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The regional forecasting of food demand

L. Juréen and H. Wold (Sweden)

Summary

A research project is briefly reported in which international comparisons of food consumption are made with a view to show the effect of rising income and changing prices. Vegetable and animal foods are aggregated in a few large groups, as is convenient in regard of the multiformity of foodstuffs and the climatic influences on food production. It is shown that aggregate demand follows a regular and stable pattern, where retail food prices and consumers' income explain most of the demand variations. The results are in agreement with earlier findings concerning demand variations within countries (U.S., Sweden). The investigation covers U.S. and 16 European countries and is based on statistical data compiled by the Food and Agriculture Organization.

With regard to possible trends in the future we conclude: (1) An improvement of food standards in Western Europe does not call for an appreciable increase in calorie supply. (2) At rising income in the future a considerable quality improvement of food standards is expected, consisting in a higher consumption of animal products and of other expensive items such as fruits and vegetables, and in a reduced consumption of cereals and potatoes. Accordingly, if the per capita demand for food is expressed in constant prices there will be a substantial increase in demand. (3) At rising income a qualitative improvement of food standards is expected even if the inter-food price relations returned towards the pre-war ones; such a tendency has, in fact, appeared in recent times. A still stronger improvement would follow if the general food price level became lower than at present.

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* General distribution of this document is limited to the introductory summary. Participants who have been invited to take part in the meeting referred to above will receive also the full text of the paper. Other participants in the Conference will receive the full text upon request.

Pour la traduction française voir au verso.

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Les prévisions régionales de besoins alimentaires

L. Juréen et H. Wold (Suède)

Résumé

L'auteur a fait un exposé succinct d'un rapport préliminaire portant sur des comparaisons internationales de la consommation alimentaire, et destiné à montrer les effets de l'augmentation des revenus et de l'évolution des prix. Etant donné la multiplicité des denrées alimentaires et les influences climatériques sur leur production, les produits alimentaires d'origine végétale et d'origine animale ont été groupés pour plus de clarté sous quelques rubriques générales. Ce rapport montre que la demande globale suit un cours stable et régulier et que ses variations sont pour la plupart expliquées par les prix de détail des denrées alimentaires et par le revenu des consommateurs. Les résultats confirment ceux d'enquêtes antérieures sur les variations de la demande dans certains pays (Etats-Unis, Suède). L'enquête a porté sur les Etats-Unis et 16 pays européens, et s'est fondée sur des données statistiques réunies par l'Organisation des Nations Unies pour l'alimentation et l'agriculture.

En ce qui concerne les tendances éventuelles futures, l'auteur conclut que : 1) une amélioration des niveaux de consommation alimentaire en Europe occidentale n'exige pas une augmentation appréciable de la quantité de calories. 2) l'on peut s'attendre à ce qu'à une future augmentation des revenus corresponde une importante amélioration de la qualité de la consommation alimentaire, qui comprendra une plus forte proportion de produits d'origine animale et d'autres denrées chères telles que les fruits et les légumes, et une moindre proportion de céréales et de pommes de terre. De même la demande alimentaire exprimée à prix constants, augmentera sensiblement; 3) si le revenu augmente, on peut s'attendre à une amélioration qualitative de la consommation alimentaire, même si les rapports entre les prix des denrées alimentaires redeviennent ce qu'ils étaient avant la guerre; en fait, on a vu cette tendance apparaître récemment. Il y aurait une amélioration encore plus grande si le niveau général des prix des denrées alimentaires était moins élevé qu'à présent.

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* Seule la présente analyse d'introduction fait l'objet d'une distribution générale. Les participants qui ont été invités à assister à la séance mentionnée ci-dessus recevront en outre le texte intégral du document. Les autres participants au Congrès recevront le texte intégral sur leur demande.

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The regional forecasting of food demand.

By L.Juréen and H.Wold /Sweden/.

Introductory.

1. The statistical data and their analysis. In order to show in general outline the effect of rising income and changing prices on food consumption it is convenient to aggregate all food items in two or three large groups. As is natural from the agricultural standpoint, our study aggregates animal foods into one group, excepting nonagricultural products such as fish and marine oils. Then the remaining group becomes rather heterogenous, including not only dominating cheap products such as cereals and potatoes, but also the somewhat more expensive subgroups, sugar and vegetable oils and fats and, furthermore, fish, fruits and vegetables, which are luxuries if attention is paid to the calorie content only. Therefore, the subgroups of cereals and of fruits and vegetables are treated separately, and some attention is also paid to the consumption of other important items.

