MAATALOUDEN TALOUDELLISEN TUTKIMUSLAITOKSEN JULKAISUJA N:o 40
PUBLICATIONS OF THE AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, FINLAND, No. 40

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PREFACE

The main part of the present study was carried out during the time I was employed by the Academy of Finland. In the course of these years, I was fortunate enough to be stationed at the Agricultural Economics Research Institute. My indebtedness for all the facilities, the inspiring working environment and the guidance I have received, goes above all to professor MATIAS TORVELA, Head of the Institute.

As usual, several persons have contributed to the completion of this study. To begin with, I would like to express my sincere thanks to my teacher in economics, professor LAURI KETTUNEN, Head of the Marketing Research Department of the Institute, for his constructive guidance and for the interest with which he shared the numerous problems the author was faced with in the course of this study. He has also made useful comments on the final manuscript.

A particular debt of gratitude is due to professor RISTO IHAMUOTILA for his support, perceptive comments and the discussions we have had from which I benefited a great deal. Apart from that, he has read the entire manuscript and made detailed suggestions that have led to substantial improvements.

I also wish to thank all the anonymous colleagues at the Institute who have helped in different ways in the completion of this study.

Since English is not my mother tongue, the contribution of Mr. JARMO JAAKOLA and Miss ANNA MACDOUGALD of Dublin Ireland, who helped me in expressing myself in proper English, is highly appreciated.

Mr. TIMO PEKKONEN has provided substantial assistance in solving the computational problems. Special thanks also go to Mrs. RITVA LINDROTH and Miss RIITTA VÄNSKÄ for their long hours of typing the different versions of the manuscript and Mrs. LEENA KOIVULA for drawing the numerous graphs.

For financial support, provided by the Academy of Finland and the University of Helsinki, I would like to express my sincere thanks.

Finally, I acknowledge my debt of gratitute to the Board of the Agricultural Economics Research Institute for including this study in its series of publications.

Helsinki, October 1979

Juhani Rouhiainen

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1. INTRODUCTION

1.1. Background

In Finland, food constitutes a major single item of private consumption expenditure. In 1976, its share was 22 per cent. Since 1950, a considerable change has taken place in the consumption structure as a whole. About 36 per cent in 1950, the share of food has declined steadily since then. Among the most important reasons prompting these developments, we may list the following: increased disposable income, changed price ratios, changed population structure, changed tastes and habits and the introduction of new products.

The food category itself has changed during the past two and a half decades (see Figure 2.2.1.). The consumption of cereals and potatoes indicates a declining trend (because of changed data sources, potato consumption registers an upward shift in 1961 and a downward one in 1976). In comparison, the consumption of some animal products such as meat, eggs and cheese, rises considerably. The same goes for fruits and berries. These developments are typical of all so-called developed countries although some national differences may exist.

Examined in terms of calorie consumption, three commodities — cereals, milk & dairy products and sugar — constituted some 80 per cent of the total calorie intake of the Finnish diet in 1950. In 1977, the respective figure was 63 per cent. The main reason for this decline is the decreased consumption of cereals. It is also worth noting that meat has become an important source of energy as in 1977, its share was about 14 per cent of the total calorie intake. In general, the Finnish diet today consists of a wider variety of commodities which are in many cases consumed in larger quantities than before. It is obvious that the same reasons that were indicated before are accountable for these changes.

On the other hand, a healthy diet should also consist of protein in proper quantities and qualities. In particular, animal protein is needed for growth because of its high-quality animo-acid content. In spite of some annual fluctuations, the total protein consumption shows little variation during the period 1950—77. A noticeable change has occured, however, in the structure of protein consumption. In 1950, the proportion taken by animal protein of the total protein consumption was about 54 per cent. In 1977, the total figure was 71 per cent.

Finally, the consumption structure of the Finnish diet and changes therein can be expressed in terms of expenditure shares (Table 1.1.1.). The figures in that table

Table 1.1.1. Expenditure shares of main food items per cent of total expenditure.

	1950 [1]	1966 [2]	1971 [3]	1976 [4]
1. Cereals	6.6	4.7	3.4	2.9
2. Potatoes	1.2	0.6	0.4	0.4
3. Sugar	1.7	1.2	0.7	0.7
4. Vegetables	1.2	0.9	0.9	1.0
5. Fruits & berries	2.8	2.0	1.9	2.0
6. Beef	4.6	3.0	2.9	2.6
7. Pork	3.4	2.6	2.7	2.4
8. Eggs	1.7	0.8	0.7	0.5
9. Fish	1.5	0.8	0.7	0.6
10. Milk & milk products	6.2	4.3	3.5	3.4
11. Cheese	0.2	0.5	0.5	0.6
12. Butter	4.0	3.0	1.6	1.2
13. Margarine & oils	0.4	0.4	0.5	0.5
Total [5]	35.5	24.8	20.4	18.8

[1] ANON. 1951, p. 428—429
[2] ANON. 1968: 11, p. 52—53
[3] ANON. 1974: 5, p. 58—59
[4] LEHTONEN 1979, p. 24—26
[5] Note that coffee, tea, cocoa, candies and spices are excluded from this total.

are based on household surveys. With some exceptions, the expenditure shares of nearly all commodities are small. In 1976, the expenditure share of several goods was less than one half of what they were in 1950/51.

Since the late 1960's, although never officially verified, the production target of Finnish agricultural policy has been self-sufficiency or production quantities slightly exceeding it. This target applies to all the main products. The adjustment of production to the level of self-sufficiency requires that we know the future consumption of agricultural products.

Apart from overproduction, Finland has, in recent years faced the problem of a disadvantageous farm structure; there are too many small farms on which people cannot make their living. The three factors — consumption, production and farm structure — make up an entity where consumption is the key factor. By virtue of reliable consumption forecasts, we are able to set production targets to meet a given self-sufficiency level, which in turn establishes good grounds for developing the farm structure.

The future consumption of food commodities is also of major importance to the food processing industry, in planning the volume of future processing capacity.

1.2. Problem and objectives of study

In developed economies such as Finland, there are usually no established human consumption targets for food. Apparently, this is because in these countries the average diet reaches or exceeds the nutritional minimum of a healthy diet. Given these circumstances, the consumption of food is determined mainly by market forces and agricultural policy. Thus, if we want to make consumption forecasts, it is essential to know the economic behavior of consumers. In other words, we ought to know how consumers respond to changes in commodity prices and in their disposable income. After first making assumptions on the future development of these factors, are we able to predict future consumption within some error margins.

Despite numerous individual studies, our knowledge of the demand for food, and factors affecting it, is at the moment inadequate. Today, we do not have, for example, updated price and income elasticities. As regards consumption forecasts and studies in that field, the lack is even more obvious, since no studies are currently available that would include consumption forecasts based on an up-to-date demand study. As indicated before, the results of such a study would be highly valued.

In this connection, it is to be mentioned that official State Committees have usually paid minor attention to the consumption of farm products. Generally, major emphasis has been placed on the means of cutting production. The future consumption levels are then usually estimated relying on past trends.

The specific objectives of this study can be expressed in terms of economic language as follows:

1) to estimate all the own-price and income elasticities of the demand for agricultural products. To estimate as many as possible of the cross-price elasticities so that these form a consistent elasticity matrix, and to detect changes in the demand elasticities,
2) to elaborate a system that enables one to make reliable forecasts for the future consumption of agricultural products; this system should include a mechanism through which the existing forecasts could be revised following access to up-to-date data,
3) to make short-term and longer-term consumption forecasts for agricultural products. In this connection, »short-term» refers to forecasts extending 2—3 years ahead; the »longer-term» time span reaches about 10 years ahead. The accuracy requirement of the latter is set lower because these forecasts are to be revised subsequently.

1.3. Previous studies

There is a large number of studies on the demand for agricultural products in Finland. Almost all of them deal with demand for single products or a small subgroup of products. Studies where all farm products are examined at the same time are not very numerous. Only the latter type of studies carried out in Finland are referred to in this section. The results of other studies are commented on in the context of the results of this study.

In 1961, KAARLEHTO (1961) published a study where he estimated demand elasticities for farm products on the basis of the 1956 budget study data. These are cross- section elasticities calculated in terms of quantities and expenditures. The data is grouped by socio-economic classes and the size of families. Two types of demand functions were used. The study covers a total of 18 commodities or commodity groups.

A demand study by MARJOMAA (1969) is based on the 1948—65 timeseries data of the consumption expenditures shown by the Finnish National Accounts. Data from the 1955/56 and 1960 budget studies was used to obtain cross-section elasticities. The study covers all products and services belonging to private consumption. Food is devided into 9 main groups of commodities which include some subgroups. The results are not considered very reliable by Marjomaa mainly because of data problems.

In 1973, HÄMÄLÄINEN (1973) published a study which may be regarded as an updated extension of the Marjomaa study. Also in this study, food is divided into 9 main groups. The data covers the years 1948—69. In addition to the above-mentioned budget studies, Hämäläinen used data from the 1966 household survey. This study includes a calculation of price elasticities of 12 commodity groups using the Frisch method. It is the first study to introduce consumption forecasts which were worked out for 1975.

The most recent consumption forecast of agricultural products was made by HAGGRÉN and KETTUNEN (1976) in 1976 (see also KETTUNEN 1976). The purpose of this study was mainly to alleviate the glaring lack of forecasts. The forecasts in this study, extending up to the year 1985, are based chiefly on past trends and subjective evaluations. However, the results of the previous studies are taken into account as far as possible. All of these forecasts are conditional because they assume the materialization of a certain price and income development. Thus they are going to be revised at some years' intervals.

2. CHANGES IN CONSUMPTION AND PRICE STRUCTURE OF FINNISH DIET

2.1. General remarks

The purpose of this chapter is to set forth the most important developments in the quantities consumed and the retail prices of the food items to be studied later. It aims to provide some background information for the economic analysis to be performed in the chapters that follow. This discussion is not meant to be complete in terms of coverage and depth. It only provides a superficial historical review of the main policy and price changes. The development of the quantities consumed is also surveyed.

After World War II, all the main foodstuffs were rationed until the end of the 1940's. The rationing was discontinued gradually so that by the early 1950's, only rice, margine, sugar and coffee were affected. The rationing of margarine and sugar was abolished at the end of 1953 and that of coffee two months later. Because the research period covers the years 1950—75, only the products mentioned are affected. The influence of ratioing is later eliminated by varying the period of analysis.

The retail prices of most foodstuffs have, with some exceptions, been under control since World War II. The control measures included price control and price freeze. Because these are, from the standpoint of this study, exogeneous factors, they are not discussed.

In 1956, the first Agricultural Price Act was passed. Even though the purpose of this act and the subsequent ones has been to stabilize the producer prices of agricultural products, they have had at least some stabilizing effect on the retail prices, too. Similar policies were also followed between 1952 and 1956 even though no formal law existed.

The Finnish mark was devalued in 1957. Subsequently, foreign trade underwent extensive liberalization. The measures taken included the abolishment of quantitative restrictions, reductions of customs and import duties. The main foodstuffs were, however, left outside the scope of these measures, as quantitative restrictions were maintained. It is very difficult to make any quantitative valuation of how much the liberalization of trade has affected the retail prices after 1957. However, we may conclude that its effect has been relatively larger on fruits and some vegetables than on f.ex. animal products, which are still placed under quantitative import restrictions.

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It is obvious that quality changes have occurred in many foodstuffs since 1950. Apart from changes in the products themselves, the packing of foodstuffs has improved considerably both in quality and quantity. Overall, these changes have been reflected in higher retail prices. In this connection, it is to be remembered that the consumption of highly packed products is usually connected with highly prepared food or fully completed meals. In other words, part of the preparing of food previously carried out by households is transferred to the food processing industry. Accordingly, we may conclude that seldom can one discover a pure price change; usually the price change observed is a mixture of quality changes and changes in packing, including the selling of certain services to consumers.

2.2. Changes in per-capita consumption

In this chapter, the main features in per-capita consumption trends are discussed in brief commodity by commodity. As pointed out earlier, this review does not purport to be a complete one.

Cereals; per-capita consumption of cereals has declined with some exceptions since 1950. While in 1950, consumption was about 123 kg/capita/year, the same figure for 1977 was only 72 kg or 59 per cent of the amount consumed in 1950 (see Figure 2.2.1.). Some levelling off can be detected in the early 1970's. Finally, we may note that bread and other bakery products in general have undergone relatively small changes in quality.

Potatoes; consumption of potatoes has declined almost at the same rate as that of cereals (Figure 2.2.1.). The spurious increase in consumption in 1961 and the decrease in 1976 are due to changes in the basic data. The quality changes for potatoes are not very many as f.ex. potato chips have not become so popular in Finland as in many other countries.

Sugar; consumption of sugar rose fairly steadily up to 1972, when the record level of 45.5 kg/capita was reached (Figure 2.2.1.). Since then consumption has declined rapidly. Quality changes in sugar during the study period are minor. It is, however, worth noting that apart from sugar consumed as such, it is widely used as an ingredient in many products, f.ex. in bakery products and in soft drinks.

Vegetables; from 1950 to the late 1960's, consumption of vegetables remained nearly unchanged; at the level of 20 kg per capita. Since then some increase has occured. The structure of vegetable consumption has obviously changed somewhat.

Fruits and berries; consumption of this group has grown rapidly, a per-capita consumption of 16.5 kg in 1950 was doubled in 1960 and tripled ten years later. In the 1970's, the growth of consumption has accelerated, reaching 81.8 kg/capita in 1977. One reason for that is the increasing use of juices in recent years which is counted as fruit consumption. Imports and the amount of domestic apples harvested are of major importance to the consumption of this group.

Beef; in 1977, consumption of beef was almost twice the amount consumed in 1950. In the middle of the 1970's, the increase of consumption has levelled off and turned slightly downwards. Beef itself has not changed very much, but some remarkable developments have occurred in processed meat products. It is estimated that one half of all beef is consumed in the form of processed meat.

Pork; consumption of pork has more than doubled in the study period. In the 1970's its use has exceeded that of beef. Since 1950, the quality of pork meat has improved considerably. As in the case of beef, approximately one half of pork is consumed in the form of processed meat.

Eggs; consumption of eggs has more than doubled during the period 1950—77. In the early 1970's, consumption seems to have settled at a level of nearly 11 kg/capita. In fact, the product itself — the eggs — has changed very little, but it is to be remembered that in recent years, more eggs have been consumed in the form of bakery products.

Fish; from 1950 to 1965, annual consumption of fish remained nearly unchanged at the level of 10.5 kg/capita. After that it has risen somewhat. In recent years, fish has been consumed on an increasing scale in frozen form. Annual catches have had an impact on consumption levels.

Milk; in addition to liquid milk, this group includes all the other dairy products except cheese and butter. From 1950 to 1970, milk consumption declined, with a few exceptions, quite rapidly each year. The increases seen in the 1970's are likely to stem from the introduction of new products such as yoghurt and kefir. Sales of unpacked milk have been discontinued and disposable cartons introduced. Some quality changes have occurred with regard to the fat content of consumption milk.

Cheese; in 1950, annual consumption of cheese in Finland was only 1.5 kg/capita. By 1977, the consumption level had increased fourfold. Still it is quite low compared with other European countries. The structure of cheese consumption has remained unchanged: the Finns eat almost exclusively Edam- and Swiss-type cheeses. Not until recently have other cheeses become more popular.

Butter; consumption of butter has declined since 1962, when the record level of 18.7 kg/capita was reached. Even though some rises have taken place, the trend is continuously pointing downward. The increased consumption experienced in the early 1960's is related to the so-called margarine scandal which will be discussed in connection with margarine. Quality changes in butter have been minimal.

Margarine; on the basis of Figure 2.2.1., it is easy to conclude that margarine consumption is closely connected with consumption of butter. In the early 1960's, consumption of margarine declined sharply because of the so-called margarine scandal. This was caused by some newspapers which attacked margarine manufacturers, accusing them of using inferior raw materials. Since the mid-1960's, the use of margarine has risen rapidly. The introduction of new soft »icebox» margarines is likely to have contributed to this development. The disputed health aspects of butter have probably also had an impact on the rising consumption of margarine.

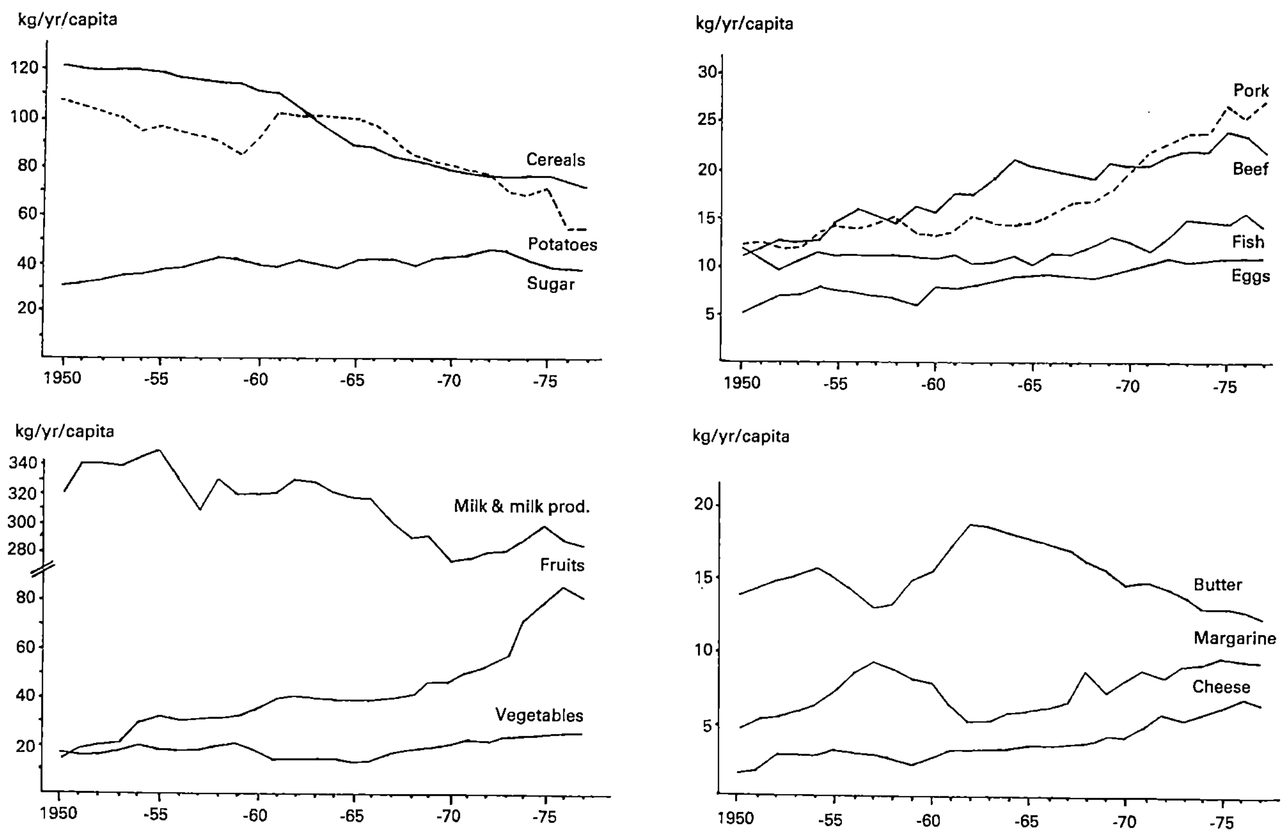

Figure 2.2.1. Consumption of main food items in Finland 1950—77, kg/year/capita.

In the early 1950's, *total calorie consumption* was some 3 000 cal/capita/day. By the mid-1950's, it rose to nearly 3 200 cal. Since then the trend has been down, so that in the mid-1970's the total consumption was less than 3 000 cal. The factors having caused the downward trend include f.ex. decreased manual labor and the urbanization of the population in general.

Because this study is devoted to the examination of demand for food items in Finland only, no in-depth comparison is made with other countries. In brief, we may state that the consumption level of cereals and potatoes is higher than the average level in European countries. On the other hand, the use of vegetables and fruits is lower. A striking feature of the Finnish diet is a high consumption of dairy products. It is one of the highest in the world. In Finland, the utilization of butter is higher than that of margarine. In Europe, the ratio is usually the other way round. Finally, we may conclude that even though the consumption levels of various food items differ from those of other countries, the consumption trends are highly comparable.

2.3. Changes in retail price structure

In this chapter, a brief historical review is presented of the retail prices of various food items. Only the relative prices are discussed. They are obtained by deflating the money prices by the consumer price index. In order to facilitate comparisons of development, the prices are converted to index figures with the year 1950 denoted by 100. It is to be pointed out already at this stage that the price and the quantity data have been collected from different sources, so they are not necessarily consistent with each other.

Cereals; the price of cereals is indicated by means of an index showing the price development of some flours and finished bakery products. This index had not risen very much by the end of the 1960's but since then a substantial increase has occurred (Figure 2.3.1.). Again, from the late 1960's onward, prices have remained stable with some exceptions. It is very hard to make any precise estimates of the extent to which quality changes and the introduction of packing have been reflected in the prices. Compared with some other products, these changes are, however, of minor importance.

Potatoes; the retail price of potatoes has fluctuated fairly widely. Variations in annual yields are probably one reason for this. In the mid-1970's, the price level has distinctly risen while the amount of potatoes sold in retail packages has also increased.

Sugar; the retail price of sugar also shows wide variations, the main reason being fluctuations in the world market prices. Quality changes have been minimal.

