4

The Psychic Reactions

§ 25. Contents and Subdivision of This Chapter

In this chapter some of the most important results of econometric research will be surveyed. We have already seen that the boundaries between econometrics and its older neighbors, economics and statistics, cannot be drawn clearly. We therefore start by more or less marking out the field of econometrics beforehand. Also in economics and statistics, important results have been attained during the last 10 or 20 years. We shall, however, only discuss those investigations which at the same time deal with measurement and have a quantitative-theoretical character. Purely mathematical-economic and consequently theoretical results, such as much of the work by Frisch, Hicks and Allen, and Marschak—to mention a few of the most successful workers in this field—will not be considered here. Also Chait's work, although connected with statistical facts, was originally achieved in the theoretical field, and therefore will not be considered.

Nor will many results of statistical investigations be discussed, as, for instance, the important results in the field of the evaluation of national income and wealth, the enormous progress in the computation of production, price and many other indices, or work like that of Leontief who has elaborated a flow network for production in the United States. The important work of pure business-cycle statisticians like Mitchell, Wagemann, Dupriez, and others, is also left out of account. Of course this does not mean that this work is of less importance. It is only as a result of a somewhat arbitrary limitation which is always necessary with a restricted amount of space that these authors will not be discussed.

The breakdown of this chapter, however, will not be accord-

ing to authors or schools, but according to the material to be investigated. In broad outline, the breakdown consists in first discussing the psychic, technical, and institutional reaction relations themselves, and subsequently the consequences of the combined presence of these elementary relations for the development of separate markets and for whole economies. A few conclusions concerning economic policy for separate markets and for the economy as a whole will follow.

§ 26. Psychic Reaction Relations; Engel Curves

We explained in § 11 that the structure of an economy can be described by a number of elementary relations, of which the reaction relations are the most important ones. As the most important examples of the latter, we mentioned the demand and supply relations. We shall therefore discuss now what results have been achieved in determining these relations. There are reasons for distinguishing between demand and supply relations referring to goods and services valued psychically, and demand and supply relations based on objective valuation of goods and services. As an example of the last category, we mention the demand for raw materials and labor exerted by an entrepreneur when supplying his products. Mainly technical and market data play a role here. The entrepreneur's psyche may exert some influence through his expectations, but as a first approximation it can be said that much more objective decisions are involved than is the case with the demand for consumption goods by the final consumer and the supply of labor and savings to the final producer. This distinction more or less corresponds to the division made by monetary economics in the achievement of economic aims; instead of considering working and consuming in such a way that a maximum total satisfaction is obtained, the procedure is often followed of first aiming at a maximum money income, and then with this given money income, at maximum satisfaction. The division has not been carried through completely, sometimes not even very far; the tendency, however, is present for the most part. The "psychically based" demand and supply functions should be seen as derived

from aiming at maximum satisfaction, the "institutionally based" functions—as we shall call them—from striving after a maximum money income, and in particular a maximum profit in the case of a business enterprise. We shall first concern ourselves with the psychically based reactions.

As we have already explained (§ 5 and following), the quantity demanded depends mainly on various factors, including *income*. This dependence on income has first been investigated statistically by the so-called budget studies, or investigations into family expenditures. We have data here concerning families with divergent incomes, and we can therefore investigate how the expenditures for various goods and services and the quantities bought change according to the size of this income. This relation has first been examined by the statistician Engel; its graphic representation is often called the *Engel curve,* both when the amounts spent and when the quantities bought are represented. A very great number of budget studies have been carried out during the last century, which have enormously increased the available statistical material. This has made it possible for econometric investigations into the character of this curve to develop. There are two ways in which we may determine the form of the curves theoretically. The first is to form an idea directly as to how the increase of incomes will influence the amounts spent. We can consequently distinguish (1) on the one hand, between so-called poverty goods or inferior goods (margarine, potatoes, bread) the expenditures for which in the long run decline with increasing incomes, because these goods are replaced by others; and, on the other hand, all other goods; and (2) on the one hand, between necessary goods, which are bought at every level of income and, on the other hand, luxury goods which are only bought if the income exceeds a certain amount. On the basis of the behavior of the curves, certain general types of formulas describing the Engel curves can be set up.

A good recent example of such attempts are the formulas computed by Törnqvist,* a few of which are mentioned below:

* See his book review in Ekonomisk Tidskrift 1941, p. 216, and in particular, p. 223.

Food: $u = \frac{26x}{x + 31}$ Animal food: $u = \frac{16x}{x + 37}$

Clothing: $u = \frac{21\,(x-10)}{x + 160}$ Vegetable food: $u = \frac{26x}{x + 31} - \frac{16x}{x + 37}$

Housing: $u = \frac{54\,(x-5)}{x + 290}$ Total expenditures: x

Another method of obtaining a theoretical formula for the Engel curves has been used by Bowley and Allen.* They assume that the indifference function has a certain shape and from this they find the shape of the Engel curves. The simplest hypothesis which can be made about the indifference function is that it is of the second degree because it must be represented by a curved surface. From this, however, it follows that the Engel curves are straight lines. As can be seen from Fig. 7, this in fact is the case over intervals of considerable length. From the constants describing these straight lines, Bowley and Allen derive a criterion for distinguishing between luxury goods and necessary goods. With luxury goods the line cuts off a positive part of the income (the horizontal) axis, with necessary goods it cuts off a positive part of the expenditure (the vertical) axis. The goods can also be listed in order of urgency, by taking into account the point of intersection with the vertical axis (above or below the origin) and by considering those goods as the most urgent whose point of intersection is highest.

Something can be said against this latter distinction: the height of the point of intersection, among other things, depends on the classification. It is possible, by splitting the item Food—which Bowley and Allen find in several cases would satisfy the most urgent need—to obtain two items each of which would be less urgent than the item House Rent, which comes after food. The sequence, therefore, is not unambiguous.

The straight lines, also, can only be approximations because negative expenditures are not possible (except negative savings). Nevertheless, it is important for further research work that

* "Family Expenditure," London, 1935.

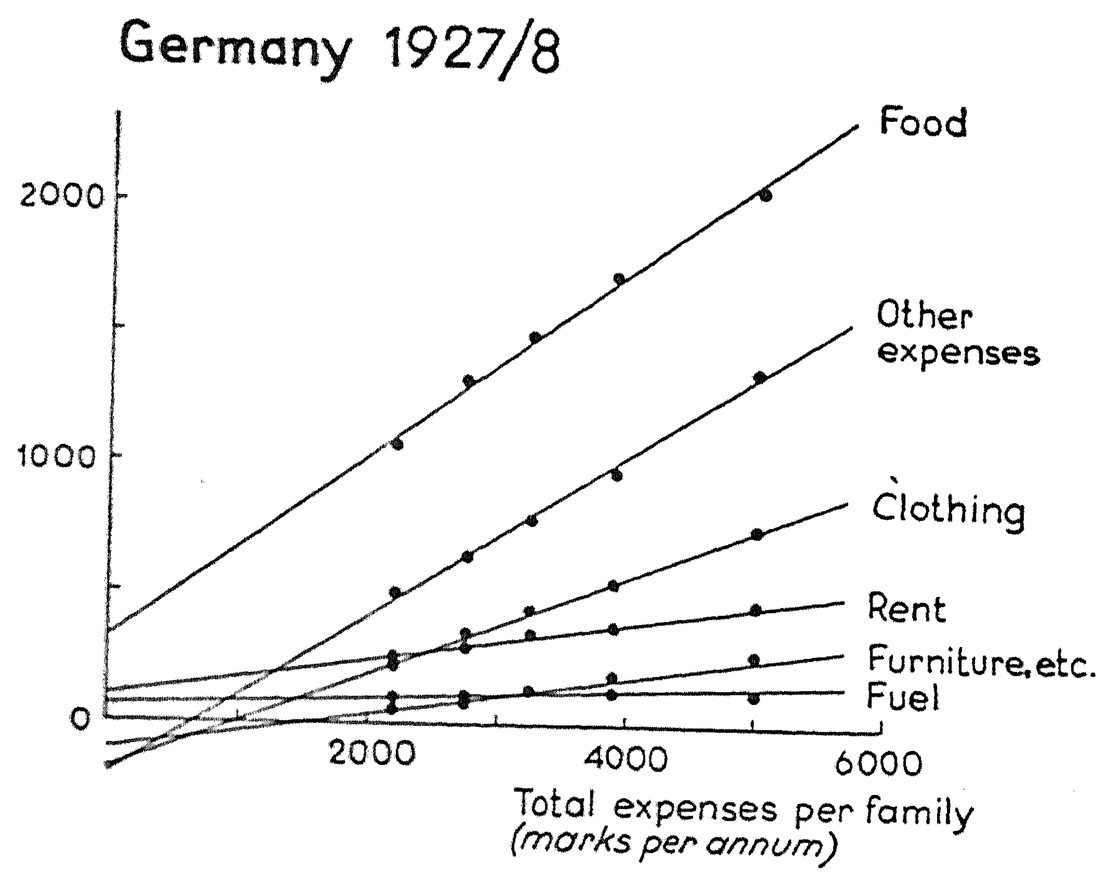

Fig. 7. Example of nearly straight Engel curves, taken from Bowley and Allen, "Family Expenditure."

linear approximation here is possible over long intervals (see § 10 and 12).

§ 27. The "Propensity to Consume" and the "Multiplier"

A special case of Engel curves is the representation of the "propensity to consume," which has been introduced so successfully by Keynes: a general consumption equation indicating how total consumption expenditures depend on the size of the income. This can be expressed in the formula: $C = f(Y)$, where C represents the consumption expenditures and Y is income. If Y undergoes a small increase ΔY, and C a small increase ΔC, then $\Delta C/\Delta Y$ is called the *marginal propensity to consume*. Because of the important influence of this reaction on the degree of activity of the national economy, an exact knowledge of the function is of great importance. Research into this subject is partly possible from family budgets. From these the individual consumption functions are found, if it may be assumed that the reaction of a family on an income change is equal to the difference existing at one moment between families with different

incomes. From these individual functions, that for the whole economy can under certain circumstances be derived. Here, however, problems are met analogous to those which we have discussed in § 10.

R. and W. M. Stone* have published the first more extensive statistical investigation in this field. When evaluating the marginal propensity to consume, they assume that all families show a proportional rise in income. From the family expenditure statistics of a few countries, they find the following values:

Marginal Propensity to Consume	
Germany 1926/7	0.73
United States 1929	0.67
" " only farmers' families	0.50
" " other families	0.67

For the Netherlands, A. L. G. M. Romboutsf has computed the following figures:

Netherlands, 1935/6	
Manual workers	0.83
Brain workers	0.82
Agricultural workers	0.79
Farmers	0.44

A second method which has been used is the *historical method.* If the Keynesian assumption is made, that consumption expenditures in fact only depend on the national income—possibly also on a trend—it is not difficult to determine, with the help of the correlation method, the regression coefficient a appearing in the equation

$$C = aY + bt + c \tag{27.1}$$

* The marginal propensity to consume and the multiplier, a statistical investigation, Review of Economic Studies VI (1938/9), p. 1.

† Statistical measurement of Keynes' concepts "propensity to consume," etc. for the Netherlands, Netherlands Business-cycle Studies XI (1940), p. 21. (In Dutch.)

where C is consumption expenditures, Y is national income, t is the time, and a, b, and c are constants. This a, again, represents the marginal propensity to consume. The Stones found:

Marginal Propensity to Consume

Germany	1925–32	0.72
"	1932–36	0.42
Gr. Britain	1929–35	0.52
Netherlands	1923–33	0.47
Poland	1928–36	0.71
Sweden	1896–1916	0.80
"	1923–30	0.60
United States	1920–35	0.75
" "	1919–35	0.70

It may be remarked here that, in general, the correlation coefficients obtained are high, so that Keynes' theory is not contrary to the facts. A few theoretical objections, however, can be raised against equation (27.1), all leading to the wish to include more variables in the equation.

The first variable which is often mentioned in this connection is some criterion for the *income distribution.* This has been stressed in particular by Staehle,* who has shown that in some cases the regression coefficient belonging to Y changes considerably if such a variable is included. The Stones mention that an income distribution criterion which they have used, namely Pareto's α, is highly correlated with Y, and therefore could not be included in the calculation without making the result very uncertain. In their coefficients, therefore, Y's influence is combined with that of α and this remains correct as long as α and Y remain correlated. As the causes of changes in α are not known, we cannot say on what conditions the continuance of the correlation between α and Y depends. From de Wolff's considerations (see § 10) it follows that it is not certain whether in equation (27.1) we can assume a term which includes α.

Another way of taking changes in income distribution into

* Retail sales and labor income, Review of Economic Statistics 20 (1938), p. 128.

account is not to include one series Y for total income as an explanatory variable, but several series, for instance labor income L and nonlabor income E. The difficulty may again be that these series are mutually highly correlated, but in several cases this is not so. In the computations where this procedure has been followed, account has been taken at the same time of the influence of the price level p. We have now arrived at the subject of *demand curves,* which will be discussed in the following sections (§ 28 to § 31).

Before doing this, we shall say a few words about the difference in propensity to consume between farm families and other families. Probably the reaction of business people in general is reflected here, which in family-budget statistics is usually only represented by farmers. Where business firms and households are separated, the household's marginal propensity to consume will be increased greatly; on the other hand, however, the surplus business income in favorable years will not be used for consumption at all. For the economy as a whole, this manifests itself in an important part of the increase in national income assuming the form of retained earnings, through which the propensity to save increases. For the Netherlands in the period from 1923 to 1933, approximately 25 per cent of the increase in national income consisted in profits retained in business. Radice* shows that for Great Britain, in the period from 1922 to 1935, 43 per cent of the increase in profits of limited liability companies assumed the form of retained earnings. The low figures found by the historical method for the marginal propensity to consume must therefore be ascribed for the most part to the phenomenon of retained earnings, and the decline compared with earlier periods must probably be ascribed to an increase in retained earnings.