The data employed in earlier demand studies are of two main types, viz. /a/ family budget data, and /b/ market statistics. Family budget data allow us to study demand as a function of the income level and of various social factors, such as family size and social stratum /Refs. 1, 7, 8, 10, 11/. Market statistics in the form of time series are used to study demand as a function of the price of the commodity considered and of other influencing factors, primarily the income level and the prices of competing commodities /Refs. 5, 6, 7, 8, 10, 11/. Income elasticities can accordingly be estimated from both sources of data, which is fortunate

for checking purposes and also because the elasticities obtained from budget data can be used as ancillary information in the analysis of market statistics /Refs. 7, 8, 10, 11/. To judge from Swedish findings the demand pattern is determined primarily by the income level and the prices, whereas differences between social strata seem to be of secondary importance /Ref. 11, Ch. 16°4/. Regularities of this simple kind are in the present report explored by multi-country comparisons, with promising results. The demand pattern seems to be determined in its broad features by the income level and the prices, with only minor deviations to be accounted for by special national habits.

The report is mainly based upon results recently obtained by L.Juréen in a research project at the Economic Commission for Europe, United Nations, Geneva. The approach in Part I is illustrated in Chart 1, where national averages of food consumption are plotted against income averages, an inter-country scatter diagram of the type wellknown from the work of Colin Clark /Ref. 2/. The resulting relations are interpreted as long-term trends in food consumption at rising income level /Table 1/. The conclusions find independent support in data from different social strata in Sweden /Table 2/ and in time-series data from U.S. and Sweden /Table 3/. In Part II the inter-country comparisons are made with a view to study demand in its dependence on prices /Table 4/. The method employed in this approach is somewhat related to certain investigations of regional market statistics /see e.g. Ref. 3, 9/. Earlier results of demand studies in U.K. and Sweden are employed partly as ancillary information, partly as independent checks upon the findings. - Some conclusions are summed up at the end of the paper.

All of the statistical experiments here reported involve the fitting of a hypothetical demand relation to the observational data. The fitting has always been performed by the method of least squares, whether the relation is linear or non-linear or involves one or more explanatory variables /cf Ref. 11, Ch. 2/.

Demand elasticities are defined with a negative sign for price and cross

elasticities, in line with Marshall's original definition /Ref. 4/, while income elasticities are defined with a positive sign /cf Ref. 11, Ch. 5·1/.

2. Limitations of results and methods. The actual food consumption in the countries considered has in broad outline been explained by a very simple demand pattern, and although some countries show deviations that are not negligible, it is the regularity that dominates the picture. The interest of the results lies in their simplicity. It is not claimed, however, that the pattern is universal. The climatic and cultural status of the countries considered is far from uniform, it is true, but it can hardly be expected that the simple pattern arrived at will cover the demand habits in tropical and/or underdeveloped countries. Further data and further research are here called for.

Food being a basic need, it is perhaps only natural that its demand pattern should be simple and rather universal. For luxuries, on the other hand, where individual tastes and the unpredictable dictates of fashion come more to the foreground, it may be argued a priori that the demand is less regular. Similarly, the sector of durable commodities is less inviting for the simple approach here adopted.

I. LONG-TERM TRENDS IN FOOD CONSUMPTION AT RISING INCOME LEVEL.

1. Chart 1 shows pre-war calorie intake per capita per day as plotted against average real income per head of population. The calories are aggregated in two groups, agricultural animal products and residual items, or briefly "animal" and "vegetable" foods. The Chart covers 16 European countries and U.S., i.e. all countries for which statistical data have been available. Demand curves of Toernqvist's type /Ref. 11, Ch. 5·5/ are fitted to the data for total calorie intake and animal products; the difference between the two curves is taken to represent the demand function for vegetable products. The demand function q(r) and the income elasticities E(r) obtained are

$$
(1)\quad \begin{cases}
\text{Animal foods:} & q_a(r) = \dfrac{1690\ r}{r + 134}\ ; & E_a(r) = \dfrac{134}{r + 134} \\
\text{All other food items:} & q_v(r) = q_t(r) - q_a(r)\ ; & E_v(r) = \dfrac{E_t(r) \cdot q_t(r) - E_a(r) \cdot q_a(r)}{q_t(r) - q_a(r)} \\
\text{Total calorie intake:} & q_t(r) = \dfrac{3308\ r}{r + 13}\ ; & E_t(r) = \dfrac{13}{r + 13}
\end{cases}
$$

where r is real income and a,v,t refer to the three aggregates.

Despite differences between countries in climatic conditions, in traditional consumption habits, and in price relations, and despite rather big errors in the data used, Chart 1 brings out a clear relationship between food consumption and real income. Some of the discrepancies between the demand curves and the original data are large, but to a great extent they can be explained. For instance, the climatic conditions go some way to explain a/ the low calorie intake in the Mediterranean region, b/ the relatively high consumption of vegetable oils and fats in the same region, and c/ the very high consumption of animal foods in Ireland and Denmark. The latter countries, moreover, are traditional exporters of animal products which means that prices show a tendency to be relatively low and, accordingly, consumption rather high. In this qualitative manner differences can be explained country by country.

The pre-war pattern of Chart 1 repeats itself after the war. This is shown in Charts 2 A-B, which refer to cereals and to animal foods. In spite of all what has happened during the last 15 years, and although price changes have not been taken into account, the fitted curves remain almost the same.