Vegetables; from a consumer point of view, the trend of vegetable prices has been favorable because ever since the early 1950's, the prices have been below the 1950 level. Annual fluctuations have been, however, substantial. Increasing use and development of packing have apparently influenced the prices, especially in the latter part of the study period.

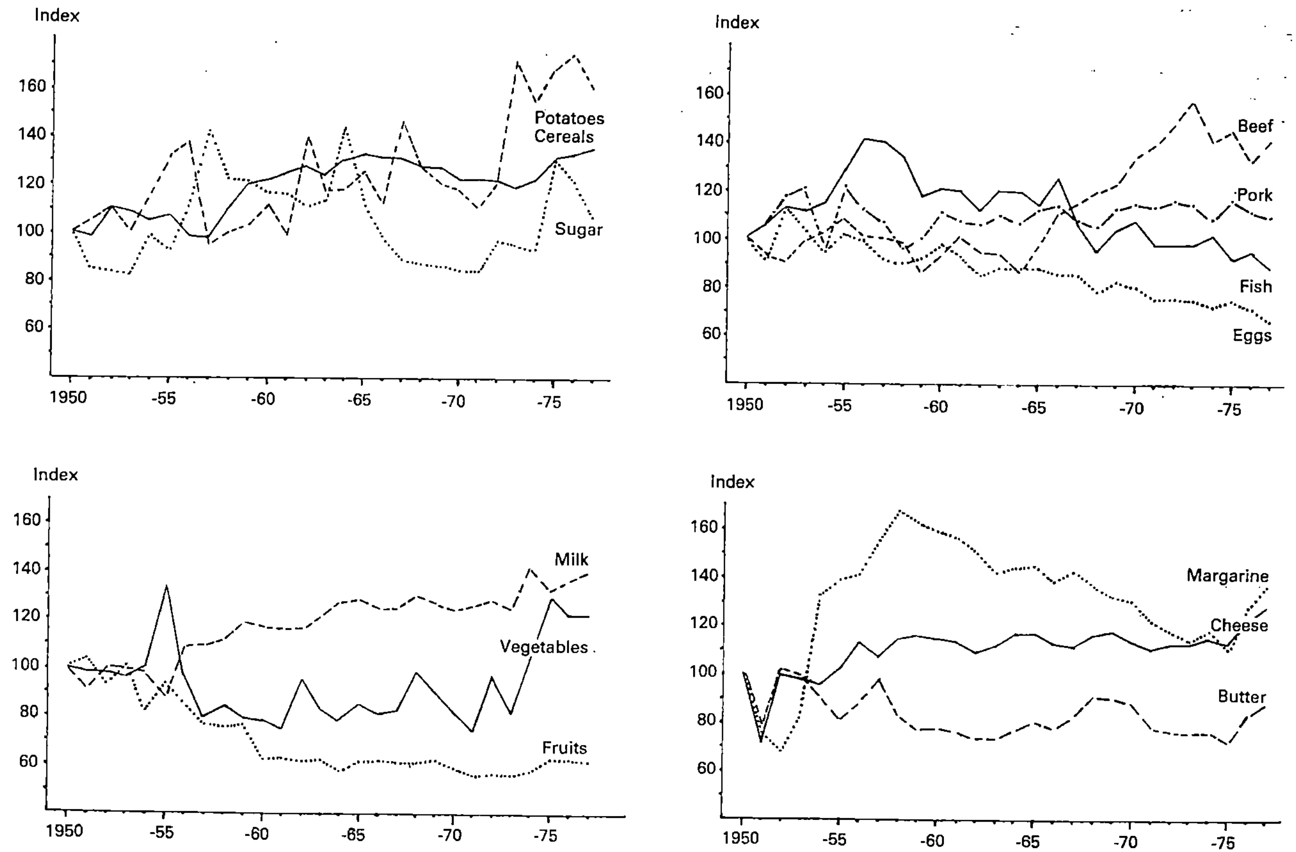

Figure 2.3.1. Development of real retail prices of the main food items in Finland 1950—77, in index numbers.

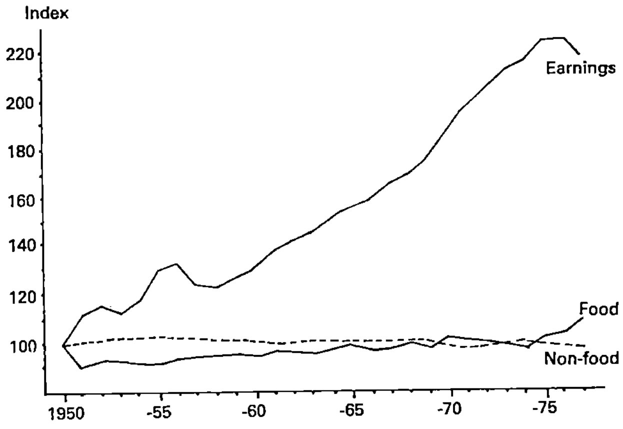

Figure 2.3.2. Development of real retail price of food, non-food goods and real earnings as index numbers.

Fruits; the trend of fruit prices has been similarly favorable from consumers' point of view. From the early 1960's to 1977, prices have been only 60 per cent of the 1950 level (Figure 2.3.1.). Price fluctuations have been slight also in this period.

Beef; the overall trend of the beef price up to 1964 was downward. Since then the price has experienced a substantial rise with some downward movements in recent years. One explanation for the price rise is the agricultural price policy, favorable for beef producers in those years.

Pork; in recent years there has been very little movement in the real price of pork. It is worth noting that despite quality improvements the price of pork has remained unchanged since 1960. The absolute price of pork has been below that of beef since 1967.

Eggs; in the long run, the real price of eggs has declined. However, there are some annual fluctuations. Compared with other animal products, the price development of eggs has been favorable for consumers. Because eggs as a product have undergone minimal change the price reflects hardly any quality changes.

Fish; the price of fish has fluctuated considerably during the study period. In part, this is due to the annual domestic fish catches. In the 1970's, prices have become established at a level below the previous prices.

Milk; the price of liquid milk has risen all the time since the mid-1950's, with some annual fluctuations. Possible reasons for the increased prices are the increased producer price for milk and the introduction of disposable cartons in retail sales.

Cheese; the development of cheese prices has been fairly stable. Although some annual fluctuations have occurred, the prices have remained at the level where they were at the end of the 1960's. Because these prices refer to a certain type of cheese, the quality changes are not very many.

Butter: the price of butter has declined over the long range. At the same time, considerable annual fluctuations have occurred. In order to reduce large stocks, butter was sold at reduced prices in 1969. Similarly, milk producers have been able to buy butter at a lower price. Even though the product itself has remained unchanged, new forms of packing have influenced the price.

Margarine; right up to the end of the 1950's, the price of margarine rose quickly. Since then a sharp decline has occurred. Because of the introduction of »icebox» margarine, this price series includes the impact of considerable quality changes. The price ratio of butter and margarine has been kept constant by means of government measures.

Figure 2.3.2. indicates the real price development of food and non-food goods. After the sharp decline in 1956, food has become gradually more expensive in real terms. The sharp rise in 1975—77 is worth noting.

The development of the index of salary and wage earners' earnings in real terms, used as the income indicator, is also depicted in that figure. The development of real earnings was fairly favorable from the late 1960's onward, the annual growth rate being about 4 per cent. A decline in real earnings took place in 1977.

3. CONCEPTUAL FRAMEWORK OF DEMAND ANALYSIS

3.1. Some principal concepts

Demand theory, i.e. the theory of economical consumer behavior, is well established. Today, demand theory is likely to be one of the most advanced fields in economics. There are also a vast number of empirical studies in this area.

The purpose of this section is not to make the reader thoroughly acquainted with demand theory, its history and applications[1]). Only the main principles are dealt with to the extent they are needed in the empirical part of this study.

Suppose that consumers within a certain time period consume different commodities in quantities $q_1, \ldots, q_n$. The respective prices are denoted by $p_1, \ldots, p_n$, and consumer income by μ. Let us introduce the following matrix notations:

(3.1.1.) $$q = \begin{bmatrix} q_1 \\ \vdots \\ q_n \end{bmatrix} \qquad p = \begin{bmatrix} p_1 \\ \vdots \\ p_n \end{bmatrix}$$

Let us suppose further a preference function:

(3.1.2.) $$u = u(q_1, \ldots, q_n),$$

where u indicates the utility achieved by consumers in consuming the commodities $q_1, \ldots, q_n$.

The following assumptions are usually made on the preference function (KATZNER 1970, p. 38 and 50):

1. u is continuous and smooth without forming kinks,
2. u is increasing and $u_i(q) > 0$ for $i = 1, \ldots, n$, and all q,
3. u is strictly quasi-concave,
4. the indifference surfaces do not intersect the boundaries of the commodity space.

The preference function can be derived from consumers' preference ordering. This is an axiomatic system which is based on the rational behavior of consumers. Let us introduce the following notations:

(3.1.3.) $$q_1 > q_2,$$

1) A brief review of the history of demand theory is available in KATZNER (1970, p. 5—13). A more comprehensive survey can be found in an article by HOUTHAKKER (1961, p. 704—740).

This implies that the commodity bundle q_1 is preferred to q_2. Here q_1 and q_2 belong to C, where C is the commodity space, i.e. the set of all possible commodity bundles. Correspondingly, the notation

(3.1.4.) $q_1 \geq q_2$

indicates that q_1 is preferred or equal to q_2. If the consumers feel that q_1 and q_2 are indifferent, the notation,

(3.1.5.) $q_1 \sim q_2$

is used.

The following four basic axioms have to be satisfied before we can define the preference function (INTRILIGATOR 1971, p. 144—145). Firstly, the preference relation needs to be reflexive:

(3.1.6.) $q \geq q$

i.e. a commodity bundle is equal to itself for any q in C.

Secondly, the preference relation has to be transitive which implies that if

(3.1.7.) $q_1 \geq q_2$ and $q_2 \geq q_3$, then

(3.1.8.) $q_1 \geq q_3$

Thirdly, the preference relation has to be complete. In other words, at least one of the relations (3.1.3.)—(3.1.5.) has to be valid. Finally, the preference relations ought to be continuous with no »gaps» in commodity space over which preferences would not exist.

Suppose that the preference relation in the commodity space is reflexive, transitive, complete and continuous. Then, there exists a continuous function u (q), so that

(3.1.9.) $u(q_1) \geq u(q_2)$, if and only if, $q_1 \geq q_2$,

i.e. if q_1 is preferred or equal to q_2. If u is a preference function, g(u(q)) is also a preference function. Then g is a monotonously increasing function. Sometimes u is called an ordinal preference function.

It is to be emphasized at this point that we cannot estimate a preference function from empirical data because the utility cannot be measured quantitatively. In other words, a preference function is a purely theoretical concept that cannot help us if we aim to measure consumer reactions in varying price situations. If we want to have an operational tool for measuring consumer behaviour, the concept of a demand function has to be defined.

The neoclassical economic problem of a consumer is that of choosing a commodity bundle that is most preferred. This is to say, the consumer seeks to maximize his preference function. In terms of the utility function, the problem is that of the following nonlinear programming:

(3.1.10.) $\max u = u(q)$

subject to

(3.1.11.) $p'q \leq \mu$.

(3.1.12.) $q_i \geq 0, \quad p_i > 0$ and $\mu > 0$

The first constraint is the budget constraint, i.e. the money used for purchasing commodities q cannot exceed the income μ. The latter constraint implies that negative quantities cannot be consumed and both the prices and the income have to be positive.

In order to solve the nonlinear programming problem, we define the Lagrangian as follows:

(3.1.13.) $y = u(q) - \lambda(p'q - \mu)$.

From this we can derive the necessary and sufficient conditions for the maximum as follows:

(3.1.14.) $u_q = \lambda p$

(3.1.15.) $p'q = \mu$

When q and λ are solved, we get the demand functions:

(3.1.16.) $q = q(p, \mu)$.

As compared to the preference function, the demand functions consist of variables that all are quantitatively measurable which in turn enables us to apply the demand functions to empirical data.

3.2. Homogeneity condition

An important characteristic of demand functions, which follows from the axioms above, is that they are free from the money illusion. This means that a consumer does not feel better off if all the prices and his income were e.g. doubled. That is to say, a consumer does not react to changes in money prices. The absence of a money illusion in the demand function (3.1.16.) means that if all prices and incomes are changed proportionally by the same amount, the quantity of each commodity demanded remains unchanged. In terms of the function (3.1.16.), this means that for any positive value of k,

(3.2.1.) $q = q(p, \mu) = q(kp, k\mu)$.

A function having this property is said to be homogenous of zero degree.

In general, the degree of homogeneity is defined as follows: the function

(3.2.2.) $(k)^s y = f(kz_1, \ldots, kz_n)$

is homogenous of s degree, because if all the independent variables are multiplied by k, the result is multiplication of the dependent variable by $(k)^s$ (k to the sth power).

For example, if s = 2, we have a second degree function. In a demand function, s = 0, i.e. the quantity demanded remains unchanged if all prices and incomes are changed in the same proportion.

Since k can be any positive number, we can make it equal to the inversion of a price. Then we have e.g.:

$$(3.2.3.)\qquad q_i = q_i(1, \frac{p_2}{p_1}, \ldots, \frac{p_n}{p_1}, \frac{\mu}{p_1}).$$

The choice of variables for the estimation of a demand function is usually carried out by selecting the price of the commodity in question and a number of other closely related prices $p_1, \ldots, p_v$ in addition to the income variable. The rest of the prices are expressed by means of an index indicating changes in the price level in general. Usually a cost of living index is used[1]). Based on the homogeneity property, the price and income variables can then be divided by the cost of living index.

This procedure is normally called deflation. It converts the money prices into »real» prices. In addition, it helps us to eliminate multicollinearity which is often apparent in the use of time series data.

3.3. Demand elasticities and their interrelationships

The main results of a demand analysis are relationships between the quantity demanded and the prices as well as between the quantity demanded and the income. These relationships are usually expressed by means of elasticities. The commonly used elasticities are presented in the following. The elasticity of commodity i with respect to income is defined as:

$$(3.3.1.)\qquad E_i = \frac{\partial \log q_i}{\partial \log \mu} \sim \frac{\Delta q_i}{q_i} : \frac{\Delta \mu}{\mu}.$$

Analogically, elasticity with respect to the price of the commodity itself is:

$$(3.3.2.)\qquad e_{ii} = \frac{\partial \log q_i}{\partial \log p_i}$$

and elasticity with respect to some other commodity price, i.e. cross-elasticity is:

$$(3.3.3.)\qquad e_{ij} = \frac{\partial \log q_i}{\partial \log p_j}.$$

A convenient interpretation of an elasticity applied f.ex. to (3.3.1.) is as follows. If the income of the consumers changes by one per cent, the elasticity figure shows by how many per cent consumption for the commodity in question changes. The same manner of interpretation is, of course, applicable to the own- and cross-elasticity.

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[1]) The prices included in the demand function should be first eliminated from it.

Suppose that we have made an analysis of all the commodities demanded by the consumers. The number of the commodities is denoted by n. Thereby all the price and income elasticities can be written as a matrix:

(3.3.4.) $$A = \begin{bmatrix} e_{11} & e_{12} \dots & e_{1n} & E_1 \\ e_{21} & e_{22} \dots & e_{2n} & E_2 \\ \vdots & \vdots & \vdots & \vdots \\ e_{n1} & e_{n2} \dots & e_{nn} & E_n \end{bmatrix}$$

The number of all the elasticities is n^2+n. Out of that amount, we have n own-price ($e_{11}, \dots, e_{nn}$) and n income ($E_1, \dots, E_n$) elasticities. The number of cross-elasticities (the rest) is n^2-n.

In the case of so-called normal commodities, the own-price elasticities are negative. With the exception of inferior commodities, the income elasticities are positive. The cross-elasticities may be positive when the commodities are substitutes, or negative when we have complementary commodities.

Because consumers' income sets limits on the quantities demanded, it is likely that there are certain interrelationships between the price and income elasticities. Because these interrelationships are later on used as one tool in solving the demand elasticity matrix, they are here discussed in some detail.

Let us introduce a fraction c_i that is defined as:

(3.3.5.) $$c_i = \frac{p_i q_i}{\mu},$$

where c_i is the expenditure share of commodity q_i out of the consumers' total expenditure. It can be proved that the elasticities realize the following relations:

(3.3.6.) $$c_1 E_1 + \dots + c_n E_n = 1$$

(3.3.7.) $$e_{i1} + \dots + e_{in} + E_i = 0$$

(3.3.8.) $$c_1 e_{1i} + \dots + c_n e_{ni} = -c_i$$

(3.3.9.) $$c_k(e_{ki} - c_i E_k) = c_i(e_{ik} - c_k E_i)$$

The equations (3.3.6.) and (3.3.8.) are technical relationships. The former indicates that the sum of weighted income elasticities equals one, when the expenditure shares are used as weights. The equation (3.3.8.) is the column sum condition. It states that the weighted sum of the elements of a column of the elasticity matrix equals the expenditure share of the respective commodity.

The equations (3.3.7.) and (3.3.9.) are based on the homogeneity conditions of a demand function. The equation (3.3.7.) is the Slutsky-Schultz-relation which states that the sum of the own- and cross-price elasticities and the income elasticity for a commodity is zero[1]). For example, if a commodity does not have any substitues or complements, the own-price and income elasticities have to be the same figure with opposite signs.

[1]) Originally Slutsky presented this idea already in 1912. It is published in a book by SCHULTZ (1938). A modern presentation is available f.ex. in WOLD (1952, p. 111—116).

The equation (3.3.9.) is the Slutsky condition specifying the relationship between two cross-elasticities. It can be interpreted more clearly if it is expressed in the form:

$$e_{ik} = \frac{c_k}{c_i} e_{ki} + c_k(E_k - E_i). \tag{3.3.10.}$$

If $c_k = c_i$ and $E_k = E_i$, a symmetry between the two price elasticities is realized, i.e. $e_{ik} = e_{ki}$. Correspondingly, if the income elasticities of commodities i and k are equal, we have:

$$\frac{e_{ik}}{e_{ki}} = \frac{c_k}{c_i}. \tag{3.3.11.}$$

This formula states that the ratio of two cross-elasticities is equal to the inverse ratio of the respective expenditure shares. The formula (3.3.11) is known as Hotelling-Juréen's relation.[1])

[1]) A paper by BRANDOW (1961) is a good example of studies where a large elasticity matrix has been calculated by means of elasticity interrelationships.

4. DATA AND FUNCTIONAL FORM

4.1. Data

Time series data were used in this study. Because the main emphasis lies on the working out of forecasts, it was thought that time series data would achieve this goal better than cross-section data. For the estimation of price and cross-elasticities, the time series data were assumed to suit better, too. Usually, it is very difficult or impossible to obtain price elasticities from cross-section data, because prices do not vary enough.

The years 1950—77 were chosen as the study period. The reason for not including earlier observations lies in the rationing of major foodstuffs. As mentioned earlier, rationing was discontinued virtually in toto by the end of the 1940's.

Only annual observations were used. This is because for only a very few food items, quarterly or semi-annual data are available in Finland. On the other hand, the authorities, who need consumption forecasts, are usually more interested in annual figures.

Food balance sheets prepared by the Agricultural Economics Research Institute were used as the source of per-capita consumption data. It is not worth discussing in detail here, product by product, how the consumption figures are obtained. Only the main principle of calculation is mentioned at this stage. The method of »commodity flow» is used in the food balance sheets by measuring commodity quantities when passing certain stages of marketing. Thus, by adding imports to domestic production, subtracting exports, taking changes in stocks into account and finally subtracting other uses than food, we get the quantities used for human consumption. These are then converted into percapita figures. The procedure for calculating Finnish food balance sheets is discussed in more detail by TORVELA and KALLIO (1969, p. 1—36).

Even though it is easy to point out several shortcomings in the figures given by food balance sheets, they do provide consistent data on food consumption as a whole. Comparisons made by the author (ROUHIAINEN 1975, p. 14) indicate that discrepancies with the results of other food consumption studies (budget studies, food consumption surveys) can easily be explained by differences in the samples and the way of collecting data. In addition, it is to be pointed out that, though the absolute consumption levels may differ, the annual changes shown by the food balance sheets are reliable because the calculations are performed uniformly every year.

From 1949 to 1970, the food balance sheets were calculated, on a split year basis. A business year beginning the first of July was used. Because of inconvenience and inconsistency with price data, all consumption figures were converted into a calendar year basis simply by calculating an arithmetic mean of two adjacent split years. Changes in consumption are in general gradual. Thus, this procedure was thought to have very little effect on the original consumption series.

Retail prices compiled by the Central Statistical Office of Finland constitute the source of price data. The price series for 1950—55 are published by the Ministry of Social Affairs and Health. Because quantity and price data are collected from different sources, it is to be pointed out that in many cases they do not correspond exactly with each other.

4.2. Variables

The Finnish diet was divided into 13 food items or groups of similar food items. Accordingly there are 13 dependent variables plus one additional variable indicating the total calories consumption.

The number of 13 was thought to be a reasonable solution because it makes the vast amount of consumption data a little more manageable in reducing the number of cross-elasticities to be estimated. On the other hand, it was felt that it is not reasonable to have too many small groups because consumer reactions to f.ex. price changes of goods representing only a marginal part of the total expenditure, are likely to be weak. In terms of calories, the 13 items contain some 90 per cent of the total calorie intake, and in terms of expenditure, 85—90 per cent of the food expenditure including coffee and tea.