Evaluations according to the new statistical method of simultaneous equations (see § 23) have been made by T. Haavelmo.† Here the consumption equation and one or two more equations,

* "Savings in Great Britain," 1922-1935, Oxford University Press, 1939.

† Methods of measuring the marginal propensity to consume, Journal of the American Statistical Association 42 (1947) p. 105.

together forming a complete system, are simultaneously tested. In the simplest case, as the best estimate of the marginal propensity to consume for the United States (1922 to 1941), 0.67 is obtained, as against 0.73 obtained by using the old method of least squares (for each equation at a time).

From the values a of the marginal propensity to consume mentioned previously, the "multiplier" M can be computed according to the well-known formula $M = \frac{1}{1-a}$. Of course, it is also possible to measure the latter directly, if we try to explain the fluctuations in national income Y from those in investments I:

$$Y = MI + Y_0$$

where Y_0 is a constant. This formula, however, is only correct for a country without relations with the outside world; if trade with foreign countries takes place, a more detailed formula will have to be chosen, for instance

$$Y = M\,(I + E) + Y_0$$

where E represents the value of exports. This has been done for Canada by Chang,* where, by the way, the terms with I and E were each taken with their own coefficients; these coefficients, as was to be expected, turned out to be nearly equal, namely 1.4 approximately.

§ 28. Demand Curves; Agricultural Products

In the theoretical analysis of demand, the emphasis has been mostly on the dependence on the price of the commodity, which is not correct in all respects. By the demand curve in the narrower sense, only this dependence on the price is meant. It has been investigated statistically only in fairly recent years, because great difficulties arose, which we partly described in § 20. The great pioneer in this field is Moore; his intellectual heir is Schultz, who in his life's work "The Theory and Measurement

* A note on exports and national income in Canada, Canadian Journal of Economics and Political Science, 13 (1947) p. 276.

of Demand"* has given us the standard work on this subject. In addition to English-speaking countries, much attention has been devoted to the statistical testing and measuring of the demand function in Scandinavia, France, and the Netherlands; and to a lesser degree in a few other countries. The historic method is most generally used; a few attempts to use the geographic method will be mentioned separately.

After the discussion of this subject in § 20 we need not be surprised that of the first attempts, nearly all referred to products of agriculture and horticulture, supplemented later by livestock products, and only in more recent times by services and industrial products. The hypotheses made about the further variables to be included in the demand relation are divergent, but with agricultural products they are in general not so relevant, because the price influence is often dominating. The extensiveness of the literature permits us to give only a rough survey of the results attained; for details we must refer to that literature. It can be said in general, that the correlations which have been attained here, are high, so that the "law of demand" for these products certainly is not contrary to the facts. In most of these demand functions only the price of the article itself plays a role; we shall deal separately with a few cases which show deviations from this rule. Instead of the price we often have to take the price divided by the general price index number. A trend nearly always is necessary, on account of the increase of the population, but an income index only rarely has to be included among the explanatory variables. When using the results it is of course desirable to become acquainted with all these particulars; and especially with the kind of price which has been used. The elasticity with respect to wholesale prices often differs considerably from that with respect to retail prices.

Many figures about *agricultural products* have been given by Schultz, for three periods in each instance; 1875 to 1895, 1895 to 1914, and 1915 to 1929, and with five different formulas.

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* The University of Chicago Press, Chicago 1938.

The median figures for the elasticity coefficients with respect to wholesale prices follow:

1. Wheat	−0.15	6. Oats	−0.58
2. Barley	−0.24	7. Potatoes	−0.62
3. Sugar	−0.29	8. Hay	−0.67
4. Cotton	−0.32	9. Maize	−0.71
5. Rye	−0.43	10. Buckwheat	−1.01

Sugar evaluations have also been made for the Netherlands by F. Weinreb.* He found an elasticity with respect to the retail price of −0.3. For the elasticity with respect to the wholesale price a lower figure would have been found.

We also mention here that Roy† puts the elasticity of the demand for wine in France at −1.

The demand elasticity for a few *horticultural products* with respect to their wholesale prices is given by G. F. Warren and F. A. Pearson.‡ They give the following figures:

Pears	−0.2	Apples	−0.6
Peaches	−0.3	Cranberries	−1.6
Bananas	−0.4	Cabbage	−1.8

A further investigation into the demand for apples in the United States has been made by W. E. Black.§

The demand for *grapes* and *tomatoes* has been investigated by J. G. W. Ignatius and H. Rijken van Olst.|| The price elasticity with respect to wholesale prices for grapes moved between 1930 and 1939 from −2 to −0.4; for tomatoes, elasticities of −0.8 and −0.9 were found, varying according to the formulas used.

The demand for *cherries* has been investigated by J. H. van

* "Statistical Determination of the Demand Curve," Haarlem 1936 (in Dutch).

† Etudes Econométriques, Paris 1935.

‡ Interrelationships of supply and price, Cornell University, Agricultural Experiment Station, Ithaca, N. Y., 1928.

§ Consumer demand for apples and oranges, Cornell University, Agric. Exp. Station, No. 800, 1943.

|| The demand for a few horticultural products, Statistical and Econometric Studies, 2 (1947) pp. 27 and 55 (in Dutch).

Stuyvenberg.* He found a price elasticity with respect to auction prices of -2 and an income elasticity of slightly more than 4, making use of time series. From family-budget statistics, however, a "long-term" income elasticity of 0.7 was found. The higher "short-term" income elasticity should probably be ascribed to the luxury character of cherries, which makes it possible to postpone demand.

Much attention has been devoted in various countries to the demand for *livestock products*. Here we have various cases of clearcut substitutability, either mutually or with other products: margarine can be substituted for butter and one sort of meat by another. Consequently, careful distinction should be made between cases where the price of the competing article is supposed to be constant (i.e., where corrections are made for changes in this price or where this price is included as a variable in the multiple-correlation calculation) and cases where it is assumed that this price has moved parallel to that of the article itself.

A first example of the difficulties in this field is the article *butter*. The year-to-year price movement of butter is nearly the same as that of margarine. It is very difficult therefore—in fact, it is only possible in cases of very high correlation between actual and calculated consumption—to separate the influences of these two prices. With Dutch data this turned out to be impossible. The difficulty can be solved, however, by considering the *seasonal fluctuations*. The margarine price does not show such fluctuations, the butter price does. In this way, the elasticity for the Netherlands has been computed at approximately -1 (in summer -0.8, in winter -1.6).† For Sweden, Wold‡ has found an elasticity with constant margarine price

* "Some Economic Aspects of Cherry Growing in the Netherlands," Haarlem 1947 (in Dutch).

† Compare the writer's article "L'élasticité de la demande des industries agricoles," Ve Congrés Intern. technique et chimique des industries agricoles, Scheveningen 1937, Comptes Rendus, p. 475.

‡ Efterfrågan på jordbruksprodukter och dess känslighet för pris-och inkomst förändringar, Statens offentliga utredningar 1940: 16, Jordbruksdepartementet, Stockholm 1940.

of — 1.4 to — 1.5, whereas the retail-price elasticity of the total demand for the two goods taken together amounts to from — 0.4 to — 0.5.

A second example of the influence of prices of other articles on the demand function is formed by the various sorts of *meat.* The evaluation of the elasticities has been solved in greatest detail by Schultz,* who has determined for the United States the influence of the prices of beef, pork, and lamb, each taken separately. The result is as follows:

	Demand Elasticity with Respect to the Price of		
	Beef	Pork	Lamb
Beef	— 0.86	0.10	0.20
Pork	0.19	— 0.70	0.00
Lamb	0.63	0.37	— 1.80

For the Netherlands only the demand for beef and pork have been studied in their mutual dependence. The following results were attained:†

	Elasticity with Respect to the Price of	
	Beef	Pork
Beef	—1.5	+1.0
Pork	0	—2.1

Wold's investigations for Sweden are somewhat different, as he finds no influence of the pork price on the demand for beef. His results are:

	Elasticity with Respect to the Price of	
	Beef	Pork
Beef and Veal	— 0.5	..
Pork	0.25	— 0.5

Between the demand elasticities of two goods with respect to each other's prices, certain relations must exist, as Hotelling

* Loc. cit., p. 638 and following.

† De Nederlandse Conjunctuur (Dutch Business-cycle Studies) May 1935, p. 15, and November 1935 (in Dutch).

and Slutsky have shown. These are tested by Schultz. The margin of error in the results often turns out to be too great to enable us to draw very exact conclusions. In any case, this problem needs further investigation.

Besides the groups mentioned above, there are a few other stock-breeding products, the results for which follow below:

Article	Country	Author(s)	Elasticity
Milk	Netherlands	Van den Briel[1] ..... Smit[2]	−0.3 to −0.4
Milk	Norway	Frisch & Haavelmo[3]	−0.4 to −1.2
Milk	Sweden	Wold[4]	−0.2 to −0.3
Cheese	Netherlands	Van den Briel[1]	−0.3 to −0.7
Cheese	England	Ruth Cohen[5]	−0.3 to −0.6
Eggs	Netherlands	Central Bureau of Statistics[6]...	−1.7
Eggs	Sweden	Wold[4]	−1.0

[1] Ve Congrés int. techn. et chim., Scheveningen 1937, C. R. vol. II p. 477. [2] Ibid. p. 498. [3] Eftersporselen efter melk i Norge, Statsok. Tidsskr. 52 (1938). [4] Loc. cit. [5] The History of Milk Prices. Oxford 1936. [6] De Ned. Conj. (Dutch Business-cycle Studies), March 1931, p. 24.

The demand for *food as a whole* has been investigated in an article referring to the United States, from 1922 to 1941, by M. A. Girshick and T. Haavelmo,* where use has been made of a system of five simultaneous equations. The variables included in this system are the food consumption per head of the population, the retail price of foodstuffs, the disposable income per head of the population (the latter two divided by the cost of living), the agricultural production of foodstuffs (per head of the population), and the prices received by the farmers (divided by the cost of living). This investigation, which is especially important as an example of the method of simultaneous equations (see § 23), results in an elasticity of −0.25 for the average values of price and quantity demanded.

Finally, the demand for all *durable goods,* all *nondurable consumer's goods,* and all *services* in the United States has been investigated by L. R. Klein for the period from 1919 to 1939.†

* Statistical analysis of the demand for food: examples of simultaneous estimation of structural relations, Econometrica 15 (1947) p. 79.

† A post-mortem on transition predictions of national product, The Journal of Political Economy 54 (1946) p. 289.

The explanatory series used for each of these categories are real national income, the relative price of the category considered with respect to the average price level, and a trend. The correlations for the first two categories were very good; for the services, however, moderate (0.73). The elasticities with respect to the group's own relative price were 2.5, 0.4, and 0.26 respectively; the marginal propensities to consume were 0.12, 0.28, and 0.26 respectively.

§ 29. Demand Curves; Services and Industrial Products

Attempts have also been made in recent years to analyze statistically the demand for other than agricultural products. The difficulties here are greater: the price changes are less frequent and smaller, whereas the goods (and services) do not possess in such a high degree the character of staple products with sharply defined qualities. The success has been greatest for a number of services and goods which are more or less monopolized. Relatively elementary methods can sometimes be made use of here. The prices or tariffs in this category usually remain unchanged for a long time, and then suddenly are brought to another level. At such a moment the other demand-determining factors as a rule do not change much; it is also possible to wait for a moment at which they again reach a level attained earlier. In other instances this is not the case and we have to resort to one of the correction methods described in § 20 or to the multiple-correlation method.

The services investigated all belong to the field of transportation. Roy* mentions that the demand elasticity for passenger transport by local railways in the vicinity of Paris amounts to -0.25, near smaller places to -0.50, and for passenger transport by railway for the whole of France to -0.40. For streetcar transportation in Marseilles, he finds -0.32.

The Netherlands Central Bureau of Statistics† evaluates the elasticity of streetcar transport with respect to tariff changes at:

* Etudes Econométriques, Paris 1935.

† The demand for transport by tram, Dutch Business-cycle Studies IX (1938) p. 12 (in Dutch).

The Hague	−0.72	Copenhagen	−0.73
Amsterdam	−0.80	Stockholm	−0.31
Rotterdam	−0.5 to −1		

The author remarks that in Dutch towns, as in Copenhagen, the competition of the bicycle is considerable, whereas the latter is much weaker in Stockholm; he thereby explains the higher elasticities in the towns mentioned earlier. Roy, in his study mentioned above, characterizes Marseilles as a town where the streetcar has no competition from a subway. For this town, as low a figure was found as for Stockholm. He could have added that also the bicycle is relatively unimportant there.

In an investigation of passenger transportation by railway* an elasticity of −0.44 was found for all passenger transportation and an elasticity of −0.7 for transportation on holiday tickets. It should be kept in mind that all these figures are valid only if all or most categories of passengers are subject to a proportional tariff change. The figure is an average of business transportation and transportation for private purposes. The latter is probably much more elastic (which also follows from the higher figure for holiday tickets) and reacts differently on certain partial tariff changes. The results cannot be applied to such tariff changes.†

Morice‡ found an elasticity of −0.60 for the demand for mail service around 1870, which gradually decreased to −0.40 in 1910 and has since remained approximately the same.

As regards the industrial products investigated, Roy§ mentions the demand elasticity for gas in Paris, which he put at −0.5. Both with gas and with electricity there is a possibility of using the method of "geographical comparison."¶ As the market for these products is usually local or provincial, and as

* J. Tinbergen and P. J. Verdoorn, The demand for passenger transport by railway, Dutch Business-cycle Studies X (1939) p. 79.

† I am indebted to Professor Goudriaan for these critical remarks.

‡ Loi de la demande d'un service monopolisé, Econometrica 6 (1938) p. 291.

§ Loc. cit.