In view of the regularity and stability of the curves in Charts 1-2 it is natural to ask whether the curves may be interpreted as genuine demand functions, and in particular whether they give information on /a/ differences in food consumption by classes of population, and /b/ the long-term consumption development

Table 1. PRE-WAR AND POST-WAR INCOME ELASTICITIES AT VARYING INCOME LEVEL. FAO DATA.

Income level per head in U.S. dollars		Income elasticities for aggregated food items											
		Animal foods			All other food items		of which: cereals			Total food in calories			Total food in constant prices		
Pre-war	post-war	Pre-war	post-war, alternative I	post-war, alternative II	Pre-war	post-war, alternative I	Pre-war	post-war, alternative I	post-war, alternative II	Pre-war	post-war, alternative I	post-war, alternative II	Pre-war	post-war, alternative I	post-war, alternative II
25	80	(.84)	(.82)	(.87)	(.27)	(.31)	(.38)	(.15)	(.21)	(.27)	(.34)	(.38)	(.44)	(.50)	(.55)	(.59)
35	110	(.79)	.76	.83	.18	.22	.28	(.03)	.08	.15	(.27)	.31	.36	.47	.49	.54
50	160	.73	.69	.77	.09	.12	.18	-.10	-.05	.01	.20	.24	.28	.42	.44	.49
75	240	.64	.60	.68	.01	.04	.07	-.23	-.18	-.14	.15	.17	.21	.37	.38	.43
100	320	.57	.53	.62	-.04	-.01	.01	-.31	-.25	-.23	.11	.14	.16	.34	.34	.39
125	400	.52	.47	.57	-.07	-.04	-.03	-.37	-.29	-.29	.09	.11	.14	.31	.31	.36
150	480	.47	.43	.52	-.08	-.06	-.06	-.40	-.32	-.34	.08	.09	.12	.29	.28	.34
200	640	.40	.36	.45	-.10	-.08	-.09	-.45	-.34	-.39	.06	.07	.09	.25	.24	.30
250	800	.35	.31	.39	-.11	-.08	-.11	-.47	-.35	-.42	.05	.06	.07	.22	.21	.26
300	960	.31	.27	.35	-.12	-.09	-.12	-.48	-.35	-.44	.04	.05	.06	.20	.18	.24
400	1 280	(.25)	.22	.29	(-.11)	-.08	-.12	(-.49)	-.33	-.45	(.03)	.04	.05	(.17)	.15	.20
600	1 920	(.18)	(.16)	(.22)	(-.10)	(-.07)	(-.12)	(-.46)	(-.29)	(-.43)	(.02)	(.03)	(.03)	(.12)	(.11)	(.15)

Note. - Framed elasticity values refer to the average income level for Europe as a whole. Elasticities referring to income levels outside the interval covered by consumption data are put in brackets. In general, pre-war data refer to 1934-38; post-war data refer to 1949/50 - 1950/51.

inside one country. This question requires careful consideration before the curves are used as indicators, since the price changes and other disturbing effects that have been disregarded in Charts 1-2 may have caused a systematic influence on the slope of the curves. We shall explore this question by comparing the curves with the findings of ordinary demand analysis in the fields /a/ and /b/. Reference is made to Table 1, where income elasticities at varying income level are given for the curves in Charts 1-2.

2. The statistical mapping in the two fields just mentioned is very fragmentary, but some findings can be quoted from Sweden and U.S. Beginning with the consumption by classes of population, Table 2 shows income elasticities for animal food in Sweden compared with results obtained from Chart 1. /See Ref. 11, Ch. 16·5./

Table 2. INCOME ELASTICITIES FOR ANIMAL FOOD. SWEDISH DATA, 1933.

Social class	Sweden: real income, kr. per family of 3.3 consumption units	Corresponding income level in Chart 1	Income elasticities		
			In Sweden		Obtained from Chart 1
			Actual estimates	Smoothed values	
Farm and forestry workers	1 087	93	0.73	0.62	0.59
Small farmers	1 245	107	0.50	0.59	0.55
Industrial workers and low grade employees	2 666	227	0.39	0.41	0.37
Middle class	5 049	431	0.27	0.26	0.24

The dependence of elasticity upon income comes out clearly in the Swedish data. In classes with low incomes, such as farm workers and small farmers, the elasticity for animal food is found to be the highest. In middle-class families with relatively high incomes the consumption is least influenced by income differences, while industrial workers and low grade employees take an intermediate position. The demand

function values corresponding to the smoothed elasticity values are plotted in Chart 1. The rather good agreement between the elasticities recorded causes that the plotted values come very near the demand curve fitted to the FAO data. A similar agreement is found, for animal foods as well as for other food items, if the Swedish data are utilized for direct comparisons between the aggregate consumption in the four classes of population /Ref. 11, Ch. 16·4/.