Independent variables i.e. the price variables were formed to correspond as closely as possible to the dependent variable in question. However, some price series are to be regarded as proxy variables representing the average development of the price of the commodity group as a whole. Thus, f.ex. the price of herring was used to indicate the price development of all fish. For some commodity groups, f.ex. cereals, a sub-price index was available. The monthly observations were converted into an annual basis by using an arithmetic mean.

The index of salary and wage earners' earnings was used as the indicator of consumer income.

The consumer price index 1967 = '100' was used as the deflator. It was chained backward to the cost of living index 1951 = '100' by applying the annual changes of the latter. The index number for 1950 was obtained on the basis of the 1938/39 index.

To eliminate the shifts in the consumption level of potatoes and the effect of the so-called margarine scandal (see section 2.2.) a dummy variable (see e.g. JOHNSTON 1963, p. 176—186) was applied in the demand function of these products.

The following is a list of the variables used. For their detailed source, see Appendices 1 and 2.

The dependent variables:

Y_1 = per capita consumption of cereals
Y_2 = —»— potatoes
Y_3 = —»— sugar
Y_4 = —»— vegetables
Y_5 = —»— fruits & berries
Y_6 = —»— beef & veal
Y_7 = —»— pork
Y_8 = —»— eggs
Y_9 = —»— fish
Y_{10} = —»— milk & milk products
Y_{11} = —»— cheese
Y_{12} = —»— butter
Y_{13} = —»— margarine & oils
Y_{14} = —»— total calories

The independent variables:

X_1 = deflated retail price index of cereals & bread
X_2 = » retail price of potatoes
X_3 = » —»— sugar
X_4 = » retail price index of vegetables
X_5 = » —»— fruits & berries
X_6 = » retail price of beef
X_7 = » —»— pork
X_8 = » —»— eggs
X_9 = » —»— fish
X_{10} = » —»— liquid milk
X_{11} = » —»— cheese
X_{12} = » —»— butter
X_{13} = » —»— margarine
X_{14} = food price index
X_{15} = non-food price index
X_{16} = index of salary and wage earners' earnings.

The dummy variables:

D_1 = potatoes dummy, $D_1 = 1$ for 1950—60 and 1976—77, otherwise $D_1 = 0$.
D_2 = margarine dummy, $D_2 = 1$ for 1961—65, otherwise $D_2 = 0$.

4.3. Functional form

The economic theory underlying the problem to be studied usually provides some indication of the appropriate functional form. Thus, in a demand analysis, the functional form with respect to price variables is commonly assumed to be linear or linear in logarithms. The functional form with respect to an income variable is more problematic. A linear or logarithmic function is commonly used also in this case. However, if the range of income is wider, other functional forms are likely to ensure better fit (see GOREUX 1961, p. 1—13).

Initially, both linear and logarithmic demand functions were estimated in this study. Using the statistical significance of the estimated regression coefficients and the R^2-value as criteria, it appeared that, with a few exceptions, the logarithmic function produced better results. For that reason, the linear form was rejected and all demand functions were estimated by applying a double-logarithmic function. The range of the income variable was not thought to be sufficient to require other types of functions in the estimation process. Moreover, some features of the double logarithmic function support its use. These include ease of parameter estimation and interpretation of the parameters as respective elasticities. In addition, the assumption of a constant variance of the disturbance term is more valid in the case of a double logarithmic function than in a linear function.

5. ESTIMATION OF DEMAND ELASTICITY MATRIX

5.1. Estimation methods

The method of ordinary least squares (OLS) was first used in estimating the parameters of the demand functions. Even though this method is commonly known, the basic assumptions of it will be dealt with briefly. This is because some of the assumptions are later removed or altered. It was thought that the knowledge of the OLS would provide the reader with better understanding of the modified estimation methods that follow. All derivations and proofs will be omitted; for them, the reader is asked to refer to literature indicated in the quotations.

In the OLS-method it is supposed that a linear relationship exists between a dependent variable y and k explanatory variables $x_1, x_2, \ldots, x_k$ and a disturbance term ε. If we collect a sample of T observations on y and each x, we write the relationship compactly in matrix notation as:

(5.1.1.) $$y = X\beta + \varepsilon,$$

where β is an unknown vector of regression coefficients. Our task is now to obtain an estimate for the unknown vector of the regression coefficients β and the disturbance term ε.

Usually the following assumptions are made on X, y, β and ε.

(i) X is a given Txk non-stochastic matrix,
(ii) y is an observed stochastic vector,
(iii) β is an unknown non-stochastic vector,
(iv) ε is an unknown stochastic vector,
(v) $E(\varepsilon) = 0$, in other words, the variable ε has zero expectation value,
(vi) $E(\varepsilon\varepsilon') = \sigma^2 I$, this assumption implies that the disturbance term has a constant variance σ^2 and its values are pairwise uncorrelated (absence of autocorrelation), the property of a constant variance is referred to as homoscedasticity,
(vii) the rank of X is $k < T$, i.e. no explanatory variable is a multiple of another or an exact linear combination of several others (absence of multicollinearity),
(viii) $\varepsilon \sim N(0, \sigma^2 I)$, i.e. this is the so-called normality assumption. It is not needed for estimation but for the testing of estimated parameters.

We can now apply the method of least squares to get the estimates for β and ε. Let

(5.1.2.) $$y = Xb+e$$

denote the empitical counterpart of (5.1.1.), where b is the estimated vector of regression coefficients and e the vector of estimated residuals, e = (y-Xb). The sum of squared residuals is:

(5.1.3.) $$e' e = \sum_{i=1}^{T} e_i^2$$

After minimizing (5.1.3.), we get the least squares estimator for β, which is, under the assumptions (i)—(vii) the best, linear, unbiased estimator for β;

(5.1.4.) $$b = (X'X)^{-1}X'y.$$

The derivation of these results is presented in any econometric textbook, f.ex. GOLDBERGER 1964, p. 156—162.

The usual Student's t-test was employed to test whether the estimated regression coefficients differ statistically significantly from zero. The significance levels used are indicated as follows:

*	statistically	significant	at the	0.90-level
**	»	»	»	0.95-level
***	»	»	»	0.99-level

Durbin—Watson statistics (DURBIN and WATSON 1950) were used to test the existence of autocorrelation (serial correlation) of the residuals (see assumption (vi)), which can be particularly troublesome in time series regression. In the presence of autocorrelation, the formula of calculating the standard errors of the regression coefficients is not valid, although the coefficients themselves are unbiased. It is to be noted, however, that with respect to the power of the test, the Durbin—Watson test is weak.

Sometimes economic theory suggests that the coefficients of a behavioral relationship should meet some restrictions. With regard to the consumption theory, the absence of the money illusion implies that the sum of all the price elasticities and the income elasticity in a demand function should be equal to zero (the homogeneity condition, see Section 3.2.).

In that case it has been proposed to use extraneous information coming from outside the sample itself (GOLDBERGER 1964, p. 255). That is achieved when estimating the demand functions by means of restricted least squares (RLS). The method itself has been discussed in detail by GOLDBERGER (1964, p. 256—265). When the regression coefficients are subject to certain linear restrictions, the model is said to be restricted, whereas a normal model is said to be a free one. A linear restriction on the coefficients

(5.1.5.) $r'\beta = c$

where $r' = [r_1, r_2, \ldots, r_k]$ is a vector and c is a given constant, is handled in this study in the way done by VÄLIAHO and PEKKONEN (1976, p. 20—21). In their computer program, which was used in this study, the introduction of a linear constraint is performed in the same way as that of an additional observation. Because of their highly technical nature, the formulas used are not given here. The reader is asked to refer to the presentation by Väliaho and Pekkonen.

The validity of the hypothesis of the homogeneity condition

(5.1.6.) $H_0: \Sigma \beta_i = 0$

in the estimated restricted models was tested using the test quantity (SEARLE 1971, p. 112)

(5.1.7.) $$F(H) = \frac{(q^* - q)/z}{q/(T-k)}$$

where q^* = the residual error sum of squares of the free model
q = —»— the same restricted model
z = the number of the linear constraints (in this study $z = 1$).

Under the null hypothesis (5.1.6.) $F(H) \backsim F_{z,\,T-k}$. In other words, F(H) has a F-distribution with the degrees of freedom of z and T-k. If $F(H) > F_{z,\,T-k}$ H_0 is rejected at a certain significance level. The significance level of F-values is denoted as follows:

*	statistically significant at the 0.95-level
**	» » » 0.99-level
***	» » » 0.999-level

The RLS-method was used along with the OLS to test which elasticities change and how much compared to the corresponding free model. Secondly, the homogeneity condition was supposed to hold and the number of the independent variables was altered to get information on cross-elasticities not obtained by means of the OLS-method.

5.2. Demand elasticities

First, the ordinary demand functions were estimated. The independent variables were initially selected on the basis of demand theory. Thus, a model having the own-price, the price of some obvious substitutes and complements and the income factor as independent variables was considered as a basic model. It was estimated first; then the basic model was completed by adding one price variable at a time until a »good» model was reached. It goes without saying that this method of variable selection is highly subjective. In addition, some statistical devices were used: the

Table 5.2.1. Demand functions for 1950—77, estimated using the OLS-method, t-values in the brackets, d = Durbin-Watson test quantity.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	—0.354* (1.9)	—0.130 (0.9)	—0.467*** (2.9)		0.116 (0.3)								
Potatoes	—0.007 (0.1)	0.109* (1.8)		—0.205 (1.0)									
Sugar	0.113* (1.9)	0.012 (0.2)	—0.125* (1.9)	0.052 (0.4)	0.506*** (4.5)								
Vegetables	0.074 (0.8)	—0.039 (0.5)		—0.012 (0.1)	0.443*** (2.4)								
Fruits & berries	—0.005 (0.0)	—0.063 (0.5)	—0.420*** (3.5)	1.002*** (3.3)	—0.499 (1.6)								
Beef	0.004 (0.0)	—0.009 (0.1)				—0.461*** (3.7)	0.432** (2.6)		0.481*** (3.2)	—0.406*** (4.9)	—0.178 (0.7)		
Pork	0.243 (1.7)	0.458*** (4.0)				0.069 (0.3)	—0.290 (0.9)		—0.486 (1.4)	—0.087 (0.7)	0.821* (2.5)		
Eggs						0.010 (0.0)	—0.458 (1.3)	0.448* (1.8)	0.063 (0.2)				
Fish						0.105 (1.1)	0.013 (0.1)		—0.075 (0.5)				
Milk & milk products						0.265 (1.5)	—0.304 (1.2)			—0.552*** (3.7)			
Cheese										0.089 (1.0)	0.013 (0.1)		
Butter	—0.247** (2.6)		—0.145 (1.3)	0.197 (0.8)							0.188 (0.8)	—0.553** (2.2)	0.042 (0.1)
Margarine & oils			0.118* (2.0)	0.223 (1.7)								0.071 (0.7)	0.444*** (3.9)
Income	—0.739*** (4.8)	—0.896*** (7.3)	0.054 (0.067)	1.137*** (4.8)	1.237*** 6.6)	1.003*** (4.9)	0.683** (2.5)	1.019** (7.8)	0.138 (0.6)	0.233** (2.1)	1.479*** (5.9)	—0.234** (2.5)	0.485*** (4.3)
Potatoes dummy		0.197*** (9.6)											
Margarine dummy													—0.346*** (4.9)
R^2	0.976	0.980	0.804	0.700	0.965	0.967	0.963	0.903	0.778	0.882	0.944	0.292	0.764
d	1.10	1.84	1.39	1.47	1.18	1.64	0.85	1.29	1.36	1.61	0.91	0.31	1.25

variables were selected on the basis of Durbin—Watson statistics, the Student's t-value, and the R^2-value.

Apart from the entire study period, the demand functions were also estimated for the periods 1950—63 and 1964—77 as a first approach to the detection of possible changes in the parameters of the functions. The demand functions estimated using the OLS-method are presented in Tables 5.2.1., 5.2.2. and 5.2.3.

Evalued in terms of the coefficient of multiple correlation (R^2) and the Durbin—Watson statistics (d), the functions for 1950—77 are satisfactory with the exception of butter. Since 1950, the consumption of butter in Finland has first risen. After 1962, the trend in consumption has gone down. Accordingly, the low d- and R^2-values have been caused by the application of a wrong functional form. A function other than the logarithmic one would have obviously produced a better fit. Also, in the case of pork and cheese, the respective d-values are low, giving an indication of a missing explanatory variable or a wrong functional form.

The coefficients of a logarithmic function can be interpreted as the corresponding elasticities per se. Thus, we may conclude that a great many of the income elasticities are statistically significant, most of them at the one per cent level. Only sugar and fish did not yield statistically significant coefficients. Accordingly, the income elasticity of these products is to be considered zero.

Most of the price elasticities are acceptable in terms of their sign and t-value. Potatoes, eggs, cheese and margarine resulted in a positive price elasticity that is inconsistent with the theory of consumer behavior. Of these, the elasticity for cheese is to be considered zero because of its low t-value. The elasticity itself is very low, too. One plausible explanation for the positive price elasticity of potatoes is that, along with the improved quality and higher price of potatoes, the consumer demand for potatoes has increased. Because of the introduction of the soft »icebox» margarines (see Section 2.2.), a similar explanation is likely to be found for the elasticity of margarine, too.

Table 5.2.2. Demand functions for 1950—63, estimated using the OLS-method, t-values in the brackets, d = Durbin-Watson test quantity.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	0.132 (0.3)	—0.546** (2.8)	0.380 (1.5)		0.605 (1.3)								
Potatoes	0.086 (0.4)	—0.055 (0.5)		0.255 (0.8)									
Sugar	0.063 (0.4)	—0.272** (3.1)	0.315* (1.9)	—0.649 (1.4)	0.658** (2.6)								
Vegetables	—0.131 (0.5)	0.093 (0.7)		—0.607 (1.4)	0.418** (2.1)								
Fruits & berries	0.313 (1.0)	—0.339* (2.2)	0.243 (1.3)	0.722* (2.1)	—0.219 (0.6)								
Beef	0.304 (0.8)	—0.055 (0.3)				0.011 (0.1)	0.212 (0.9)		0.569** (2.8)	—0.254 (1.4)	0.246 (0.6)		
Pork	0.008 (0.0)	0.167 (1.7)				0.075 (0.4)	—0.176 (0.7)		—0.380 (1.5)	—0.090 (0.7)	0.350 (1.0)		
Eggs						—0.137 (0.6)	—0.380 (1.4)	0.472 (1.3)	—0.036 (0.1)				
Fish						0.169 (1.5)	0.264** (2.0)		0.044 (0.3)				
Milk & milk products						0.335* (2.2)	—0.059 (0.3)			—0.531** (2.9)			
Cheese										0.058 (0.5)	—0.479* (1.8)		
Butter	0.007 (0.0)		0.124 (0.9)	0.209 (0.6)							1.038* (2.7)	—0.335 (1.1)	0.491 (1.3)
Margarine & oils			0.055 (0.7)	0.650** (2.8)								—0.186* (1.9)	0.434*** (3.5)
Income	—0.236 (0.6)	—0.509** (3.5)	0.624** (3.2)	—0.357 (0.7)	1.703*** (4.8)	1.082*** (5.7)	0.327 (1.4)	1.275*** (4.8)	—0.176 (0.9)	0.284** (2.3)	3.008*** (5.8)	0.772* (2.0)	1.513** (2.8)
Potatoes dummy		—0.138*** (6.1)											
Margarine dummy													—0.466*** (5.1)
R^2	0.869	0.970	0.920	0.723	0.969	0.973	0.869	0.685	0.705	0.681	0.923	0.586	0.875
d	1.43	2.15	2.08	1.92	0.88	2.83	2.85	1.70	1.80	2.65	1.80	1.15	1.91

Only a few of the estimated cross-price elasticities turned out to be statistically significant. In addition, the sign of some of them was not in accordance with the expectations.

In these functions and in the functions to follow, multicollinearity, i.e. the intercorrelation among the independent variables (see Appendices 3,4 and 5), was not considered high enough to have made the standard errors of the coefficients larger than would be the case in the absence of it. Multicollinearity violates the assumption (vii) on the independent variables. Recently, researchers have avoided establishing criteria for »harmful» multicollinearity. VALENTINE (1969, p. 102) f.ex. points out that the decision of a harmful level of multicollinearity depends on many factors, some of them subjective to the investigator (see also FARRAR and GLAUBER 1967, p. 92—107).

In general, the demand functions for 1950—63 and 1964—77 (Tables 5.2.2. and 5.2.3.) are similar to that of 1950—77 with respect to their R^2- and d- values. Only in the case of fruits & berries for 1950—63 and eggs for 1964—77, is there some evidence of positive autocorrelation (see the basic assumption vi in Section 5.1.) between the residuals (a low d-values). Pork for 1964—77 indicates a slight negative autocorrelation. As compared with 1950—77, the demand function for butter turned out to be quite satisfactory for both periods.

Again, most of the income elasticities are statistically significant and acceptable. But a greater number of the price and cross-elasticities for both periods are now wrong in sign or they have a low t-value. One possible reason for that might be the reduced number of observations, only 14 for each function. Possible elasticity changes over time will be analyzed later on.

The homogeneity condition was taken into account in the next step of the estimation process of the demand elasticity matrix. The functions presented above were re-estimated using the RLS-method. The dummy variables and the intercepts were, of course, excluded from the linear restriction. In the case of some products,

Table 5.2.3. Demand functions for 1964—77, estimated using the OLS-method, t-values in the brackets, d = Durbin-Watson test quantity.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	—0.567**	0.437*	—1.488		1.869*								
	(3.0)	(2.1)	(1.4)		(1.8)								
Potatoes	—0.008	0.162***		—0.063									
	(0.1)	(3.6)		(0.6)									
Sugar	—0.004	0.009	—0.154*	—0.058	0.168								
	(0.1)	(0.2)	(1.9)	(0.6)	(1.1)								
Vegetables	0.025	0.008		0.272	0.311								
	(0.4)	(0.1)		(1.9)	(1.2)								
Fruits & berries	0.284	—0.740**	0.259	—0.781	—0.765								
	(0.9)	(2.9)	(0.4)	(1.7)	(0.8)								
Beef	—0.240*	0.064				—0.490**	—0.011		—0.012	—0.308*	—0.260		
	(2.6)	(0.6)				(3.4)	(0.1)		(0.0)	(2.2)	(1.1)		
Pork	0.094	1.150***				0.490	0.041		—0.947	0.397	0.527		
	(0.4)	(5.0)				(1.0)	(0.1)		(1.0)	(1.0)	(1.3)		
Eggs						0.271	—0.745**	0.022	0.295				
						(0.9)	(2.6)	(0.1)	(0.4)				
Fish						0.043	0.071		0.299				
						(0.2)	(0.4)		(0.8)				
Milk & milk products						—0.009	—0.459			0.555			
						(0.0)	(1.1)			(1.2)			
Cheese										—0.295	0.889		
										(1.0)	(1.8)		
Butter	—0.298**		—0.568	0.288							—0.154	—0.125	0.749
	(3.4)		(1.6)	(1.1)							(0.6)	(1.0)	(1.7)
Margarine & oils			0.293	0.192								—0.335*	—0.700
			(0.6)	(0.7)								(1.9)	(1.3)
Income	—0.340**	—1.151***	0.010	1.170***	1.775***	1.009***	1.331***	0.588***	1.199**	—0.079	1.822***	—1.060***	0.800**
	(3.1)	(8.9)	(0.1)	(5.8)	(6.9)	(3.9)	(5.6)	(5.2)	(2.6)	(0.4)	(6.5)	(10.9)	(2.8)
Potatoes dummy		—0.175***											
		(10.4)											
Margarine dummy													—0.070
													(0.8)
R^2	0.995	0.999	0.853	0.984	0.971	0.908	0.993	0.926	0.836	0.836	0.989	0.971	0.897
d	2.27	2.61	1.81	2.32	2.43	2.33	3.00	0.89	2.09	1.41	2.45	1.85	2.94

the number of independent variables was increased. For example, in the case of sugar for 1950—77, the sum of elasticities equals —0.985 which suggests that sugar has some substitutes. Similarly, in some functions the number of independent variables was decreased.

In this process, the F-value was used as a yardstick in evaluating the validity of the model. The corresponding OLS-functions are not presented unless they are the same as those in Tables 5.2.1., 5.2.2. and 5.2.3. The regression coefficients of the RLS-functions were not tested.

The restricted demand functions for 1950—77, 1950—63 and 1964—77 are presented in Tables 5.2.4., 5.2.5. and 5.2.6.

In general, the R^2-values of the functions for 1950—77, obtained by using the RLS-method, are of the same order of magnitude as those of the OLS-functions. The R^2-value of the butter demand function was improved. According to the F-test, the hypothesis of the homogeneity of the demand function was rejected in the case of seven products. In the functions for 1950—63, the homogeneity condition seems to be consistent with the observations in eight products.

The R^2-values of the RLS-functions for 1964—77 are changed only a little. Here the homogeneity condition seems to hold in the case of nine products.

It is easy to point out reasons why the hypothesis of the homogeneity condition had to be rejected in respect to some products. These reasons include, along with the data problems, changes over time in consumer preferences, changes in the products themselves and the introduction of entirely new products. Another plausible supposition is that substitutes and complements of some food items in question are to be found in goods other than food. The homogeneity condition has been frequently rejected by several authors, as pointed out by BARTEN (1977, p. 27 and p. 45). According to Barten, it passes more easily for small systems and might be more true in the long run than in the short run.