¶ Dutch Business-cycle Studies, May 1935, p. 26; August 1937, p. 83; and November 1937, p. 127 (in Dutch).

there are rather considerable price differences between the municipalities and the country districts, an attempt can be made to determine the demand curve from such local data. This geographic method, of course, is only possible if it can be assumed that the material is homogeneous, i.e., that the other factors influencing demand are the same from place to place. This may be assumed as far as the general economic situation is concerned; it is less certain regarding the general preference and mentality; and it is very questionable whether it is true as regards the "electricity civilization." The latter may easily be developed to a greater degree in places where there have been power stations for some time or in places where intensive propaganda has been made than in places with young or small active enterprises. This lack of homogeneity is not so serious in itself, as long as it is not systematically linked with the explanatory variable, the price. It is not easy to answer this question with certainty. We therefore only mention the difficulty and we remark that it may be neglected only if the elasticity turns out to be very high.*

Of the other, still rather scarce, investigations into the demand for industrial products, we mention in particular that of Roos and Von Szelisky† concerning the demand for automobiles, which is also of importance from a methodologic point of view. The authors start from the assumption that the demand for automobiles is a derived demand, namely, derived from the demand for transportation by car. These services are rendered by all available cars, and the demand for new cars, therefore, depends on the number that the consumers wish to use. It is assumed, further, that for every income level and price level of cars, there is a certain optimal number of automobiles which the public wants to possess. This optimal number, therefore, is variable; moreover, it cannot immediately be realized, but only

* In the article "The Demand for Electricity," Dutch Business-cycle Studies, May 1935, p. 26 (in Dutch), figures are given, from which an elasticity of 1.7 can be computed.

† "The Dynamics of Automobile Demand," edited by the General Motors Corp., with contributions of S. L. Horner and others, New York 1939, pp. 21-99. As another example we mention M. J. Schut, "Tin Restriction and Tin Price," Haarlem 1940 (in Dutch).

be striven after. Here we have a nice example of a dynamic method of treatment.

The hypothetical number can be approximated by making use of a property of the logistic curve.

In this curve there is a linear relation between the percentage increase at each point with respect to the preceding one (during a given small time unit) and the actual level which has already been reached. If, therefore, that percentage increase is measured along the vertical axis (see Fig. 8) and the absolute level along the horizontal axis, we obtain points lying on one line. This is not quite the case in Fig. 8, because besides the normal growth tendency, other influences are active as well, through which the whole growth curve moves, so to speak, up and down. In depression years the points are lower than in years of prosperity. The point of intersection with the horizontal axis indicates the optimal number of automobiles, because for all points

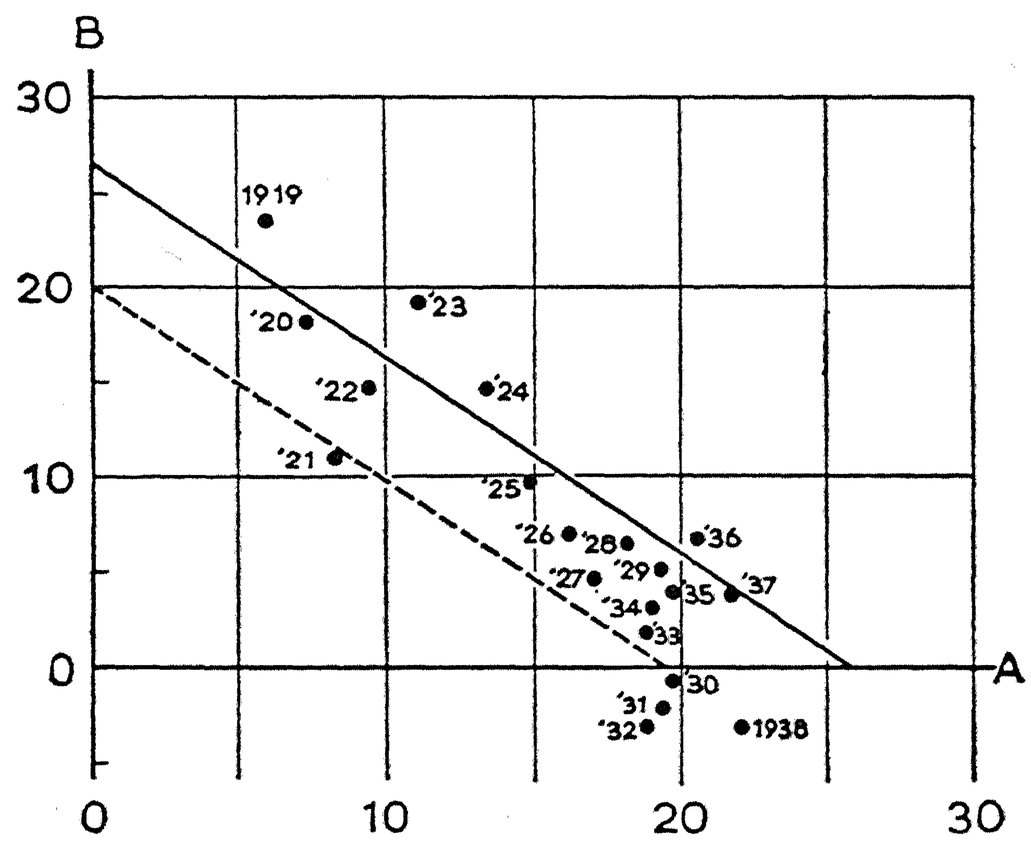

Fig. 8. Determination of the optimal number of automobiles according to Roos and Von Szelisky. Vertically: percentage increase of the number of cars in operation with respect to the preceding year; horizontally: total number of cars in operation. The optimal number can be read off as the abscissa of the point of intersection with the horizontal axis.

on the horizontal axis the vertical coördinate (the percentage rate of increase) is zero.

The authors explain the movements by the price of automobiles and by "free income." This is the part of national income remaining after a certain quantity of goods has been bought by each family for the first necessities of life.

Besides the demand for automobiles for the increase in the total number, of which we have only spoken so far, there is also a demand for the *substitution* of worn-out cars. The latter depends on the age distribution of cars actually in operation and, in a high degree, on the economic situation. Similar results were attained by de Wolff in a study which appeared earlier.*

With this product, as with a number of other industrial products, the demand elasticity cannot be determined so easily, because the price influence, in comparison to that of other factors, is relatively unimportant. Roos and Von Szelisky, therefore, came to the conclusion that it is not possible to determine whether the demand is elastic or inelastic. De Wolff, who used another price series, concluded that the demand is inelastic during a business-cycle boom, and very elastic during a depression.

An example of an industrial product permitting a rather exact determination of the demand elasticity is alcoholic spirits, for which Derksen and Van Lottum found an elasticity of – 1.4† (see Fig. 9).

§ 30. The Demand Function for All Goods Taken Together

For various problems regarding the economy as a whole—especially for problems of general economic policy—it is not so important how the demand for separate goods reacts on price changes of those goods, but how the total demand for all goods as a whole changes. We have tried here to proceed by macroeconomic investigations—in economic theory, by Keynes and

* The demand for passenger cars in the United States, Dutch Business-cycle Studies, Nov. 1936, p. 18 (in Dutch).

† Statistical analysis of the sales of beer and spirits, Dutch Business-cycle Studies 1938, p. 43 (in Dutch).

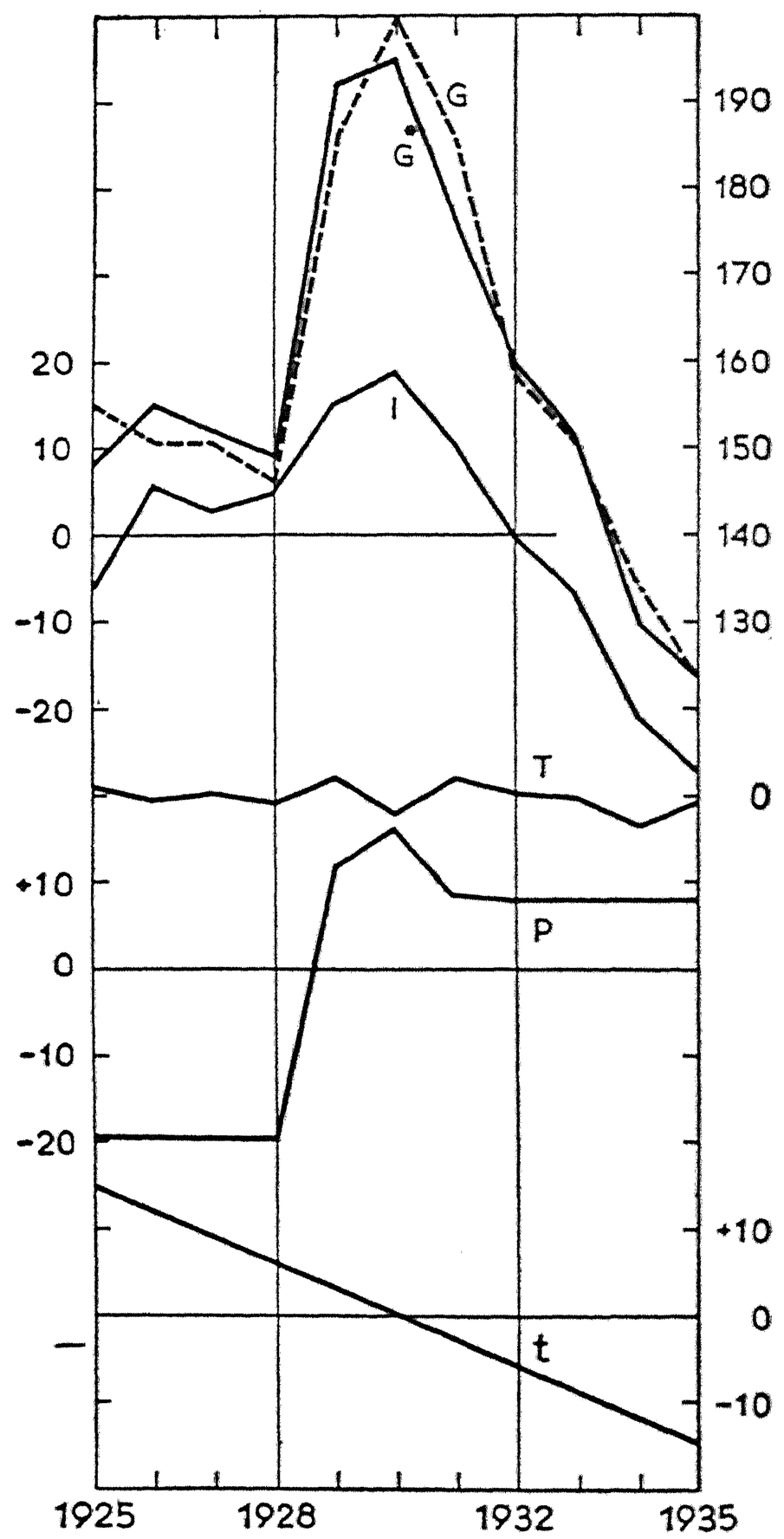

Fig. 9. Determination of the demand function for spirits, according to Derksen and Van Lottum. G: Consumption of spirits, in 10 million liters.
G*: Consumption computed as the sum total of:
I: Influence of incomes
T: Influence of the temperature
P: Influence of the price
t: Influence of gradually changing factors.

his followers; in statistical research, by the econometricians. To begin with, a distinction has been made between consumer goods and investment goods. We shall now only speak of the former; thereby at the same time continuing § 27, which dealt with determining the influence of income changes on total consumption expenditure.

In two investigations* the author has tried to explain total consumption expenditures, C, as far as the fluctuations are concerned, from some income and price series. Use has been made of more than one income series, in order to take the income distribution into account, as has already been indicated in § 27. For the United States, separate series were included in the multiple-correlation calculation for labor income (L), nonlabor income (E), and capital gains, whereas for England only the former two were considered: capital gains there were of much less importance. As a price series, the index number of the cost of living (p) was taken. The possibility of a lagged influence was taken into account only with incomes E and with p.

There were some difficulties through a number of interrelations giving rise to multicollinearity (see § 22). For the United States, L and E are strongly correlated, whereas for England, L and $E_{-\frac{1}{2}}$ show a high correlation. The influences of these variables, therefore, cannot be separated. Use had to be made of one or more of the methods described in § 23. It seemed to be the best solution to allot to series L a regression coefficient chosen beforehand, and to add this condition to the usual assumptions. On the basis of divergent budget inquiries the marginal propensity to consume for laborers' families was put at 80 per cent; the results found for England were such that an alteration of that figure did not seem advisable. For the United States, this figure was finally changed into 95 per cent, on the basis of the requirement that the marginal propensity to consume for laborers' families should be higher than for non-

* For the United States, 1919-1932, together with Dr. J. J. Polak in "Business-Cycles in the United States of America," Geneva 1939; for England 1870-1914 in: "Does consumption lag behind incomes?" Review of Economic Statistics, 1941.

laborers. With a value of 80 per cent this result could not be attained.

A number of further experiments was also undertaken, for which we must refer to the publications themselves. The most satisfactory results finally led to the following figures:

	Marginal Propensity to Consume			
	Laborers	Nonlaborers	Capital Gains	Demand Elasticity
United States 1919-'32	0.95	0.77 ± 0.32	0.28 ± 0.13	0.95 ± 0.15
England 1870-1914	0.8	0.3 ± 0.1	—	0.2 ± 0.1

The figures behind the ± sign indicate the standard deviation, according to Fisher (§ 22). As would be expected, the marginal propensity to consume for capital gains is lower than for other incomes. The elasticity of total demand for all consumption goods for the United States is nearly equal to 1. For England we find a very low figure both for this elasticity and for the marginal propensity to consume of nonlaborers. Both point to a great stability (or rigidity) in the consumption habits of the English. When we compare the figure mentioned last with the American figure, it should be borne in mind that retained earnings are included in the English E series, as a result of which the figure is somewhat biased downward—although not seriously for the period considered.