The combined results suggest the conclusion that differences in the average consumption levels are, not only between classes of population but also between countries, primarily determined by the average income level, while differences in geographical position, consumption habits and income distribution seem to have relatively small influence on the consumption. In any case the disturbing influence on the elasticity estimates in Table 1 seems to be very small and this is of crucial importance for the practical use of the results.

Coming to the question of the consumption development in time inside countries, it is illuminating to examine the long-term trends in countries where the nutritional standards today are high, and where national income has been on the increase during a long period. We shall briefly comment upon data for U.S. and Sweden /not reproduced here; cf Ref. 11, Table 1·6·5/.

In Sweden the national income has since 1870 increased at an average rate of about 2% per capita per year. The consumption data for 1876-85 correspond roughly to the income level 70 in Chart 1. The per capita consumption of cheaper vegetable foods reached its peak already before World War I, from which time a steady decline has occurred. The consumption of animal products climbed from one-fourth of the total calorie intake in 1880 to about one-third prior to World War I, and is now approaching half the total consumption. However, the time is still far off when the animal consumption per capita has reached its maximum level. On the other hand the total per capita consumption in calories has increased only slightly since World War I. An increase in the per capita consumption of animal products is, therefore,

from now on likely to be accompanied by a corresponding decline of the same size in the consumption of cheaper products.

The higher standard of living in U.S. is reflected in the consumption trends. After 1910 the total calorie intake per capita of cereals, sugar and potatoes dropped in both countries during a period of roughly 15 years by 5 to 6%. In both countries animal consumption increased but the rate of increase was considerably lower in the U.S., viz. about 4% for the whole animal group, including vegetable oils and fats, as against 20% for Sweden. The data on the recent development in the U.S. indicate that a stagnation has occured in the consumption of meat and fish, and oils and fats.

Long-term data of the kind now discussed can be compared with the demand curves in Charts 1-2. Without going into details in this matter, it may be said that multi-country curves of the type chosen can be used as a framework in sketching what happens with food consumption in the long run in a country when average income rises. As an empirical support to this somewhat tentative conclusion it may be sufficient here to give only one more exemple. Table 3 shows elasticities, based on yearly time-series data, for Sweden in the inter-war period /Ref. 11, Tables 17·5·1, 17·6·2 and 17·7·1-2; standard errors given in brackets/ and the corresponding values obtained from the multi-country curves at the Swedish pre-war average income level. On the whole the agreement between the results is rather close.[1]

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[1] However, direct estimates which have been made of income elasticities in U.K. and U.S. agree less well /see Refs. 7, also for further references, and 8/. For considerations of space the discrepancies cannot be taken up for discussion here.

Table 3. INCOME ELASTICITIES FOR AGGREGATED FOOD ITEMS AT A HIGH PRE-WAR INCOME LEVEL.

Aggregate	Income elasticities derived from Swedish time-series		multi-country curves
	1921-39	1923-38	
Animal foods	0.36 (0.05)	0.35 (0.03)	0.37
All other food items	- 0.12 (0.08)	-0.26 (0.05)	- 0.11
of which: cereals	- 0.56 (0.09)	..	- 0.37
Total food in calories	0.07 (0.04)	..	0.05
Total food volume in constant prices	0.28 (0.02)	0.23 (0.04)	0.23

3. To judge from the tests in no. 2, the results in Charts 1-2 and Table 1 may be accepted as fairly reliable. They will now be briefly commented.

The demand for animal foods is steadily higher at higher income levels but the elasticity is much lower at the high levels than at the low ones. The possible improvement of animal consumption is still significant, the average income elasticity for Europe as a whole having a value around 0.5. In the poorer regions - say countries with an income level below the European average, i.e. countries having almost 60% of the total European population within their boundaries - the average elasticities probably range from 0.5 to 0.8, and in the other countries - roughly the north-western European region - from 0.35 to 0.5.

As to the heterogeneous group "all other food items" the aggregated demand is almost unelastic, except in the very poorest countries. The main subgroup included is cereals, and here the consumption shows, broadly speaking, three phases:

a/ rising demand in countries with very low standards of living;

b/ constant demand in countries with still rather low standards; and

c/ falling demand in countries with a medium or high standard.

As far as could be judged from inter-country comparisons southern Europe, except

Italy, is in the first phase, while Italy and the eastern European countries are in the second, and north-western Europe is in the third. The peak in cereal consumption thus is reached at a rather low income level. In Sweden it occurred in 1906-15 and in U.S. probably in the last decades of the 19th century.

In some cases the above conclusions are contrary to the actual consumption pattern in Europe in recent years, several countries showing a stagnation in animal consumption and also a stagnation or even a slight increase in the demand for cereals and other cheap products. A more detailed analysis shows, however, that the extraordinary changes in the food price relations since the pre-war period have had an influence on food demand strong enough to work against the long term trends connected with rising standards of living. The effect of price changes is dealt with in Part II.

