
	s_x	590	646	567	159	490	598
	n	45	53	24	4	15	141
Sugar beet,	kilos/hectare	20 700	26 200	26 600	33 000	26 200	25 600
	s_x	4 121	8 700	11 516	5 049	7 873	8 466
	n	17	41	9	7	3	77
Feed unit yield/hectare		2 644	2 814	3 002	4 933	2 794	2 856
	s_x	659	681	854	760	565	802
	n	79	78	45	7	17	226
Milk production, kilos/cow		4 403	4 530	4 298	4 682	3 856	4 428
	s_x	692	818	498	625	799	725
	n	56	60	24	3	4	147
Farms more than 20 hectares							
Rye,	kilos/hectare	1 993	2 156	1 971	1 820	2 355	2 182
	s_x	666	642	660	748	733	697
	n	18	51	25	3	64	161
Spring wheat,	kilos/hectare	2 071	2 201	2 129	2 168	2 219	2 185
	s_x	691	488	468	437	511	513
	n	20	67	30	7	88	212
Sugar beet,	kilos/hectare	23 400	27 100	28 500	27 800	25 300	26 900
	s_x	6 841	7 697	9 306	3 780	5 137	7 221
	n	4	32	16	8	16	76
Feed unit yield/hectare		2 436	2 868	3 054	4 437	3 014	2 952
	s_x	464	700	663	963	527	692
	n	31	86	51	8	98	274
Milk production, kilos/cow		4 447	4 596	4 706	4 865	4 776	4 632
	s_x	633	633	552	420	663	622
	n	27	67	34	3	29	160

4. Variations in the use of human labor in forestry and by-enterprises

Although this study is confined to an examination of agricultural production, the use of labor is so closely related to forestry and by-enterprises that they have been referred to in this connection for the sake of comparison. The volume of by-enterprise work has also been used as a factor in the factor analysis.

The following figures show the labor input in forestry supplied by the farmer, his family and permanent hired labor.

	Farms of less than 10 hectares	Farms of 10 to 20 hectares	Farms of more than 20 hectares
Farmer's family, males, hours/farm	244	308	289
Hired labor, males, -"-	10	24	170
Forestry work, total, -"- [1]	263	345	467
Forest land, average, hectares/farm	19	32	80

In the small-farm category, forestry work on the farm has amounted to an average of 33 eight-hour work days per annum. On farms of 10 to 20 hectares, the corresponding figure is 43 work days and on farms of more than 20 hectares, 58 work days. On the larger farms, the amount of forestry work per farm is greater than on the smaller farms. Yet, the labor input supplied by the farmer and his family plus the permanent hired personnel on the farm is substantially lower on farms with large forest lands. It is clear that on the bigger farms, their own labor capacity has been insufficient to cover all forestry work.

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[1] Human working hours are the combined working hours of men and women added with one-half of the working hours of children.

Members if the farmer's family have been engaged in permanent by-enterprises outside the farm as follows:

	Farms of less than lo hectares	Farms of 10 to 20 hectares	Farms of more than 20 hectares
By-enterprise work, males, hours/farm	297	190	168
- " - , females -"-	19	16	18
- " - , total hours/hectare	320	210	207

On farms of less than 10 hectares, the average labor input in by-enterprises corresponds to 40 work days, on farms of 10 to 20 hectares as well as on farms of more than 20 hectares, 26 work days. By-enterprise work is primarily done by men. As regards by-enterprise work on farms representing different production lines, persons on plant cultivation farms specialized in growing grains have clearly had most time for by-enterprise work.

II. DEPENDENCE OF GROSS RETURN ON VARIOUS FACTORS OF PRODUCTION

1. Selection of factors influencing gross return by means of factor analysis

A. General

The preceding has been concerned with an examination of variations in different agricultural gross return and the factors influencing them plus their average levels in terms of production lines on farms of different size categories. It does not, however, show how different factors affect gross return. The second part of this study attempts to solve this problem by estimating production functions describing the aforementioned interdependence. Actually, this study employs gross return functions because production quantity is given in monetary terms. Efforts have been made to give the study more depth in order to differentiate it from an ordinary function analysis through the use of a factor analysis as a preliminary study primarily intended to reveal the factors affecting the formation of observed items related to a certain phenomenon. Involved is, then, in most cases the expression of a large group of variables by means of a few factors. In most cases, it can also be used in the study of interdependence and accordingly, in an analysis preceding a regression analysis in the selection of variables for a model.

B. Factors examined in the factor analysis and production function analysis

In the application of the factor analysis and later on, in the production function analysis, the following method has been used as regards the various factors involved.

Milk production (X_1) corresponds to the amount of milk produced by cows in the year in question. This information has been obtained from nearly all farms as part of a separate so-called milk recording scheme and the results are based on regular measurements made at certain intervals.

Plant cultivation work (X_2) includes the regular farm work performed in order to achieve the return arising from plant cultivation. Thus, it includes land preparation, fertilization, sowing, repairs and harvest handling. Also, it includes various forms of transportation work as well as any possible storage work. The figures represent the work done by the farmer and his family plus any hired labor.

Animal husbandry work (X_3) includes the care for domestic animals plus the handling and transfer of feed in the building reserved for domestic animals. It also includes milk handling and transportation.

Other agricultural work (X_4) includes functions which could not be included in the above categories. This group contains various forms of transportation, storage, repair and maintenance work. Yet, it does not include investment work or work done in forestry or other non-agricultural work.

Management work (X_5, X_6) includes that part of the farmer's work which is concerned with farm management, planning and other related work.

By-enterprise work (X_7) involves the amount of work done outside the farm. This does not include forest work done on the farm itself.

Horse and tractor work (X_8, X_9) has been calculated on the same principle as the use of human labor in agricultural work.

Arable land in adjusted-hectare terms (X_{10}) refers to the cultivated land which, apart from cropland, includes garden land and regularly harvested meadows. In bookkeeping, the conversion is made in per-hectare terms. In practice, the size of arable land in adjusted-hectare terms is very close to the actual size of land under cultivation.

The various items of gross return (X_{11}-X_{23}) are given in the form they are defined in the calculation of gross return in agriculture. Cattle husbandry return includes, f.ex. the return yielded by meat production. As regards plant cultivation, the return insofar as grains, f.ex., are concerned, does not include that part of the yield used on the farm by animals. These items are included among the various forms of domestic animal husbandry return.

The various cost items (X_{24}-X_{36}) correspond to the various items of production expenses according to agricultural bookkeeping. It is to be noted that purchased feed costs (X_{24}) consist of the costs of arising from the use of purchased feed during the year in question. This group also includes the vitamins, mineral substances and other related additives purchased for domestic animals.

The costs arising from the use of purchased fertilizers (X_{25}) include the use of various fertilizers and agricultural lime unless a major liming is involved.

The costs arising from the use of pesticides (X_{23}) include purchased pesticides. If the spraying has been done by an outsider, it is also included in the labor costs.

Farm machinery and equipment depreciation, as shown in bookeeping, plus maintenance costs and annual costs arising from the purchase of minor equipment have been taken into consideration in machinery and equipment costs (X_{33}). Maintenance costs include purchased materials and the timber obtained from the farm. If maintenance work is done by members of the farmer's family or permanent hired personnel, labor costs are not included in machinery and equipment costs. Included in machinery and equipment costs is also the purchase of such new materials for which no annual depreciation values are provided. In principle, building costs (X_{34}) have been calculated in the same way as machinery and equipment costs. Land improvement costs (X_{35}) mainly consist of costs occasioned by drainage with depreciation and maintenance costs included.

The size of land under bread grain (rye and wheat) and sugar beet cultivation (X_{37}, X_{39}, X_{41}) is calculated in terms of percentage points of the entire area of arable land. Rye (X_{38}), spring wheat (X_{40}) and sugar beet (X_{42}) harvests represent the gross harvest in terms of kilos.

Feed unit harvest (X_{43}) means the average feed unit harvest per hectare of all plants grown on the farm. Tops and other byproducts are included in the feed unit harvest if they are collected for use on the farm.

List of variables

X_1	Milk production	kilos per cow
X_2	Plant cultivation work	hours per hectare
X_3	Animal husbandry work	- " -
X_4	Other agricultural regular work	- " -
X_5	Management work, men	- " -
X_6	Management work, women	- " -
X_7	Byenterprise work	hours per farm
X_8	Horse work in agriculture	hours per hectare
X_9	Tractor work in agriculture	- " -
X_{10}	Arable land on the farm	adjusted hectare
X_{11}	Cattle husbandry return	marks per hectare
X_{12}	Dairy farming return	- " -
X_{13}	Pig husbandry return	- " -
X_{14}	Poultry husbandry return	- " -
X_{15}	Domestic animal husbandry return	- " -
X_{16}	Domestic animal husbandry return o/oo of gross return	
X_{17}	Plant cultivation return, total	marks per hectare
X_{18}	Wheat return	- " -
X_{19}	Rye return	- " -
X_{20}	Pea etc. return	- " -
X_{21}	Potato return	- " -
X_{22}	Rutabaga return	- " -
X_{23}	Sugar beet return	- " -

X_{24}	Purchased feed costs	marks per hectare
X_{25}	Purchased fertilizer costs	- " -
X_{26}	Purchased seed costs	- " -
X_{27}	Pesticide costs	- " -
X_{28}	Electricity costs	- " -
X_{29}	Fuel costs	- " -
X_{30}	Costs of purchased supplies, total	- " -
X_{31}	Domestic animal costs, total	- " -
X_{32}	Labor costs	- " -
X_{33}	Machinery and equipment costs	- " -
X_{34}	Building costs	- " -
X_{35}	Land improvement costs	- " -
X_{36}	Other costs, total	- " -
X_{37}	Land under rye cultivation o/oo of the total	o/oo[1]
X_{38}	Rye harvest	kilos per hectare
X_{39}	Land under spring wheat cultivation o/oo of the total	o/oo[1]
X_{40}	Spring wheat harvest	kilos per hectare
X_{41}	Land under sugar beet cultivation o/oo of the total	o/oo
X_{42}	Sugar beet harvest	kilos per hectare
X_{43}	Feed unit harvest, average	feed units per hectare

C. Factor analysis model

In the following, the assumption is that the observed information lies in the form of a so-called observation vector composed of the variables that are to be measured. Let us assume that there are N observation vectors and each vector contains n variables. To denote the j^{th} variable we will mark it X_j ($j = 1,2,\ldots n$). To denote the j^{th}

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[1] In the regression analysis, the combined variable $X_{37} + X_{39}$ refers to land under bread grain cultivation

variable of the i^{th} observation vector, we will mark it X_{ji} ($j = 1,2,...n$, $i = 1,2,...N$). Factor analyses usually rely on the standardized variable of z_{ji} which is derived by subtracting from the original variable its mean value and by dividing the balance by the standard deviation of the variable or

$$(1) \qquad z_{ji} = \frac{X_{ji} - \bar{X}_j}{s_j}$$

With these entries, the factor model assumes the following form:

$$(2) \qquad z_j = a_{j1}F_1 + a_{j2}F_2 + \ldots + a_{jp}F_p + \ldots + a_{jm}F_m + a_jU_j,$$

in which F_p ($p = 1,\ldots,m$) is a common factor which the factor analysis is designed to reveal. Each variable, then, is formed by means of these actual factors. U_j ($j = 1,\ldots,n$) is a unique factor characteristic of each variable. The coefficient a_{jp} is called the loading of the variable z_j on the factor F_p and the matrix consisting of the a_{jp} series is called the factor matrix A. In an examination of the problems involved in the determination of the A matrix, the assumption is that the factors are orthogonal, i.e. independent of each other and standardized.