Important further studies concerning total demand for consumption goods have been made in the United States since the Second World War. These have partly become possible because more statistical material became available, going back to 1889. It was found that during the whole period since 1889, the average propensity to save has moved about 12 per cent, although the average income has greatly increased. A distinction has been made, now, between short-term influences and long-term influences exerted by income changes; besides, there are gradual and sometimes apparently sudden changes in saving habits. The short-term influence may also be called the cyclical income influence. This very probably is smaller than the long-term in-

fluence, i.e., a cyclical rise of incomes leads to a smaller increase in demand than a persistent rise.*

§ 31. Dynamic Demand Functions

The demand functions dealt with in the previous sections, in general, take little account of expectations as to the future or other facts giving rise to dynamic relations. The case of the demand for automobiles was an exception. Most consumer goods do not give rise to that sort of relation. Some of the complications which arise may be demonstrated by the results obtained for the price formation of shares. We have already explained in § 7, that the "valuation" of shares, expressed in their price, does not change proportionately with increases and decreases of the dividend percentage, but "more conservatively," i.e., the share prices are approximately half as much above or below normal as would correspond with the dividend fluctuations. We ascribe this to the expectation that the dividend will in the long run become normal again.

All this is based on the investor's viewpoint, where only the dividend expectation is important. If we consider shares which in a considerable degree serve as objects of speculation, we see in times of extremely active stock-market speculation that their prices also deviate from the level just described. It may be assumed that the expected gains in share prices play a role here. A dynamic relation may be supposed to exist; it may be assumed, namely, that the price rise in a preceding period stimulates the desire for speculation. It could be determined from a number of investigations† that this theory is not contrary to the facts. If we accept the theory, the influence of this speculative demand factor on share-price fluctuations was the greatest

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* For a survey of these recent American investigations, the reader is referred to discussions in the Review of Economics and Statistics (1946) pp. 1 and 197, and (1948) p. 45.

† J. Tinbergen, Business Cycles in the United States, 1919-1932, Geneva 1939; J. J. J. Dalmulder, The factors determining share prices, Dutch Business-cycle Studies (1939) p. 111 (in Dutch); J. Tinbergen, The dynamics of share-price formation, The Review of Econ. Stat. (1939) p. 153.

in the United States between 1926 and 1929, weaker in the United States before 1914 and in England during the same period, and practically absent in Germany. The result for the United States is in agreement with the fact that the price for a stock-exchange seat paid about 1929 was several times as high as ever before.

It has also been observed in a few other cases that the demand function is more in harmony with the facts if it is assumed that the rate of increase in prices a little earlier is also an explanatory factor.

§ 32. The Foundations of Demand Curves: Indifference Surfaces

Thus far we have considered the Engel curve and the demand curve as more or less given functions. This is also done by Cassel. It has already been pointed out that most theoretical economists do not consider these functions as the final data, but derive them from *indifference functions* or indifference surfaces. Econometricians have tried to take this step in the reverse direction and to derive the indifference functions from the data concerning the behavior of economic subjects.

A first attempt was made by Frisch.* His purpose was more limited in scope than the determination of all particulars of the indifference lines. He tried to determine the dependence between the size of income and the size of the marginal utility belonging to each income. According to the marginal utility theory, every income is spent on various goods in such a way that the utility of the last cent spent on each good, i.e., the marginal utility of the monetary unit is equal for every cent. This marginal utility is called the *marginal utility of income.* It decreases as income increases, because less urgent needs can be satisfied. The question of to what degree it decreases is of interest to taxation theorists, as it may serve as a basis for the choice of the income-tax progression. Even if marginal utility

* "New Methods of Measuring Marginal Utility," Tübingen 1931 and "Confluence Analysis by Means of Complete Regression Systems," Oslo 1934.

itself is not measurable (which is practically a *communis opinio*), it is conceivable that the relation between the marginal utility of two different incomes is measurable. This is Frisch's opinion. The simplest case he considers is the one where the existence of *independent goods* is supposed. A good is called independent of all other goods, if its marginal utility only depends on the quantity consumed of that particular commodity.

If, now, a certain person in two different situations—for instance, at different moments of time with different prices and different incomes—consumes the same amount of that commodity, the marginal utility per gram is the same. One gram, however, represents a different number of money units; a number proportionate to the price. The marginal utilities of the money unit, then, are inversely proportional to the prices of that independent commodity in the two situations.

In his first investigation, Frisch assumed that sugar is such a good. From the figures of a big Paris coöperative store he selected the months for which the total sugar consumption was equal. The total income of the group of consumers concerned he put proportionate to the total consumption expenditures. (This was an approximation, which of course has nothing to do with the principle.) For these two amounts of income the marginal utilities, therefore, were inversely proportionate to the sugar prices. In this way Frisch determined the flexibility of the marginal utility, i.e., the ratio between a small relative change of marginal utility and the relative income change. He found values of 3.5 for the lowest incomes. An income decrease of 1 per cent, therefore, leads to an increase of the marginal utility by 3.5 per cent. For higher incomes this value rapidly decreases.

Later Frisch made similar evaluations for American families, where he started from demand curves for independent goods. It would lead us too far to discuss the mathematical details; the principle does not differ from the previous one. He also tried to introduce corrections for the case where no independence exists. This was done by assuming that the prices of other goods also exert influence on the marginal utility of the

good considered, and by correcting for changes in those prices with the help of multiple-correlation calculations. For the United States he found a flexibility of approximately 1. It is possible in principle to check the results obtained for one commodity with those of another. This check was carried out for one other article; it led to satisfactory results.

Later attempts to determine the indifference functions as a whole have been undertaken by Wald.* Wald assumes that the ophelimity function or utility function in the vicinity of the point for which one wants to determine it is a function of the second degree. Depending on the number of goods considered, there is a certain number of coefficients fixing that function. For instance, if we have three commodities, x, y, and z, the quantities of which are commanded by an economic subject, the utility function is

$$W(x, y, z) = a_{00} + a_{01}x + a_{02}y + a_{03}z + a_{11}x^2 + a_{12}xy + a_{13}xz + a_{22}y^2 + a_{23}yz + a_{33}z^2$$

and this function is known, if a_{00}, a_{01}, a_{02} . . . to a_{33} inclusive are known. Wald shows that if for a number of different price situations the subject's Engel curves are known, i.e., if it is known how much he will buy at various sizes of income, a calculation is possible of the *ratios* of coefficients, except a_{00}. This, however, is sufficient for the solution of all economic problems pertaining to the subject; the absolute height of W is indifferent here, only the course of the surfaces of equal utility is important. Knowledge of the ratios of the other coefficients is sufficient to this end. The number of coefficients increases rapidly if more goods are taken into consideration. It is also necessary that the Engel curves for an increasing number of different price situations are known. The computational work is very intricate for four or more goods, but in principle it is possible.

* The approximate determination of indifference surfaces by means of Engel curves, Econometrica 8 (1940) p. 144.

5

The Technical Relations

§ 33. Cost Curves for Separate Industrial Enterprises (Microeconomic Cost Curves)

Concerning cost curves for separate enterprises, of course very much is known inside those enterprises; but these data are usually secret. The research worker outside the business firm, therefore, is handicapped. This handicap is gradually decreasing through the growing number of publications in this field. On the other hand, if the figures are available, they are often not suitable for further research in general economic problems. The structure of most industrial enterprises is intricate and there are many ways in which the available means of production may be used. A textile factory may increase its production in different ways; for instance, the number of looms in a weaving mill operated by one man or woman, may be varied; also the speed of the machines can be varied. The production costs, therefore, do not depend in an immediately discernible way on the rate of production. How costs react on demand fluctuations depends on many individual details. With macroeconomic problems, on the other hand, we are concerned with the total increase of costs of large groups of enterprises or of branches of industry in relation to the rate of production. It can easily happen that in those investigations, tendencies become apparent which, although in principle present in every enterprise separately, are nearly invisible in the latter, through the influence of individual factors outweighing the systematic ones. It is therefore possible that macroeconomic relations which have little use microeconomically are valid, and conversely. This is exactly the same in the psychic sphere.

For the two reasons mentioned, we shall deal very briefly with cost curves for individual enterprises. As regards their role in econometrics, we shall only make a few remarks.

That econometric methods can also be applied within the enterprise for the solution of cost problems becomes clear, for instance, from Dean's work.* With the help of the multiple-correlation method, this author has tried to approximate the variations in real cost by a combination of the following variables: rate of production, average size of orders, number of times the style was changed (furniture), changes of production rate, personnel turnover, and quality of raw materials.

A few very rough tendencies which have become apparent from quantitative investigations and which are of importance for econometrics are the following.

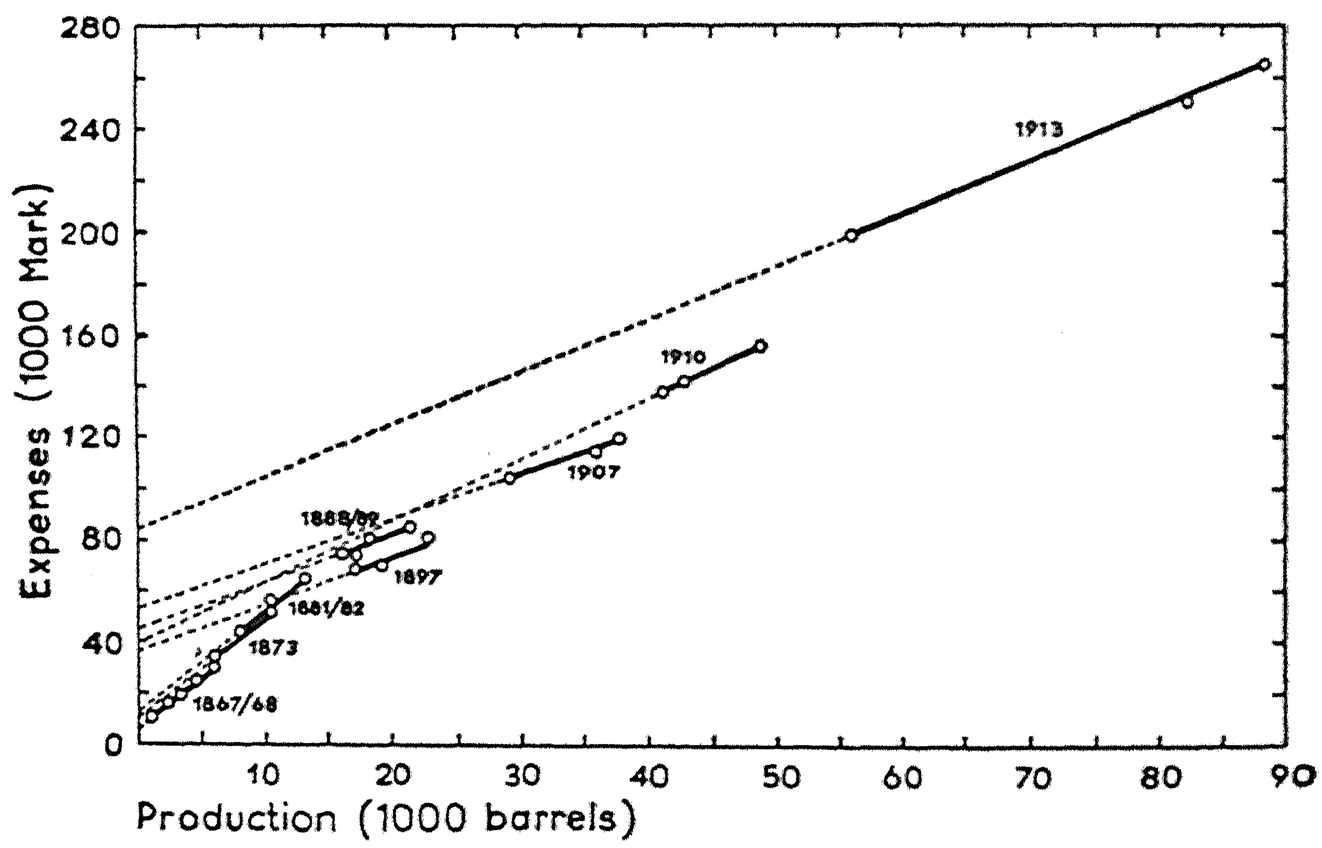

Fig. 10. Example of a number of cost curves in a cement factory, according to Ehrke (Die Überproduktion in der Zementindustrie, 1858-1913, Jena 1933) and Schneider; these curves correspond to the situation in various periods of time. It can be observed that the capacity of the enterprise has increased considerably; the importance of fixed costs (to be read off as the ordinate of the point of intersection with the vertical axis) has increased. The curves are nearly straight.

* Statistical cost curves, Journal of the American Statistical Association 32 (1937) p. 83, and his book: "Statistical Determination of Cost with Special Reference to Marginal Cost," Chicago, 1936.

It has been found in the first place, that in a number of industries the course of total costs in their dependence on the production size can, within rather wide limits, be represented by a straight line. Fig. 10 is an example. At the same time, this graph is an example of the structural changes which have taken place in the course of the last few decades. We see, for instance, an increase of fixed costs, manifesting itself in a rise of the point of intersection of the cost curve with the vertical axis, and a considerable rise in capacity.

A second point of importance is the variance in costs between the separate enterprises in one branch of industry. Very exact material about this variance is not available; but the various more or less serviceable existing data all show that the enterprises (weighted according to their production) are usually distributed over the various cost intervals according to the normal curve. The static supply curve for many branches of industry can consequently be represented by a line with high elasticity in the middle and small elasticities in the vicinity both of very low production and of the capacity limit.

§ 34. The Production Function (Macroeconomic Cost Curves)

We shall now consider what approximate relations can be assumed for great aggregations with respect to the connection between the rate of production and the required quantities of production factors. It is useful to distinguish here between *short-term* and *long-term* changes.