Table 5.2.4. Demand functions for 1950—77, estimated by the RLS-method supposing the sum homogeneity condition.

of the elasticities equals zero, d = Durbin-Watson test quantity, F(H) = test quantity of testing

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	0.043	0.107	—0.238		—0.704			—0.003		0.483	—1.242	0.952	—1.152
Potatoes	0.044	0.141		—0.176									
Sugar	0.217	0.083	—0.057	—0.008	0.361								
Vegetables	—0.053	—0.111		0.158	0.735								
Fruits & berries	0.218	0.106	—0.335	0.528	—1.290								
Beef	0.209	0.119	0.121	0.326		—0.669	0.416		0.470		—0.796		
Pork	0.377	0.519	0.480	—1.327		0.004	—0.292		—0.458		0.023		
Eggs						—0.396	—0.492	—0.515	—0.025				
Fish						0.068	0.010		—0.083				
Milk & milk products						—0.092	—0.329			—0.373			
Cheese										0.143	—0.082		
Butter	—0.202		—0.081	—0.109							—0.150	—0.431	—0.132
Margarine & oils			0.179	—0.035								—0.030	0.488
Income	—0.853	—0.964	—0.069	0.647	0.898	1.085	0.687	0.518	0.096	—0.254	2.247	—0.491	0.796
Potatoes dummy		—0.209											
Margarine dummy													—0.250
R^2	0.954	0.966	0.741	0.606	0.945	0.941	0.955	0.828	0.738	0.720	0.889	0.543	0.789
d	3.59	1.73	0.99	0.78	1.27	1.71	0.90	0.99	1.39	1.14	1.15	0.47	1.49
F(H)	6.72*	3.69	3.52	6.93*	7.92*	9.22*	0.03	18.85***	0.10	6.27*	15.12***	0.18	0.63

Table 5.2.5. Demand functions for 1950—63, estimated by the RLS-method supposing the sum homogeneity condition.

of the elasticities equals zero, d = Durbin-Watson test quantity, F(H) = test quantity of testing

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	—0.076	0.024	—0.185		—0.551			—0.293			—1.101		—0.865
Potatoes		0.154		0.269									
Sugar	0.028	—0.094	0.032	—0.689	0.095								
Vegetables		—0.150		—0.627	0.323								
Fruits & berries	0.145	0.108	—0.203	0.685	—1.157								
Beef	0.118	0.343				—0.416	0.132		0.561	0.036	—0.798		
Pork	0.018	0.184				0.270	—0.180		—0.371	0.074	0.480		
Eggs						—0.747	—0.440	—0.517	—0.050				
Fish						—0.201	0.281		0.046				
Milk & milk products						—0.227	—0.117			—0.243			
Cheese						0.386				—0.040	0.084		
Butter	0.006		—0.013	0.172							—0.409	—0.449	—0.304
Margarine & oils			0.093	0.662								—0.181	0.498
Income	—0.239	—0.569	0.276	—0.472	1.290	0.935	0.324	0.810	—0.186	0.173	1.744	0.630	0.671
Potatoes dummy		—0.155											
Margarine dummy													—0.336
R^2	0.734	0.741	0.740	0.479	0.912	0.922	0.781	0.310	0.572	0.333	0.375	0.503	0.707
d	1.06	2.35	1.28	1.86	1.21	2.86	3.57	1.15	1.79	2.19	1.11	1.23	1.35
F(H)	0.11	9.50*	6.97*	0.07	7.80*	0.12	0.23	0.77	0.01	3.59	34.75***	0.18	5.47*

The elasticity matrices for the three time periods were then formed based on the results of the OLS- and RLS-functions and on the relationships between two cross-elasticities (Formulas 3.3.10. and 3.3.11.). These formulas were applied only in cases where the calculation of an additional cross-elasticity could be based on a statistically significant elasticity. If a price elasticity did not give a meaningful result (a negative sign), it was set to zero. The matrices are presented in Tables 5.2.7., 5.2.8. and 5.2.9. In the following text, the results are analyzed food item by food item.

Cereals; the income elasticity and the cross-price elasticity with respect to butter of the OLS- and RLS-functions for 1950—77 are quite consistent. The RLS-function would suggest a price elasticity close to zero instead of the —0.35 obtained when

Table 5.2.6. Demand functions for 1964—77, estimated by the RLS-method supposing the sum of the elasticities equals zero, d = Durbin-Watson test quantity, F(H) = test quantity of testing homogeneity condition.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	0.204	0.122	—1.430		—0.022			—0.196					—0.447
Potatoes	0.056	0.079		0.008									
Sugar		0.107	—0.030	—0.121	0.179								
Vegetables		—0.130		0.491	1.018								
Fruits & berries			—0.080	—1.520	—2.181								
Beef		0.116	0.176			—0.616	—0.029		0.037	—0.074	—0.380		
Pork	0.503	0.715	1.179			0.243	—0.049		—1.181	0.056	—1.282		
Eggs						—0.117	—0.795	—0.236	—0.075				
Fish						0.078	0.086		0.276				
Milk & milk products						—0.436	—0.589			0.303			
Cheese						—0.217	0.013			0.304	—0.226		
Butter	—0.184		—0.357	0.304						—0.411	—0.217	—0.249	0.652
Margarine & oils			0.619	0.009						0.088		0.697	—0.841
Income	—0.579	—1.009	—0.077	0.829	1.006	1.065	1.363	0.432	0.943	—0.266	2.105	—0.448	0.636
Potatoes dummy		—0.188											
Margarine dummy													—0.078
R^2	0.900	0.992	0.892	0.948	0.886	0.771	0.987	0.896	0.732	0.815	0.923	0.786	0.824
d	1.70	1.64	1.92	2.21	1.92	2.29	2.39	1.04	2.29	1.24	1.81	0.97	2.43
F(H)	9.31*	0.07	5.32	4.68	13.91**	2.13	0.14	1.93	1.03	0.01	29.16***	52.58***	1.41

Table 5.2.7. Elasticity matrix for 1950—77 [1]).

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	—0.35*	(0.11)	—0.47***					(—0.00)			(—1.24)	[—0.42]	(—1.15)
Potatoes	(0.04)	0.00		—0.21			[0.11]						
Sugar	0.11*	(0.08)	—0.13		0.51***								
Vegetables	0.07	(—0.11)		—0.01	0.44***								
Fruits & berries	(0.22)	(0.11)	—0.42***	1.00***	—0.50								
Beef	(0.21)	(0.12)	(0.12)			—0.46***	0.43**		0.48***		(—0.80)		
Pork	0.24	0.46***	(0.48)			0.07	—0.29						
Eggs						0.01		(—0.52)	0.06				
Fish						0.11	0.01		0.08				
Milk & milk products						0.27				—0.55***			
Cheese										0.09	0.00		
Butter	—0.25**										(—0.15)	—0.55***	0.04
Margarine & oils			0.12*									0.07	0.00
Income	—0.74***	—0.90***	0.00	1.14***	1.24***	1.00***	0.68**	(0.52)	0.14	0.23**	1.48***	—0.23**	0.49***

[1]) The elasticities without any brackets are obtained using the OLS-method, the stars refer to the significance of the t-test. The elasticities in brackets are based on the RLS-functions. The elasticities in squarebrackets are calculated using the relationships between two cross-elasticities (Formulas 3.3.10. and 3.3.11.).

using the OLS-method. Given the negative income, price and cross-price elasticity with respect to butter, the homogeneity condition would suggest some substitutes for cereals. Of these only sugar has a significant coefficient. Because the OLS-function for 1950—63 did not result in any significant elasticity, it is difficult to draw conclusions about possible elasticity changes from the early period to the later one.

However, it seems evident that the number of substitutes has decreased. Some of them (potatoes and vegetables) are likely to be very small.

Previous studies have usually resulted in a positive income elasticity for cereals. For example MARJOMAA (1969, p. 44) obtained an elasticity of 0.2 . . . 0.4 for 1948—65. When the time period was expanded to 1948—69, an income elasticity

Table 5.2.8. Elasticity matrix for 1950—63 ¹).

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	(—0.08)	—0.55**	0.38		0.61			(—0.29)					(—0.87)
Potatoes	0.09	—0.06		0.26									
Sugar	0.06	—0.27**	0.00		0.66**								
Vegetables		0.09		—0.61	0.42**								
Fruits & berries	0.31	(0.11)	0.24	0.72	—0.22								
Beef	0.30	(0.34)				(—0.42)	0.21		0.57**	(0.04)	0.25		
Pork	0.01	(0.18)				(0.27)	—0.18		[0.68]	(0.07)	0.35		
Eggs						0.14	—0.38	(—0.52)					
Fish						0.17	0.26**		0.00				
Milk & milk products						0.34*	—0.06			—0.53**			
Cheese						(0.39)				0.06	—0.48*	[0.13]	
Butter	0.01		0.12	0.21							1.04*	—0.34	0.49
Margarine & oils			0.06	0.65**								—0.19*	0.00
Income	—0.24	—0.51**	0.62**	—0.36	1.70***	1.08***	0.33	1.28***	—0.18	0.28**	3.01***	0.77*	1.51**

¹) See footnote in Table 5.2.7.

Table 5.2.9. Elasticity matrix for 1964—77 ¹).

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	—0.57**	0.44*	—1.49		1.87*			(—0.20)				[—0.69]	
Potatoes	(0.06)	0.00					[0.18]						
Sugar		0.01	—0.15*		0.17								
Vegetables	0.03	0.01		0.00	0.31								
Fruits & berries	0.28		0.26	—0.78	—0.77								
Beef		0.06	(0.18)			—0.49**	(—0.03)		(0.04)				
Pork	(0.50)	1.15***	(1.18)			0.49	(—0.05)						
Eggs						0.27	—0.75**	(—0.24)	0.30				
Fish						0.04	0.07		0.00				
Milk & milk products							—0.46			0.00			
Cheese										(0.30)	(—0.23)		
Butter	—0.30**			0.29								—0.13	0.75
Margarine & oils			0.29	0.19								[0.23]	—0.70
Income	—0.34**	—1.15***	0.01	1.17***	1.78***	1.01***	1.33**	0.59***	1.20**	—0.08	1.82***	—1.06***	0.80**

¹) See footnote in Table 5.2.7.

of —0.004 was obtained (HÄMÄLÄINEN 1973, p. 66). The cross-section studies of the 1950's and 1960's indicate that the income elasticity varies between 0.59 and 0.74 (see HÄMÄLAINEN 1973, p. 73). IHAMUOTILA (1972 p. 45) obtained from time series data an income elasticity of —0.3 for 1951—63 and —0.7 for 1958—70. The price elasticities varied respectively between —0.1 . . . —0.2 and —0.2 . . . —0.3.

Although the results mentioned above are not fully comparable to those obtained in this study, we may, however, conclude that, with the exception of those by Ihamuotila, they are generally different. Further, it is to be noted that no attempt has been made in the previous studies to estimate cross-price elasticities.

Potatoes resulted in a negative price elasticity only for 1950—63. In the other elasticity matrices, it was set at zero. However, because the quality of potatoes has in recent years improved coupled with a higher price, a positive price elasticity is not ruled out. A comparison between the results for 1950—63 and 1964—77 would suggest that potatoes now have fewer substitutes. At the same time, they have become stronger.

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According to AALTONEN (1976, p. 31), potatoes would have a zero price elasticity or a slightly negative one. The income elasticity obtained by Aaltonen varies between —0.52 and —0.69. In his study, rice turned out to be a substitute for potatoes. These results are based on time-series data for 1952—72. The income elasticity derived by MARJOMAA (1969, p. 73) is —0.4 . . . —0.5.

Sugar has evidently a small price elasticity. During the study period, the income elasticity is likely to have diminished. Because sugar is widely used as an ingredient in bakery products and as a conservation agent in berries and fruits, the negative elasticities with respect to cereals and fruits & berries are obvious even though the elasticities change in the sub-periods. No definite substitutes were found for sugar. Margarine & oils are likely ones but they did not show a statistically significant coefficient for the sub-periods. According to MARJOMAA (1969, p. 83), the income elasticity of sugar would be zero in 1948—65. The cross-series studies undertaken in the 1950's and 1960's (see HÄMÄLÄINEN 1973, p. 73) show, on the contrary, rather high positive income elasticities (0.67 . . . 0.87). Similarly, the income elasticity obtained by HÄMÄLÄINEN (1973, p. 66) for 1948—68 is rather high, 0.72.

Vegetables; on the whole, the elasticities for vegetables turned out to be unstable. The heterogeneity of the food item group may be one reason for that. In addition, some new products or old products in new form (f.ex. frozen vegetables) were introduced during the study period. In any event, it is likely that the income elasticity of vegetables is relatively high.

Previous studies suggest that the income elasticity of vegetables, including fruits and berries, is 0.60 . . . 0.93 (MARJOMAA 1969, p. 71 and HÄMÄLÄINEN 1973, p. 73).

Fruits & berries; although this group has similar data problems as vegetables, the results are more definite. Fruits and berries show a rather high income and price elasticity. Sugar, vegetables and later on cereals are the likely substitutes.

As for previous studies, see the text in connection with vegetables.

Beef; the price and income elasticity of beef seems to be rather stable. The results from the sub-periods suggest that pork and eggs have become stronger substitutes. On the other hand, fish, milk & milk products and cheese have lost their importance as substitutes.

The results by KETTUNEN (1968, p. 83) for 1956—65 are in keeping with those of the present study. Kettunen obtained an income elasticity of 1.47 and a price elasticity of —0.59. The cross-elasticity with respect to the price of pork turned out to be zero. The results from monthly data for 1963—70 by PÖLKKI (1971, p. 78) are somewhat different with regard to the price elasticity (0.26). Generally, the income and cross-price elasticities with respect to pork are of the same order of magnitude as those obtained in this study.

Because no distinction was made between beef and pork in the studies by Marjomaa and Hämäläinen, the results of their studies are not comparable.

Pork; according to Table 5.2.7., pork is less price- and income-elastic than beef. At the same time, it is to be noted that over time, pork has become more income-elastic and less price-elastic (Tables 5.2.8. and 5.2.9.). It seems evident that beef is a substitute for pork, but it has lost its importance in that respect. Fish shows the same kind of evidence. The rather high negative elasticities with respect to eggs and milk are difficult to interpret.

In the study mentioned above, KETTUNEN (1968, p. 82—83) obtained a higher price elasticity (—0.44) for pork but a lower income elasticity (0.24). Kettunen's cross-elasticity with respect to beef is 0.21. The income elasticity of pork by PÖLKKI (1971, p. 78) is also low (0.14). The price elasticity (—0.36) and the cross-elasticity of beef (0.65) are both higher than those obtained in this study.

Eggs; turned out to be a problematic food item in this study. With the use of the DLS-method, it was possible to get a meaningful coefficient only for the income variable. Taking into account the marginal proportion of eggs in the total of consumer expenditure (less than one per cent, see Table 1.1.1.) it is evident that consumer response to price changes is weak. In addition, it is to be borne in mind that in recent years, more eggs have been consumed in the form of bakery products (see Section 2.2.). The negative coefficient of the cereal price variable, obtained by using the RLS-method, is consistent with that idea. When using the RLS-method, the egg price variable also resulted in an acceptable elasticity.

The previous studies by MARJOMAA (1969, p. 59) and HÄMÄLÄINEN (1973, p. 66) showed an income elasticity of 0.4 . . . 0.5 for eggs. The income elasticities based on cross-section data are somewhat higher, 0.65 . . . 0.86 (see HÄMÄLÄINEN 1973, p. 73) In addition to eggs, the dependent variable of all these studies includes milk and cheese. In a recent study, NEVALA (1976, p. 471) obtained, from semiannual data for 1956—70, a price elasticity of —0.60 and an income elasticity of 0.37 for eggs.

Fish; no price elasticity different from zero was obtained for fish. There are some obvious reasons for that. First, the expenditure share of fish is a marginal one (see Table 1.1.1.). Second, part of fish is consumed directly without going through the market mechanism. It is to be noted that the income elasticity of fish varies considerably. Beef and pork show evidence of being substitutes for fish, particularly in the early period.

The previous time-series analyses show a low income elasticity for fish, 0.1. . . 0.3 (MARJOMAA 1969, p. 57 and HÄMÄLÄINEN 1973, p. 66) while the cross-section studies have resulted in higher elasticities, 0.65 . . . 0.89 (see HÄMÄLÄINEN 1973, p. 73).

Milk & milk products; consumer behavior with respect to these products is likely to have changed. Based on Tables 5.2.8. and 5.2.9., milk & milk produsts have become less price- and income-elastic. No substitutes or complements were found.

KALLIO (1974, p. 57 and 60) found milk to be price-inelastic, while cream has a high price elasticity (—1.22). Milk resulted in an income elasticity of —0.54 . . .

—0.61. These results are based on time-series data from 1961—72. As to the previous studies, see also the text relating to eggs.

Cheese turned out to be another problematic food item. A reliable price elasticity was obtained only for the early period. The results would suggest that beef and pork (evidently in the form of sausage) have previously been substitutes for cheese but not any more. The high income elasticity of cheese probably also includes the impact of non-economic factors. These factors are likely to be connected with the way of living and with the social life of consumers as cheeses are becoming popular at parties and convenient snacks in everyday life. The high income elasticity would suggest that cheese has some complements, but these are likely to be found in products other than food.

The previous studies have resulted in lower income elasticities. KETTUNEN (1971, p. 49) obtained, from quarterly data for 1954—59, an income elasticity of 0.50 and a price elasticity of —0.75. According to KALLIO (1974, p. 55), the income elasticity of cheese varied between 1.12 and 1.20 in 1955—72. See also the text in connection with eggs.

Butter demand has undergone considerable changes. It looks like butter has become an inferior food item. The results do not suggest evidence that butter is a substitute for margarine. Obviously the price elasticity of butter is rather low.

KETTUNEN (1971, p. 31) estimated from quarterly data for 1954—60 an income elasticity of 0.38 and a price elasticity of —0.61 for butter. Nor did butter turn out to be a substitute for margarine in this study. KALLIO (1974, p. 53) obtained a high price elasticity for butter (—0.63 . . . —0.90), but an income elasticity of around zero (—0.11 . . . 0.15). In the above-mentioned studies by Marjomaa and Hämäläinen, all fats are treated as one item. Accordingly, they are not comparable to the results of this study.

Margarine; because of the introduction of so-called icebox margarine (see Section 2.2.), it is apparent that consumer demand for margarine has changed. These changes are reflected, in particular, in a higher price elasticity. According to the results, margarine is a substitute for butter, which is quite obvious when we take into account the recent upward trend of margarine consumption.

Also in the study by KETTUNEN (1971, p. 40), margarine turned out to be a rather strong substitute for butter (with a cross- elasticity of 0.95). According to Kettunen, the price and income elasticity of margarine is only —0.04 and 0.03 respectively. His study covers the years 1954—60.

In summary, we may conclude that with respect to the income elasticities, the results are in general satisfactory. Of the price elasticities, only a part of them gave reliable and consistent (negative) estimates. It was possible to obtain a cross-price elasticity only in a very few cases. On the other hand, it is probable that quite a large number of them are rather small.

The reasons for the failure to obtain an estimate and, in particular, a reliable estimate only for a small part of the elasticities of the demand matrix lie in the rigid price structure (see Section 2.3.) and in the relative unimportance of some food items in the consumers' total expenditure (see Table 1.1.1.). It is likely that quite a few of the price variables were potential so that their influence upon the dependent variable could not be estimated, because they remained constant or their variation was small during the observation period. A potential variable may become factual in the course of time if it shows sufficient variation and can accordingly have an influence upon the independent variable. For the exact definition of these concepts, see HAAVELMO (1944, p. 26). The reader is also asked to refer to TERÄSVIRTA (1970, p. 8—9). In a demand analysis, such as this one, it can conceivably be assumed that the prices of some substitutes or complements have not always varied enough to have had a factual influence upon demand for the commodity in question. As noted before, there has been a tendency, for institutional and other reasons to maintain the prices of some food items as stable as possible.

Only in the case of some products was it possible to notice changes in the demand elasticities over time.

5.3. Dynamic demand functions

All the demand functions presented above are static in nature. Hence, the approach taken thus far is usually called comparative statics. It deals by no means with the adjustment process through which consumers move from one equilibrium to another when f.ex. the prices of commodities change. Obviously, however, there is a time lag while consumers change the quantities demanded to correspond to the new price ratios. Some possible explanations for the time lags are: some consumers buy on the basis of habit, it takes some time before all consumers become aware of the price changes, some goods may be such as require complementary commodities or they must be used up before a new one is purchased. Because individual consumers react to price changes in different ways and with varying time lags, it is reasonable to think that the complete adjustment should be spread out over the whole period in which the adjustment takes place.

Because it is probable that these factors have had an impact on the behavior of consumers, the adjustment process was studied by means of distributed- lag functions.

Since the early 1950's, demand functions based on distributed lags have been developed for measuring the adjustment process. The first application was by KOYCK (1954) to investment functions. Subsequently, NERLOVE (1958a, p. 45—65 and 1958b, p. 301—311) is to be mentioned as one of the persons developing further the idea of distributed lags.