To try to give an interpretation to the elements of the factor matrix - the loadings - it is necessary to figure out the Pearson correlation coefficient between the variable z_j and the factor F_p (cf. HARMAN 1960, p.17).

$$(3) \qquad r_{z_jF_p} = a_{j1}r_{F_pF_1} + a_{j2}r_{F_pF_2} + \ldots + a_{jm}r_{F_pF_m}$$

Because in the above, the assumption was that the factors F_p are independent of each other, the formula (3) is simplified as follows:

$$(4) \qquad r_{z_jF_p} = a_{jp} \quad (j = 1,2,\ldots,n, p = 1,2,\ldots,m)$$

Thus, the loading a_{jp} of the variable z_j on the factor F_p is to be interpreted as a product moment correlation coefficient between the variable and the factor.

The variance of the variable z_j may be written in the form:

(5) $$s_j^2 = 1 = a_{j1}^2 + a_{j2}^2 + \ldots + a_{jm}^2 + a_j^2$$

In this dissection, the sum of the first component of m, $h_j^2 = a_{j1}^2 + a_{j2}^2 + \ldots + a_{jm}^2$, is called the communality of the variable. It is, therefore, part of the variance of the variable which may be explained by means of common factors. The rest of the variance a_j^2 contains the specificity and the unrealiability of the variable.

The correlation coefficient between the variables as calculated from the factor matrix may be written in the form:

(6) $$r_{jk} = a_{j1}a_{k1} + a_{j2}a_{k2} + \ldots + a_{jm}a_{km} \quad (j \neq k,\ j,\ k = 1,2,\ldots,n).$$

or written in the matrix form:

(6') $$R^+ = AA',$$

in which R^+ is a so-called reduced correlation matrix in which variable communalities $h_j^2 = r_{jj}$ are on the principal diagonal. This equation (6') was called by the inventor of the multiple factor theory, Thurstone, the basic equation of the factor analysis. In the application of the equation to a correlation matrix, the problem is how to select proper principal diagonal elements because, unfortunately enough, there is no a priori information about the communalities. A common, simple way to solve this problem is to choose for the principal diagonal the highest correlation coefficient of the corresponding variable along with the other variables. In practice, this method is accurate enough provided the number of the variables is substantial. There is empirical evidence proving that it is not of very great significance just what values ones of smaller than one are placed on the principal diagonal of the observed correlation matrix when the number of the variables is greater than 20, for instance (HARMAN 1960, pp.88 - 89).

D. Factor solution and rotation

A factor solution refers to the derivation of the factor matrix A from the matrix describing the interdependency of the variables, the matrix which almost always is a correlation matrix. There are several methods whereby a factor solution is performed but today the one used almost exclusively is the principal-factor solution developed by Hotelling in the 1930s (cf. HARMAN 1960, pp.135 - 186).

The result of the factor solution, factor matrix A, is not unique because it may be replaced by any matrix obtained through an orthogonal transformation. The purpose of a rotation is to find such a transformation whereby it is possible to figure out from the rotated factor matrix the relationship between the variables in a simple way and in a form that can easily be studied.

THURSTONE (1953 pp. 319 - 346) laid down five so-called simple structure requirements for a orthogonally rotated matrix (cf. also RIIHINEN 1965, p. 120):

1. Each factor matrix line must have at least one zero loading.

2. If there are m common factors, each factor matrix column must have at least m zero loadings.

3. There should be several variables for each pair of factor matrix columns whose loadings remain unessentially small in one column but not in the other one.

4. If there are four or more common factors, a substantial portion of the variables should have zero loadings in both columns per each pair of columns.

5. In addition, it is desirable that for each pair of columns there should be only a small number of variables with essential loadings in both columns.

In practice, it is hardly possible to meet all these requirements except in special cases. Furthermore, another drawback of these criteria is their qualitative character; they cannot be dressed in the form of mathematical equations and the absence of exact definitions leads to more or less subjective rotation solutions. For this reason, efforts were made in the 1950s to develop more accurate definitions than those of THURSTONE.

In agriculture, factor analyses have been applied, above all, in the study of the effect of human factors on economic results (VAINIO-MATTILA 1966, TAURIAINEN 1966). Somewhat different was a study by the Danish researcher NIELSEN seeking to explore variations in the statistical data obtained from bookkeeping farms (NIELSEN 1964) and to describe a group of variables by mean of a few non-correlated factors.

In this study, the factor analysis is not a primary objective but represents a preliminary study preceding a production function analysis. It is employed to examine the interdependence of the variables and to study whether there might be such primary factors as produce empirical results from the bookkeeping material. A production function analysis is, of course, possible without a factor analysis. The problem is, above all, the selection of variables which may involve logical deduction or, with some reservations, a so-called selective regression (cf. Appendix I) analysis although the latter, being a blind method, may give illogical results. In the early stage of a study, a factor analysis may, however, confirm the selection of variables made on the basis of logical deduction of bring new variables under consideration. Moreover, it gives a preview of the importance of the variables in the model.

2. Results of factor analysis

A. Farm of less than 10 hectares

A factor analysis has been applied to three farm categories examined in this study, i.e. farms of less than 10 hectares, of 10 to 20 hectares and of more than 20 hectares. The purpose of this categorization has been to examine the effect of farm size on the formation of various factors and their order of importance.

In the small farm category, there are some distinct factors which are mainly recognizable as different production lines. As Table 12 shows, sugar beet cultivation is the strongest factor. In the case of this factor, the strongest loadings are to be found in the yield of sugar beet cultivation (variable x_{23}) and the size of farm land under sugar beet cultivation (x_{41}). In addition, purchased fertilizers (x_{25}) and harvest per feed unit (x_{43}) consequently have large loadings. Other loadings, too, with the exception of milk production, fit this factor.

The second factor is called cattle husbandry, because the returns yielded by dairy farming (x_{12}) and cattle husbandry (x_{11}) have the biggest loadings. Plant cultivation ought not to be included in this factor. It is, however, closely related to cattle husbandry, a fact which obviously explaind the large loadings characterizing plant cultivation return (x_{17}), pea and other plants (x_{20}) plus potato (x_{21}). As they are, however, relatively small, they are not confusing this distinct factor. In this connection, it should be noted that it is difficult, indeed impossible, to assess the significance of feed cultivation on the basis of its return because the return corresponding to the feed grown on the farm is only manifest in the form of final products. Thus, gross return does not inolude any yield from feed culture. Instead, it is reflected in milk, meat, egg etc. return. For this reason alone, the use of return components may in some cases be confusing.

Table 12. Rotated factor matrix, farms of less than 10 hectares

Variables/factors	Sugar beet cultivation 1	Cattle husbandry 2	Use of human labor 3	Pig husbandry 4	Rye cultivation 5	Wheat cultivation 6	Degree of mechanization 7	8	9	10	11	12	13	14	15	Communality h_j^2
1 Milk output, kilos/cow	.220	.394										-.470				.471
2 Plant cultivation work, hours per hectare			-.864					.208								.878
3 Animal husbandry work, hours per hectare		.638	-.303										.250	-.202	.276	.802
4 Other regular agricultural work, hours per hectare			-.233								.570					.513
5 Management work, men, hours per hectare															.619	.473
6 Management work, women, hours per hectare											.456				-.206	.419
7 By-enterprise work, hours per farm									.471							.299
8 Horse work in agriculture, hours per hectare			-.227				.730									.653
9 Tractor work in agriculture, hours per hectare	.243						-.681				.226	-.346				.667
10 Adjusted hectare, hectare			.291						-.442							.540
11 Cattle husbandry return, marks per hectare		.799														.721
12 Dairy farming return, marks per hectare		.845														.801

Variables/factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	h_j^2
13 Pig husbandry return, marks per hectare				.691						-.489						.808
14 Poultry husbandry return, marks per hectare				.421				.464		.362						.646
15 Domestic animal husbandry return, marks per hectare		.427		.819												.964
16 Domestic animal husbandry return o/oo of gross return	-.417	.525											.329	-.312		.878
17 Plant cultivation return, marks per hectare	.619	-.350	-.251					.340						.274		.902
18 Wheat return, marks per hectare						.874										.810
19 Rye return,marks per hectare					-.931											.918
20 Pea etc.return, - " -		-.237											-.615			.543
21 Potato return, - " -		-.277	-.450											.358	.376	.616
22 Rutabaga return,- " -								.748								.659
23 Sugar beet return, - " -	.970															.966
24 Purchased feed costs, - " -				.972												.998
25 Purchased fertilizer costs- " -	.739							.416								.838
26 Purchased seed costs								.571	.370	-.257						.616
27 Pesticide costs - " -	.442					.311		.600								.749
28 Electricity costs - " -				.308				.254		-.570						.547
29 Fuel costs - " -											.607					.536
30 Costs of purchased supplies, total - " -	.247			.916				.252								.999

Variables/factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	h_j^2
31 Domestic animal costs, **total, marks per hectare**		.511								-.419						.533
32 Labor costs - " -		.329	-.695								.247				.325	.936
33 Machinery and equipment costs, marks per hectare	.386		-.209				-.458	.406								.744
34 Building costs - " -									.587		.248					.503
35 Land improvement costs - " -				.232			-.253		.282			-.250			.334	.430
36 Other costs, total -"-	.475			.269				.596							.202	.764
37 Land under rye cultivation o/oo of the total, o/oo					-.923											.915
38 Rye, harvest, kilos/hectare					-.755											.688
39 Land under spring wheat cultivation o/oo of the total, o/oo						.861										.806
40 Spring wheat, harvest, kilos/hectare						.438					-.312	-.290	-.204			.521
41 Land under sugat beet cultivation o/oo of the total, o/oo	.953		-.300													.972
42 Sugar beet, harvest, kilos/hectare	.591										-.230					.605
43 Feed unit harvest, per hectare	.809															.783
The eigenvalues of the the unrotated factor matrix	7.87	5.45	3.08	2.56	2.34	1.77	1.40	1.32	1.07	.972	.709	.572	.490	.437	.339	
The eigenvalues o/oo of the number of variables (cumulative)	183	310	382	442	496	537	570	601	626	649	665	678	689	699	707	

The use of labor is the third major factor which may seem suprising because many production function analyses have shown that productivity of labor is fairly low and the said variable is a fairly insignificant one (TORVELA 1966, p.98). In this analysis, the use of human labor, however, proved an important variable. On small farms, the use of labor may be of considerable importance in the efforts to increase the intensity of production.

Pig husbandry, the fourth factor, represents a type of special production which, because of its intensity, may have a decisive effect on the economic results achieved in agriculture. Thus, it is understandable that pig husbandry emerged distinctly in this analysis. The occurance of poultry return on this factor obviously indicates that actually, a special production factor in domestic animal production is involved. Pig and poultry husbandry are without question the major forms of special production on the bookkeeping farms involved in this study.

The fifth and sixth factors, rye and wheat cultivation, are pure production line factors with only obligatory loadings. The seventh factor may be regarded as a mechanization factor due to the horse and tractor work loadings.

A fixed computer program gave 15 different factors of which factors 8 to 15 are hard to interpret which is the reason why they ware not named at all. The eighth factor, for instance, could be described as rutabaga culture factor. As the rest of the factors have loadings belonging to mutually unrelated variables, no conclusions can be drawn about them.