The elasticities for total food demand in calories confirm the wellknown fact that the calorie intake is almost satiated in the rich countries while a certain increase is to be expected in the poorest countries if economic conditions were improved. - From the agricultural standpoint the estimates in the last line in Table 1 are more interesting because they indicate the probable increase of the space of the market at rising income level. In north-western Europe total food volume is now rather stable, income elasticity being 0.2 or 0.3. In the other countries the elasticity is substantially higher, perhaps 0.4 or 0.5 or even higher in the poorest regions.

It may be pointed out that the elasticity estimates referred to above are based on the assumption that the income distribution remains unchanged. If an average income rise in a country were mainly the result of a standard improvement in the lowest income groups, food demand should increase more rapidly than shown above. In countries with high average standards this tendency is small or negligible, but in poorer countries it must be taken into account. In countries with an income distribution like the Italian, for example, a standard improvement

merely in the lowest income groups means that the average elasticity of the total food volume could be up to 50% higher than in the case of unchanged income distribution.

II. THE INFLUENCE OF CHANGES IN FOOD PRICES.

1. We shall now report an attempt to use the multi-country data for investigating food demand in its dependence upon prices. Many difficulties are involved, notably the possibility of substitution between food items, which makes it necessary to take cross elasticities into account, and furthermore the data are scanty. The attempt should therefore be regarded as tentative, but it is hoped that the results may serve as an aid in order to strengthen qualitative judgments of common type. We shall first record the basic assumptions and the final results and then give a brief account of the successive steps in the analysis.

2. Assumptions. Food items are aggregated in three groups, viz. a/ animal food, b/ cereals and potatoes, and c/ fruits and vegetables. As regards the type of demand function to be chosen, we may start with the following two assumptions:

1/ The average income level remains stable, i.e. the income elasticities can be left out of the picture.

2/ Cross elasticities for total food demand with respect to prices on other items than food can be neglected.

Then the three aggregates can be analysed by the same set of three explanatory variables, viz. the average prices of the three aggregates. For total food demand the average price of all food items can be used as a single explanatory variable. Chosing demand functions with constant elasticities the variations of demand are described by the following relations:

$$(2)\quad \begin{cases} \text{Animal foods:} & q_a = k_a \times p_a^{-e(a,a)} \times p_c^{-e(a,c)} \times p_f^{-e(a,f)} \\ \text{Cereals and potatoes:} & q_c = k_c \times p_a^{-e(c,a)} \times p_c^{-e(c,c)} \times p_f^{-e(c,f)} \\ \text{Fruits and vegetables:} & q_f = k_f \times p_a^{-e(f,a)} \times p_c^{-e(f,c)} \times p_f^{-e(f,f)} \\ \text{Total food demand:} & q_t = k_t \times p_t^{-e(t,t)} \end{cases}$$

where q is a demanded quantity, p an average price, e a price- or cross-elasticity, k a constant and a, c, f, t refer to the aggregates.

3. Results. The final estimates for the elasticities are:

$e(a,a) = 0.45$; $e(c,a) = -0.40$; $e(f,a) = -0.20$; $e(f,f) = 0.80$; $e(t,t) = 0.20$ and the remaining elasticities nil. Table 4 is based on these elasticities and shows some estimates of the changes of the demand for foods when prices are reduced.

Table 4. ESTIMATED CHANGES OF DEMAND AT CERTAIN REDUCTIONS OF PRICES.

Price reduction for:	Demand for:	Price reductions, percentage		
		10	20	30
		Demand changes, percentage		
Animal foods	Animal foods	+5	+11	+17
	Cereals and potatoes	-4	- 9	-13
	Fruits and vegetables	(-2)	(- 4)	(- 7)
Fruits and vegetables	Fruits and vegetables	+9	+20	+33
Animal foods and Fruits and vegetables	Animal foods	+5	+11	+17
	Cereals and potatoes	-4	- 9	-13
	Fruits and vegetables	(+7)	(+15)	(+24)

The estimates refer to the north-western European region. For example, a 20% reduction of the prices of fruits and vegetables is expected to be followed by a 20% increase of the consumption value in this area. Total consumption being about 6.3 million tons of fruits and 10.4 million tons of vegetables, the expected increase is about 3 million tons, of which 1.7 million tons of fruits and 1.3 million tons of vegetables.

4. A first attempt at estimating the ten elasticities is made by drawing from earlier demand studies. Results of the type in question is available for U.K. /Refs. 6, 7/ and Sweden /Refs. 10, 11/. This approach gives tentative estimates for the four price elasticities and two of the cross elasticities. The original estimates require some adjustment with regard to income elasticities derived from family budget data, and in rounded figures the tentative estimates read:

e(a,a) = 0.45	e(c,c) = 0.05	e(f,f) = 0.80
e(a,c) = -0.05	e(c,a) = -0.40	e(t,t) = 0.20

5. An experiment based on national statistics from ten countries. The elasticities in no. 4 are combined empirical findings referring merely to Sweden and U.K. The next step is to investigate whether these estimates can be used for the north-western European area as a whole. Table 5 shows the data used for this purpose, namely consumption totals and price ratios for ten European countries. A complication in using these data is that the average income level varies from country to country, whereas the number of countries concerned is too small to permit income being an extra variable in the analysis. Instead, making use of the income elasticities reported in Part I, the consumption data have been adjusted in advance in order to show the probable consumption distribution at a constant income level. The adjusted values are included in Table 5.