As regards the first, it may usually be assumed that the quantity of fixed factors of production is constant. This hypothesis of economic theory is supported by the gradual trend of such symptomatic factors as the total horse-power and the number of machines of various types and their capacity. The other factors—raw materials, energy, labor, etc.—mostly show a close correlation between the fluctuations of quantities of the factors used with the rate of production. This is in agreement with the simplest theory conceivable, namely, that the variable real costs are proportionate. This does not mean proportionality of, for instance, production and working hours, but proportionality

of their fluctuations. For great complexes it is usually found that an increase of production by 10 per cent can be brought about by a 7 or 8 per cent increase in personnel. Of course, there are differences for separate branches of industry; for production of electricity, for instance, the figure is much lower.

If we have more accurate figures at our disposal, the analysis can be refined. For the mining industry* for instance, we find that a tendency existed for an increase of labor productivity shortly after the deepest trough of the depression had passed. This does not mean that at that time the productivity was greatest, but merely that its *increase* was greatest. The phenomenon is more complicated than the automatic influence of a higher and lower level of employment; here probably more purposeful changes in methods, or in the choice of the strata exploited, are involved.

Attempts in another direction to make a further analysis of macroeconomic data can be found in a study by Stone and Tweddle.† They adapt exponential production functions to labor productivity data and in this way set up more complicated (nonlinear) cost functions. They find that marginal labor costs decrease in five cases and increase in three cases; in five or six cases, however, they are practically constant, which would be in accordance with our first approximations.

When studying *long-term* changes, we also have to consider as variable the quantity of fixed means of production. The question now comes to the fore, how great is the quantity of the product which is produced with a given quantity of labor and a given quantity of means of production. By far the most important attempt undertaken in econometrics to set up a general function for this relation (the production function), has been made by Douglas and his co-workers.‡ If the quantity of "capital"—by which Douglas sometimes means only the fixed means of production and in other investigations the whole

* The influence of the business-cycle on labour productivity, Dutch Business-cycle Studies, June 1934, p. 13 (in Dutch).

† A study of costs, Econometrica 4 (1936) p. 226.

‡ See Douglas: "The Theory of Wages," Chicago 1936 and numerous articles in American economic periodicals.

wealth of an enterprise—is denoted by K, the quantity of labor by a and the quantity of product by u, Douglas has tried to find a function

$$u = ca^{\lambda}K^{\mu} \tag{34.1}$$

which finds as close an approximation for u as possible. In this formula, c, λ, and μ are constants, so Douglas has chosen the simplest type of exponential function (see § 8). On the basis of the assumption that the optimum size of enterprises is considerably smaller than the complexes he has investigated, Douglas sometimes assumes that an increase of a and K in a given proportion, for instance $1\frac{1}{2}$, must lead to an increase of u in the same proportion. This restricts the function (34.1) in that it must be linearly homogeneous, which in this case means that $\lambda + \mu = 1$.

Douglas has tried to test relation (34.1) by historic and by geographic equations. From production statistics, he computed time series of a, K, and u for various countries (United States, Australia), as well as figures for a, K, and u relating to different industries in the same period.

His results are always such that he finds roughly $\frac{3}{4}$ for λ and $\frac{1}{4}$ for μ when taking the first regression equation. The conclusions he draws from the production function found in this way

$$u = ca^{\frac{3}{4}}K^{\frac{1}{4}} = c\sqrt[4]{a^3K} \tag{34.2}$$

are very important. In the first place, it can be deduced that the *distribution of the national product between labor and capital* will always be in the same proportion, namely $\frac{3}{4}$ for labor and $\frac{1}{4}$ for capital. Edelberg,* who has worked along similar lines, but who also takes the production factor of land into consideration, finds somewhat lower figures and also a small percentage for land. A second conclusion which can be drawn from (34.2) is that with a given stock of capital, the demand elasticity for labor is 4, i.e., that a wage decrease of 1 per cent

* An econometric model of production and distribution, Econometrica 4 (1936) p. 210.

will increase employment by 4 per cent. This is a long-term reaction, i.e., after complete adaptation of the production method to the new wage level. The great importance of function (34.2) therefore, is clear.

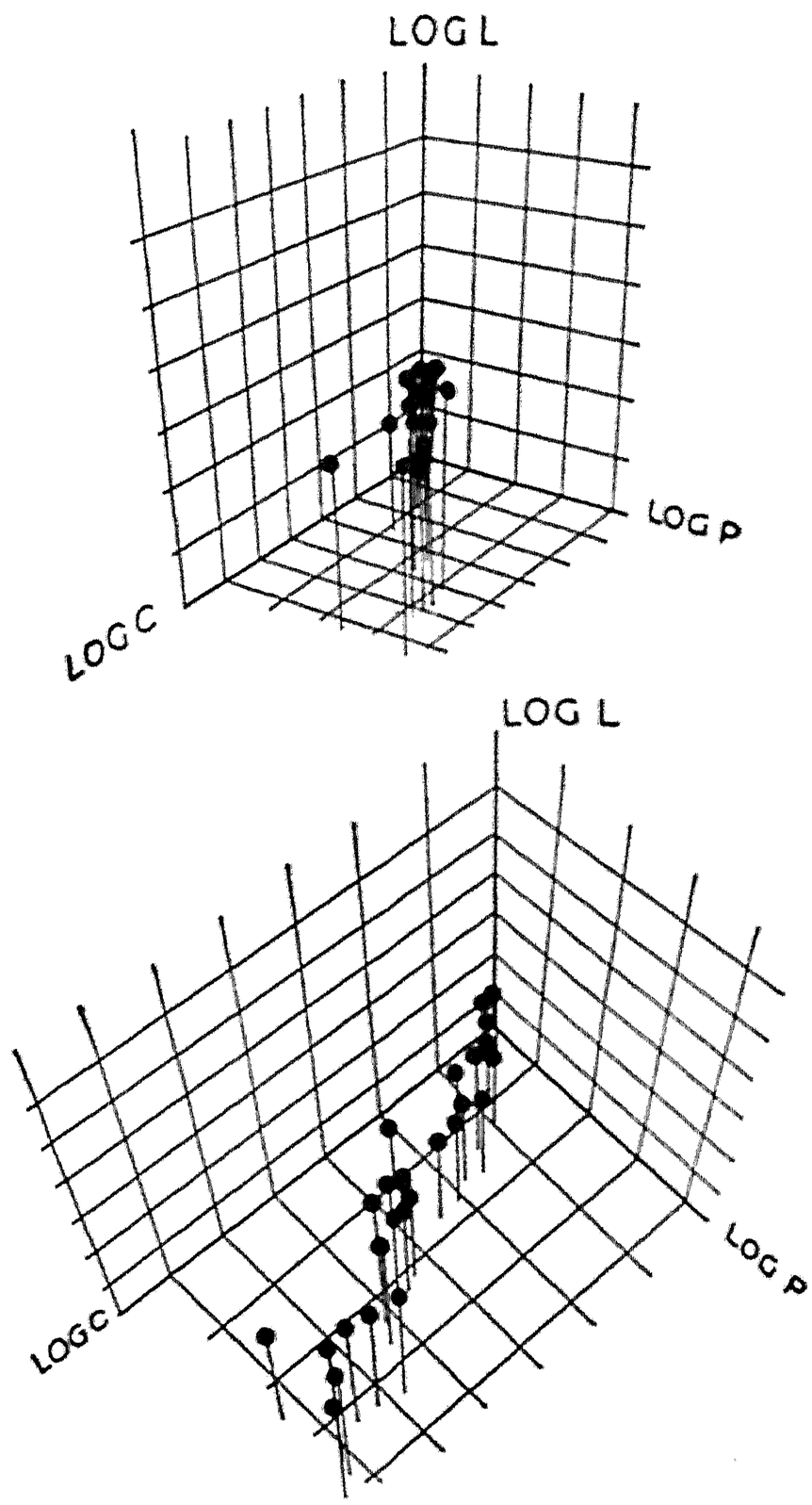

Fig. 11. Spatial representation according to Mendershausen of Douglas's statistical material for determining the production function. P: product; L: labor; C: capital. The points are nearly on one line, which makes the determination of the regression surface very difficult.

Douglas's results, however, are subject to serious criticism. As regards the historical method, Mendershausen* has pointed out that Douglas's material is to a high degree multicollinear. This also becomes clear if the other regression equations are computed. Mendershausen demonstrates this by Fig. 11, giving a spatial representation of the situation of the points. They turn out to lie practically on one line. The regression plane

$$\log u' = \lambda \log a + \mu \log K$$

(in Douglas's notation: $\log P = \lambda \log L + \mu \log C$), therefore, is to a high degree indefinite. Mendershausen concludes that, strictly speaking, Douglas's λ is nothing other than the ratio $\frac{\alpha - \gamma}{\beta - \gamma}$, where α is the yearly percentage increase of production, β of the quantity of labor, and γ of the quantity of capital.

Douglas's result, however, would again be perfectly acceptable, if it may be assumed on *a priori* economic grounds that $\lambda = 1 - \mu$. The problem is then reduced to one of simple correlation. There are, however, a number of other criticisms one may make.†

With respect to the geographic investigations, one should also be skeptical, as I have indicated elsewhere.‡ These investigations, which are of the greatest importance for macroeconomic problems, show clearly that there are serious dangers in applying the method of multiple correlation uncritically.

§ 35. Technical Development

If we want to describe the phenomenon of technical development we can make use of exponential and logistic trend lines (see § 16). The development of certain forms of technique, for instance—the length of the railway system, of the telephone

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* On the significance of Professor Douglas' production function, Econometrica 6 (1938) p. 143.

† See D. H. van Dongen Torman: "The Cobb-Douglas Production Function," Rotterdam 1950 (in Dutch).

‡ Professor Douglas's production function, Revue de l'Institut International de Statistique, 1942: ½.

system, the number of automobiles, of radio sets, etc.—nearly takes place along a logistic curve. The growth of production in general and of labor productivity can very well be approximated by exponential curves, or by straight lines, if a logarithmic scale is used.

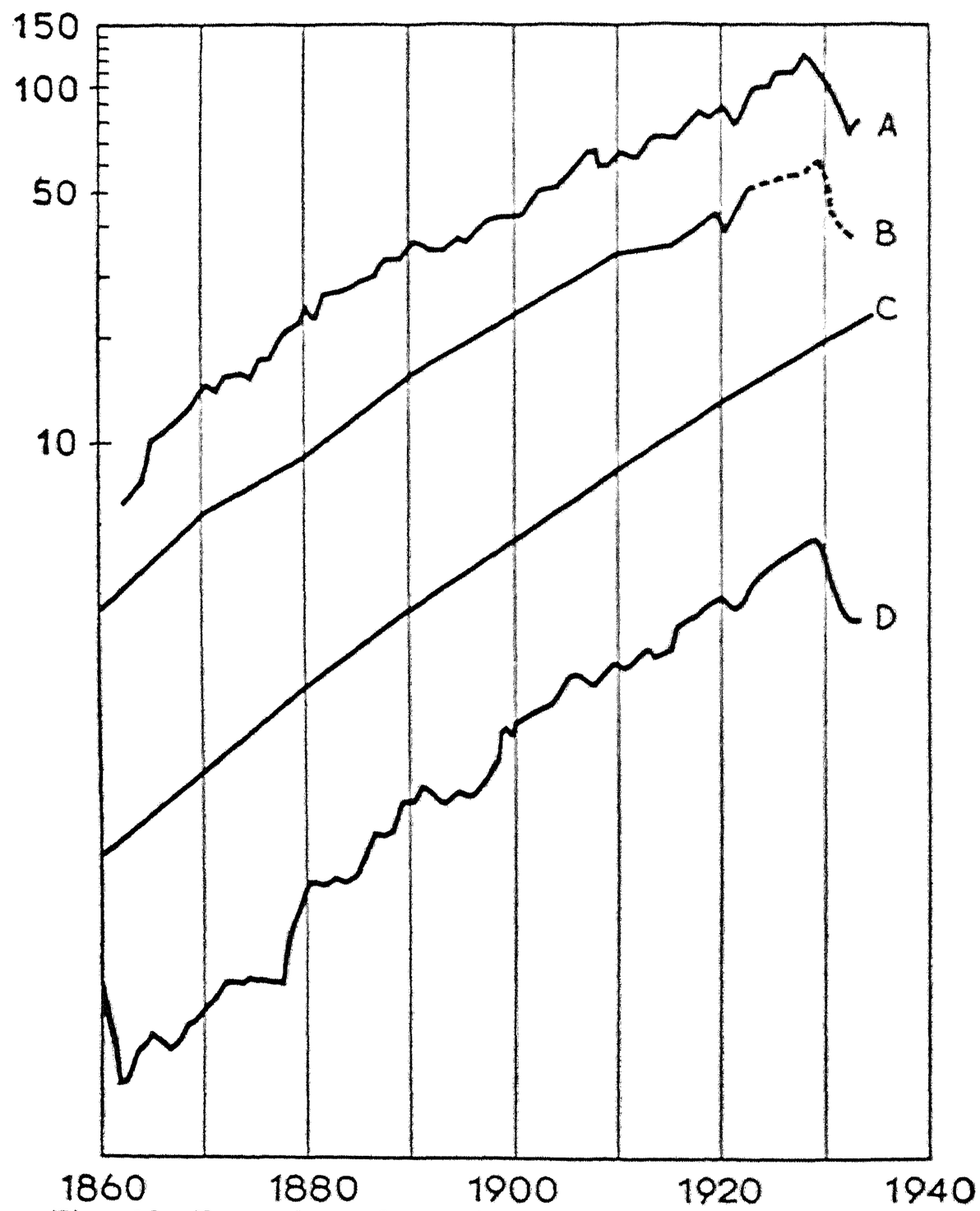

Fig. 12. Examples of nearly exponential growth curves (straight lines with logarithmic scale) for production, taken from Snyder.

A: Index of the total volume of production.
B: Index of industrial production.
C: Index of commercial transactions (real).
D: Index of payments (real; namely "clearing debits" divided by price index).