B. Farms of 10 to 20 hectares

On farms of 10 to 20 hectares of arable land, the major factors are the same as in the previous category with the exception that in this group, the fifth factor is recognizable as a beet and potato production factor (Table 13). The order of the factors, too, is somewhat changed. Sugar beet culture is still the first one but the second factor in the previous category, cattle husbandry, has dropped to seventh place, a circumstance which may be partly explained by the fact that on larger farms, cattle husbandry is not necessarily as predominant as on the smaller ones. It is to be noted, however, that on farms of more than 20 hectares, cattle husbandry is one of the major factors.

The second factor, the use of labor, is clearly recognizable in this category. Factors 3 to 7 are distinct production line factors, mainly describing various production components in agriculture which constitute the gross return. The mechanization factor, No. 8, is distinct in terms of its loadings. On the other hand, it is difficult to find any clear meanings for the ninth factor while its loadings are small and the biggest loading with regard to income from by-enterprises (x_7) does not seem to fit in with the others.

Poultry husbandry and management emerge as new factors (factors 10 and 11). The rest of this solution is even in this case incoherent and unclear.

C. Farms of more than 20 hectares

Perhaps surprisingly, cattle husbandry ranks first in this category. In the previous chapter, it was pointed out that on the larger farms, cattle husbandry does not play as significant a role as on the smaller ones. It is to be noted, however, that of the 277 farms included in this category, some are fairly small. Of these farms, 115 have an area of 20 to 30 hectares and 109 an area of 30 to 50 hectares. There are only 53 farms of more than 50 hectares which may be regarded as rational production units in terms of their size. For this reason, the central importance of cattle

Table 13. Rotated factor matrix, farms of 10 to 20 hectares

Variables/factors	1 Sugar beet cultivation	2 Use of human labor	3 Pig husbandry	4 Rye cultivation	5 Potato and rutabaga cultivation	6 Wheat cultivation	7 Dairy farming	8 Degree of mechanization	9	10 Poultry husbandry	11 Management	12	13	14	15	Communalities h_j^2
1 Milk output, kilos/cow							-.631									.432
2 Plant cultivation work, hours per hectare		-.688							-.221			-.285				.774
3 Animal husbandry work,		-.695	-.228			.257	-.299					.219		-.202		.822
4 Other regular agricultural work, hours per hectare												.399				.241
5 Management work, men, hours per hectare											-.404					.272
6 Management work, women, hours per hectare											.484					.252
7 By-enterprise work, hours per farm									.340							.142
8 Horse work in agriculture, hours per hectare		-.262						-.674								.580
9 Tractor work in agriculture, hours per hectare	-.298							.670								.614
10 Adjusted hectare, hectare		.572														.420
11 Cattle husbandry return, marks per hectare		-.333				.271	-.538		.271							.647

Variables/factors	1	2	3	4	5	6	7	8	9	10	11	13	14	15	h_j^2
12 Dairy farming return, marks per hectare		-.392					-.623								.732
13 Pig husbandry return, marks per hectare			-.641				.227		-.216						.637
14 Poultry husbandry return, marks per hectare										.816					.711
15 Domestic animal husbandry return, marks per hectare		-.246	-.617			.273	-.296			.436					.892
16 Domestic animal husbandry return, o/oo of gross return	.430	-.279	-.297			.541	-.250					-.305			.907
17 Plant cultivation return, marks per hectare	-.708				-.318	-.472									.937
18 Wheat return, marks per hectare		.230				-.846									.876
19 Rye return, marks per hectare				-.930											.898
20 Pea etc. return, - " -												.515			.309
21 Potato return, - " -					-.775										.675
22 Rutabaga return, - " -					-.777										.667
23 Sugar beet return, - " -	-.971														.987
24 Purchased feed costs - " -	.200		-.451							.799					.967
25 Purchased fertilizer costs - " -	-.675						-.204							-.287	.717
26 Purchased seed costs			-.222											-.455	.321
27 Pesticide costs - " -	-.597					-.382							.250		.651
28 Electricity costs - " -			-.553												.423
29 Fuel costs - " -		-.284	-.370						.278	.306					.436
30 Costs of purchased supplies, total - " -	-.374		-.479							.706				-.282	.996

Variables/factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	h_j^2
31 Domestic animal costs, total, marks per hectare			-.631				-.403									.687
32 Labor costs, marks per hectare		-.841				.234	-.222									.924
33 Machinery and equipment costs, - " -	-.400		-.350					.393								.571
34 Building costs, - " -			-.473													.359
35 Land improvement costs, - " -																.284
36 Other costs, total, - " -	-.649								-.225					.411		.580
37 Land under Rye cultivation o/oo of the total, o/oo				-.923												.895
38 Rye, harvest, kilos/hectare				-.784												.677
39 Land under spring wheat cultivation o/oo of the total, o/oo						-.895										.885
40 Spring wheat, harvest, kilos/hectare						-.550								.315		.473
41 Land under sugar beet cultivation o/oo of the total, o/oo	-.958															.975
42 Sugar beet, harvest, kilos/hectare	-.623											-.298				.631
43 Feed-unit harvest, per hectare	-.697		-.272				-.229									.696
The eigenvalues of the unrotated factor matrix	7.08	6.00	2.85	2.35	1.86	1.39	1.31	1.13	.823	.674	.558	.468	.410	.356	.295	
The eigenvalues o/oo of the number of variables (cumulative)	165	305	372	417	460	492	522	548	567	583	596	607	617	625	632	

husbandry in this category is understandable. The result may also signify that on these farms, the economic results may be essentially raised, through intensive cattle husbandry, from the low average yield occasioned by extensive farming. The factor contains, however, many other loadings, some of which belong to plant cultivation, such as the area under spring wheat cultivation (x_{39}), for instance. Thus the character of this factor is not quite clear (Table 14).

Sugar beet cultivation is in this category one of the most significant factors. The distinct character of this factor is traceable to the fact that sugar beet cultivation clearly differs in terms of its intensity, for instance, from the production of several other products. The third factor, pig husbandry, also represents special production which is evident in terms of high intensity in feed costs (x_{24}), for instance. The fourth and fifth factors (rye and wheat cultivation) are again distinct factors because they only have the necessary loadings.

The other factors could also be partly examined. Yet, an interpretation is difficult because the loadings are small compared with the others. A combination of the loadings with each other does not seem sensible, either. Factors 8 and 9 may perhaps be regarded as poultry husbandry and potato culture factors. Factor 7 is perhaps a cost-describing factor because it contains several components belonging to production expenses.

Table 14. Rotated factor matrix, farms of more than 2C hectares

Variables/factors	1 Cattle husbandry	2 Sugar beet cultivation	3 Pig husbandry	4 Rye cultivation	5 Wheat cultivation	6	7	8 Poultry husbandry	9 Potato cultivation	10	11	12	13	14	15	Communalities h_j^2
1 Milk output, kilos/cow	.633															.56C
2 Plant cultivation work, hours per hectare	.519								.323		-.216			.564		.809
3 Animal husbandry work, hours per hectare	.870															.858
4 Other regular agricultural work, hours per hectare												-.448				.211
5 Management work, men hours per hectare									.317							.288
6 Management work, women, hours per hectare																.307
7 By-enterprise work, hours per farm										-.491						.301
8 Horse work in agriculture, hours per hectare	.326													.364		.413
9 Tractor work in agriculture, hours per hectare	.384	-.306							.303		-.395					.593
10 Adjusted hectare, hectare	-.408										.336					.397
11 Cattle husbandry return, marks per hectare	.693									.235						.631

Variables/factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	h_j^2
12 Dairy farming return, marks per hectare	.859															.810
13 Pig husbandry return, marks per hectare			.857				.231	.223					.272			.892
14 Poultry husbandry return, marks per hectare								-.555					.477			.359
15 Domestic animal husbandry return, marks per hectare	.582		.670				.258									.918
16 Domestic animal husbandry return o/oo of gross return,	.813	.215	.263		-.209								.264			.886
17 Plant cultivation return, marks per hectare	-.603	-.520			.314				.222							.907
18 Wheat return, marks per hectare	-.572				.612											.801
19 Rye return, marks per hectare				-.939												.917
20 Pea etc. return, - " -										-.453						.342
21 Potato return, - " -									.512							.301
22 Rutabaga return, - " -																.107
23 Sugar beet return, - " -		-.965														.994
24 Purchased feed costs, - " -			.924				.203	-.235								.976
25 Purchased fertilizers costs, - " -		-.608				.261						-.203	-.251			.612
26 Purchased seed costs, - " -						.537										.339
27 Pesticide costs, - " -	-.208	-.602			.204		.250									.615
28 Electricity costs, - " -			.297				.601									.504
29 Fuel costs, - " -			.275				.575	-.205								.530
30 Costs of purchased supplies, total, - " -			.891				.284	-.211								.996

Variables/factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	h_j^2
31 Domestic animal costs, total, marks per hectare	.712						.244									.737
32 Labor costs, marks per hectare	.778	-.250							.238					.292		.938
33 Machinery and equipment costs, marks per hectare		-.379					.417		.251		-.268					.554
34 Building costs, marks per hectare	.240		.229				.590									.524
35 Land improvement costs, marks per hectare							.394								.291	.395
36 Other costs total, marks per hectare		-.271									-.272					.284
37 Land under rye cultivation o/oo of the total, o/oo				-.916												.908
38 Rye, harvest, kilos/hectare				-.782												.677
39 Land under spring wheat cultivation o/oo of the total, o/oo	-.469				.660											.731
40 Spring wheat, harvest, kilos/hectare					.644											.493
41 Land under sugar beet cultivation o/oo of the total, o/oo		-.957														.981
42 Sugar beet, harvest, kilos/hectare		-.644												.260	-.284	.615
43 Feed-unit harvest, per hectare		-.715					.285									.719
The eigenvalues of the unrotated factor matrix	8.41	5.36	3.42	2.29	1.19	1.03	.920	.819	.702	.606	.519	.470	.389	.331	.271	
The eigenvalues o/oo of the number of variables (cumulative)	196	321	401	454	482	506	527	546	562	576	589	590	599	607	613	

D. Application of factor analysis results

To summarize the results, it may be noted that the various categories of farms share several factors. The only distinct difference between the various categories is that on farms of 10 to 20 hectares, milk production has been given less emphasis than in the other categories. This does not, however, necessarily have to represent an essential difference because in practice, the actual difference need not be as marked as indicated by the relative order established on the basis of mathematical calculations.

The factors which emerged generally indicate a production line. Thus, the factor analysis did not clearly produce anything which would affect the production function analysis to be examined later on. A factor analysis is used to reveal potential undisclosed or hard-to-find factors. Thus, in psychological studies, a factor analysis may have been used to dig up, for instance, various talent factors which cannot, as such, be directly associated with various results of learning. Although in this study, the factor analysis could not be used to reveal actual dummy variables, it does not rule out the possibility that such factors should influence agricultural production. In this analysis, the variables are input and production factors whose influence is both physical and biological and in that sense easier to gauge. In the case of human factors, the actual factor has to be replaced by several components. Yet, in this connection, the factor analysis was applied before the actual production function analysis. Despite the fact the factor analysis did not disclose any unknown production factors, it strengthened the importance and mutual interdependence of the explanatory variables with an eye to the production function analysis.