The relationship between estimated consumption and price ratios has been analysed by means of ordinary regression techniques, using the formula:

$$q_a = k'_a \times \left(\frac{p_a}{p_c}\right)^{-e(a/c)} \times \left(\frac{p_a}{p_f}\right)^{-e(a/f)}$$

Table 5. FOOD CONSUMPTION DISTRIBUTION AND CALORIE PRICE RATIOS. FAO DATA 1950/51

Country	Actual calorie intake				Actual income level	Estimated consumption at income level = 100			Calorie price ratios		
	Animal products q_a	Cereals and potatoes q_c	Fruits and vegetables q_f	Total		Animal products	Cereals and potatoes	Fruits and vegetables	$\frac{p_a}{p_c}$	$\frac{p_f}{p_c}$	$\frac{p_f}{p_a}$
Austria	28	67	5	100	60	34	59	7	4.5	8.1	1.8
Denmark	42	53	5	100	100	42	53	5	5.0	9.2	1.8
France	32	62	6	100	70	36	56	8	7.5	10.0	1.3
Western Germany	31	64	5	100	70	35	59	6	5.9	11.7	2.0
Italy	14	79	7	100	40	21	68	11	8.1	5.1	0.6
Netherlands	33	61	6	100	70	37	55	8	5.9	9.6	1.6
Norway	38	59	3	100	90	39	58	3	5.7	16.3	2.9
Sweden	50	46	4	100	115	47	49	4	3.2	9.2	2.8
Switzerland	39	53	8	100	100	39	53	8	6.6	8.5	1.3
United Kingdom	43	52	5	100	100	43	52	5	5.7	11.2	2.0

Main sources for FAO data:

FAO balance sheets /Table 5 and Charts 1-2/.

Economic survey /Charts 1-2/.

and similar formulas for q_c and q_f. The results obtained are as follows:

$$
\begin{aligned}
q_a &= k'_a \times (p_a/p_c)^{-0.03} \times (p_a/p_f)^{-0.39} \\
q_c &= k'_c \times (p_c/p_a)^{-0.19} \times (p_c/p_f)^{0.09} \qquad (3) \\
q_f &= k'_f \times (p_f/p_a)^{-0.69} \times (p_f/p_c)^{-0.24}
\end{aligned}
$$

In practice the three prices vary in a nearly functional relationship, to the effect that the price variations can be approximately expressed in terms of the two price ratios employed. This implies that relations /3/ become comparable with /2/. Hence the following estimates are obtained from /3/:

$e(a,a) = 0.03 + 0.39 = 0.42$; $e(c,c) = 0.10$; $e(f,f) = 0.93$.

The results are in rather close agreement with the estimates in no. 4, which have been derived from quite different sets of data. These facts may possible be taken as a sign of the price elasticities found having rather reliable values though the standard errors are rather large in the two sets of estimates.

6. For the price elasticity $e(c,c)$ and the cross elasticity $e(a,c)$ the estimates in no. 4 are so small as to be negligible in practice. The final estimates for these two elasticities have therefore been taken as nil.

Finally, comparing the sum $(q_a + q_c + q_f)$ and q_t in /2/ and using the Hotelling-Juréen theorem on cross elasticities /Ref. 11, Ch. 6·3/ it is possible to obtain some information about the value of the cross elasticities in /2/ not yet estimated. Though no exact solution can be arrived at, it seems to be a safe conclusion that the elasticities $e(a,f)$, $e(c,f)$ and $e(f,c)$ are very small or nil, while $e(f,a)$ has a positive value probably around 0.2. However, the last estimate is a very crude one, and the results in Table 4 based on this value are therefore put in brackets.

CONCLUSIONS.

For the main aggregates of animal and vegetable foods, the actual consumption

in U.S. and in 16 European countries is shown to follow a rather regular pattern. Food demand is primarily determined by retail food prices and by consumers' income, and the relationships involved are largely stable both in time and space.

To summarize the development since 1934-38 in western Europe we note: /1/ At gradually rising income a substantial improvement of food standards still is the normal feature. /2/ Total calorie intake is not far from saturation level. The rising food standards consist in a higher consumption of animal products and of other expensive items such as fruits and vegetables, and in a reduced consumption of cereals and potatoes. Sugar consumption is on the increase. /3/ Since 1934-38 this long-term tendency has been concealed in most countries because food prices have increased more than other prices, and because inter-food price relations have shown extraordinary changes. Yet the long-term tendency is apparent in countries with rapidly growing income per head. /4/ In north-western Europe the average price elasticity of the demand for animal foods is about 0.4 or 0.5, while demand is practically independent of changes in cereal prices.