As a starting point, Nerlove uses the functions:

(5.3.1.) $$q_t^* = \alpha_0 + \alpha_1 p_t,$$

(5.3.2.) $$q_t - q_{t-1} = \gamma(q_t^* - q_{t-1}),$$

Table 5.3.1. Distributed-lag models for 1950—77, t-values in the brackets.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	—0.234 (1.5)	—0.088 (0.6)	—0.472*** (3.2)		0.005 (0.0)								
Potatoes	0.014 (0.2)	0.114* (1.8)		—0.204 (1.0)									
Sugar	0.142** (2.8)	0.028 (0.5)	—0.107* (1.8)	0.056 (0.4)	0.446*** (4.3)								
Vegetables	0.072 (1.0)	—0.039 (0.5)		—0.001 (0.0)	0.484*** (2.9)								
Fruits & berries	0.005 (0.1)	—0.043 (0.4)	—0.424*** (4.0)	0.970*** (3.0)	—0.529* (1.9)								
Beef	0.168 (1.3)	0.050 (0.4)				—0.574*** (4.0)	0.409** (2.1)		0.436*** (2.9)	—0.376*** (3.7)	—0.042 (0.2)		
Pork	0.167 (1.4)	0.430*** (3.7)				0.087 (0.4)	—0.293 (0.9)		—0.409 (1.2)	—0.088 (0.7)	0.651*** (3.0)		
Eggs						—0.023 (0.1)	—0.464 (1.3)	0.271 (1.2)	0.026 (0.1)	0.026 (0.3)			
Fish						0.182 (1.7)	0.028 (0.2)		—0.003 (0.0)				
Milk & milk products						0.161 (0.9)	—0.335 (1.2)			—0.521*** (3.2)			
Cheese										0.086 (0.9)	—0.211 (1.2)		
Butter	—0.207** (2.6)		—0.081 (0.8)	0.224 (0.8)							0.085 (0.5)	—0.449* (1.8)	0.210 (0.8)
Margarine & oils			0.097* (1.8)	0.211 (1.5)								0.048 (0.5)	0.320*** (3.2)
Income	—0.886*** (6.4)	—0.944*** (7.1)	0.029 (0.5)	1.102*** (4.3)	1.066*** (5.8)	1.187*** (5.1)	0.728** (2.2)	0.795*** (5.8)	0.211 (0.9)	0.196 (1.5)	0.812*** (4.0)	—0.260*** (2.9)	0.339*** (3.3)
Potatoes dummy		—0.201*** (9.6)											
Margarine dummy													—0.289*** (4.7)
Dependent $variable_{t-1}$	0.024*** (3.0)	0.008 (0.9)	0.032** (2.4)	0.016 (0.4)	0.075** (2.4)	—0.038 (1.5)	—0.009 (0.2)	0.107*** (2.9)	—0.043 (1.2)	0.003 (0.5)	0.412*** (5.5)	0.072 (1.7)	0.200*** (3.3)
R^2	0.984	0.981	0.848	0.703	0.973	0.970	0.963	0.928	0.792	0.883	0.977	0.373	0.842

were q_t^* denotes the equilibrium in the long run and γ is the coefficient of adjustment. Formula (5.3.1.) indicates simply that the long-term equilibrium quantity is a function of the price p_t. According to (5.3.2.), a change in the quantity demanded is a certain proportion of the difference between q_t^* and the quantity of the previous period. If $\gamma = 1$, we have an immediate adjustment. If $\gamma = 0$, there is no adjustment at all. Usually it is supposed that $0 < \gamma \leq 1$.

Because the long-run equilibrium (q_t^*) is not known, the functions (5.3.1.) and (5.3.2.) cannot be estimated from empirical data. By inserting q_t^* from (5.3.1.) to (5.3.2.), we get:

(5.3.3.) $$q_t = \gamma\, \alpha_0 + \gamma\, \alpha_1\, p_t + (1-\gamma)\, q_{t-1}.$$

If we denote, $\gamma\alpha_0 = \beta_0$, $\gamma\alpha_1 = \beta_1$ and $(1\text{-}\gamma) = \beta_2$, (5.3.3.) has the form:

(5.3.4.) $$q_t = \beta_0 + \beta_1 p_t + \beta_2 q_{t-1}$$

The parameters β_0, β_1 and β_2 can now be estimated using f.ex. the method of least squares. The magnitude of the coefficient of adjustment is obtained from the formula: $\gamma = 1\text{-}\beta_2$.

Distributed-lag models are usually interpreted in such a way that the function (5.3.4.) indicates consumer reactions in the short run. If we have a logarithmic function, the parameter β_1 itself is the price elasticity. The respective long-run elasticity is obtained by dividing β_1 by γ. Because $0 < \gamma \leq 1$, the long-run elasticities are higher than the corresponding short-run elasticities. In other words, consumers react more strongly to price changes in the long run than in the short run. The same thing may be expressed in another way: there is a certain time lag before consumer reactions are fully realized.

Table 5.3.2. Distributed-lag models for 1950—63, t-values in the brackets.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals	0.279 (0.8)	—0.701** (3.5)	0.338* (2.1)		0.648 (1.6)								
Potatoes	0.161 (0.8)	—0.145 (1.3)		0.245 (1.3)									
Sugar	0.160 (1.1)	—0.402** (3.6)	0.285** (2.7)	—0.309 (1.1)	0.734*** (3.5)								
Vegetables	—0.137 (0.6)	0.112 (1.0)		—0.242 (0.9)	0.600** (3.2)								
Fruits & berries	0.291 (1.1)	—0.414* (2.9)	0.165 (1.3)	0.312 (1.4)	—0.413 (1.3)								
Beef	0.453 (1.3)	—0.149 (0.9)				—0.191 (0.8)	—0.115 (0.4)		0.456* (2.3)	—0.227 (1.1)	0.259 (0.8)		
Pork	0.083 (0.4)	0.109 (1.2)				0.069 (0.3)	—0.208 (0.9)		—0.290 (1.2)	—0.086 (0.7)	0.574* (1.9)		
Eggs						—0.160 (0.7)	—0.401 (1.6)	0.352 (1.0)	—0.081 (0.3)				
Fish						—0.079 (0.6)	0.413*** (2.6)		0.135 (0.9)				
Milk & milk products						0.199 (1.1)	—0.288 (1.2)			—0.504* (2.3)			
Cheese										0.057 (0.5)	—0.319 (1.4)		
Butter	—0.057 (0.3)		0.103 (1.2)	0.113 (0.6)							0.375 (0.9)	—0.285 (1.0)	0.478 (1.7)
Margarine & oils			0.078 (1.6)	0.519** (3.6)								—0.244*** (2.4)	0.455*** (4.7)
Income	—0.689 (1.6)	—0.163 (0.6)	0.293 (1.8)	—1.363** (3.1)	0.867* (1.8)	1.268*** (5.4)	0.598* (2.1)	0.886** (2.3)	—0.111 (0.6)	0.246 (1.3)	1.589* (2.0)	1.234** (2.5)	0.404 (0.7)
Potatoes dummy		—0.104** (3.6)											
Margarine dummy													—0.312*** (3.4)
Dependent variable$_{t-1}$	0.019 (1.6)	—0.014 (1.6)	0.030** (3.3)	0.094** (3.5)	0.070* (2.1)	—0.029 (1.3)	—0.042 (1.5)	0.090 (1.4)	—0.036 (1.6)	0.002 (0.3)	0.275* (2.2)	—0.061 (1.4)	0.174** (2.6)
R^2	0.929	0.984	0.971	0.919	0.981	0.979	0.903	0.737	0.782	0.684	0.954	0.657	0.934

The examination of distributed-lag models in this study is based on static price expectations. It is to be mentioned that there are a number of different versions of distributed-lag models other than static.

The distributed-lag models of the original functions (Tables 5.2.1., 5.2.2. and 5.2.3.) are presented in Tables 5.3.1., 5.3.2. and 5.3.3. In general, the elasticities of these functions are of the same order of magnitude as those of the original function.

In the functions for 1950—77, the coefficients of the lagged dependent variable are, with the exception of eggs, cheese and margarine & oils, very close to zero. Accordingly, the coefficient of adjustment does not differ very much from one. So, we may conclude that consumer reactions to price changes are fully realized within a year. Because a year is quite a long time, this result is consistent with the expections. The reasons why cheese and margarine & oils did not produce satisfactory results are likely to be found in the changing consumption patterns of these products.

The results for 1950—63 are similar to those for the whole period. In the later period, a greater number of products resulted in a notably smaller coefficient of adjustment than one. However, it is premature to draw the conclusion that consumer reactions have become slower. In addition, it is to be noted that in many cases, the coefficient of the lagged dependent variable turned out to be, contrary to expectations, negative.

5.4. Demand for food as a whole

To complete the picture of consumer demand for food in Finland, demand functions for food as a whole were also run. The dependent variable in these functions was the total calorie consumption/day/capita. It was explained by the food price index, the non-food price index and the wage & salary index. A logarithmic functional form was used also in this case. The results are presented in Table 5.4.1.

Table 5.3.3. Distributed-lag models for 1964—77, t-values in the brackets.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef
Cereals	—0.571*	0.549**	3.023***		0.597	
	(2.3)	(3.2)	(3.4)		(0.4)	
Potatoes	—0.007	0.134**		—0.075		
	(0.1)	(3.6)		(0.6)		
Sugar	—0.003	0.042	—0.269***	—0.038	0.095	
	(0.0)	(0.9)	(3.9)	(0.3)	(0.6)	
Vegetables	0.024	0.004		0.273	0.277	
	(0.3)	(0.1)		(1.8)	(1.1)	
Fruits & berries	0.286	—0.725**	0.668	—0.792	—0.578	
	(0.8)	(3.8)	(1.5)	(1.5)	(0.6)	
Beef	—0.244	0.157				—0.552**
	(1.6)	(1.7)				(3.4)
Pork	0.095	1.010***				0.625
	(0.3)	(5.4)				(1.2)
Eggs						0.159
						(0.5)
Fish						0.077
						(0.4)
Milk & milk products						0.060
						(0.1)
Cheese						
Butter	0.300**		1.301**	0.343		
	(2.5)		(3.7)	(1.0)		
Margarine & oils			0.535	0.176		
			(1.5)	(0.6)		
Income	—0.345	—1.112***	0.103	1.283*	1.038	1.090***
	(1.7)	(11.1)	(0.7)	(2.5)	(1.4)	(3.9)
Potatoes dummy		—0.165***				
		(12.0)				
Margarine dummy						
Dependent variable$_{t-1}$	—0.016	0.107	—1.148**	—0.090	0.407	—0.211
	(0.0)	(2.0)	(3.0)	(0.2)	(1.1)	(0.9)
R^2	0.995	0.999	0.946	0.985	0.975	0.919

	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Marg. & oils
Cereals							
Potatoes							
Sugar							
Vegetables							
Fruits & berries							
Beef	—0.041		—0.004	—0.118	—0.170		
	(0.2)		(0.0)	(1.1)	(0.5)		
Pork	—0.040		—0.928	0.437	0.499		
	(0.1)		(0.9)	(1.7)	(1.2)		
Eggs	—0.811*	0.078	0.317				
	(2.0)	(0.4)	(0.4)				
Fish	0.083		0.292				
	(0.4)		(0.7)				
Milk & milk products	—0.474			0.569*			
	(1.1)			(1.9)			
Cheese				—0.435*	1.322		
				(2.3)	(1.1)		
Butter					—0.317	—0.169	1.064**
					(0.6)	(1.3)	(2.4)
Margarine & oils						—0.159	—0.868
						(0.8)	(1.7)
Income	1.548	0.368**	1.163*	0.003	1.902***	—0.587	1.366**
	(1.7)	(2.3)	(1.9)	(0.0)	(5.3)	(1.7)	(3.2)
Potatoes dummy							
Margarine dummy							—0.071
							(0.9)
Dependent variable$_{t-1}$	—0.129	0.425	0.040	0.783*	—0.132	0.442	—0.466
	(0.2)	(1.7)	(0.1)	(3.4)	(0.4)	(1.4)	(1.7)
R^2	0.993	0.943	0.836	0.939	0.989	0.977	0.924

Table 5.4.1. Demand functions for food as a whole. Dependent variable = total calorie consumption/day/capita, t-values in brackets, d = Durbin-Watson test quantity.

	Food price index	Non-food price index	Income
Period 1950—77, R^2 = 0.715	—0.351**	0.351	—0.016
d = 0.61	(2.6)	(1.9)	(0.3)
Period 1950—63, R^2 = 0.536	—0.152	—0.070	0.175**
d = 0.72	(1.2)	(0.4)	(2.6)
Period 1964—77, R^2 = 0.574	—0.280	0.259	0.008
d = 0.99	(1.3)	(0.8)	(0.1)

In general, demand elasticities for the total demand for food are small. In the early period, food seems to have been income elastic, but no longer in recent years. Both the price elasticity and the cross- elasticity with respect to non-food items are small. In addition, they do not differ statistically from zero.

It is quite natural that food consumption as a whole in a developed economy such as Finland's is no longer sensitive to price or income. Nowadays, the potential demand is not any more directed to energy (calories), but to protein items. Thus there is a shift from cereals and potatoes to meat and other protein food while the total energy consumption remains unchanged or changes only marginally.

6. TESTING STABILITY AND UP-DATING OF DEMAND ELASTICITIES

6.1. Problem of changing parameters over time

In econometrics, regression analyses are usually run by applying as long time series as possible to get reliable parameter estimates. At the same time, these analyses are based on the assumption of a constant regression relationship over time. However, as pointed out by BROWN et. al. (1975, p. 149), the validity of this assumption is open to question. Particularly in the field of social sciences, there might be a good case for supposing that the structure of a regression model changes in the course of time. In that case, the assumption of an unchanged regression relationship is wrong. If the model is to be used for forecasting, as in the present study, this problem is of crucial importance.

The structural changes are divided into two stability concepts: stability over time of the regression coefficients and stability of the distribution of the error term. Because the former is by far more important in practical applications, the following examination is devoted to that problem only.

In the framework of a demand study, we may think that consumer preferences, which indicate the behavior of consumers with respect to prices and income, are subject to changes over time. These changes might stem from shifts in the socio-economic structure of the population, changes in the goods studied, product development or the introduction of entirely new products. As analyzed in Section 2.2., similar changes have occurred in the Finnish diet during the past two decades. Consequently, the estimated demand functions above are likely to be outdated with respect to present consumer behavior. As one of the objectives of this study is to make forecasts, the examination of the parameter changes and the updating of the parameters of the demand functions have to be undertaken first.

As a first approach to the detection of parameter changes, we could think of running two regression analyses of the study period: one for the early and the other for the latter part. This procedure was followed in the preceeding section, but as stated before, no definite conclusions could be drawn.

The number of sets of parameter estimates can be further expanded by adding one observation to the end of the study period and leaving out one from the beginning. Applying this procedure we move ahead stepwise along the study period. This method of using regression techniques is, accordingly, called stepwise regression analysis. For the statistical theory of stepwise regression analysis, the reader is asked to refer f. ex. to TERÄSVIRTA (1970, p. 11—23).

By means of stepwise regression analysis, we are able to get a sequence of subsequent models instead of a single model. In other words, a time series of the estimated parameters is obtained, which gives us more information about the development of the parameters over time. If they seem to alter smoothly, it is consistent to assume that structural changes have taken place in the regression model.

Traditionally, systematic changes in time series analyses are taken into account by inserting a trend factor among the independent variables. Through this procedure it is, however, not possible to measure any changes in the parameters themselves, but the method is primarily used to avoid getting biased estimates for the rest of the parameters. In many cases, the interpretation of the trend coefficient is also difficult.

6.2. Testing of parameter changes

In this study, neither the stepwise regression analysis nor the inclusion of a trend factor were used, but the parameter changes were tested using the tests recently introduced by BROWN et. al. (1975, p. 149—163). After that the models were updated by means of the discounted regression analysis (Section 6.4.).

The major points and features of the tests by BROWN et. al. will be discussed in the subsequent text, following closely the presentation of the authors. For further details, the reader is asked to refer to the original article.

Let us express the null hypothesis, i.e. the hypothesis of constancy of the regression coefficients over time, as follows:

(6.2.1.) $$H_0\colon \beta_1 = \beta_2 = \ \dots \ = \beta_T = \beta.$$

Let us further assume H_0 to be true and b_{r-1} to be the least squares estimate of β based on the first r-1 observations. According to (5.1.4.),

(6.2.2.) $$b_{r-1} = (X'_{r-1}X_{r-1})^{-1}X'_{r-1}y_{r-1}.$$

Then we calculate the w_r-values using the formula:

(6.2.3.) $$w_r = \frac{y_r - x_r b_{r-1}}{\sqrt{(1+x'_r(X'_{r-1}X_{r-1})^{-1}x_r}}, \ r = k+1, \ \dots, \ T.$$

where y_r and x_r constitute the rth observation.

The numerator of (6.2.3.) gives us the prediction error of y_r when predicted from the model which is based on the r-1 observations. This is standardized by the denominator and called the standardized prediction error. BROWN et. al. (1975, p. 152) have proved that the w_r-values are normally distributed with zero means and a constant variance, i.e. $w_r \backsim N(0, \sigma^2)$, when H_0 is true.

If the w_r's are subsequently calculated, introducing into the model one observation at a time, we obtain a time series of standardized recursive residuals. Now, if β_t is constant up to time $t = t_0$ and differs from this constant value from then on, the w_r's will have zero means for r up to t_0 but in general, will have non-zero means after that. To examine possible departures of the means of the w_r's from zero, Brown et. al. have suggested the use of cumulative sum (hence called cusum) of the w_r's. First, the cusum quantity:

$$W_r = \frac{1}{\hat{\sigma}} \sum_{i=k+1}^{r} w_i \qquad (6.2.4.)$$

is calculated and plotted agains r. Here $\hat{\sigma}$ denotes the estimated standard deviation from the whole data. The expected value of W_r under the null hypothesis, $E(W_r)$ is zero.

Then a suitable procedure to test the significance of the departure of the sample path of W_r from zero is to find a pair of lines lying symmetrically above and below the line $W_r = 0$. If we choose a certain significance level, say α, these lines would be located in such a way that the probability of crossing one or both lines is α. Brown et. al. have derived these lines to go through the points:

$$\{k, \pm a\sqrt{T-k}\}, \ \{T, \pm 3a\sqrt{T-k}\}, \qquad (6.2.5.)$$

where k is the number of regressors, T is the number of observations and a is a parameter which depends on the significance level α. The authors have suggested the following useful pairs of values of a and α:

$\alpha = 0.01,$	$a = 1.143$
$\alpha = 0.05,$	$a = 0.948$
$\alpha = 0.10,$	$a = 0.850$

Here, the probability of W_r crossing both lines is assumed to be negligible. This test is called the cusum test (CUS-test).

Brown et. al. have also suggested another test to complete the cusum test, particularly when the departure from the constancy of the β's is haphazard rather than systematic. This is the cusum of squares test (COS-test). It is based on the squared recursive residuals, w_r^2 and on the plot of the quantities:

$$s_r = \left(\sum_{i=k+1}^{r} w_i^2\right) \Big/ \left(\sum_{i=k+1}^{T} w_i^2\right) = S_r/S_T, \ r = k+1, \ldots, T. \qquad (6.2.6.)$$

Assuming H_0 to be true, s_r may be shown to have a beta distribution with mean (r-k)/(T-k). As in the case of the cusum test, a pair of lines:

$$z_r = \pm c_0 + (r-k)/(T-k) \qquad (6.2.7.)$$

is constructed parallel to the mean value line in such a way that the probability of the sample path crossing one or both lines is α, the required significance level. To find the value of c_0, use is made of modified Kolmogorov—Smirnov statistics. If (T-k) is even, we enter the table of DURBIN (1969, p. 4) at 1/2(T-k) —1 and $1/2\alpha$. If (T-k) is odd, a linear interpolation is made between the values for n = 1/2(T-k)—3/2 and n = 1/2(T-k)—1/2.

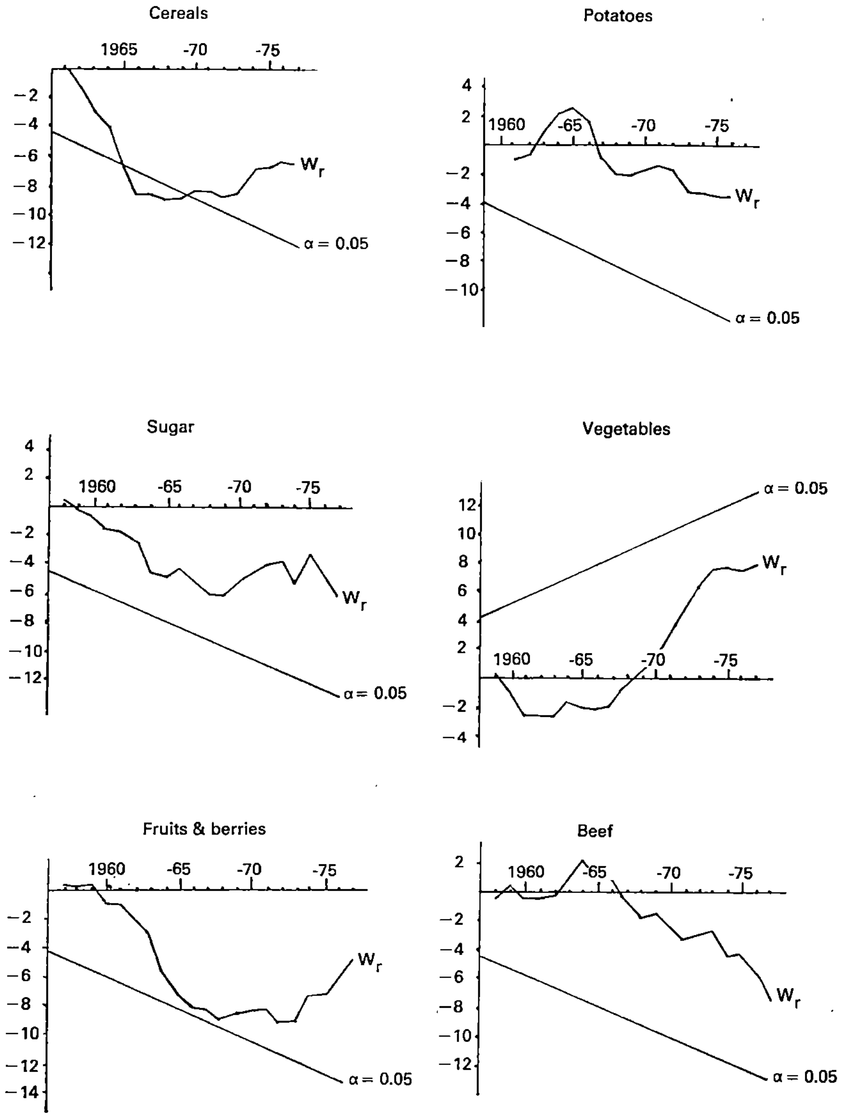

Figure 6.2.1. Cusum-tests of the demand functions, W_r = CUS-test quantity, α = significance level.