3. Production function analysis

A. On production functions in general

Production functions refer to the dependence of the volume of production, the yield, on various production factors[1]. This study is concerned with the dependence of agricultural gross return or its subdivisions, domestic animal husbandry or plant cultivation return, on such inputs as labor (human or machine labor), land (its quality and quantity), fertilization, feed use above all, the use of concentrated feed, pesticides, and so forth. The aforementioned factors can also be expressed by means of several different variables whereby their impact can be examined more accurately. The problem often is how to express quantitatively the factors, a task which is not always easy or even possible within the framework of a farm enterprise.

Among the concepts related to the production function

$$Y = f\,(X_1, X_2, \ldots, X_n)$$

in which Y = production and $X_1, X_2, \ldots, X_n$ are inputs only marginal product (MP) (cf. f.ex. HEADY 1952) may be mentioned here.

$$MP_i = \frac{\partial Y}{\partial X_i} = \frac{\partial f(X_1, X_2, \ldots, X_n)}{\partial X_i} \qquad i = 1, 2, \ldots, n.$$

Later on, this will be used in an examination of the logicality of the estimated models, for instance.

In order to make various production items commensurable, we have to use gross, animal husbandry and plant cultivation returns as dependent variables. Also, most inputs are given in monetary terms. Because this study covers only one year, the drawbacks arising from price differences are not great. Similarly, the farms are located practically in the same region, helping to reduce price variations. In the case of some inputs, a pecuniary form may prove even better because in part, at least, it measures the differences occasioned by quality (cf. f.ex. TORVELA 1966, p. 92).

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[1] As regards the concept and general application in agriculture of production functions, see BERINGER 1956, HEADY 1952, KETTUNEN 1966, TINTNER 1952, WEINSCHEENK 1964.

B. Selection of production function form and variables

In the application of a regression analysis, the specification of individual functions must be performed first, i.e. the selection of variables and the definition of the form of the function, to be followed by the choice of an estimation method.

As regards the choice of variables, there are several studies closely related to a discussion of this subject (BRULAND et al.1957, JENSEN E. VESTERGAARD 1964, RYYNÄNEN 1967, SANDQVIST 1961, TORVELA 1966). On the other hand, the problem itself examined in this study, the dependence of gross return on various factors of production, provides clear hints with regard to the selection of variables. The real problem is that all conceivable variables cannot be included in a model because of lacking statistical data. One such important variable is land quality which obviously affects crop results (cf. RYYNÄNEN 1967, p.51). One may attempt to solve the problem of variable selection by using purely statistical methods, for instance, by employing a so-called selective regression analysis to pick up out of a great number of variables those which on the best and/or certain criteria meaningfully explain the variations of a given variable (cf. Appendix I). Admittedly, this method is not satisfactory in every respect because a seeming correlation may produce errors. Logical deduction may be the best method in choosing the variables. Thereby it will be possible to seek a maximum number of variables and thereafter select the final, most useful variables by means of statiatical methods, for instance.

The choice of a form for the function is perhaps even more difficult because of the large number of alternative forms, particularly if the best possible form is to be sought for each variable. To define a form for the function, attention must be paid to the path of the function with all possible argument values. In other words, the value of the function must be examined with argument values from zero to the infinite, extreme values and inflection points must be calculated and the logicality of function changes must be examined by means of the marginal product (marginal revenue product), for instance (cf. KETTUNEN 1966, p. 10).

It is not always possible to find the correct final result on the basis of the available material, because it may be too limited for estimation purposes. Statistical data is often obtained from practical life while there is no way of influencing it systemically. Experimental arrangements are not often possible, for instance, with respect to the entire production of a farm. For this reason, the range of the variables is often too narrow and it does not contain the extreme values or not even necessarily the area of profitable production, not to mention a situation containing observations about the use of production factors in an area which is clearly unprofitable while production begins to fall (excessive use of fertilizers and feed, f.ex., area IV, Diagram 1).

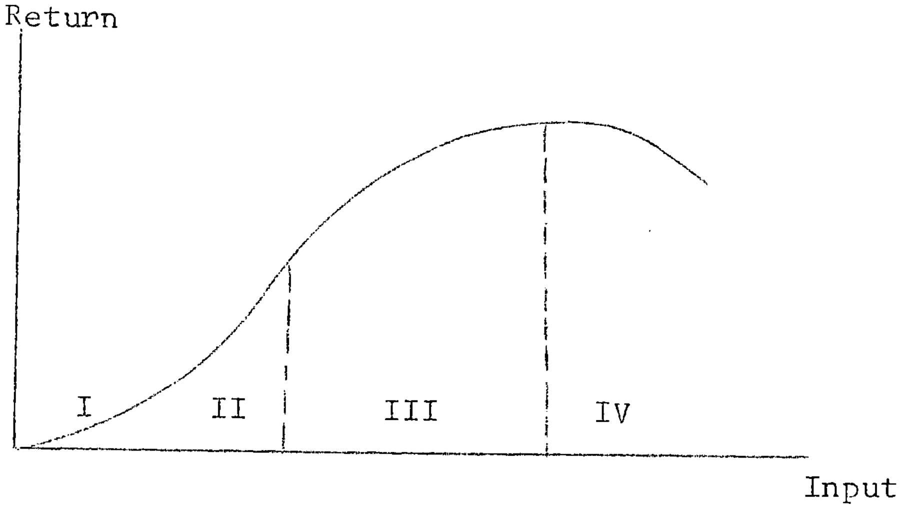

Diagram 1. Production function

Thus, the observations may be, for instance, entirely inside area II (Diagram 1) whereby the function model should be the model of a continuously growing function and the result applicable only within the area of observation. On the other hand, due caution needs always to be observed when a function model is applied outside the observation area. The maximum or optimum given by an estimated function may provide some hints with regard to the logicality of the model (cf. KETTUNEN 1966, pp.12-15).

The types of function most frequently applied are the linear and logarithmic models. Their applicability depends, of course, on the problem under examination. There are, however, general criteria on the basis of which it is possible to assess different types of function. For instance, the constant marginal product given by the linear model is unsatisfactory considering the entire potential range. The logarithmic model is in this respect more logical even though its marginal product may also be assessed because it is constantly getting bigger or smaller.

The type of function used in this study is transcendental:

$$(1) \quad \log Y = a + \sum_i b_i \log X_i + \sum_i c_i X_i + u.$$

One of its advantages is its elasticity because it gives a wide range of marginal products depending on the regression coefficients and their signs. If we examine a simple transcendental function:

$$(2) \quad \log Y = a + b \log X + cX$$

the marginal product is:

$$(3) \quad \frac{dY}{dX} = \left(\frac{b}{X} + c \right) Y$$

The function reaches its maximum when

$$(4) \quad X = - \frac{b}{c}$$

The following cases may be distinguished on the basis of regression coefficients and their signs: (Diagram 2).

1. $c < o$, $b > 1$. The most typical production function. Production grows at first at an accelerating pace, then slows down after the point of inflection to subsequently reach the maximum, goes down at an accelerating pace, slowing down after the point of inflection.

2. $c < 0$, $1 > b > 0$. Production grows, reaches the maximum and turns down.

3. $c = 0$, $0 < b < 1$. Production grows at a falling pace (the general logarithmic model).

4. $c = 0$, $b = 1$. Constant marginal product (the linear model).

5. $c < 0$, $b < 0$. Production falls steadily.

6. $b = 0$, $c < 0$. Production declines at a falling pace.

7. $c > 0$, $1 > b > 0$. Marginal product > 0, first declining then growing after the inflection point.

8. $c > 0$, $b \geq 1$. The same model as No. 9.

9. $c = 0$, $b > 1$. Production grows at an accelerating pace (logarithmic model)

10. $b = 0$, $c > 0$. Production grows at an accelerating pace.

11. $c > 0$, $b < 0$. Production falls at first, achieves the minimum and turns to a rise

12. $c = 0$, $b = 0$. Constant product.

Of the foregoing models, No.'s 1, 2 and 3 are generally acceptable for agricultural production functions. Their extreme values and production function values with argument values 0 and ∞ are logical. On the other hand, models 7, 9 and 10 obviously are not logical because it is unthinkable that by substantially increasing one input, better results could be obtained. Model 11 is partly acceptable but not entirely. The same is true of model 5. Model 6 is also partly

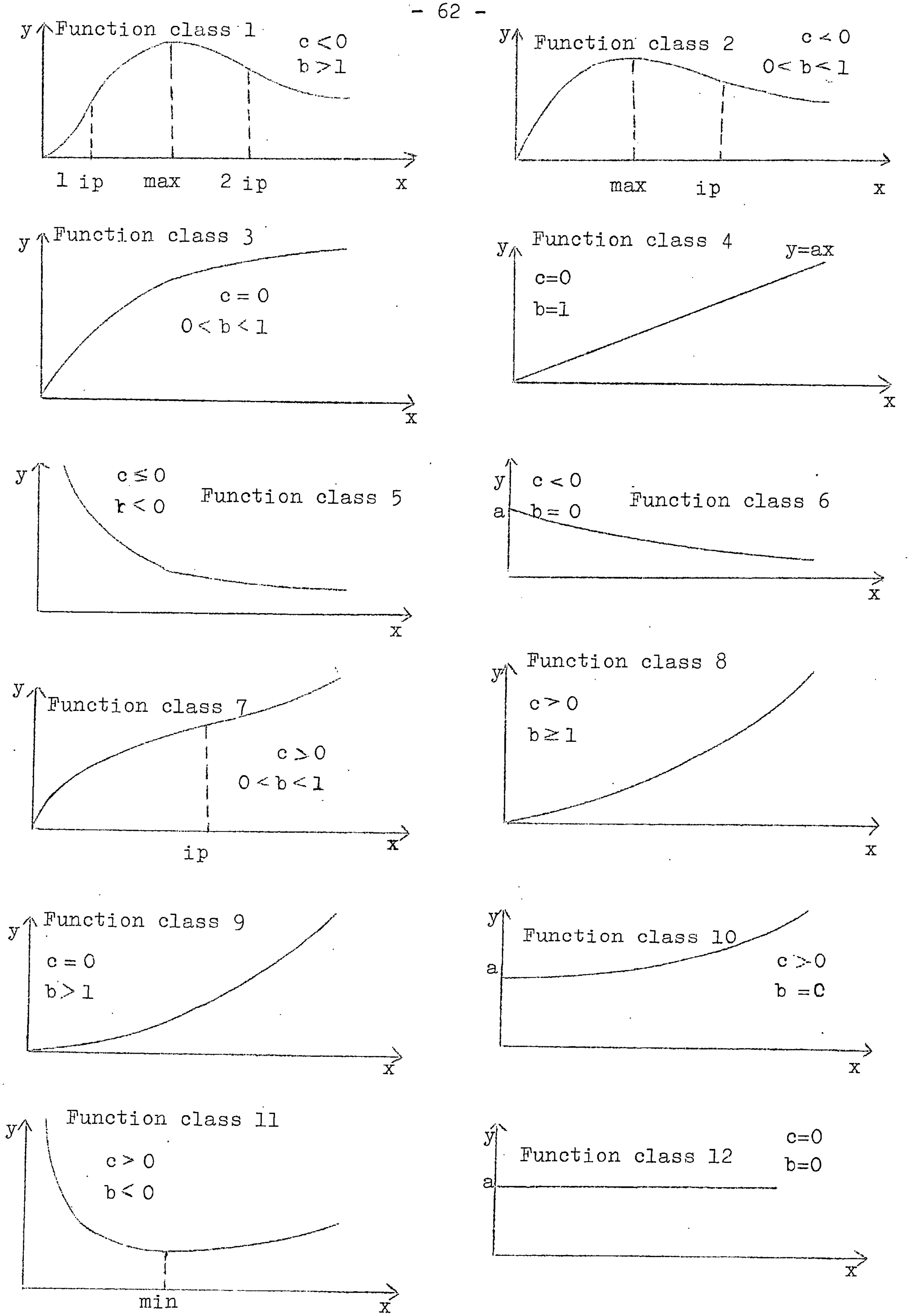

Diagram 2. Form of transcendental function at different parameter values.

acceptable. Models 3, 6, 5, 9 and 10 are only parts of a general model, for which reason they are plausible at some point of the range but are not to be generalized. Should the estimation give these models, the assumption is that the statistical material is too limited for the estimation of the entire production function. It has given only part of the said function.