With regard to possible trends in the future we conclude: /1/ An improvement of food standards in western Europe does not call for an appreciable increase in calorie supply; i.e. total calorie supply has not to rise much more than needed to keep pace with the population growth. /2/ At rising income in the future a shift from cheaper to more expensive foods is expected, giving rise to a considerable quality improvement of food standards. Accordingly, if the per capita demand for food is expressed in constant prices there will be a substantial increase in demand. /3/ At rising income a qualitative improvement of food standards is expected even if the inter-food price relations remain unchanged. The improvement would be strengthened if price relations returned towards the pre-war ones; such a tendency has, in fact, appeared in recent times. A still stronger improvement would follow if the general food price level became lower than at present.

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List of notations in Charts 1 and 2 A-B.

1. Country list for Charts 1 and 2:

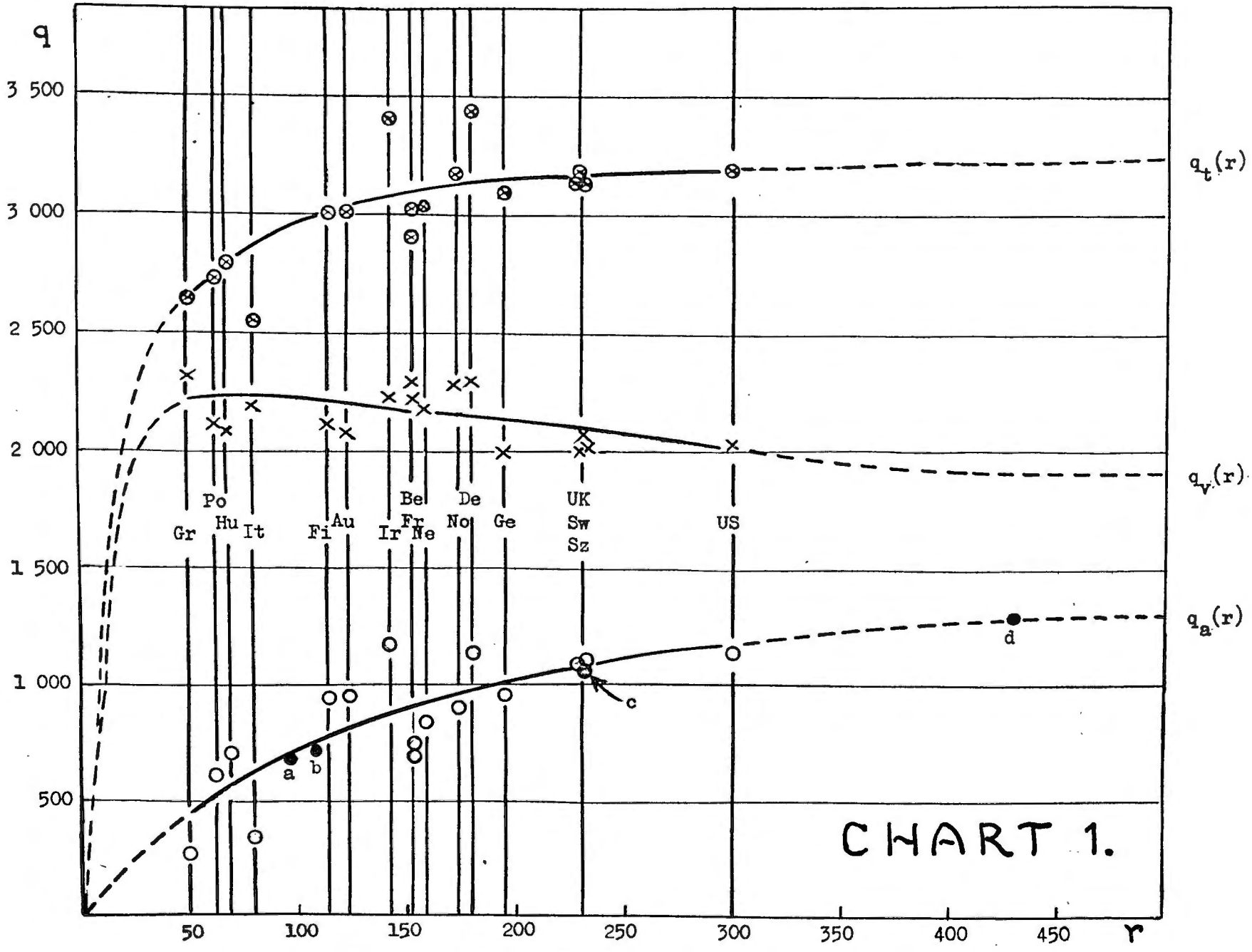
Gr = Greece	Ir = Ireland	Ge = Germany
Po = Poland	Be = Belgium	UK = United Kingdom
Hu = Hungary	Fr = France	Sw = Sweden
It = Italy	Ne = Netherlands	Sz = Switzerland
Fi = Finland	No = Norway	US = United States
Au = Austria		

2. Special notations in Chart 1:

a: Farm and forestry workers. b: Small farmers.
c: Industrial workers and low grade employees. d: Middle class.