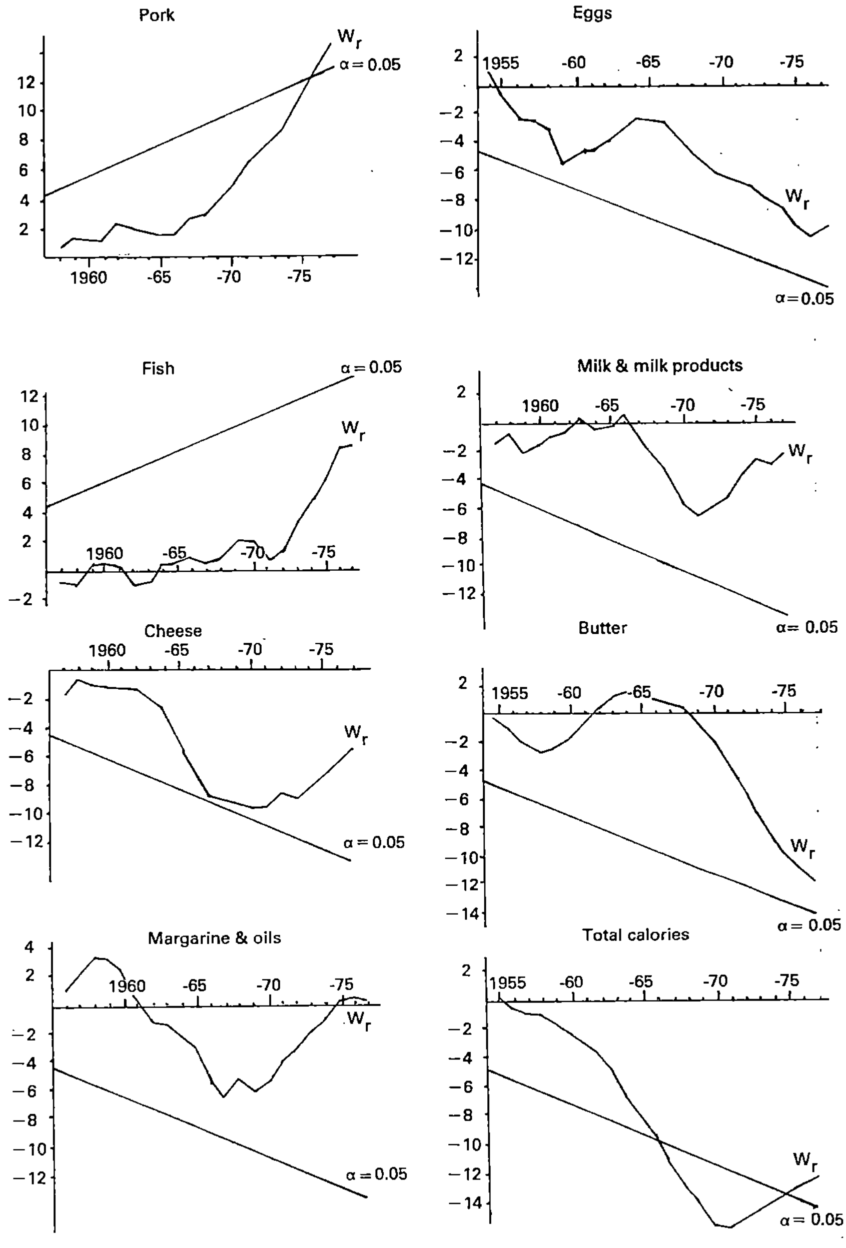

Figure 6.2.1. (Continued)

Both the CUS- and the COS- tests were applied in this study. Finally, it is to be noted, as the authors point out, that these tests provide a yardstick for evaluating structural changes, although, of course, they can be used as a formal test to reject the H_0, if the sample path travels outside the region between the lines.

The CUS- and COS-tests applied to the original demand functions (Table 5.2.1.) for 1950—77 are presented in Figure 6.2.1. and 6.2.2. The significance level of 0.05 ($\alpha = 0.05$) was chosen for both tests. The results are presented in a compact form in Table 6.2.1.

The CUS-test gave a positive result only in three cases and the COS-test in five cases. However, it is to be noted that in a number of products, the W_r- and s_r-curves go very close to the critical lines. Due to the non-definite nature of these tests, there are good grounds in these cases for supposing the occurrence of parameter changes, at least to some extent.

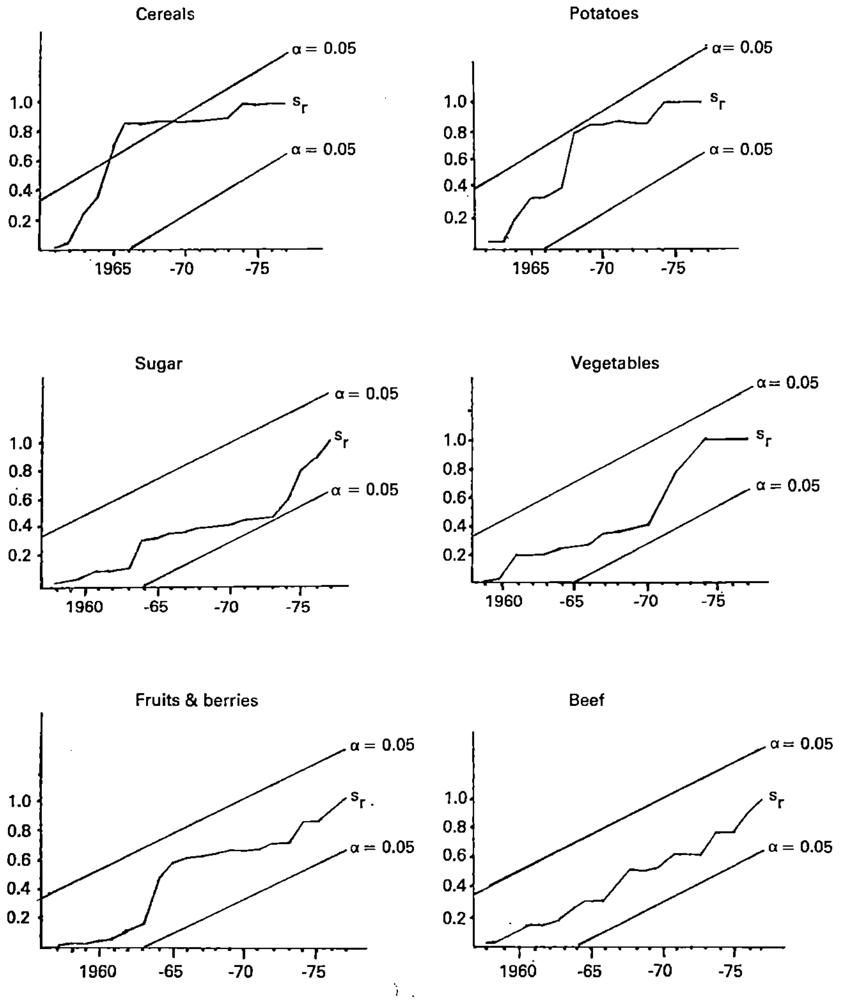

Figure 6.2.2. Cusum of squares tests of the demand functions, s_r = COS-test quantity, α = significance level.

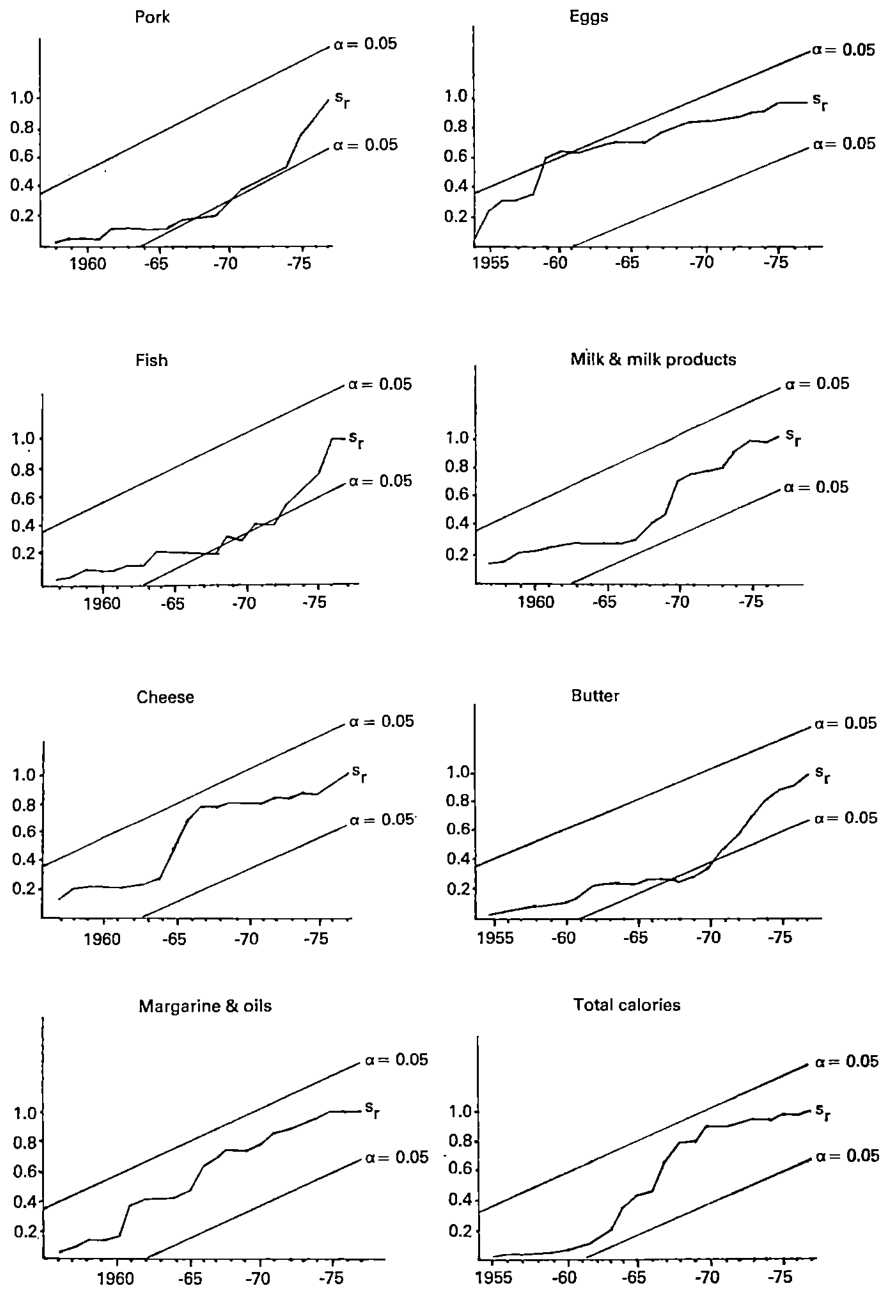

Figure 6.2.2. (Continued)

Table 6.2.1. The results of the CUS- and COS-tests. The hypothesis of the constancy of the regression coefficients rejected (+), not rejected (—).

	CUS-test	COS-test
Cereals	+	+
Potatoes	—	—
Sugar	—	—
Vegetables	—	—
Fruits & berries	—	—
Beef	—	—
Pork	+	+
Eggs	—	+
Fish	—	+
Milk & milk products	—	—
Cheese	—	—
Butter	—	+
Margarine & oils	—	—
Food as a whole	+	—

6.3. Estimation method of discounted regression analysis

Even though the hypothesis of constancy of the regression coefficients was not rejected in the case of all food items, it was felt that before making forecasts by means of these demand elasticities, they ought to be updated.

The updating was performed by means of discounted least squares (DLS), which gives more weight to recent data than to data from the distant past. By way of comparison, it is to be noted that the method of ordinary least squares (OLS) implies that data from some decades ago is as relevant for estimating the parameters and, in particular, for making forecasts, as data from the past few years.

Already in 1957, TÖRNQVIST (1957, p. 222—223) suggested the application of a discounted regression analysis. Later, the method has been further developed. For a detailed presentation, see e.g. GILCHRIST (1967, p. 355—369).

The method of discounted least squares (DLS) belongs to the general class of methods of weighted least squares. Generally, if we have a diagonal weighting matrix $W = \ulcorner w_1, w_2, \ldots, w_T \lrcorner$ and we want to weight the ith observation with w_i, the estimator of weighted least squares for β_w is calculated by minimizing:

$$e'We \tag{6.3.1.}$$

instead of $e'e$. The formula for b then assumes the form:

$$b_w = (X'WX)^{-1}X'Wy, \tag{6.3.2.}$$

compare with the Formula (5.1.4.).

We can now proceed from the weighted regression discussed above to the method of discounted least squares (DLS) as follows, First, a discounting factor ϱ, $(0 < \varrho < 1)$ is chosen. If T observations are included in the model, the observations have the weights $\varrho^{T-1}w_1, \varrho^{T-2}w_2, \ldots, \varrho w_{T-1}, w_T$. In other words, the weights will be discounted by a figure diminishing geometrically. Usually $w_i = 1$, $(i = 1, \ldots, T)$. Then the weights from the first observation to the last one are:

(6.3.3.) $\varrho^{T-1}, \varrho^{T-2}, \ldots, \varrho, 1.$

The discounting method used in this study is discussed in more detail by VÄLI-AHO and PEKKONEN (1976, p. 27). The different discounting schemes with varying ϱ's will be dealt with in the appropriate empirical section of this study.

Finally, it is to be noted that the usual criteria for evaluating a regression model are no longer valid when using DLS because the disturbance term has, no more a constant variance. Accordingly, instead of the traditional R^2-value, t-tests of the regression coefficients and Durbin—Watson statistics, only the predictive performance was used to measure the »goodness» of a model. Because the functions are used for forecasting purposes, this criterion was considered justified. The »best» discounting scheme has to be found by empirical experiment. Different ϱ's were applied by the »trial and error» method, using the predictive performance of the model as a yardstick. Just how this was performed, will be discussed in Section 7.1.

6.4. Updating of demand elasticities

The updating of the demand elasticities estimated before was made by means of discounted least squares (DLS). The cross-price elasticities which were found to be of minor importance were omitted from the DLS-functions. Their influence on the forecasts would in any case be negligible. A total of five different ϱ-values were used. Discounting with different ϱ-values involves that the lower the ϱ-value, the more the most recent observations are taken into account. Thus, when weighting time (years) with given weights (Formula 6.3.3.), we are able to get estimates stemming from a more up-to-date time, the lower the ϱ-value is.

For example, if the time period 1950—77 is weighted by $\varrho = 0.95$ (see Formula 6.3.3.), we end up with a weighted average of 1966.7. In other words, the elasticities origiriate approximately from the third quarter of 1966. The following different ϱ-values, expressed with time points, were used.

ϱ	time point			
0.95	third	quarter	of	1966
0.85	»	»	»	1971
0.75	first	»	»	1974
0.65	»	»	»	1975
0.55	fourth	»	»	1975

Because some food items did not result in meaningful elasticities when using heavy weighting (low ϱ-values), only the greater ϱ's were used in those cases. To detect the consistency of OLS-estimates with those of DLS, the corresponding functions were run for 1950—77 and 1964—77 using the OLS-method.

The results are presented in Figure 6.4.1. In some cases, the demand elasticities vary considerably, in other cases only moderately. The elasticities seem to alter smoothly in the cases where there have been only minor changes in the food item group itself. These groups include cereals, potatoes, sugar and eggs. With some exceptions the DLS- and OLS-estimates coincide: the OLS-estimates follow approximately the trends of the DLS-elasticities.

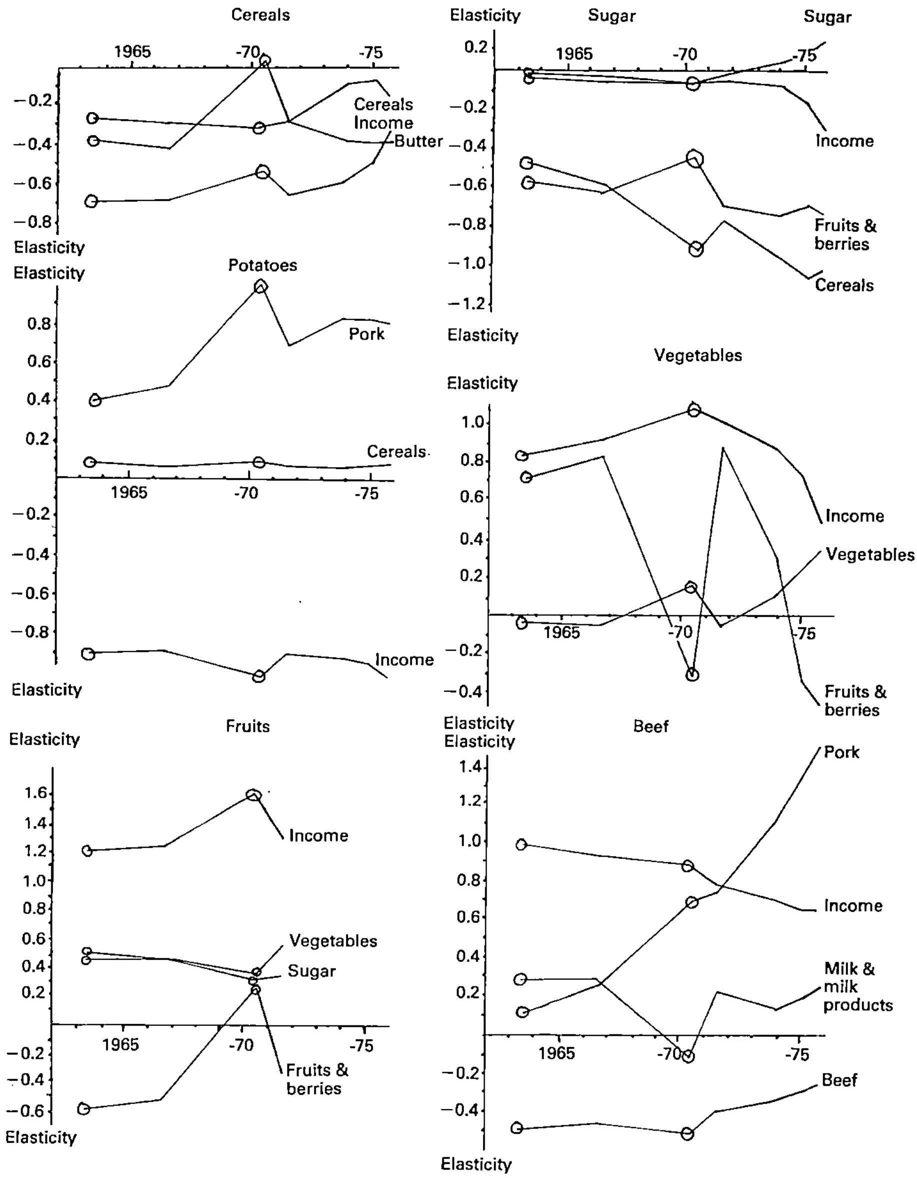

Figure 6.4.1. Demand elasticities with respect to income and price of different food items as a function of time. The elasticities within a circle are OLS-estimates.