The above examination is also applicable to a multiple variable model (1). With the use of a two-dimensional graphic presentation, changes in the values of other values mean a shift in the entire curve on the system of coordinates. The special points of the curve, of course, change if the values of the other factors change. One drawback of the transcendental function is its difficult mathematical form for which reason it is hard to figure out the extreme points, for instance.

The least-squares method may be used to estimate the functions because in principle, the models only contain one function and only a one-way dependency can be assumed to exist between the dependent and explanatory variables. The choice of an estimation method becomes problematical in the case of a two-way dependency whereby so-called multiple-equation models consisting of several functions have to be used.

4. Results of production function analysis

A. Compulsory regression model

A compulsory model refers in this case to a regression equation including all variables selected for examination. The purpose is to study how variables chosen a priori fit in a production function. The selective regression analysis used in the second phase picks up only statistically significant variables. Thereby some variables affecting the return are obviously left out but their effect is so small that it does not become manifest in terms of statistically significant regression coefficients because of the large variance. Thus, the non-meaningful coefficients of a compulsory model may attract some interest. The explanatory variables used here include the following:

X_1 = Milk production	kilos per cow
X_2 = Plant cultivation work	hours per hectare
X_3 = Animal husbandry work	-"-
X_8 = Horse work	-"-
X_9 = Tractor work	-"-
X_{10} = Arable land on the farm	adjusted hectare
X_{24} = Purchased feed costs	marks per hectare
X_{25} = Purchased fertilizer costs	-"-
X_{27} = Pesticide costs	-"-
X_{33} = Machinery and equipment costs	-"-
X_{35} = Land improvement costs	-"-
X_{37} + X_{39} = Land under rye + wheat cultivation	%
X_{41} = Land under sugar beet cultivation	%
X_{43} = Feed unit harvest	feed units per hectare

In addition to the regression coefficients (b) and their standard errors (s_b), the following tables show the function class as indicated above. The coefficient of determination of the function is expressed by the correlation coefficient R.

The dependent variable corresponds to the logarithm of the gross return and the returns of animal husbandry and plant cultivation and the independent variables are 14 variables, both linear and logarithmic, chosen consciously on the basis of the preceding factor analysis. The model has been applied to each farm category.

Table 15. The dependence of gross, animal husbandry and plant cultivation return on different inputs, regression coefficients b, their standard errors s_b, function class fl (see Diagram 2) and their common correlation coefficient R Farms of less than 10 hectares.

Variable	Gross return			Animal husbandry return			Plant cultivation return		
	fl	b	s_b	fl	b	s_b	fl	b	s_b
Constant		1.93848	.79935		-1.27162	1.13731		.72640	2.60464
X_1	11	.00001	.00001	5	-.00000	.00002	2	-.00003	.00004
X_2	7	.00010	.00025	2	-.00056	.00036	2	-.00026	.00083
X_3	11	.00060	.00020	1	-.00129	.00022	2	-.00076	.00051
X_8	2	-.00072	.00063	5	-.00020	.00090	5	-.00027	.00206
X_9	2	-.00071	.00123	2	-.00017	.00175	5	-.00002	.00401
X_{10}	2	-.00895	.02470	11	.01174	.03515	11	.18093	.08049
X_{24}	7	.00007	.00002	7	.00006	.00004	11	.00010	.00008
X_{25}	2	-.00029	.00040	2	-.00064	.00058	11	.00013	.00134
X_{27}	11	.00229	.00101	2	-.00016	.00143	2	-.00017	.00329
X_{33}	2	-.00010	.00024	11	.00044	.00035	7	.00090	.00080
X_{35}	2	-.00006	.00132	2	-.00014	.00188	2	-.00241	.00429
$(X_{37} + X_{39})$	2	-.00367	.00196	7	.00211	.00278	7	.00793	.00637
X_{41}	2	-.00163	.00426	5	-.00040	.00606	2	-.00130	.01387
X_{43}	7	.00002	.00004	7	.00001	.00007	2	.00003	.00015
$\log X_1$		-.01181	.01695		-.00976	.02412		.00299	.05523
$\log X_2$		.06859	.11670		.31275	.16604		.72309	.38027
$\log X_3$		-.23299	.04985		1.13226	.07093		.00756	.16244
$\log X_8$		.02085	.02359		-.00838	.03356		-.09379	.07685
$\log X_9$		.05239	.06390		.01151	.09092		-.20831	.20822
$\log X_{10}$		-	.35736		-.15509	.50845		-2.96896	1.16445
$\log X_{24}$		.16530	.03146		.27753	.04475		-.17668	.10250
$\log X_{25}$		.20534	.11664		.31808	.16595		-.02335	.38005
$\log X_{27}$		-.02968	.02978		.01293	.04237		.01877	.09702
$\log X_{33}$		.10304	.11393		-.05531	.16210		.08249	.37123
$\log X_{35}$		.00481	.02973		.00003	.04230		.08010	.09687
$\log(X_{37}+X_{39})$		.05237	.03479		.03123	.04940		.00904	.11337
$\log X_{41}$		.00315	.04449		-.03731	.06330		.37537	.14497
$\log X_{43}$		.11665	.28387		.08507	.40388		.48280	.92495
R		.90669			.97568			.79355	

Table 15. Cont'd, Farms of 10 to 20 hectares

Variable	Gross return			Animal husbandry return			Plant cultivation return		
	fl	b	s_b	fl	b	s_b	fl	b	s_b
Constant		.87938	.93232		1.72014	1.63897		-1.91167	3.14734
X_1	11	.00001	.00001	11	.00001	.00002	11	.00002	.00004
X_2	11	.00005	.00028	11	.00009	.00049	11	.00039	.00095
X_3	11	.00056	.00013	1	-.00239	.00023	2	-.00116	.00045
X_8	2	-.00024	.00091	7	.00011	.00160	2	-.00406	.00307
X_9	11	.00037	.00126	11	.00157	.00221	11	.00329	.00426
X_{10}	5	-.00224	.02155	2	-.01182	.03787	11	.11708	.07274
X_{24}	7	.00008	.00004	7	.00001	.00007	11	.00013	.00013
X_{25}	2	-.00029	.00027	2	-.00053	.00047	7	.00025	.00090
X_{27}	11	.00450	.00142	11	.00119	.00250	2	-.00172	.00480
X_{33}	11	.00040	.00027	11	.00068	.00047	7	.00018	.00091
X_{35}	7	.00157	.00199	2	-.00124	.00349	11	.00848	.00670
$X_{37}+X_{39}$	2	-.00282	.00079	2	-.00245	.00139	7	.00684	.00267
X_{41}	2	-.00268	.00257	5	-.00461	.00452	7	.00658	.00868
X_{43}	2	-.00001	.00004	2	-.00001	.00007	1	-.00019	.00014
$\log X_1$		-.01695	.01334		-.00452	.02345		-.02454	.04503
$\log X_2$		-.02357	.07944		-.02900	.13965		-.08209	.26817
$\log X_3$		-.10702	.03354		1.26641	.05895		.08414	.11322
$\log X_8$		.00064	.01872		.01486	.03292		.05936	.06322
$\log X_9$		-.04538	.06391		-.02997	.11235		-.26915	.21575
$\log X_{10}$		-.01047	.73440		.33269	1.29104		-3.83037	2.47920
$\log X_{24}$		.13546	.02475		.27937	.04351		-.14449	.08356
$\log X_{25}$		.11453	.06428		.12125	.11300		.18032	.21700
$\log X_{27}$		-.02873	.02227		-.02339	.03915		.05383	.07517
$\log X_{33}$		-.03218	.11252		-.13269	.19780		.12973	.37984
$\log X_{35}$		.01537	.02721		.03157	.04783		-.09075	.09187
$\log(X_{37}+X_{39})$		.01874	.01809		.00467	.03181		.13639	.06109
$\log X_{41}$		.02650	.02834		-.03290	.04982		.27220	.09566
$\log X_{43}$		.60044	.26262		.48672	.46169		2.10465	.88658
R		.87507			.96864			.78928	

Table 15. Cont'd, Farms of more than 20 hectares

Variables	Gross return			Animal husbandry return			Plant cultivation return		
	fl	b	s_b	fl	b	s_b	fl	b	s_b
Constant		1.39524	1.18079		-4.30690	3.04323		4.45560	3.71274
X_1	11	.00002	.00001	2	-.00002	.00003	11	.00003	.00004
X_2	11	.00022	.00047	2	-.00098	.00121	11	.00034	.00147
X_3	11	.00084	.00018	1	-.00329	.00049	2	-.00213	.00059
X_8	7	.00104	.00161	11	.00021	.00345	11	.00419	.00421
X_9	11	.00048	.00161	11	.00113	.00414	11	.00229	.00505
X_{10}	2	-.00024	.00073	2	-.00036	.00188	2	-.00262	.00229
X_{24}	7	.00012	.00002	2	-.00002	.00005	2	-.00041	.00006
X_{25}	11	.00036	.00021	2	-.00101	.00055	11	.00093	.00067
X_{27}	2	-.00089	.00091	2	-.00292	.00234	2	-.00397	.00285
X_{33}	2	-.00033	.00038	2	-.00060	.00099	2	-.00043	.00121
X_{35}	2	-.00257	.00176	11	.00272	.00455	2	-.01136	.00555
$X_{37}+X_{39}$	11	.00167	.00056	2	-.00041	.00145	7	.00332	.00177
X_{41}	2	-.00250	.00292	11	.00841	.00752	2	-.00784	.00918
X_{43}	7	.00006	.00006	1	-.00013	.00016	11	.00036	.00019
$\log X_1$		-.02996	.01498		.02127	.03860		-.05156	.04709
$\log X_2$		-.05444	.08035		.039114	.20708		-.10400	.25264
$\log X_3$		-.02969	.02004		1.03122	.05167		.00728	.06304
$\log X_8$		.00323	.02033		-.00797	.05239		-.05464	.06392
$\log X_9$		-.04865	.08700		-.18769	.22422		-.15144	.27354
$\log X_{10}$		.04802	.08583		.04880	.22120		.38019	.26986
$\log X_{24}$		.07790	.01426		.47423	.03675		.05523	.04484
$\log X_{25}$		-.06282	.06713		.19262	.17300		-.10027	.21107
$\log X_{27}$		.05481	.02171		.07901	.05594		.15859	.06824
$\log X_{33}$		.22594	.14889		.30128	.38371		.33186	.46813
$\log X_{35}$		.02387	.02716		-.01626	.07001		.14481	.08541
$\log(X_{37}+X_{39})$		.03001	.01748		.01707	.04504		.06194	.05495
$\log X_{41}$		.02131	.02978		-.10542	.07675		.11326	.09363
$\log X_{43}$		.29907	.39945		1.04325	1.02950		-1.08112	1.25599
R		.88120			.97501			.80781	

A general feature characterizing the models is that only a few regression coefficients are statistically significant with a 95 per cent significance. Significant variables are animal husbandry work, purchased feed costs, pesticide costs, land under sugar beet cultivation and arable land in a linear and/or logarithmic version. The coefficient of determination of the functions is very good. It seems the return of animal husbandry can be explained best while the coefficient of determination for the return of plant cultivation is clearly smaller.