Fig. 12, taken from C. Snyder,* demonstrates this very clearly for various series representing the rate of production, whereas graphs by W. P. de Lange† show it for labor productivity. An important question is whether we can explain theoretically, exactly why an exponential curve should appear here. To answer this question, we must formulate a theory concerning the development of the economy. The first germs of such a theory can be found in Cassel's views about the uniformly developing economy in his *Theoretische Sozialökonomie*. He explains that an economy, the development of which is exclusively determined by saving sometimes actually shows an exponential development of production. If we try, however, to generalize this theory by including an increasing labor productivity, an exponential production trend is much less likely. Much remains to be done in this field of investigation.

We also mention Douglas's opinion that the increase of labor productivity in the past is exclusively a consequence of the higher capital intensity of production, and not of a change in technical knowledge. He finds no contradiction, therefore, between a development process through saving (and capital formation) on the one hand and by increased labor productivity on the other hand. We doubt whether this opinion can be maintained in the light of the increase in efficiency practically without enlargement of capital, which has come so much to the fore in the past decades.

The trend of labor productivity itself has also been a subject of econometric research. Besides the attempts concerning labor productivity in the mining industry (§ 34), which have already been referred to, we mention an investigation by Van der Schalk‡ into the influence of the number of working hours on labor productivity.

* Measures of industrial growth and their significance, in: "Beiträge zur Konjunkturlehre," Hamburg 1936.

† Labour productivity in manufacturing industry, Dutch Business-cycle Studies, December 1933, p. 10 (in Dutch).

‡ The mathematical-statistical analysis of labour productivity and its application in practice to a few branches of industry and enterprises in the Netherlands, Haarlem 1938 (in Dutch).

6

Reactions of Business Life

§ 36. Supply of Products

We have seen in § 26 that in dealing with the supply of products and with the demand for labor and raw materials, much more objective decisions are concerned than with demand and supply functions, which only have a psychic basis. After having discussed a few technical relations regarding production, therefore, we now turn to the aforementioned reaction relations of enterprises. If short-term reactions are concerned, it is, strictly speaking, not necessary to distinguish between supply of products and demand for production factors, as these represent one and the same decision and come into being *uno actu*.

It has already been pointed out in § 9 that although the logical coherence of quantity supplied and price is different as production for the market and production to order is considered, in both cases the same magnitudes appear in the supply relation. These magnitudes generally will be the production, u; the price, p; and the cost factors of a representative firm, k.

Attempts have been made to determine supply relations for a number of divergent branches of industry. With *agricultural enterprises* the particular circumstance occurs that we can distinguish between the production plans—to be read off from the acreage cultivated—and the real production, which is influenced by the changing yields per acre. The farmer's reaction can be most accurately determined from the former. Various investigations show that prices play a decisive role and that rather high elasticities appear. Interesting figures, obtained by Bean,* indicate that these elasticities lie above 1 for the most part. He finds

* The farmer's response to price, Journal of Agricultural Economics (1929) p. 368.

at the same time, however, that lags of one or two years appear and that the elasticity becomes considerably less if the price changes are large. It can be added that this is correct for relative price changes of one product with respect to another; if all prices decrease at the same time, only a very small decrease of the total acreage cultivated results. Bean's observations, therefore, refer to substitution elasticities rather than to total elasticities.

Also for livestock products it has been found that the prices show a high correlation with the quantities supplied, but likewise after a certain time interval. The supply of hogs, for instance, is high 1½ years after a high price level,* as a result of the length of the "production process." The supply elasticity according to Hanau lies between ½ and 1. This investigation was started from an *a priori* combination of prices and costs, as has been described in § 20.

For *mining* products there is usually a high correlation between prices and quantities, almost without lags, because the production process is very short. As we have seen in § 20, the correlation can in principle be interpreted as a supply function. The elasticity of this supply function was not very high in the period before 1914, namely, in the neighborhood of 0.4.

A number of investigations concerning products of *manufacturing industry* have been carried out by the author.† We tried here to approximate the price of finished products, p, by a linear function of the price of raw materials, r, of the wage rate, l, and of the rate of the production, u. A satisfactory correlation was found both for the Netherlands after 1921 and for England between 1870 and 1914, where the regression coefficient for the u term was small. If we accept the theory as correct, these figures would point to a very large supply elasticity of the goods, namely, of the order of magnitude of 3 to 10. A lower figure was found for investment goods in the period prior to

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* A. Hanau: Die Prognose der Schweinepreise, Sonderheft 18 der Vierteljahreshefte zur Konjunkturforschung, Berlin 1930.

† The coherence between the prices of imported raw materials and of finished products in the Netherlands, Dutch Business-cycle Studies 10 (1939) p. 150 (in Dutch).

1914, which is in accordance with the fact that in these branches of industry the capacity limits were reached more often.

It should be expected that the supply function in the vicinity of full employment of productive capacity shows a distinct kink. Most investigations are disappointing in this respect; obviously either the data are too rough or the production remains in these regions for so short a time that only little of it can be shown statistically. An interesting exception to this rule is an investigation by T. Koopmans* into the supply of tankers. In times of underemployment the supply, likewise, is very elastic and in periods of full employment—which were sufficiently frequent to permit of statistical research—very inelastic.

The long-term reactions, of course, are also influenced by changes in productive capacity, which appear as consequences of changes in profit possibilities. This brings us to our next point.

§ 37. The Demand for Investment Goods

Regarding the factors determining the demand for investment goods by entrepreneurs, various partial theories have been advanced, i.e., theories which accentuate only a few factors while neglecting others. As the fluctuations of investment activity play an important role in business-cycle fluctuations, many business-cycle theorists, particularly, have occupied themselves with these problems.

In this connection, the so-called acceleration principle has often been advanced during the last few years. According to this principle the demand for investment goods is determined by the increase per time unit of the production of consumption goods. In its simplest form the reasoning is very clear: if the production of consumption goods first increases from 100 to 110 and in the year afterwards from 110 to 115, we first need means of production to produce 10 units extra, and in the year afterwards, to produce five units. New investments, in this way, will decrease to half the original amount. J. M. Clark, who

* Tanker freight rates and tankship building, Haarlem 1939, p. 83.

first called this the *acceleration principle*, gives figures for the American railways, which are in agreement with it. A further investigation, however, shows that for the majority of branches of industry the principle is in conflict with the facts.*

Another one-sided theory explains the fluctuations of investment activity in particular by the fluctuations of the *interest rate*.

In this situation a synthetic research was needed, trying with the help of multiple-correlation calculations to determine the relative importance of the different factors. This was tried in my investigation for the League of Nations,† where the following explanatory variables were used:

1. the profits of business life as a whole (Z);
2. the price of investment goods (q);
3. the rate of interest (m);
4. the rate of increase of the production of consumption goods (Δ u);
5. the rate of increase of the price level of investment goods (Δ q);
6. the profit margin per unit of product (z).

Variable 1 was included to represent the influence of profit expectations, assuming, therefore, that the *expectations* will depend in a considerable degree on actual profits. The inclusion of variables 2 and 3 was based on the following reasoning: in the profits, Z, the prices of investment goods and the rates of interest of many preceding years play a role, because the depreciation allowances and the interest burden are usually based on previous investments and loans, respectively. For profits on new investments, however, the prices and the interest rate of this moment will be the determining magnitudes. These may differ considerably from the averages of previous years. These averages, by the way, show little movement as soon as they are calculated over a period of more than one business-cycle wave: they are only trends. Variable 3 was included to represent the

* J. Tinbergen: Statistical evidence on the acceleration principle, Econometrica 5 (1938) p. 164. This article is reprinted in Appendix B.

† "Statistical Testing of Business-Cycle Theories I," Geneva 1939.

theories which attribute a dominating role to the interest rate.

The basis for variable 4 was to interpret the purely technical factor embodied in the acceleration principle. Variable 5 may have influence if speculative motives—the consideration that the goods to be constructed will rise or decline in value—will lead to an earlier, or to a postponed, investment. Variable 6, finally, was included, because according to some writers the profit *margin* per unit of product rather than total profits determines the investment activity. Changes in the degree of utilization of capacity are also expressed in total profits: in dull times the profits are low, particularly on account of the low level of production. As there is more reason to expect a complete utilization for new investments than for other parts of the production apparatus, we may—according to these theorists—assume a given constant utilization of the new means of production.

The variable Z, total profits, at the same time represents the profit *rate*, i.e., the profit per unit of capital; the course of these two series is nearly perfectly parallel, because the quantity of capital, by which Z has to be divided to obtain the profit rate, has a gradual trend.

In the above list of variables, therefore, many theoretical viewpoints have been united.

In a few cases the lag was assumed *a priori* to be six months; in other cases it was assumed to be six months for the less important variables and was left "free" for the main variable, Z. This means that the lag was to be determined by the correlation calculation itself. On the average a lag of about six months was also found for Z.

The correlation calculations show that a rather good approximation of the course of investment activity, v, can be obtained with the help of these variables and that, assuming our list of variables to be correct, the variables 4, 5, and 6 play a very small role. Nearly as good an explanation is possible with 1, 2, and 3. From these variables, Z's influence is by far the greatest; q's and m's influences are secondary.

The result provides a check against economic theory: the coefficients of q and m must both be negative (see § 24, under

6). In almost all cases investigated, this requirement was actually satisfied. If we accept the theory that investment activity is mainly determined by Z, q, and m, the influences of q and m also turn out to be weak, as has been pointed out.

The influence of q can be expressed in the form of an elasticity coefficient. If we take the price of pig iron, the elasticity is 0.2 to 0.3; if the prices of finished products (e.g. machines) are taken, this elasticity would rise to 0.3 to 0.5, which still is distinctly below 1.

The accurate evaluation of this elasticity is always very difficult, because the gross correlation between q and v is positive; obviously the fluctuations in v are in the first place brought about by another magnitude (Z, according to our theory), which shows nearly the same fluctuations as q, and q's influence is inverse, but weaker. That influence, then, is the difference between v and Z's influence on v, and this difference cannot be determined accurately: small random deviations in Z and small errors in the lag used in the calculation may have a great influence on the elasticity determined.

The influences of Z and m may also be formulated as follows: the difference between the profit rate and the interest rate determines the level of the investment activity. This becomes clear from the order of magnitude of the coefficients and is not true as a matter of course. It is in accordance, however, with the well-known formulation that investments are determined by the *difference between "natural" interest and market interest* —at least if, as often happens, the natural interest is identified with the profit rate. Much more could be said about this than the scope of this book allows and so we shall not go into this further.

The fact that the market rate of interest, m, nevertheless, has a relatively small influence, is a consequence of the circumstance that the fluctuations of the profit rate are much greater than those of m.

It may finally be remarked that the influence both of the interest rate and of the acceleration principle has turned out to be more important for investments in *railway material* than

for total investments. This is possibly connected with the longer life of those goods. In this connection the fact pointed out by Zimmerman* is important that before 1910 railway investments formed a much more important part of total investments than after that year.

§ 38. Substitution Elasticities

In commercial relations—which belong to the field of "objective" decisions described in § 36—competition still plays an important role and consequently also the *substitution elasticity* between products supplied by competing firms or countries. The trade of a small country in particular is strongly influenced by the price level, not only of its own, but also of competing products. To quote an example, the demand for Dutch butter in the London market depends on the prices both of Dutch butter and of Danish and Australian butter. Knowledge of these substitution elasticities is of particular importance for several problems of commercial and monetary policy. Moreover, as trade statistics provide very comprehensive data, it is difficult to understand that an attempt has not been made earlier to determine the substitution elasticities for a number of products. For the Netherlands this has been done by Derksen and Rombouts.† Although many difficulties still have to be solved when dealing with these investigations, a satisfactory result can already be recorded in a number of cases.

The authors start from the theory that the ratio of quantities of a certain product bought from the Netherlands and from other countries is determined by the ratio of the prices charged by the Netherlands and by the other countries. If the quantities are denoted by u_N and u_F respectively, and the prices by p_N and p_F, it is assumed that:

$$\frac{u_N}{u_F} = -a\frac{p_N}{p_F} + b \qquad (38.1)$$

* "Saving and Investing in Economic Literature," The Hague 1941 (in Dutch).

† The influence of the price level on exports, Special Investigations of Dutch Business-cycle Studies, No. 1, The Hague 1939 (in Dutch, with English summary).

If both ratios are measured as percentage deviations from their trend, a is the substitution elasticity. This is an example of an *a priori* combination of variables (§ 20), in which a relation between four magnitudes is determined by only one regression coefficient. The combination is given by the definition of substitution elasticity (§ 20). Nevertheless, it could be asked whether the influence of still other factors should be assumed, in particular, income in the market concerned. This is possible, although of course the most important influence of income in the ordinary demand function (on u_N, therefore) is counteracted by an influence into the same direction exerted on u_F. In other words, it is conceivable that the *ratio* of the quantities bought in the Netherlands and elsewhere depends only slightly on income. The authors have made sure that in the cases they have investigated no great change would be brought about by including income as an additional variable.

In the following table a few of the values which they have found are summarized.

Article	Market	Competing Countries	Period	Substitution Elasticity
Butter*	England	Australia & New Zealand	1922-37	−2.0
Cheese	England	Canada & New Zealand	1927-37	−1.2
Cheese	Belgium	France	1927-37	−2.3
Bacon	England	All other countries	1926-37	−3.0
Coal	Belgium	" " "	1926-37	−2.0
Cotton Goods	Neth. Indies	" " "	1927-37	−4.8†
Shoes	Neth. Indies	" " "	1928-38	−2.8

* Danish and Dutch butter together.

† Average figure for separate periods.