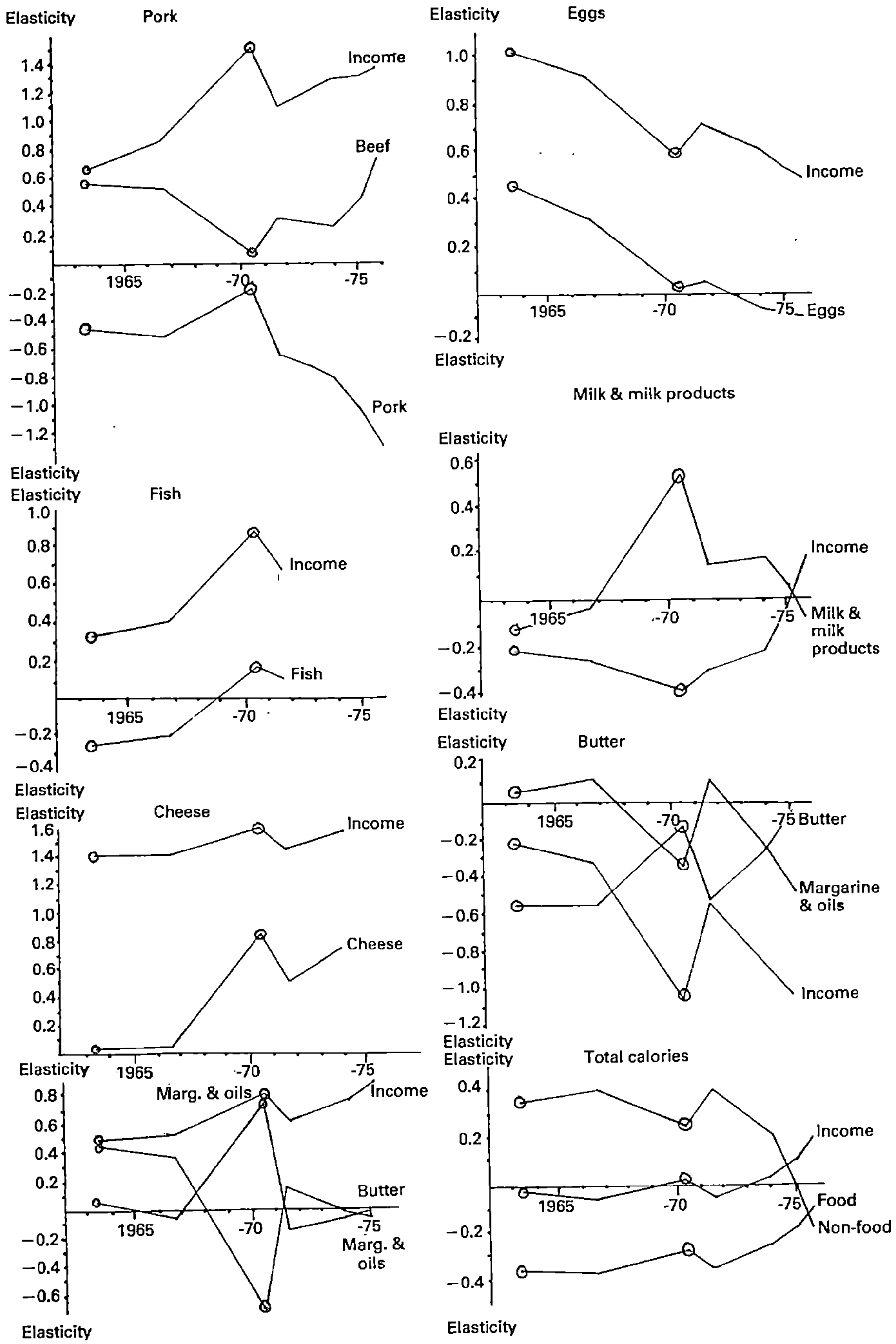

Figure 6.4.1. (Continued)

Table 6.4.1. Updated elasticity matrix based on DLS-functions, in some cases OLS-estimates are also taken into account.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Margarine & oils
Cereals	—0.15		—0.95										
Potatoes		0.00											
Sugar			—0.05		0.35								
Vegetables				0.00	0.50								
Fruits & berries			—0.60	—0.30	—0.30								
Beef						—0.50	0.50						
Pork		0.80				0.70	—1.00						
Eggs								—0.10					
Fish									0.00				
Milk & milk products						0.20				—0.10			
Cheese											0.00		
Butter	—0.38											—0.20	
Margarine & oils													—0.05
Income	—0.35	—0.95	—0.10	0.80	1.30	0.90	1.30	0.50	0.70	—0.20	1.50	—0.90	0.65

The consistency of the results with the tests by Brown et. al. is evident. In those cases where the change of the coefficients was notable and smooth, the CUS- and COS-tests or both of them suggested the rejection of the hypothesis of constancy. These food items include cereals, pork, eggs, fish, butter and food as a whole. In the two lastmentioned cases, the changes are not as obvious as in the others.

The updated elasticities based on the DLS-functions are presented in Table 6.4.1. In those cases where the DLS-method did not give meaningful results, the OLS estimates were taken into account. The same procedure was followed to a certain extent when the CUS- and COS-tests gave negative results. The price elasticities were again set at zero in the cases where they turned out to give a positive elasticity. In most cases, they were only slightly positive. Because they produced unstable estimates, the cross-price elasticity of butter with respect to margarine & oils and the cross-price elasticity of margarine & oils with respect to butter were omitted.

7. CONSUMPTION FORECASTS FOR 1980, 1985 AND 1990

7.1. Forecasts for 1980

One of the objectives set for this study was to make short-term consumption forecasts. As mentioned before, »short-term» here refers to a time span of 2—3 years ahead. Because of processing, food consumption data have a one-year time lag. At the moment, provisional figures for 1978 are available. Accordingly, the year 1980 was chosen as the year for which the short-term forecasts were prepared. To eliminate year-to-year fluctuations, the average consumption figure of the three-year- period 1976—78 was taken as a basis for making the forecasts. Hence, the actual time span to be forecasted was three years. At the time the forecasts were made, we were in late 1979. From this point of view, 1980 seems to be too close ahead. However, the choise of 1980 enables one to check the accuracy of the forecasts shortly, i.e. in mid-1981, when the 1980 consumption figures are published.

The method of DLS was applied in the following way. First, the demand functions having only income and the most important prices as independent variables (see Section 6.4.) were estimated for the period 1950—74. A discounting factor (ϱ) giving the most accurate forecasts for 1975—77 on the average was then chosen. To find out the ϱ-value, a method of trial and error was used in estimating a large number of functions with different discounting schemes. Second, the demand functions were re-estimated using the 1950—77 data and the ϱ-values obtained in the first step. After that, the forecasts for 1980 were made applying the parameters obtained in the second step and using the average consumption of 1976—78 as the base year.

The optimal values of ϱ varied from 0.500 (cheese) to 0.925 (vegetables) (Table 7.1.1.). The elasticities used in making the 1980 forecasts (Table 7.1.1.) are, with some exceptions, of the same order of magnitude as the updated elasticities (Table 6.4.1.).

The method of making forecasts by means of demand elasticities is conditional in the sense that the future income and price development has to be forecasted first. As the price elasticities are, with a few exceptions, close to zero, the forecasting of future price development does not play an important role. On the other hand, the future income development is of crucial importance.

An annual growth rate of 3.3 per cent in the real disposable income of households was applied in the making of the forecasts for 1980. This estimate was made by the

Table 7.1.1. The elasticities used in making forecasts for 1980, ϱ = discounting factor.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Margarine & oils
Cereals	—0.07		—0.99										
Potatoes		0.06											
Sugar			0.06		—0.22								
Vegetables				—0.05	0.64								
Fruits & berries			—0.74	0.88	0.73								
Beef						—0.33	0.36						
Pork		0.69				1.24	—0.93						
Eggs								0.09					
Fish									—0.07				
Milk & milk products						0.16				—0.01			
Cheese											0.66		
Butter	—0.39											—0.54	
Margarine & oils.													0.01
Income	—0.45	—0.92	—0.09	0.97	1.66	0.67	1.33	0.49	0.53	0.07	2.09	—0.91	0.82
ϱ	0.625	0.850	0.725	0.925	0.700	0.700	0.700	0.550	0.900	0.600	0.500	0.675	0.700
Change in the real retail price, per cent/year	0.00	0.50	0.00	0.50	0.00	2.50	0.50	—0.50	—0.50	0.50	0.50	0.50	0.00

Ministry of Finance (ANON 1979, p. 50). Real disposable income was used instead of real earnings because the former is a better indicator of real income development in 1978—80, mainly due to recent changes in taxation.

It is far more difficult to make any estimates on future price development, but, as mentioned earlier, the inherent inaccuracy is reflected only marginally in the final consumption forecasts. Two main lines were followed in making the price forecasts. Firstly, the price level of food as a whole was supposed to remain rather stable. Secondly, the past trends of prices were followed in rough terms. Accordingly, the real price of eggs and fish was assumed to go further down. The price of cereals, sugar, fruits & berries and margarine was supposed to follow the general price level. Further real increases were anticipated to occur in potatoes, vegetables, dairy products, pork and particularly in beef. The price rise for beef stems from the assumption that beef will be in short supply with the declining number of cows in Finland. Further, it was assumed that because pork production is abundant, beef is not going to be imported or will be imported only temporarely.

Given the elasticities and the price developments in Table 7.1.1. and the annual growth rate in real income of 3.3. per cent, forecasts were made for 1980. As mentioned earlier, the average of 1976—78 was used as the base year. The results are presented in Table 7.2.2.

Apart from the 13 food items analyzed, Table 7.2.2. includes a total of 25 goods or groups of goods. Although the large majority of the additional food items are only of marginal importance from a nutritional point of view or in terms of agricultural production policy, they were included in order to obtain the total calorie consumption which enables us to check the consistency of the forecasts as a whole. With the exception of poultry, these forecasts were based on past trends. The starting point in forecasting the future poultry consumption was the previous estimate on its income elasticity. In 1966—68, the income elasticity of poultry was estimated to be as high as 2.00 ... 3.00 (IKÄHEIMO & ROUHIAINEN 1973, p. 272). At present and in the near future, the income elasticity is assumed to be lower, i.e. 1.50.

Overall, in terms of calorie intake, the total food consumption would be slightly above the 1976—78 level. The individual food items seem to develop in the way implied by the elasticities in Table 6.4.1. with the exception of whole milk which is supposed to remain at, or be slightly above, the level at which it was in 1976—78. This is because in applying the DLS for 1950—77, milk obtained a slightly positive income elasticity, 0.07 (see Table 7.1.1.). Usually, the making of forecasts is affected by subjective considerations. Here they were, however, ignored, because the aim was primarily to test the suitability of the DLS-method for forecasting.

The application of both the OLS- and DLS-methods in making forecasts for 1975—77, a process where an optimal ϱ-value was chosen, enables us to compare the forecasting ability of the two methods. This is done in Table 7.1.2. Without an exception, the accuracy of forecasting could be improved considerably by using the DLS-method. Only in three cases, (pork, milk and cheese) was the forecasting

Table 7.1.2. Forecasting errors for the years 1975—77 on the average when using both the OLS- and DLS-method, ϱ = the discounting factor.

	Error in kilos		Error in per cent		ϱ
	OLS	DLS	OLS	DLS	
Cereals	—4.3	0.3	—5.8	0.4	0.625
Potatoes	1.9	0.7	3.0	1.1	0.850
Sugar	9.0	—0.4	23.8	—1.1	0.725
Vegetables	—2.1	—0.2	—7.6	—0.7	0.925
Fruits & berries	—6.6	—1.3	—8.0	—1.5	0.700
Beef	1.2	0.0	5.2	0.0	0.700
Pork	—2.3	—1.7	—13.5	—6.4	0.700
Eggs	0.6	0.0	5.5	0.0	0.550
Fish	—1.3	—0.8	—8.8	—1.4	0.900
Milk & milk products	—9.9	—6.4	—3.4	—2.2	0.600
Cheese	—0.6	—0.4	—9.5	—6.3	0.500
Butter	2.3	0.2	18.1	1.6	0.675
Margarine & oils	—0.7	0.0	—7.4	0.0	0.700

error more than 2 per cent. However, it is to be borne in mind that the forecasts do not include errors made in predicting the future price and income development. So, the forecasts for 1980 are not necessarily all that good.

It is very difficult to draw any conclusions, based on the above results, about the kind of demand function and the circumstances of the DLS-method, which give the best results. That would require further study which is outside the scope of the present one. It seems, however, likely that the DLS-method takes more into account the most recent relationships of the dependent and independent variables, thus resulting in better forecasts.

The second objective set for this study was to elaborate a system enabling us to make reliable forecasts, including a mechanism by which the forecasts could be revised occasionally.

Based on the experience of this study, it seems likely that the longer-term forecasts can be revised in due course by means of the DLS-method in the following way. First, a number of DLS demand functions are estimated to find out the optimal ϱ-value giving the most accurate forecast for the two or three years ahead. These observations are retained as reference data at this stage. Second, the demand functions are re-estimated using all the available data and the ϱ-value obtained in the first stage.

After that, forecasts are made some years ahead using the parameters obtained in the second stage. The good results previously reported by the author (ROUHIAINEN 1978, p. 154—165 and ROUHIAINEN 1979, p. 349—359) support the idea of using the DLS-method in short-term forecasting.

7.2. Forecasts for 1985 and 1990

The consumption forecasts for 1985 and 1990 were made using the traditional method of forecasting by means of demand elasticities.

The elasticities of Table 6.4.1. were, as such, considered to be unsuitable for forecasting because, as analysed earlier in this study, the demand elasticities, income elasticities in particular, change over time.

For that reason, it was felt necessary to have elasticities which would be valid in the 1980's. One opportunity for forecasting the elasticities would be to follow their trends in Figure 6.4.1. This procedure was, however, considered too formal and rigid. Thus, subjective deliberation was used to some extent while at the same time taking the trends of the elasticities into account. The principle of a gradually stabilized diet was followed. This implies that the income elasticities diminish over time.

As to the income elasticities, the largest deviations from the trend (Figure 6.4.1.) were registered for pork, milk & milk products and cheese. This is because it was thought that the income elasticities of these food items do not only have an income effect but also include trend factors which in turn consist of such things as new products, better quality or a particular item finding entirely new consumers (See Section 2.2.). No major changes were assumed to occur in the price elasticities. As mentioned before, they are of minor importance from the standpoint of forecasting accuracy. The demand elasticities used in making forecasts for 1985 and 1990 are given in Table 7.2.1.

The 1985 and 1990 forecasts were made by using three alternative rates of real pnnual income growth; 1.0, 2.5 and 4.0 per cent. Given the present economic arospects, the forecasts with 2.5 per cent income growth are considered the most likely ones. The same real income growth for 1978—82 has been estimated by the Research Institute of the Finnish Economy (ANON. 1978a, p. 34). The forecasts with 1.0 and 4.0 per cent annual income growth were introduced in order to determine the composition of the Finnish diet in conditions of relatively low and high economic growth. At the moment, the 4.0 per cent growth rate seems rather unrealistic.

The price changes were assumed to be the same as in the 1980 forecasts (Table 7.1.1.).

The forecasts for 1985 and 1990 are presented in Table 7.2.2. The food items with a high starch content (cereals, potatoes and sugar) show a general declining trend, potatoes a sharp one and sugar only a slight one. The decreased consumption of these items is going to be substituted for by protein food items, notably by pork, but also to some extent by beef, eggs, fish and cheese. With only a slight downward trend, milk seems to maintain its prominent position as one of the main food items in the Finnish diet. It is also worth noting that although the consumption of butter goes down and that of margarine up, the total fat consumption remains unchanged, i.e. at the level of 21 kg/year/capita. Food consumption as a whole in terms of total calorie intake also seems to remain almost unchanged with the exception of the forecasts with 4.0 per cent real income growth for 1990. But as mentioned earlier, that forecast is unrealistic.

Table 7.2.1. Elasticities used in making forecasts for 1985 and 1990.

	Cereals	Potatoes	Sugar	Vegetables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk prod.	Cheese	Butter	Margarine & oils
Cereals	—0.10		—0.90										
Potatoes		0.00											
Sugar			—0.05		0.40								
Vegetables				0.00	0.50								
Fruits & berries			—0.60	0.70	—0.50								
Beef						—0.30	0.30						
Pork		0.80				0.80	—0.90						
Eggs								—0.10					
Fish									0.00				
Milk & milk products						0.20				0.00			
Cheese											0.00		
Butter	—0.35											—0.20	
Margarine & oils.													—0.10
Income	—0.30	—0.95	—0.20	0.80	0.70	0.40	0.85	0.20	0.30	—0.20	1.40	—0.85	0.60

Table 7.2.2. Forecasted consumption kg/year/capita. As to the methods used, see the corresponding text.

	1976—78	1980	1985			1990		
Growth in real income per cent/year		3.3	1.0	2.5	4.0	1.0	2.5	4.0
Cereals	73.5	69.5	70.8	68.5	66.3	69.0	65.0	61.5
Potatoes, fresh	55.4	51.0	53.0	48.0	43.8	51.5	43.0	36.5
» , flour	4.5	4.7	4.7	4.7	4.5	4.7	4.7	4.5
Sugar	37.8	37.5	37.2	36.2	35.6	36.8	35.5	34.2
Syrup	1.8	2.1	2.0	2.0	1.9	2.0	2.0	1.9
Honey	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cocoa	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Pulses & nuts	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Vegetables	25.2	27.6	26.9	30.0	33.3	28.0	33.0	38.3
Fruits & berries	82.2	96.5	88.9	97.0	107.0	93.0	107.0	122.6
Beef & veal	22.5	23.9	22.8	24.0	25.0	23.0	24.5	26.8
Pork	27.2	31.1	30.0	33.5	37.5	31.5	37.4	44.0
Poultry	2.5	2.8	2.8	3.3	3.4	3.0	3.5	4.5
Mutton	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Other meat	2.0	2.2	2.0	2.0	2.0	2.0	2.0	2.0
Edible offals	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.3
Eggs	11.2	11.7	11.4	11.7	12.0	11.6	12.0	12.5
Fish	14.9	15.7	15.3	15.8	16.4	15.5	16.5	17.4
Whole milk	197.3	198.6	197.0	190.0	185.5	196.8	185.0	178.0
Skimmed milk	79.5	75.0	74.0	70.0	68.0	73.0	68.0	66.0
Cream	5.7	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Dried milk	2.8	2.6	2.6	2.6	2.5	2.6	2.6	2.4
Cheese	6.4	7.8	7.2	8.7	10.8	7.7	10.9	13.5
Butter	12.3	11.1	11.4	10.5	9.5	10.9	9.5	8.0
Margarine & other fats	9.4	10.2	9.9	10.5	11.5	10.2	11.5	12.8
Total cal./day	2 853	2 885	2 854	2 857	2 897	2 854	2 871	2 958
Total kJ/day	11.95	12.08	11.95	11.96	12.13	11.95	12.02	12.38

Some differences are observed in comparing the above results with the forecasts for 1985 made by KETTUNEN (1976, p. 389), which are generally based on previous studies and past trends assuming a real annual income growth of 4.0 per cent. It seems that most of the differences between the two forecasts are due to different assumptions on the real income growth, because the 4.0 per cent forecasts of both studies coincide fairly well.

7.3. Some reservations and implications

A number of reservations are to be made about the forecasts discussed above.

First, the consumption figures are not to be interpeted as point forecasts, i.e. a forecast does not necessarily indicate the level of consumption in that particular year but rather a two- or three-year average. This applies more to the forecasts for 1985 and 1990 than to the 1980 forecast.

The future growth rate of real income is of crucial importance. In particular, it affects the ratio of consumed meat to cereals & potatoes. In the event of a different real income development, the forecasts have to be revised accordingly.

In general, retail prices have only a minor influence on demand. However, if the price rises of especially beef and pork deviate from the assumptions made before, some revision is needed in the respective consumption forecasts.

Supply factors add an element of uncertainty to the forecasts. In particular, that goes for fruits, vegetables, poultry meat, other meat (the number of elks shot) and, to some extent, for beef. Foreign trade policy has similar effects, too.

The possible introduction of new products or product development may violate the forecasts. Thus, the mixture of butter and margarine introduced in 1979 may disturb the forecasts on butter and margarine. For the moment, it is, however, premature to make any assessments of how the consumption of the two items is affected.

Although outside the scope of this study, some implications of the results are finally outlined in a very general way.

With the exception of fruits & berries, beef, pork and butter, the price elasticities turned out to be very low, which gives scope for price setting at the retail level. In other words, price changes have very little or no impact at all on the quantities demanded. Some institutional developments such as increasing availability of messing facilities where different meals are served at a uniform price and the growing amount of prepared meals sold nowadays contribute to this development.

The results provide outlines as to how agricultural production should look like in 1990. Assuming a 100 per cent self-sufficiency level, a real annual income growth of 2.5 per cent and a total population of 4.9 mill. (ANON, 1975, p. 10) in 1990, we may conclude that beef production ought to be 13—14 per cent and pork production 18—19 per cent higher compared with 1978 (in the case of 1.0 per cent real income growth, (the figures would be 6—7 and 0 per cent respectively). On the other hand, considerable reductions are needed in the other animal products if the 100 per cent self-sufficiency level is to be reached by 1990, i.e. 23 (26) per cent in eggs, 26 (43) per cent in cheese and 36 (26) per cent in butter. Because of recent crop failures, it is impossible to make a similar comparison about cereals. We may only conclude that the demand for cereals is decreasing at an annual rate of 0.6 per cent (0.2 per cent).

It is very difficult to draw any precise conclusions about the area of land and other production capacity needed in 1990. This is because, apart from consumption, factors affecting production e.g. intensity of fertilizing, technical and biological development, should be taken into account. In general, one may conclude that in the case of favorable real income growth, more food is eaten in the form of animal products, which requires more arable land and other inputs in agriculture and increased utilization of energy in the processing industry, although food consumption in calorie terms remains unchanged. By the same token, in the case of low real income growth, more food is eaten in the form of plant products, and less energy is required. A further study is, however, needed to carry out all these calculations.

8. SUMMARY AND CONCLUSIONS

The purpose of this study was to estimate demand elasticities for agricultural products, to detect their changes, to elaborate a system of making consumption forecasts and updating them. Another target was to work out short- and longer-term consumption forecasts.