Because of the mathematical nature of the model, no direct conclusions can be drawn from the size of individual regression coefficients. Rather, they should, for instance, be turned into marginal revenue products at mean levels. Marginal revenue products, however, depend on the input level. Thus, it is more interesting to study the form of the function itself with each variable separately while other factors remain unchanged. Here we may note first that the most widespread function class seems to be No. 2 (cf. Table 15). It could quite possibly become the general production function along with function class No. 1. Therefore, we may say that generally, the estimated models conform to the assumption. Earlier references have been made to the fact that all variables do not realize this class of function and that this may stem from too narrow a range. On the other hand, models 1 and 2 need not be universal, i.e. applicable to all production functions. As regards the sub-functions, animal husbandry and plant cultivation returns, all variables are not logical. The computer program used in this study gave the functions as by-products and because they may supply additional information about the formation of the components forming the gross return, they have been presented in this connection along with the actual principal function.

In many instances, the variables of empirical material are mutually correlated. Thus, any increase or decrease in the number of variables generally affects all regression coefficients. While the models have a total of 28 variables and only a small portion of them are statistically significant, the estimated models may be regarded as unsatisfactory in this respect. Statistically non-meaningful variables are usually left out of the model. For this reason, the estimation was also conducted with a selective regression analysis whereby only statistically significant regression coefficients were obtained.

B. Selective regression analysis

In this study, a regression analysis has been applied separately to each production line and farm-size category. The transcendental model has again been used as the basic model along with all the variables used in the previous analysis. The tables will show the order in which the computer program added the variables to the model. At the same time, the said order indicates the importance of the variables. The criterion by which the variables are selected in the selective analysis is the F value of the analysis of variance, is 10 i.e. it has been constant regardless of the degrees of freedom. With a growing number of variables, the F value should, however, diminish if the same level of reliability is to be achieved in all models. The t values suggest that in some models, the reliability of regression coefficients is at least 99 per cent and in others, at least 95 per cent. Within the framework of a fixed computer program, it is impossible, however, to devote attention to a settlement of this problem.

a. Gross return

Farms of less than 10 hectares

The selective regression analysis gave the farms of less than 10 hectares of arable land 8 statistically significant terms while there were only 5 terms in the compulsory model. Plant protection

(X_{27}) is missing in the selective regression analysis - in the compulsory model its coefficient is significant - but coming to its place are $\log X_2$, $\log X_{25}$, $\log X_{33}$ and $\log X_{43}$. A similar exchange of significant variables appears later on: the number of significant variables grows in the selective regression analysis. The overall correlation also rises higher than in the compulsory model due to increased degrees of freedom while the number of variables diminishes.

The gross return function on farms of less than 10 hectares contains 6 variables of which plant cultivation work, purchased fertilizer plus machinery and equipment costs, feed unit yield are included only as logarithmic versions whereby the coefficients are elasticities as such. The coefficients related to them are largely logical because an input increase gives an ever diminishing return. On the other hand, the results are also partly illogical because the maximum is infinitely great. Purchased feed costs and animal husbandry work appear in the model in an actual transcendental form and, as was pointed out before, their interpretation would require their transformation into gross revenue products. They depend, for their part, on the overall input level. Thus, a simple method of assessment is not to be found. The type of function (11) related to animal husbandry work which gives a minimum of 161 hours per hectare with a range of 0 to 678 hours per hectare while other variables are at their mean levels. There is no reliable explanation as to why the return drops initially. Also, it seems obvious that the return does not grow infinitely if the input is constantly increased. Therefore, the estimated model is not generally applicable as regards this coefficient.

Table 16. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Gross return as dependent variable. Farms of less than 10 hectares

Step No.	R	a	Purchased fertilizer costs ($\log_{10}$)	Purchased feed costs	Plant cultivation work ($\log_{10}$)	Feed-Unit yield, average ($\log_{10}$)	Purchased feed costs ($\log_{10}$)	Animal husbandry work ($\log_{10}$)	Animal husbandry work	Machinery and equipment costs ($\log_{10}$)
1	.689	2.169 (.108)	.521 (.051)							
2	.819	2.327 (.087)	.417 (.042)	.00018 (.00002)						
3	.850	1.934 (.116)	.386 (.039)	.00017 (.00002)	.208 (.044)					
4	.872	1.009 (.244)	.270 (.046)	.00017 (.00002)	.192 (.042)	.349 (.083)				
5	.881	1.099 (.237)	.301 (.045)	.00012 (.00002)	.184 (.040)	.274 (.083)	.062 (.020)			
6	.893	1.151 (.226)	.245 (.046)	.00009 (.00002)	.193 (.038)	.315 (.080)	.140 (.029)	-.113 (.032)		
7	.906	1.362 (.219)	.219 (.044)	.00009 (.00002)	.134 (.039)	.329 (.075)	.144 (.028)	-.201 (.038)	.00046 (.00011)	
8	.912	1.327 (.212)	.181 (.044)	.00009 (.00002)	.121 (.038)	.281 (.074)	.142 (.027)	-.185 (.037)	.00050 (.00011)	.122 (.041)
Type of function			3	7	3	3	7	11	11	3

The function model relating to purchased feed costs is not universal, either. Its marginal revenue product is first diminishing but after the inflection point, it turns to a rise. The inflection point is in this case, while the other variables are at their mean levels, X_{24} = 1 134 marks per hectare with a mean value of X_{24} = 336 marks per hectare and the range of X_{24} being 0 - 2 411 marks per hectare. Thus only a small portion of the observations fall inside the area of growing marginal revenue product. Of course, the estimated model is possible within the range of the variable but it is not to be generalized.

As regards purchased fertilizers, the elasticity is 0.181 in the last step. This means that a 1 per cent increase in fertilizer costs results in a 0.18 per cent increase in gross return. On the mean level, ($\overline{Y}$ = 2 055 marks per hectare and $\overline{X}_{25}$ = 149 marks per hectare) this gives a marginal revenue product of 2.5 Thus, fertilization has been remarkably profitable at this level. While fertilization increases, however, the marginal revenue product declines although the optimum moves within the framework of the model to a higher level with higher input levels. - Separate studies are planned to facilitate an optimum examination on the basis of these results.

Also, as regards plant cultivation work, the marginal revenue product is greater than 1 (1.3) on the mean level. Involved is, however, marginal revenue product per hour of work. Thus, it depends on the price of the working hour whether the optimum is reached on the product level in question. Labor input obviously has exceeded the optimum level because, on the average, the price of a working hour is higher than 1.3 marks.

Comparing the results given by the selective regression analysis here with the compulsory regression model, we may note that the selective regression analysis gave 8 significant coefficients while there were only 5 in the compulsory. Additional variables have reduced the significance obviously because of internal correlation. One of the variables, pesticide costs (X_{27}) is not included among the significant variables. In its place came other factors related to plant cultivation. In the selective regression model, the correlation coefficient is slightly higher than in the compulsory model, a circumstance caused by savings in the degrees of freedom.

Tables 17 and 18 show all the estimates of the intermediary stages of the model. They offer concrete evidence of the changes in regression coefficients while new factors are added to the model. Of course, the coefficient of determination grows in each stage in accordance with the computer program, but it may be fairly high even in an intermediary stage and so, such an intermediary model may be applicable. Obviously, the models must, however, be applied in toto because individual coefficients change from model to model.

Farms of 10 to 20 hectares

As regards farms of 10 to 2o hectares of arable land, (Table 17) it may be noted that the number of significant coefficients increased by 5 compared with the compulsory model with X_{24}, X_{27}, X_{33}, X_{35}, X_{43} and $\log X_{43}$ being new terms. The interpretation of the model with regard to several coefficients is, however, unclear. Referring to purchased feed, again, is function class No. 7 but in this case, the point of inflection, X_{24} = 1 100 marks per hectare, is outside the range of 0 - 968 marks per hectare. As regards animal husbandry work, the result is the same as in the previous category: the function type is No. 11. Feed unit yield in the estimated model is, some what unexpectedly, function type No. 2. As the feed unit yield rises ceteris paribus, the gross return should also rise. In the case of this variable, the gross return reaches its maximum at a point outside the range. Thus, the empirical material does not include the declining portion of the production function curve.

Table 17. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Gross return as dependent variable. Farms of 10 to 20 hectares

Step No.	R	a	Feed-Unit yield. average ($\log_{10}$)	Purchased feed costs	Machinery and equipment costs	Animal husbandry work	Purchased feed costs ($\log_{10}$)	Pesticide costs	Animal husbandry work	Land improvement costs	Feed-Unit yield average
1	.701	.009 (.213)	.915 (.062)								
2	.816	.514 (.179)	.753 (.052)	.00030 (.00003)							
3	.832	.714 (.177)	.678 (.053)	.00028 (.00003)	.00037 (.00008)						
4	.850	.688 (.169)	.666 (.050)	.00024 (.00003)	.00040 (.00008)	.00040 (.00008)					
5	.856	.662 (.166)	.654 (.050)	.00018 (.00003)	.00043 (.00008)	.00028 (.00009)	.047 (.016)				
6	.864	.842 (.169)	.593 (.051)	.00015 (.00003)	.00033 (.00008)	.00031 (.00009)	.060 (.016)	.0028 (.0007)			
7	.871	1.088 (.179)	.543 (.052)	.00008 (.00003)	.00032 (.00008)	.00059 (.00012)	.122 (.023)	.0031 (.0008)	-.107 (.031)		
8	.877	1.207 (.179)	.503 (.052)	.00008 (.00003)	.00020 (.00008)	.00060 (.00011)	.125 (.023)	.0031 (.0007)	-.111 (.030)	.0026 (.0008)	
9	.879	.034 (.609)	.892 (.200)	.00009 (.00004)	.00030 (.00008)	.00060 (.00011)	.124 (.023)	.0035 (.0008)	-.108 (.030)	.0026 (.0008)	-.00005 (.00003)
Type of function			2	7	10	11	7	10	11	10	2

Table 18. Selective regression analysis. Regression coefficients and, inside brackets, their standard-errors, constant a and common correlation coefficient R. Gross return as dependent variable. Farms of more than 20 hectares

Step No.	R	a	Feed-unit yield, average	Purchased feed costs ($\log_{10}$)	Purchased feed costs	Pesticide costs ($\log_{10}$)	Animal husbandry	Feed-unit yield, average ($\log_{10}$)	Land under rye+wheat cultivation % ($\log_{10}$)	Animal husbandry work ($\log_{10}$)	Machinery and equipment costs ($\log_{10}$)
1	.630	2.718 (.030)	.00013 (.00001)								
2	.808	2.559 (.025)	.00012 (.00001)	.1064 (.0075)							
3	.847	2.611 (.024)	.00012 (.00001)	.0754 (.0078)	.00013 (.00001)						
4	.855	2.602 (.023)	.00010 (.00001)	.0781 (.0076)	.00013 (.00002)	.0500 (.0127)					
5	.863	2.598 (.023)	.00011 (.00001)	.0554 (.0095)	.00014 (.00002)	.0601 (.0126)	.00046 (.00011)				
6	.869	.055 (.744)	-.00001 (.00003)	.0545 (.0093)	.00014 (.00002)	.0616 (.0124)	.00050 (.00011)	.834 (.244)			
7	.869	.361 (.170)		.0546 (.0093)	.00014 (.00002)	.0609 (.0123)	.00050 (.00016)	.733 (.051)			
8	.874	.262 (.170)		.0631 (.0095)	.00014 (.00002)	.0495 (.0126)	.00060 (.00011)	.753 (.050)	.0010 (.0003)		
9	.878	.368 (.171)		.0906 (.0130)	.00012 (.00002)	.0477 (.0124)	.00091 (.00015)	.728 (.050)	.0010 (.0003)	-.0548 (.0181)	
10	.881	.298 (.171)		.0886 (.0129)	.00011 (.00002)	.0383 (.0128)	.00086 (.00015)	.689 (.052)	.0011 (.0003)	-.0512 (.0180)	.0968 (.0369)
Type of function				7	7	3	11	3	3	11	3

Of all the estimated models, this one includes the greatest number of terms. New terms not included in the previous category are: pesticide and land improvement costs. The latter appears only in this model as a significant variable. Both are in function class No.10, a fact which apparently does not have universal applicability.