Important investigations concerning substitution elasticities for the whole of imports and the whole of exports of a number of countries have been carried out by Tse-Chun Chang in four

studies.* He explained the fluctuations of exports, in general, from fluctuations in: (1) the size of world exports, representing the income of the receiving countries; (2) the price level of export products of the country concerned; and (3) the price level of competing countries. The fluctuations in imports were explained by fluctuations in: (1) real income or employment, (2) the ratio of the import price level and the domestic price level, and (3) the size of exports. The results shown in the following table were obtained:

Country	Import Elasticity	Export Elasticity	Total
Lithuania	−0.48	−1.84	−2.32
Canada	−1.34	−0.35	−1.69
Hungary	−0.54	−1.10	−1.64
Estonia	−0.34	−1.29	−1.63
Norway	−0.86	−0.62	−1.48
Finland	−0.25	−1.23	−1.48
United States	−0.97	−0.43	−1.40
Australia	−0.67	−0.66	−1.33
France	−0.32	−0.77	−1.09
Denmark	−0.63	−0.45	−1.08
Italy	−0.27	−0.81	−1.08
Japan	−0.47	−0.60	−1.07
Germany	−0.37	−0.58	−0.95
South Africa	−0.64	−0.31	−0.95
New Zealand	−0.34	−0.52	−0.86
Sweden	−0.37	−0.36	−0.73
Switzerland	−0.26	−0.44	−0.70
Great Britain	−0.28	−0.40	−0.68
Chile	−0.32	−0.17	−0.49

Chang's figures concerning export elasticity are lower than a number of figures obtained in an investigation by the author.†

* International comparison of demand for imports, The Review of Economic Studies 13 (1945-46) p. 53; The British demand for imports in the inter-war period, The Economic Journal 56 (1946) p. 188; The British balance of payments, 1924-1938, The Economic Journal 57 (1947) p. 475; and A statistical note on world demand for exports, The Review of Economics and Statistics 30 (1948) p. 106.

† Further measurements of the substitution elasticity, Monthly Bulletin of the Netherlands Central Bureau of Statistics, 1943, p. 151 (in Dutch).

In this latter investigation, the price index of world trade was started from as a competing price index. In this respect Chang's calculations are to be preferred. As regards his evaluations of the import elasticity, some doubts may be raised in connection with the facts that he neglects the existence of the quota system, that sometimes he takes the cost of living as a competing price index, and that sometimes the employment figures are taken as an income index. Nevertheless, his results deserve confidence, because the differences between the one group of countries and the other can be explained satisfactorily. The results are particularly interesting because the balance of payments equilibrium is under certain conditions indifferent if the sum total of the two elasticities mentioned is equal to 1 and unstable if the sum total is < 1.

Another example is given in Fig. 13: it refers to the substitution elasticity of American iron and English iron imported into the United States. In this case the ratio of imports to total consumption (including imports) has been taken instead of the ratio of the quantities.

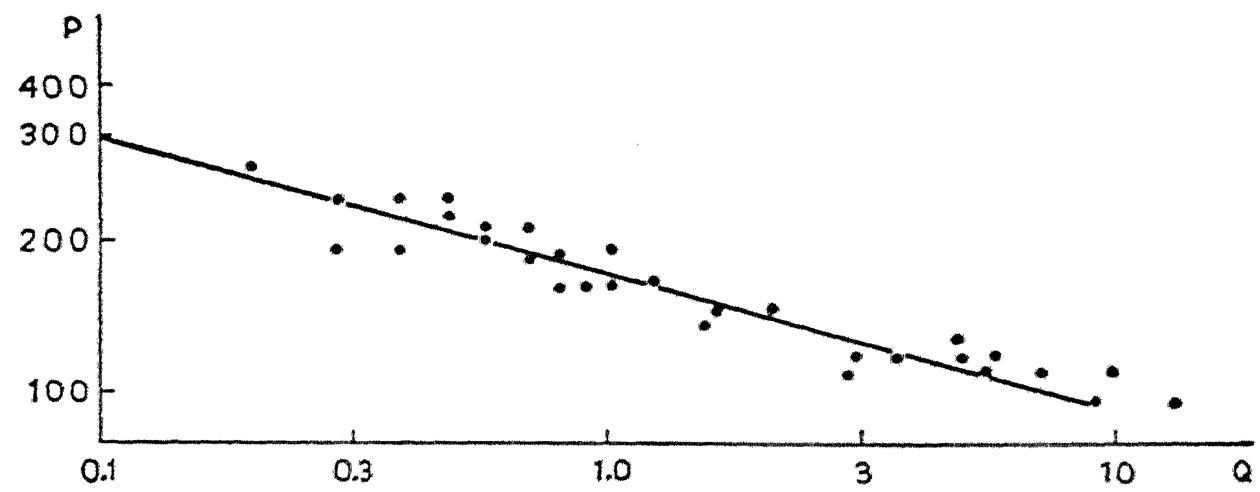

Fig. 13. Evaluation of the substitution elasticity of pig iron imported into the United States for pig iron produced there.
P: ratio of the price of imported iron to domestic price (%).
Q: imports as a % of consumption.

Although most of the figures found lie above 1, they are not as high as has often been supposed on the basis of suggestive theoretical writings concerning this subject. If the figures are correct, a price decline of Dutch products will not result in as

sharp a rise of Dutch exports as has sometimes been thought. It will consequently have less importance for the promotion of exports.

There are reasons to assume that the elasticities just discussed are higher for long-run than for short-run reactions. For a more complete discussion of some evidence on this point the reader may be referred to Appendix C.

§ 39. Reaction Relations in the Financial Sphere

It took some time before reactions in the financial sector of the economy were investigated econometrically. It is not impossible that the education of many econometricians as natural scientists is a reason why they found the commodity sphere more interesting than the financial and why, consequently, they held aloof. Now, however, a few attempts to check and measure demand and supply functions are available in this field also. Keynes' theoretical work, and the discussion it has provoked, have stimulated this.

A first example is an attempt by A. J. Brown to determine a relation for the demand by the London clearing banks for various sorts of assets.* Brown subdivides these assets into four groups, namely

1. cash and short loans (C),
2. bills discounted (B),
3. investments (I),
4. advances (A),

of which 1 and 2 represent the more liquid group and 3 and 4 the less liquid group. He argues, on the ground of the liquidity theory, which we cannot entirely restate here, that the ratio both of C to B and of I to A will depend on

a. the ratio of the yields and
b. the total resources in each group which the banks have at their disposal.

If the yield of B is represented by Y_B and that of C by Y_C, he gives the relation in the following form:

* The liquidity preference schedules of the London clearing banks, Oxford Economic Papers 1 (1938) p. 49.

$$\log C/B = a_1 + b_1 \log \frac{Y_B}{Y_C} + c_1 \log (CB) \qquad (39.1a)$$

and similarly:

$$\log I/A = a_2 + b_2 \log \frac{Y_A}{Y_I} + c_2 \log (IA) \qquad (39.1b)$$

As we see, this is another application of the idea of elasticity of substitution; because the logarithmic form of the equations has been chosen, b_1 is the substitution elasticity of cash for bills, etc., and b_2 that of investments for advances. The third term denotes the influence of the resources. The author has taken the product CB instead of the total C + B, because, according to the theory, the total utility of C and B is involved and this will depend on CB rather than on C + B. The indifference curves, in other words, have the form CB as constant (rectangular hyperbolas) rather than C + B as constant (straight lines). For small variations the difference will not be great, if the averages of C and B do not deviate strongly. Brown's results are:

$$b_1 = -0.26 \qquad c_1 = -0.83$$
$$b_2 = -0.66 \qquad c_2 = +1.54$$

which, on acceptance of (39.1a) and (39.1b), would point to a rather low substitution elasticity. It is remarkable that c_1 is negative and c_2 positive. This means that an increase of total resources in the more liquid group—also with unchanged yields—will lead to a relative decrease of cash, and an increase of resources in the less liquid group to a relative increase of the item investments. The author also measures the changes which the coefficients underwent during the depression period; but it would lead us too far to go into this.

A second example may be taken from my study of the business-cycle mechanism in the United States during the period 1919-1932.* It refers to the supply elasticity of money (in the sense of means of payment) by the entire banking system. The supply relation can best be regarded as a price-fixation relation (see § 9) for short money: by their interest rates the banks regu-

* "Business Cycles in the United States, 1919-1932," Geneva 1939.

late the amount of credit granted. They do this in such a way that their debt position with the Federal Reserve Banks remains within the prescribed limits. That debt position can be indicated by the amount: rediscounts minus surplus reserves, or $Bi - R^e$. The short-term interest rate m_s indeed shows a high correlation with $Bi - R^e$, as can be seen from Fig. 14. This is a good example of nonlinear correlation. If the amount of money available becomes very large, the rate of interest becomes insensitive to changes in $Bi - R^e$ (left-hand side of the figure), whereas the dependence is much stronger when the market is tight. For the period 1917-1932 the following equation was found by rough approximation:

$$m_s = 4\,(Bi - R^e) + 2 \qquad (39.2)$$

The right-hand side of this equation must be expressed in terms of the corresponding quantity of money. This correspond-

Assets	Liabilities
Gold reserve, Au	Reserves of member banks, R^r
Discounts, Bi	Surplus reserves of same, R^e
Bills of exchange and bonds bought in open market, P	Bank notes in circulation, M'

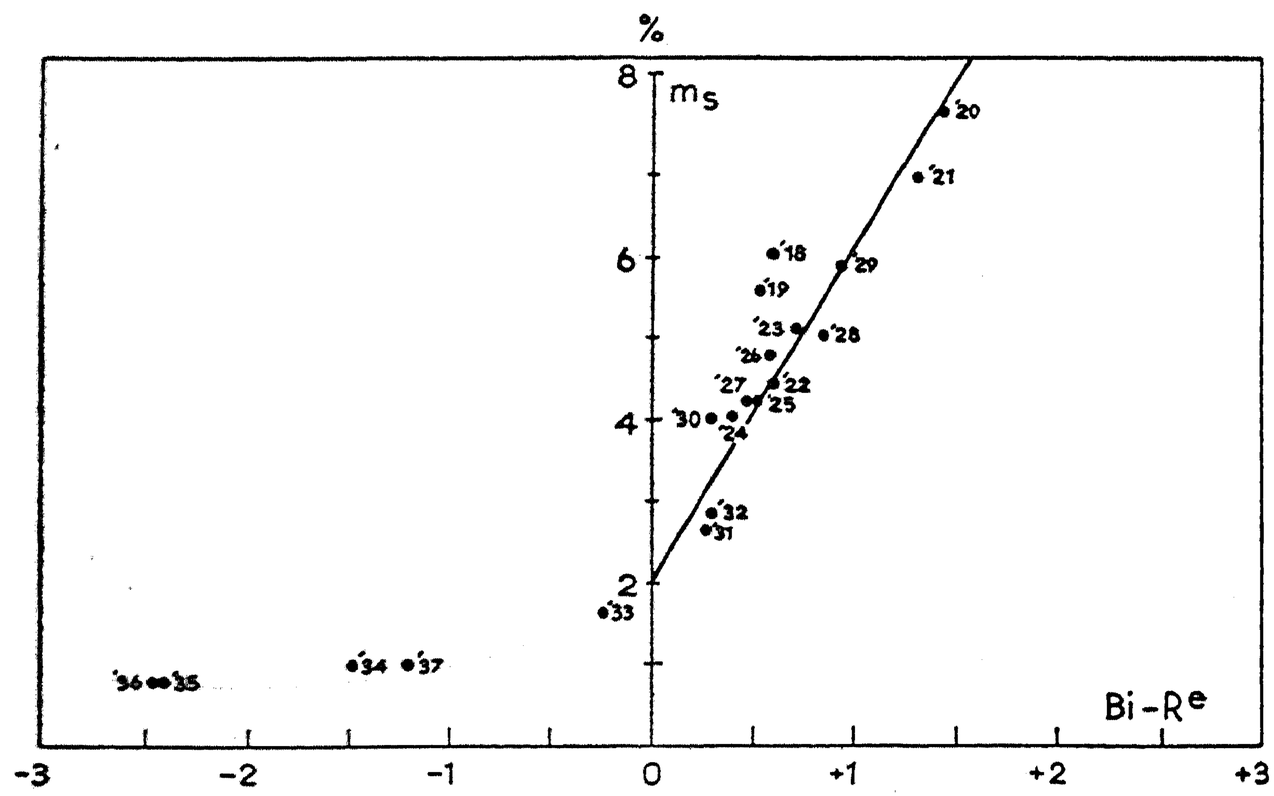

Fig. 14. The relation between $Bi - R^e$, rediscounts with the Federal Reserve Banks less surplus reserves of member banks (billions of dollars) and m_s, the discount rate in per cent.

ence is reflected in the balance sheets of the Federal Reserve Banks and in the legal reserves requirements against deposits prevailing in the United States. The aggregate balance sheet of the Federal Reserve Banks can be written as follows:

Item P has been denoted in the above way, because the credit policy of the government and the central banks manifests itself in this magnitude. The member-bank reserves keep a relation prescribed by the law with outstanding deposits M'', with which they are proportionate for each type of member bank separately (in central-reserve cities, reserve cities, and in the country). Although the relative importance of the deposits of these banks fluctuates during the business cycle, there is nevertheless a nearly linear relation between R^r and M'', which, according to simple correlation calculations, reads as follows (omitting a constant):

$$R^r = 0.038\ M'' \tag{39.3}$$

From the balance sheet, further, it follows that

$$Bi - R^e = M' + R^r - (Au + P) \tag{39.4}$$

which can be written in combination with (39.3), as follows:

$$Bi - R^e = M' + 0.038\ M'' - (Au + P) \tag{39.5}$$

In this way the right-hand part of (39.2) has been expressed in the two components of money circulation, M' and M''.

These, however, do not appear in such a way that their sum total $M' + M''$ can be determined. This total, which we shall indicate by M, consequently, not only depends on $Bi - R^e$ and $Au + P$, but also on one of the two components M' or M''. The factors determining M, therefore, are not only the rate of interest m_s (which may be taken instead of $Bi - R^e$), the gold reserves Au and the policy of the monetary authorities (which determines P), but also M' or M''. As M' is much less important than M'', it is most interesting to assume that M' is given. We then derive from (39.2) and (39.5), that (omitting a constant):

$$0.038\ M = 0.038\ (M' + M'') = 1/4\ m_s - 0.962\ M' + Au + P$$

or

$$M = 6.6\ m_s - 25\ M' + 26\ (Au + P) \tag{39.6}$$

In this way a supply relation for money has been found, from which an elasticity can be calculated (assuming a constant M') of approximately 0.65.