Since the late 1960's, the production target of Finnish agricultural policy has, in practice, been self-sufficiency or production quantities slightly exceeding this. If this policy is followed in the future, which seems likely, the future consumption trends have to be known. By virtue of reliable consumption forecasts, we are also able to establish good grounds for developing the farm structure. The future consumption of food commodities is of major importance to the processing industry, as well. Another reason for undertaking this study was the lack of recent studies where all the food items would have been analysed simultaneously. In addition, longer-term consumption forecasts for food items in Finland are unavailable or they are out-of-date.

A striking feature of the Finnish diet is a high per-capita consumption of dairy products. The consumption level of cereals and potatoes is also higher than the average level in European countries. On the other hand, the use of vegetables and fruits is lower. The consumption trends in Finland are presented in Table 2.2.1.

The development of the relative prices of the main food items in Finland between 1950—77 is depicted in Figure 2.3.1. In general, the real retail prices have developed smoothly, with some exceptions.

The estimation of demand elasticities was based on the traditional theory of rational behavior of consumers. Annual data from the time period 1950—77 was analysed. A total of 13 food items or groups of similar food items and the total calorie intake were studied. The dependent variables were expressed on a per-capita basis. The corresponding retail prices or price indicis and the index of salary and wage earners' earnings were used as the independent variables. All the independent variables were deflated by the consumer price index 1967 = '100'. To eliminate shifts in the consumption level of potatoes and margarine, a dummy variable was applied. A logarithmic functional form was used for its better fit over the linear one and for its ease of estimation and interpretation.

The demand functions were first estimated for the entire study period using the method of ordinary least squares (OLS) as the estimation method. The subperiods of 1950—63 and 1964—77 were also estimated as a first approach to the detection of possible changes in the parameters of the demand functions (Tables 5.2.1., 5.2.2. and 5.2.3.).

The homogeneity condition (see Section 3.2.) was taken into account in the next step in estimating the demand elasticity matrix. In this case, the method of restricted least squares (RLS) was applied (Tables 5.2.4., 5.2.5. and 5.2.6.). By virtue of the F-test, the hypothesis of the homogeneity condition had to be rejected in the case of some food items.

The elasticity matrices for the three time periods were then formed on the basis of the results of the OLS- and RLS-functions and of the relationships between two cross-elasticities (Tables 5.2.7., 5.2.8. and 5.2.9.).

Dynamic demand functions were also estimated to detect the adjustment process through which consumers move from one equilibrium to another when the price of a commodity changes. The results are presented in Tables 5.3.1., 5.3.2. and 5.3.3.

The demand functions for food as a whole were estimated by using the food price index, the non-food price index and the income index as independent variables (see Table 5.4.1.).

The stability over time of the parameters of the demand functions was checked using the tests recently developed by Brown et.al. It was assumed that consumer preferences, reflected in the parameters of demand functions, are subject to changes over time. These changes might stem from shifts in the socioeconomic structure of the population, changes in the goods studied, product development or the introduction of entirely new products. Since one of the objectives of this study was to make forecasts, the examination of the parameter changes was considered to be of great importance. When used as formal tests, the tests by Brown et. al. suggested the rejection of the hypothesis of constancy of the parameters in the case of five items. But considering the fact that in several cases, the tests were just about to give a positive result and that the tests can also be used as an informal yardstick, it is likely that at least minor parameter changes have occurred in the other food items, too.

Given the parameter changes over time, it was felt necessary to update the demand elasticities before making any forecasts. The updating was performed by means of the discounted least squares (DLS), which gives more weight to recent data than to data from the distant past. At this stage, only the most important independent variables were included in the demand functions. Through the application of different discounting factors, it was possible to express the demand elasticities as a function of time, the most recent of them stemming from the fourth quarter of 1975 (Figure 6.4.1.). An updated elasticity matrix (Table 6.4.1.) was then constructed relying primarily on the results of the DLS-estimates but, with regard to some food items, also taking into account the elasticities obtained by the OLS- and RLS-methods.

Nowadays, food consumption in Finland is determined mainly by consumer income. With the exception of some products, prices have only marginal importance. One possible explanation is the marginal proportion of total expenditure in these products. It seems that when the expenditure share becomes less than one per cent, the food item in question becomes insensitive to price changes. Similarly, only very few cross-price elasticities are relevant in determining the quantities demanded. The elasticities are presented in Table 6.4.1.

Since the price elasticities, with the exception of fruits & berries, beef, pork and butter, are low or zero, there seems to be scope for price setting at the retail level, with this having very little or no impact at all on the quantities demanded.

The relatively high income elasticities of fruits & berries, pork and cheese do not include only the income effect but they are also likely to imply the trend factors which are associated with such things as new products, better quality and an increased number of new consumers of these products.

As expected, the dynamic demand functions revealed that consumers adjust to new price rations within one year.

The demand for food as a whole turned out to be inelastic with respect to income. The price elasticity and the cross-elasticity with respect to non-food items are also likely to be very low.

Two different types of forecasts were made; short-term forecasts for 1980 and longer-term forecasts for 1985 and 1990. An annual growth rate of 3.3 per cent for real income was assumed up to 1980 and 2.5 up to 1985 and 1990. Two alternative forecasts, with an annual income growth of 1.0 and 4.0 per cent were also made for 1985 and 1990. The real prices were supposed to develop in accordance with their past trends, with the exception of beef which was anticipated to become relatively more expensive (for the annual price changes, see Table 7.1.1.). The average of 1976—78 was used as the base year from which the forecasts were made.

The method of DLS was used when forecasting for 1980. First, the optimum discounting factors were chosen which produced the most accurate forecasts for 1975—77 on the average. They were selected through the method of trial and error in estimating numerous functions for 1950—74. Then, the same demand functions were re-estimated using the 1950—77 data and the discounting factors obtained. After that, forecasts were made by applying the parameters of these functions. The forecasts for 1980 are presented in Table 7.2.2.

The consumption forecasts for 1985 and 1990 were made by using the traditional method of forecasting with demand elasticities. It was felt that the present elasticities (Table 6.4.1.) are unsuitable for forecasting a longer time ahead. Therefore the elasticities, likely to be valid in the 1980's, were first calculated by following closely their past trends, with some exceptions. These elasticities are presented in Table 7.2.1. Based on these elasticities and on the assumption above, consumption forecasts were made for 1985 and 1990 (Table 7.2.2.).

A number of reservations are to be made about the forecasts. These refer more to the forecasts for 1985 and 1990 than to the 1980 forecast. The reservations involve, first of all, an income and price development different from the one outlined before, introduction of new products and unexpected changes in the supply of some products. Accordingly, the 1985 and 1990 forecasts are to be interpreted within a certain margin of error.

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Appendix 1. Consumption of various food items, kg/year/capita.

	Cereals	Potatoes	Sugar	Vege-tables	Fruits & berries	Beef	Pork	Eggs	Fish	Milk & milk products	Cheese	Butter	Margarine & oils	Total calories
1950	122.5	107.1	31.2	17.8	16.5	12.1	12.6	5.1	12.3	318.9	1.5	13.9	4.7	2 989
51	121.7	105.0	32.6	17.7	18.0	13.1	12.6	6.1	10.9	341.5	2.1	14.6	5.2	3 018
52	120.9	103.0	33.8	17.0	20.5	13.5	12.2	6.9	9.7	342.2	2.7	14.9	5.4	3 063
53	120.1	100.9	35.3	19.2	21.0	13.3	12 3	7.3	10.6	342.5	2.8	15.3	5.7	3 088
54	120.1	94.9	35.6	21.5	28.0	13.6	13.6	7.7	11.6	345.3	2.7	15.6	6.4	3 139
55	119.0	97.1	37.1	19.1	32.2	14.8	14.5	7.5	11.2	349.3	3.1	15.2	7.2	3 175
56	117.7	94.8	38.7	18.0	30.6	15.9	14.1	7.4	11.3	333.0	3.3	14.2	8.5	3 178
57	116.6	93.0	40.2	19.1	30.6	15.0	14.7	7.1	11.2	307.5	2.7	13.0	9.4	3 127
58	115.0	92.1	40.7	20.3	30.9	14.6	15.0	6.6	11.2	333.2	2.5	13.4	8.8	3 104
59	113.7	86.4	40.3	21.4	32.2	16.3	13.8	6.0	11.0	320.4	2.3	14.7	8.1	3 107
1960	111.7	93.3	39.8	18.3	35.8	15.4	13.4	7.9	10.9	320.3	2.7	15.5	7.8	3 103
61	110.5	102.8	39.4	15.1	38.9	17.6	13.9	7.9	11.3	324.0	3.2	17.2	6.3	3 129
62	105.3	101.8	40.3	15.3	40.7	18.1	15.2	8.0	10.3	330.9	3.3	18.7	5.1	3 110
63	99.7	101.5	40.1	15.3	39.8	19.4	14.5	8.7	10.4	328.7	3.4	18.6	5.4	3 075
64	94.4	101.1	38.9	14.9	39.3	21.4	14.4	9.0	11.2	324.7	3.4	18.0	5.6	3 009
65	89.9	100.4	40.9	14.7	39.4	20.4	14.6	9.1	10.6	317.9	3.5	17.7	5.7	2 985
66	88.3	98.8	42.1	15.0	38.8	20.1	15.6	9.2	11.5	318.6	3.5	17.4	6.3	2 998
67	84.7	91.8	40.4	17.0	39.9	19.5	16.8	8.9	11.3	308.1	3.5	17.0	6.5	2 931
68	82.3	85.3	39.8	18.6	41.3	19.0	16.9	8.9	12.0	292.2	3.7	16.4	8.9	2 881
69	81.4	83.8	41.1	18.9	44.6	20.8	18.0	9.4	13.0	290.8	4.1	15.6	7.0	2 908
1970	79.7	80.4	42.8	20.3	46.8	20.4	20.3	9.8	12.6	275.3	4.3	14.7	8.0	2 888
71	78.0	79.4	43.7	22.1	51.2	20.5	22.0	10.4	11.5	275.8	4.8	14.9	8.8	2 959
72	77.1	77.5	45.5	22.5	53.6	21.9	23.1	10.8	13.3	280.2	5.5	14.6	8.4	2 954
73	76.3	70.2	45.3	24.1	56.0	22.3	24.6	10.7	15.1	281.4	5.2	13.7	9.0	2 971
74	77.3	69.8	41.8	24.4	72.7	22.3	24.5	10.7	14.7	288.4	5.6	12.9	9.3	2 943
75	77.0	70.8	38.5	24.8	79.3	24.2	26.7	10.9	14.6	292.8	6.1	13.3	9.6	2 919
76	73.7	55.4	38.0	25.6	86.3	23.6	25.9	11.0	15.6	289.9	6.7	12.7	9.4	2 869
77	71.8	55.4	37.4	25.6	81.8	22.0	27.4	10.9	14.2	284.8	6.2	12.2	9.2	2 825

Source: Food Balance Sheets conducted by the Agricultural Economics Research Institute, Helsinki

Appendix 2. Retail prices, price indices and income index used.

	Price index of cereals&bread¹)	Potatoes price Fmk/kg²)	Sugar price Fmk/kg²)	Price index of vegetables¹)	Price index of fruits&berries¹)	Beef price Fmk/kg³)	Pork price Fmk/kg³)	Eggs price Fmk/kg²)	Fish price Fmk/kg²)	Liquid milk price Fmk/kg²)	Cheese price Fmk/kg²)	Butter price Fmk/kg²)	Margarine price Fmk/kg²)	Food price index⁴)	Non-food price index⁴)	Consumer price index 1967 = '100'⁵)	Index of salary and wage earners' earnings⁶)
1950	76.9	0.12	0.69	80.9	97.5	1.97	2.03	1.88	0.60	0.21	2.54	3.60	1.20	44	43	43	33
51	89.8	0.15	0.70	94.1	120.8	2.18	2.57	2.05	0.75	0.23	2.19	3.37	1.05	47	52	51	44
52	102.6	0.16	0.70	95.8	112.3	2.16	2.92	2.58	0.82	0.25	3.07	4.42	1.00	50	53	52	46
53	102.1	0.15	0.70	96.3	120.6	2.38	3.02	2.44	0.82	0.25	3.06	4.39	1.22	51	54	53	46
54	100.0	0.17	0.84	100.0	100.0	2.50	2.42	2.19	0.85	0.25	3.01	4.05	1.98	50	54	53	48
55	97.2	0.19	0.76	128.4	108.6	2.53	2.94	2.30	0.91	0.22	3.08	3.46	1.99	48	52	51	51
56	100.6	0.22	1.02	103.2	110.9	2.67	3.09	2.49	1.12	0.30	3.83	4.15	2.24	55	58	57	58
57	112.2	0.17	1.47	94.9	112.5	2.95	3.25	2.59	1.25	0.34	4.03	5.18	2.79	62	65	64	61
58	136.1	0.19	1.34	107.1	117.1	3.06	3.10	2.71	1.28	0.37	4.62	4.76	3.16	66	69	68	64
59	147.6	0.20	1.34	102.5	120.8	2.72	3.27	2.80	1.13	0.40	4.73	4.51	3.16	67	70	69	67
1960	155.1	0.22	1.34	105.1	101.4	3.06	3.76	3.03	1.20	0.41	4.81	4.64	3.16	69	72	71	71
61	161.3	0.18	1.34	101.2	103.6	3.36	3.63	2.95	1.21	0.41	4.81	4.64	3.16	71	72	72	76
62	170.1	0.29	1.34	133.9	103.1	3.28	3.77	2.81	1.16	0.43	4.83	4.64	3.16	74	75	75	81
63	175.5	0.26	1.44	123.9	111.3	3.39	4.12	3.06	1.32	0.47	5.19	4.90	3.16	77	80	79	88
64	203.7	0.29	2.01	129.3	114.4	3.42	4.42	3.31	1.46	0.54	5.99	5.59	3.50	87	87	87	100
65	216.5	0.32	1.65	147.4	125.7	4.04	4.85	3.46	1.45	0.57	6.30	6.08	3.68	92	91	91	109
66	223.1	0.31	1.49	146.3	131.0	4.80	5.12	3.57	1.67	0.58	6.32	6.17	3.69	95	95	95	117
67	233.8	0.41	1.43	155.3	138.3	5.28	5.13	3.75	1.49	0.61	6.61	6.86	4.00	100	100	100	127
68	247.1	0.39	1.52	203.9	150.9	5.96	5.44	3.76	1.45	0.69	7.46	8.30	4.20	111	109	109	141
69	254.1	0.38	1.56	190.2	157.0	6.35	5.95	4.05	1.63	0.70	7.77	8.44	4.20	115	111	112	151
1970	254.4	0.38	1.56	178.6	154.3	7.09	6.24	4.01	1.71	0.70	7.77	8.56	4.20	116	115	115	164
71	270.5	0.38	1.66	173.2	155.2	7.75	6.54	4.05	1.67	0.75	7.94	7.96	4.20	121	122	122	185
72	287.8	0.45	2.04	240.1	169.8	8.90	7.16	4.40	1.79	0.82	8.60	8.40	4.32	133	130	131	206
73	313.1	0.70	2.25	227.1	190.3	10.47	7.91	4.80	1.99	0.90	9.62	9.30	4.64	149	145	146	238
74	375.6	0.75	2.60	328.7	223.1	11.07	8.87	5.50	2.45	1.19	11.71	11.18	5.60	173	171	172	285
75	474.9	0.95	4.24	495.6	288.5	13.38	11.11	6.60	2.60	1.31	13.49	12.36	6.24	209	200	202	347
76	543.4	1.13	4.58	535.5	331.6	14.18	12.28	7.23	3.06	1.55	16.75	16.20	8.16	243	227	231	399
77	628.9	1.16	4.49	599.9	368.1	17.00	13.53	7.47	3.24	1.78	19.62	19.06	9.96	288	251	260	433

¹) Source: MARJOMAA (1969), supplementary data up to 1977 were obtained from the Central Statistical Office.
²) Source: Bulletin of Statistics 1950—78, Central Statistical Office of Finland.
³) Source: Data from Ministry of Social Affairs and Central Statistical Office.
⁴) Source: Consumer price index 1967 = '100'.
⁵) Source: Bulletin of Statistics 1968—78, Central Statistical Office of Finland. The figures prior to 1967 have been calculated according to the changes of the corresponding indicis 1951 = '100' and 1938/39 = '100'.
⁶) Source: ANON. 1972, p. 6 and ANON. 1978b, p. 115—119.

Appendix 3. Correlation matrix of independent variables 1950—77.

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}
x_1	1.0															
x_2	0.462	1.0														
x_3	0.117	0.009	1.0													
x_4	-0.058	0.558	-0.087	1.0												
x_5	0.848	-0.434	-0.183	0.276	1.0											
x_6	0.380	0.645	-0.270	0.334	0.520	1.0										
x_7	0.164	0.339	-0.307	0.262	-0.087	0.338	1.0									
x_8	-0.658	-0.652	-0.063	-0.187	0.751	-0.796	-0.033	1.0								
x_9	-0.447	-0.520	0.356	-0.409	0.323	-0.677	-0.125	0.677	1.0							
x_{10}	0.839	0.538	0.232	-0.096	-0.902	0.570	0.060	-0.842	-0.467	1.0						
x_{11}	0.690	0.394	0.383	-0.077	-0.713	0.350	-0.072	-0.503	-0.094	0.779	1.0					
x_{12}	-0.518	-0.325	-0.309	0.136	0.580	-0.161	-0.051	0.410	0.058	-0.437	-0.200	1.0				
x_{13}	0.355	0.011	0.554	-0.325	-0.512	-0.063	-0.343	-0.204	0.382	0.386	0.651	-0.369	1.0			
x_{14}	0.666	0.564	0.123	0.255	0.593	0.643	0.101	-0.769	-0.661	0.786	0.693	-0.050	0.153	1.0		
x_{15}	-0.706	-0.609	-0.077	-0.273	0.651	-0.705	-0.105	0.857	0.712	-0.795	-0.595	0.216	-0.133	-0.954	1.0	
x_{16}	0.714	0.751	-0.012	0.222	0.788	0.867	0.350	-0.914	0.627	0.847	0.590	-0.430	0.143	0.735	-0.808	1.0

Appendix 4. Correlation matrix of independent variables 1950—63.

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}
x_1	1.0															
x_2	0.048	1.0														
x_3	0.258	—0.167	1.0													
x_4	—0.440	0.570	0.678	1.0												
x_5	—0.806	—0.078	0.694	0.627	1.0											
x_6	—0.383	0.165	—0.011	0.462	0.148	1.0										
x_7	—0.400	0.348	—0.438	0.388	0.211	0.128	1.0									
x_8	—0.360	0.011	—0.608	0.444	0.635	0.114	0.607	1.0								
x_9	—0.091	0.141	0.612	—0.199	—0.289	0.341	0.125	—0.091	1.0							
x_{10}	0.706	—0.091	0.755	—0.821	—0.878	—0.420	—0.296	—0.575	0.255	1.0						
x_{11}	0.541	0.081	0.681	—0.447	—0.670	—0.002	—0.059	—0.134	0.542	0.730	1.0					
x_{12}	—0.657	—0.291	—0.326	0.238	0.668	0.190	0.122	0.685	—0.097	—0.524	—0.213	1.0				
x_{13}	0.432	0.111	0.856	—0.410	—0.750	0.195	—0.359	—0.593	0.610	0.657	0.757	—0.539	1.0			
x_{14}	0.302	—0.216	0.388	—0.362	—0.347	—0.044	—0.261	—0.100	—0.159	0.524	0.568	0.109	0.265	1.0		
x_{15}	—0.445	0.156	—0.319	0.307	0.477	—0.039	0.349	0.400	0.318	—0.483	—0.320	0.250	—0.289	—0.812	1.0	
x_{16}	0.659	0.409	0.498	—0.294	—0.812	0.008	0.177	—0.480	0.512	0.635	0.571	—0.750	0.672	—0.023	—0.150	1.0

Appendix 5. Correlation matrix of independent variables 1964—77.

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}
x_1	1.0															
x_2	0.108	1.0														
x_3	0.570	0.344	1.0													
x_4	0.364	0.689	0.410	1.0												
x_5	0.752	0.377	0.307	0.618	1.0											
x_6	—0.510	0.481	—0.357	0.423	—0.116	1.0										
x_7	—0.210	0.033	0.005	0.058	—0.051	0.474	1.0									
x_8	0.094	—0.620	—0.034	—0.700	—0.087	—0.776	—0.122	1.0								
x_9	0.150	—0.580	0.085	—0.679	—0.170	—0.777	—0.081	0.849	1.0							
x_{10}	0.210	0.633	0.312	0.796	0.284	0.333	—0.214	—0.747	—0.533	1.0						
x_{11}	0.593	0.351	0.365	0.579	0.592	—0.082	—0.318	—0.459	—0.274	0.670	1.0					
x_{12}	0.121	—0.161	—0.442	0.079	0.403	—0.038	—0.397	—0.078	—0.179	0.063	0.517	1.0				
x_{13}	0.588	—0.462	0.014	—0.357	0.298	—0.809	—0.556	0.560	0.561	—0.277	0.339	0.490	1.0			
x_{14}	0.446	0.567	0.277	0.765	0.587	0.362	0.001	—0.733	—0.624	0.657	0.831	0.350	—0.044	1.0		
x_{15}	—0.357	—0.582	—0.264	—0.737	—0.442	—0.448	—0.056	0.800	0.626	—0.714	—0.775	—0.218	0.155	—0.963	1.0	
x_{16}	—0.275	0.683	0.035	0.663	0.017	0.893	0.405	—0.901	—0.815	0.623	0.176	—0.156	—0.819	0.525	—0.626	1.0