Farms of more than 20 hectares

As regards the farms of more than 20 hectares of arable land, (Table 18) the model is logarithmic with the exception of animal husbandry work and purchased feed costs, and thus the coefficients are elasticities as such. Admittedly, their interpretation would require, above all, a gross revenue product analysis. In this study, however, the interpretation has been conducted through the use of the function classes referred to earlier. The actual transcendental variables are similar in form to those cited before, i.e. purchased feed costs conforming to function class No. 7 and animal husbandry work to No. 11. Thus, in each farm category, an illogical result was achieved in respect to this variable, a result which cannot, therefore, be haphazardous. As regards pesticide costs, feed unit yield, land under bread grain cultivation, machinery and equipment costs, the model is an ordinary logarithmic function: the marginal revenue product declines as the input grows. Insofar as they are concerned, the model is obviously logical at least considering the material examined. A special feature characterizing the estimated results of this model is the replacement of the linear term of the feed unit yield by a logarithmic term in the seventh step.

To summarize what has been said about gross return functions, their coefficient of determination is fairly high but individual coefficients are not entirely logical nor do they meet the expectations. Of the available variables, only the percentage of land under sugar beet cultivation was not selected for the models but it is indirectly manifest, for instance, in the feed unit yield. Also excluded is milk production per cow which conceivably might have very clearly explained variations in the gross return. It is to be remembered, of course, that included in the models are inputs indirectly reflecting variations in the return.

b. Animal husbandry return

Because the farms examined in this study largely represent farms practicing animal husbandry, the production on several farms has been designed keeping animal husbandry specifically in mind. It is perhaps for this reason that the results, insofar as the formation of animal husbandry return is concerned, were the best in terms of their coefficient of determination and logicality (Tables 19 - 21). As far as animal husbandry work is concerned, the estimated model is in each farm category the classical production function model No. 1. On the farms of less than 10 hectares, the return reaches its maximum point with human labor at point 395 hours per hectare while the other factors are at their mean levels.

In the material examined in this study, this value is near the middle of the range 0 - 678 hours per hectare. In the second category (10 to 20 hectares), the maximum point is 234 hours per hectare and in the third category (more than 20 hectares) 142 hours per hectare while the other factors are at their mean levels (the range being 0 - 277 hours per hectare and 0 - 169 hours per hectare respectively). It is to be remembered again that the value of the variable giving the maximum point within the framework of the model rises as the other inputs grow. Animal husbandry work is in each farm category the best independent variable. As regards the other variables, the models are logarithmic (Cobb-Douglas type). Thus, the marginal revenue products diminish as the inputs grow. It is natural that purchased feed should belong to this model just as feed unit yield

Table 19. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Animal husbandry return as dependent variable. Farms of less than 10 hectares

Step No.	R	a	Animal husbandry work ($\log_{10}$)	Purchased feed costs ($\log_{10}$)	Animal husbandry work	Machinery and equipment costs ($\log_{10}$)
1	.923	.400 (.105)	1.134 (.044)			
2	.959	.392 (.077)	.806 (.047)	.346 (.036)		
3	.972	.201 (.069)	1.001 (.047)	.365 (.030)	-.0012 (.0002)	
4	.974	-.243 (.151)	1.062 (.049)	.336 (.030)	-.0012 (.0002)	.171 (.052)
Type of function			1	3	1	3

Table 20. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Animal husbandry return as dependent variable. Farms of 10 to 20 hectares

Step No.	R	a	Animal husbandry work ($\log_{10}$)	Purchased feed costs ($\log_{10}$)	Animal husbandry work	Animal husbandry work ($\log_{10}$)	Feed-unit yield, average ($\log_{10}$)
1	.922	.239 (.077)	1.256 (.035)				
2	.949	.258 (.062)	.936 (.041)	.331 (.031)			
3	.966	-.012 (.057)	1.232 (.044)	.320 (.025)	-.0020 (.0002)		
4	.971	.012 (.053)	1.196 (.041)	.257 (.026)	-.0022 (.0002)	.162 (.026)	
5	.972	-.652 (.275)	1.232 (.043)	.238 (.026)	-.0023 (.0002)	.153 (.026)	.188 (.077)
Type of function			1	3	1	3	3

Table 21. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Animal husbandry return as dependent variable. Farms of more than 20 hectares

Step No.	R	a	Animal husbandry work ($\log_{10}$)	Purchased feed costs ($\log_{10}$)	Animal husbandry work
1	.939	.431 (.051)	1.262 (.028)		
2	.968	.349 (.038)	.846 (.034)	.444 (.029)	
3	.975	.222 (.036)	1.091 (.041)	.433 (.025)	-.0033 (.0004)
Type of function			1	3	1

(Table 20). As regards machinery and equipment costs, the result does not seem a priori logical (Table 19). The fact that it belongs to the model may be associated with feed growing and thus the use of home grown feed at least in cases in which the farms have been engaged in intensive feed production. However, it has not been used as an individual variable because of lacking statistical data.

As regards the logarithmic variables (animal husbandry work, purchased feed costs, machinery and equipment costs and feed unit yield), their marginal revenue products are greater than 1 at the mean level. Thus, an economic optimum has apparently not been achieved as far as these variables are concerned. In these models, the number of variables is smaller than in the gross return or plant cultivation return functions. The reason may be that other input variables clearly affecting the animal husbandry return were not available. The coefficient of determination, however, is high although the number of variables is small.

If we compare the results of the selective regression analysis with the corresponding compulsory models, we may note that to the smallest farm category (of less than 10 hectares), the logarithmic term of machinery and equipment costs has been added. Added to the second category (10 to 20 hectares) are animal husbandry costs and feed unit yield in logarithmic terms. The variables in the third category (more than 20 hectares) are exactly the same as in the compulsory models. In the case of both types, the correlation coefficients are practically the same or nearly the same.

One would have expected the per-cow milk production to be reflected in these models but this did not happen. The reasons may be the same as before. Thus, this factor probably has been replaced by other factors. For the sake of uniformity, the animal husbandry return function is estimated by figuring out all variables per hectare. This procedure is not, however, defensible in every respect because with the help of purchased feed, even small farms are able to practice animal husbandry. The domestic animal - and not the size of arable land - is, then, the production unit. Thus, both the production and the inputs could have been calculated in terms of the number of animals by converting the animals, for instance, into cattle units and calculating the return and the inputs in terms of the unit in question.

As regards the model used here, it is to be noted that there are more statistically meaningful variables in the selective model than in the compulsory regression model. Additional variables are plant cultivation work (X_2), purchased fertilizers (X_{25}), land under bread grain cultivation (X_{37} + X_{39}) plus machinery and equipment costs ($\log X_8$).

The priority order of the variables of this model seems logical: purchased fertilizers are in first place, followed by machinery and equipment costs describing work efficiency, soil preparation etc. The importance of the size of land under sugar beet cultivation is natural, too because it represents highly intensive farming. The size of lands used for growing bread grains, rye and wheat, also represents special production compared with plant cultivation in general. This is also manifest in the form of meaningful regression coefficients. The fact that plant cultivation work is included in the model is closely related to machinery and equipment costs either as a substitute or as a complement. The results suggest that a complement case is in question because the coefficient presupposes a growing marginal revenue product. The farms included in this study are mechanized only to the extent that horse work and human labor, for instance, complement each other. In many cases, the degree of mechanization also depends on the production line involved.

In the 10 to 20 hectares category (Table 23), only 4 variables and terms are explanatory factors, namely, purchased fertilizers, land under rye and wheat cultivation (%), land used for growing sugar beet (%) and feed unit yield. Compared with the compulsory model, missing are animal husbandry work, something, which is quite logical and the logarithmic term of the size of land under bread grain cultivation. Added is, however, one important factor, namely,purchased fertilizers. The results indicate that insofar as purchased fertilizers and land under rye and wheat cultivation are concerned, not even a diminishing marginal revenue product phase was achieved. As regards

Table 22. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Plant cultivation return as dependent variable. Farms of less than 10 hectares.

Step No.	R	a	Purchased fertilizers	Machinery and equipment costs ($\log_{10}$)	Land under sugar beet cultivation % ($\log_{10}$)	Land under rye and wheat cultivation %	Plant cultivation work	Converted hectares ($\log_{10}$)	Converted hectares
1	.596	2.020 (.059)	.00257 (.00032)						
2	.654	.794 (.319)	.00178 (.00036)	.612 (.157)					
3	.704	.813 (.299)	.00091 (.00041)	.612 (.147)	.304 (.076)				
4	.728	.856 (.289)	.00107 (.00039)	.556 (.143)	.307 (.073)	.0099 (.0033)			
5	.751	.825 (.278)	.00100 (.00038)	.496 (.139)	.292 (.071)	.0121 (.0032)	.00089 (.00028)		
6	.760	1.209 (.330)	.00091 (.00038)	.523 (.138)	.314 (.071)	.0125 (.0032)	.00071 (.00030)	-.474 (.226)	
7	.772	1.997 (.456)	.00084 (.00037)	.514 (.135)	.325 (.069)	.0126 (.0031)	.00091 (.00030)	-2.998 (1.058)	.182 (.075)
Type of function			10	3	3	10	10	11	11

Table 23. Selective regression analysis. Regression coefficients and, inside brackets, their standard errors, constant a and common correlation coefficient R. Plant cultivation return as dependent variable. Farms of 10 to 20 hectares.