3. Special notations in Charts 2 A-B:

q = consumption in calories per capita per day.
r = real income per head /in pre-war US dollars/.
o and - - - - - - - refer to pre-war data.
> " ———————— refer to post-war data.


q
3 500
3 000
2 500
2 000
1 500
1 000
500
50
100
150
200
250
300
350
400
450
r
$q_t(r)$
$q_v(r)$
$q_a(r)$
Gr
Po
Hu
It
Fi
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Bel
Fr
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De
No
Ge
UK
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US
a
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c
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CHART 1.

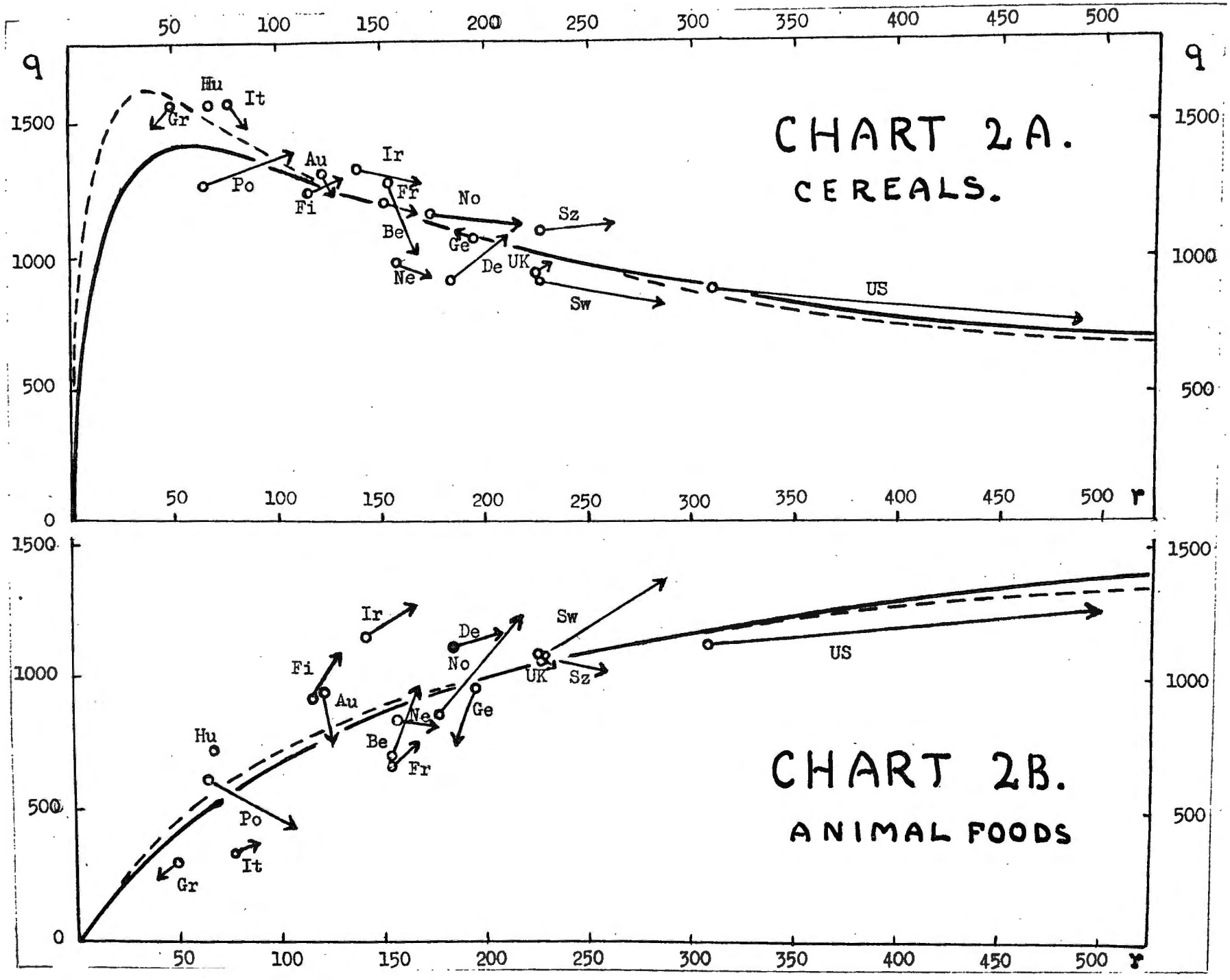
CHART 2A.
CEREALS.
q
r
50
100
150
200
250
300
350
400
450
500
1500
1000
500
0
Hu
It
Gr
Au
Ir
Po
Fi
Fr
No
Sz
Be
Ge
Ne
De
UK
Sw
US
CHART 2B.
ANIMAL FOODS