Step No.	R	a	Purchased fertilizers	Land under rye and wheat cultivation %	Land under sugar beet cultivation % ($\log_{10}$)	Feed-unit yield, average ($\log_{10}$)
1	.505	2.011 (.050)	.00306 (.00035)			
2	.673	1.862 (.046)	.00304 (.00030)	.0134 (.0015)		
3	.747	1.906 (.042)	.00172 (.00032)	.0150 (.0013)	.370 (.050)	
4	.765	-.744 (.672)	.00096 (.00037)	.0155 (.0013)	.329 (.050)	.801 (.203)
Type of function			10	10	3	3

Table 24. Selective regression analysis. Regression coefficient and, inside brackets, their standard errors, constant a and common correlation coefficient R. Plant cultivation return as dependent variable. Farms of more than 20 hectares

Step No.	R	a	Land under rye and wheat cultivation %	Feed-unit yield ($\log_{10}$)	Converted hectares ($\log_{10}$)	Purchased fertilizers	Land improvement costs	Land improvement costs ($\log_{10}$)	Pesticide costs ($\log_{10}$)	Converted hectares
1	.468	2.449 (.032)	.0104 (.0012)							
2	.648	-3.430 (.602)	.0104 (.0010)	1.699 (.174)						
3	.675	-3.733 (.587)	.0093 (.0010)	1.600 (.170)	.433 (.100)					
4	.686	-2.746 (.670)	.0087 (.0010)	1.274 (.201)	.452 (.099)	.00087 (.00029)				
5	.696	-2.951 (.665)	.0084 (.0010)	1.342 (.200)	.464 (.098)	.00101 (.00030)	-.0082 (.0029)			
6	.715	-2.811 (.648)	.0083 (.0010)	1.300 (.195)	.378 (.098)	.00102 (.00029)	-.0271 (.0056)	.351 (.089)		
7	.721	-2.317 (.671)	.0075 (.0010)	1.140 (.202)	.374 (.097)	.00089 (.00029)	-.0281 (.0055)	.351 (.988)	.116 (.046)	
8	.727	-3.092 (.744)	.0075 (.0010)	1.157 (.201)	.987 (.281)	.00090 (.00029)	-.0277 (.0055)	.334 (.087)	.117 (.045)	-.0058 (.0025)
Type of function			10	9	2	10	2	2	3	2

the use of purchased fertilizers and the extent of bread grain cultivation, the results suggest that it would be possible to improve the economic results of the farms examined in this study. In the case of the two other variables, on the other hand, a diminishing marginal revenue product throughout the entire range is involved.

In the more-than-20-hectare-category, (Table 24) new variables in the model are pesticide and land improvement costs, both as logical function models No. 3 and 2. Also, function class No. 2 has been obtained for arable land size, offering a basis for estimating the optimum size of a farm. On the mean level of the other variables, the maximum return is achieved with a size of 73.4 hectares. In other respects, the model is comparable with the previous ones.

The examination of plant cultivation return has not been as successful as that of animal husbandry return, partly because of the small number of distinct plant cultivation farms. No information is available on, for instance, land quality which plays a central role in plant cultivation. Similarly, weather and other environmental conditions plus differences in farm location have a decisive impact on the harvest results of different plants. It has not, however, been possible to taken them and factors relating to plant varieties into consideration within the framework of the material available for this study.

It is to be noted, furthermore, that at no stage was horse or tractor work added to the models which might have been of some interest with a view to their substitutes and the use of labor on the whole.

The fact that the coefficients in the compulsory model were not nearly significant obviously indicates that other inputs are of decisive importance to the formation of the return and that they also determine the use of horse and/or machines in general. As regards plant cultivation return, the actual inputs include plant nutritives (purchased fertilizers), land improvement plus external environmental conditions, temperature and rainfall. Other inputs are merely indirect variables needed for the realization of those mentioned above. Of course, a good harvest is essentially influenced by sowing time, varieties suitability and successfull reaping. In addition, crop damage affects the quality and quantity of the harvest in terms of certain risk elements. The output of plant cultivation is obviously much greater with such external factors which cannot easily be expressed numerically.

In this study, is has not been possible to examine the farmer's own input and human factors as a separate factor in general. These activities by the farmer himself are only partly reflected in the activities examined above.

III. SUMMARY AND FINAL CONCLUSIONS

The purpose of this study has been to study gross return in agriculture and the factors influencing it. The material selected for this study consists of 615 bookkeeping farms in South Finland and their economic results in fiscal 1967. Part one of the study is concerned with a general examination of the formation of gross return and its level in terms of different production lines and size categories. The use of different production factors has been examined in a similar manner. Because the size of a farm significantly affects the formation of gross return and the use of production factors, the farms have been grouped into three categories: farms of less than 10 hectares, of 10 to 20 hectares and of more than 20 hectares. The criterion used to establish different production lines is the formation of gross return in agriculture. The main lines are animal husbandry- and plant cultivation-oriented farms plus a number of subdivisions in each group. Examined in this study are the average gross return levels and the major production factors on each farm and in each category mentioned above. Particular attention has been devoted to the dispersal of various factors, leading to the conclusion that because of the extent of the dispersal, the available material cannot be properly used without grouping it into uniform categories. It is clear that farms specialized in, for instance, milk, beef, pork, sugar beet or bread grain production differ significantly from each other in terms of gross return and production factors. For this reason, in some groups the use of certain inputs may be manifold compared with other groups. It seems obvious, then, that in drawing conclusions from the results reported by the bookkeeping farms, one should examine the farms in terms of production lines.

Part two is concerned with the interdependence of gross return and production factors, opening with a factor analysis in order to select the variables to be included in a later regression analysis. The factors that were obtained could in general be recognized as factors describing a production line. Part of the factors remained, however, unexplainable because the fixed computer program produced only 15 factors some of which were obviously unnecessary. Because a factor analysis was employed only in a preliminary examination, the analysis was not broadened, for instance, by recalculating the factor analysis in terms of the factors that were explained. Among the factors, sugar beet cultivation, cattle husbandry, use of human labor and pig husbandry (Tables 12 to 14) proved the most important. Also, rye and wheat cultivation plus the degree of mechanization clearly emerged as distinct factors. Some potential illogicalities were included in the factors but because of the small loadings, it was thought that they were not disturbing factor interpretation.

With a view to the actual production function analysis, the factor analysis produced nothing essentially new. It did not reveal any such dummy factors as were not in any way gauged but which should be added to the model. Admittedly, the analysis performed here cannot prove that such do not exist because no variables describing, for instance, human factors were included among the variables.

In this study, the so-called transcendental function was selected as the production function model:

$$\log Y = a + b_1X_1 + \ldots + b_nX_n + c_1\log X_1 + \ldots + c_n\log X_n.$$

Chapter II (3.B) is concerned with an examination of the form of this function in terms of one variable with different parameter values. This type of function proves a very flexible basic model giving a wide variety of results within the framework of the material in question. Function class No. 1 may be regarded as the most typical production function form, a desirable starting point in the case of many variables in agricultural production. In this study, the estimated model has generally been considered a successful one if it has proved to be function class No. 1.

In the estimation of the dependence of gross, animal husbandry and plant cultivation return on the variables selected for this study (Table 15) it was found that only part of the coefficients were statistically significant. This can, of course, be explained by the minor degree of the interdependence and partly by the too small range of the variables whereby it is generally impossible to obtain reliable coefficients.

In the second phase, a selective regression analysis was employed for selecting the variables whose regression coefficients were statistically significant. Thereby, the models consisted of a maximum of 8 explanatory factors (gross return functions, Tables 16 to 18) while the number of variables as regards animal husbandry return was 4.

The estimated models largely conform a priori to the assumptions (Tables 16 to 24) and even as regards the variables unfit for universal reference, the obtained estimates are plausible within the framework of the material used in this study. The target, function class No. 1, was achieved in the case of several variables. No detailed examination of the advantages of each production factor in general has been undertaken in this study nor of the extent to which the use of production factors could be increased in order to achieve the optimum return, for instance.

In a generalization of the results of this study, attention must be paid to the fact that bookkeeping farms involved in this study are not selected on the random sample principle. Therefore, they cannot be regarded as representative of all the farms located in South Finland. Furthermore, it is to be noted that this study is confined to one fiscal year. Also, the range of a number of factors has been so narrow that only part of the production function curve has been examined. Moreover, as regards gross return and expenditure, price differences between various farms have not been taken into consideration but on the other hand, they may not be very great because the farms are located within a fairly limited area.

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APPENDIX I. Selective Regression Analysis

The basic idea underlying a selective regression analysis is to form a regression equation with the optimum independent variables chosen from a given group of variables being the independent variables. This takes place step by step as some kind of an accumulating process through the estimation of intermediary models. The successive models are established by testing;

a) whether the regression equation, following the addition of the independent variables, has so changed as to include statistically insignificant variables. Should this be the case, the least explanatory variable is dropped from the equation.

b) Should all the variables included in the model be significant, tests are to be made to see whether the variables outside the model include such as explain an additional portion of the variation of the dependent variable, a portion which is significant. If this is the case, the most explanatory variable is added to the model.

The buildup of the model is continued in this manner until negative answers have to be given to both tests by which time the process is concluded.

Process realization

As a starting point, we may use the information gathered from the variables in the form of a partitioned correlation matrix A (RALSTON-WILF 1960, p.194).

(1) $$R = A = \begin{bmatrix} S & t \\ t' & z \end{bmatrix} = \begin{bmatrix} a_{ij} \end{bmatrix} \quad (n \times n) - \text{matrix}$$

in which the last vertical and horizontal lines correspond to the correlations of the dependent variable along with the independent variables. Application of a certain transformation, the so-called Jordan exchange, to the matrix corresponds either to the addition or removal of a variable from the regression equation.

The criterion of the addition of the variable to the model is, as was mentioned earlier, the additional portion of the variation of the dependent variable explained by the variable. This is calculated by means of the following formula (RALSTON-WILF, 1960, p.196).

$$(2) \quad V_i = \frac{a_{in} a_{ni}}{a_{ii}}, \qquad x_i \text{ not included in the model}$$

If $\max_i V_i$ proves significant in terms of an F test, the corresponding variable X_i is added to the model. In the case of a completely arbitrary model, no particular variables are forced into the equation on the basis of a priori information. Thus, the first variable to be added to the model is obtained by calculating from the formula (2) the coefficients of determination for the variables and by selecting to the model the variable corresponding to the biggest coefficient of determination, should its coefficient of determination prove significant.

A possible removal of a variable from the model is performed by calculating for the variables included in the model their coefficients of determination V_i from the formula (2). Because of the characteristics of the Jordan exchange, they are negative. Thus, the item to be tested is $\min_i |V_i|$ (X_i belongs to the model). If the portion of the variance of the dependent variable explained by the corresponding variable proves insignificant in terms of an F test, the variable is removed from the model.

It is to be noted that the regression coefficients with their standard errors of the regression equation corresponding to each step can be calculated from the matrix A. Thus, in order to perform the process, it is sufficient to handle the matrix A only.

The Jordan exchange (RALSTON-WILF, 1960, p.195).

If we assume that the variable to be added to or removed from the model is X_k, the elements $\acute{a}_{ij}$ of a new matrix are obtained as follows:

$$a'_{ij} = \begin{cases} a_{ij} - \dfrac{a_{ik}a_{kj}}{a_{kk}} & \text{if } i \neq k \text{ ; } j \neq k \\[2ex] \dfrac{a_{kj}}{a_{kk}} & \text{if } i = k \text{ ; } j \neq k \\[2ex] -\dfrac{a_{ik}}{a_{kk}} & \text{if } i \neq k \text{ ; } j = k \\[2ex] \dfrac{1}{a_{kk}} & \text{if } i = j = k. \end{cases}$$