An attempt was made in the publication mentioned to determine the reactions in the whole financial sphere, as regards their main features. To this end a very rough model of this sphere has been designed, in which only broad categories have been regarded as separate assets: shares, bonds, short claims, banknotes, and gold. For other purposes, of course, microeconomic research is needed. Investment advisers, in particular, have made many investigations into the factors determining the course of separate share prices. Most of these, however, have not been published. We have already mentioned a few macroeconomic investigations in this field in § 7 and § 31.

7

The Functioning of Economic Systems

§ 40. Separate Markets (Echo Principle, Hog Cycle, Building Cycle)

Our previous discussions concerning the results of econometric research belong to what we have called earlier in this book (§ 4) the first and the second stage of investigation: formulating and testing the theory, and carrying out measurements. We have now reached the third stage, in which mathematical-economic conclusions are drawn. These conclusions refer either to the explanation of a given historic course from the data, or to the probable consequences of certain measures of economic policy. For both sorts of conclusions it is necessary to know the functioning of economic systems. Such a system may be a single market or a whole economy, possibly also a group of connected markets. The functioning is reflected in a number of equations, with the phenomena to be explained as unknowns. With one market, there are two phenomena: price and quantity sold; with a larger system there may be many more.

We shall first consider the functioning of a few types of separate markets. We choose the examples and their sequence for reasons of exposition. They facilitate somewhat the understanding of more intricate systems.

The fluctuations in a market may be caused exclusively by *exogenous* factors. Most seasonal fluctuations are examples. Butter production, for instance, fluctuates because the cows give less milk in winter. The lower milk supply and, consequently, the lower supply of butter and other products, raises the price in winter, unless a seasonal leveling has been attained by cold storage.

Another example of a market showing fluctuations which are exclusively caused exogenously is the *anchovy* market. The catch

of this fish varies very greatly and one year may be a hundred times as great as in another year. The main cause is the fluctuation in temperature in the area where the young fish has to grow in the spring. The fluctuations of the catch cause fluctuations of stocks, which in their turn largely explain the enormous fluctuations both in prices and in sales. A great part of the catch, consequently, is kept for several years because old anchovy is valued higher than new.

The markets where *endogenous* causes of fluctuation are active in addition to exogenous ones are of more importance for economic science.

A very simple case is the so-called *echo principle,* which usually appears in markets of durable goods. The quantities sold at such markets are partly intended to replace old items. The quantity required for this purpose is partly determined by the quantity which has reached the maximum age, and this largely depends on quantities sold earlier. If the lifetime of the good amounts to 10 years, the production of 10 years ago determines today's demand. Other factors will usually also determine the demand for replacement. If we could abstract from these for a moment and if we could assume that the lifetime is a sharply defined number of years, it would be possible to explain a fluctuating movement, the period of which would be equal to the lifetime of the goods considered, by the repetition of earlier sales ("echo"). This mechanism shows quite a number of interesting aspects, which we cannot go further into here. We therefore refer to the literature.* An illustration of what has been discussed can be found in the study mentioned concerning the demand for automobiles (§ 28), and in Fig. 15. This figure refers to the replacement demand for ships and is taken from an article by J. Meuldijk, Jr.† The course of this replacement demand can very well be explained by a combination of earlier production and freight prices, the latter repre-

* Einarsen: "Reinvestment Cycles," Oslo 1938.

† Der englische Schiffbau während der Periode 1870-1912 und das Problem des Ersatzbaues, Weltwirtschaftliches Archiv 52 (1940) p. 524.

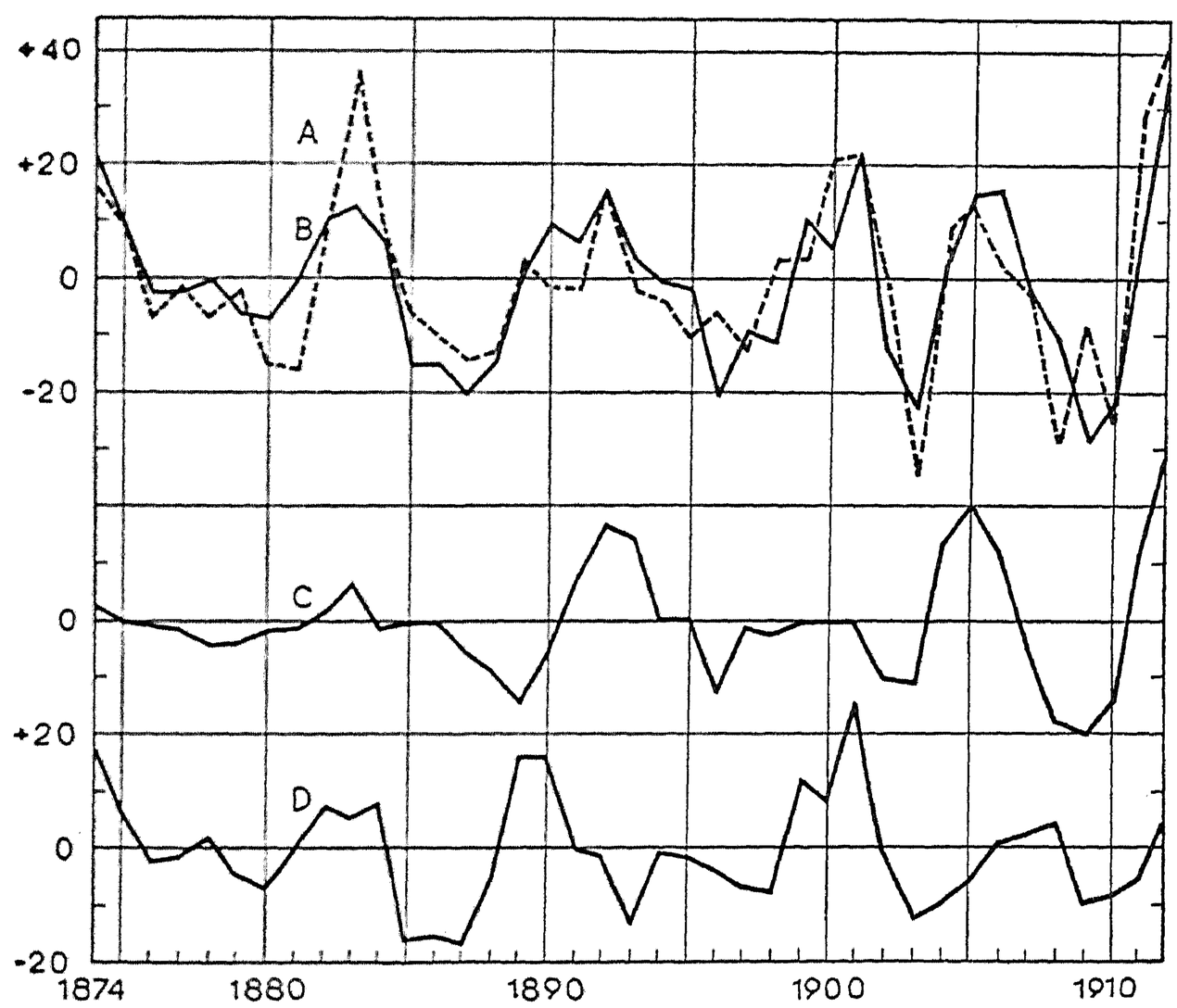

Fig. 15. Explanation of the course of shipbuilding for replacement (A) from (B), the total of the influences of: (C), the production of approximately 20 years ago, and (D) the level of freight rates, one year ago. (Taken from J. Meuldijk, Jr.: Der englische Schiffbau während der Periode 1870-1912 und das Problem des Ersatzbaues, Weltwirtschaftliches Archiv 52 (1940) p. 524.)

senting the shipping cycle at the moment itself. The fact that this factor has to be included with a lag of one year has to be ascribed to the length of the shipbuilding process.

A somewhat more complicated fluctuation mechanism is obtained, if the so-called *cobweb theorem** can be applied, which is approximately the case in the *hog market.* This mechanism presents itself in its purest shape if demand and supply depend only on the price, the former without, the latter with, a lag. If at a certain moment the price has reached a peak, this will

* The name of this theorem is due to the shape of a graph which is often used in this connection.

result in the supply also showing a peak after a one-unit lag. This, however, reduces the price at that moment to a minimum, because otherwise the demand cannot absorb the quantity supplied. This minimum price after a one-unit lag causes a minimum supply, through which at that moment the price again takes a maximum position. This situation can be compared to that of the starting point; one period has been completed. This period, however, is *double* the lag unit (see Fig. 16).

It has already been remarked that this situation appears roughly in the hog market. There are also a number of other less evident examples, where disturbances (exogenous forces) influence the picture somewhat. The well-known tendency to a two-year agrarian cycle is one of these examples.

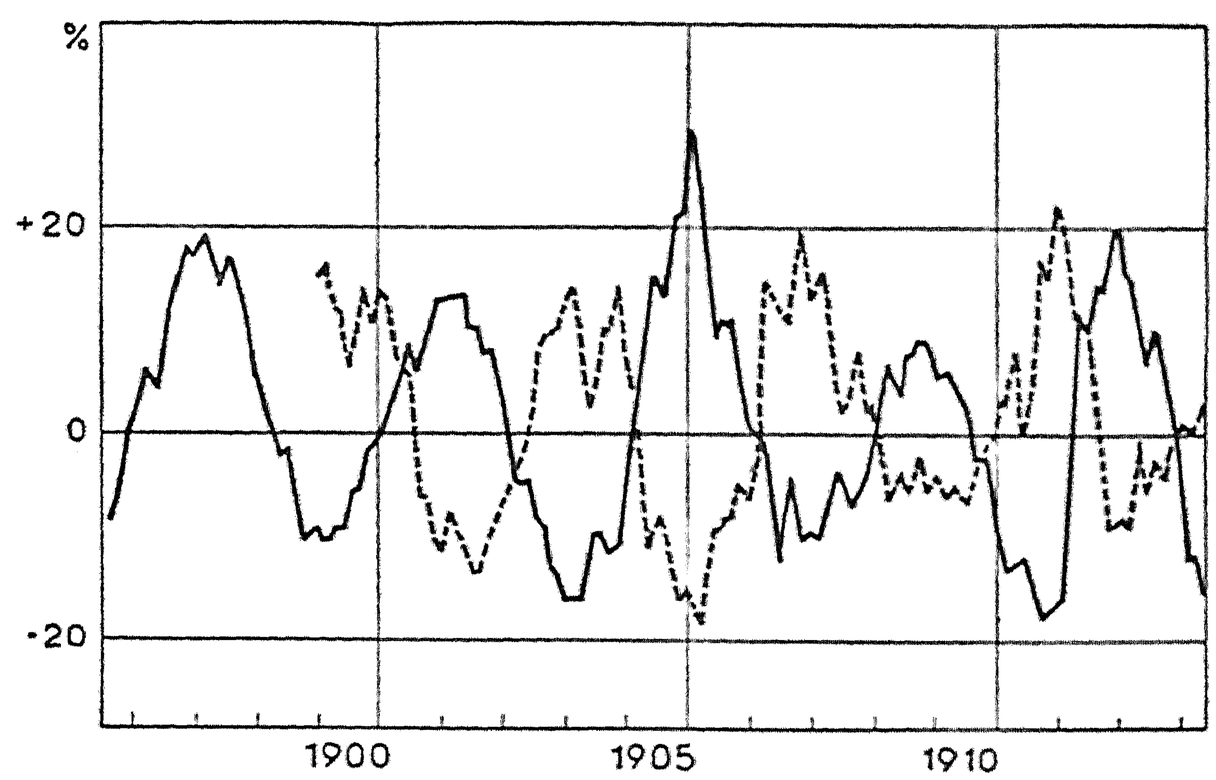

Fig. 16. Example of the operation of the "cobweb theorem": the hog market, according to Hanau.
——— Pork price, percentage deviation from trend.
— — — — Supply of slaughter-pigs, deviation from trend.

A high sugar price leads to a large cultivated area in the next year; if the yield per acre is normal, the production therefore will be high. The price, however, will be low. This low price results in a small area being cultivated and, if the crop

yield is normal, a low level of production. Through this, the price rises again, and a two-year cycle has been completed. This phenomenon is often found with many agricultural products. But if the yield per acre diverges strongly from the average, irregularities appear in the movement. The latter, therefore, only maintains itself for a short time.

A type of endogenous movement which again is somewhat more complicated appears in the market of services of some durable goods, such as houses or ships. The movements usually are mixed with other elements. In its pure form the mechanism works as follows. Suppose at a certain moment there is a high price for the service in question, for instance, a high house rent. This high rent, now, stimulates, after the building period, not the total supply of houses, but the supply of *new* dwellings. This, however, does not immediately cause a low rent; the rent also depends on the total quantity of houses available, i.e., in principle, of the cumulation in time of newly built houses. As, however, the stock of houses was relatively low at the starting point—otherwise the rent would not have been relatively high —it takes a considerable time before the increased building activity leads to a relatively high stock of dwellings. Only in that case is the minimum rent to be expected and half the period has been accomplished. The movement described here, therefore, has a longer period than twice the lag unit which plays a role; normally it is even about *four times* as long.

We have already pointed out that apart from the causal relations mentioned, other disturbing factors are active here. The system, consequently, does not work itself out accurately. Such disturbing circumstances may be, for instance, that not only the level of rents, but also building costs and the interest rate influence the building activity; rent, further, is determined not only by the stock of houses, but also by the income, the growth of the number of families, etc. Only if the shortages at a certain moment are very great and if the other factors move rather narrowly in comparison to them, may this mechanism make itself felt. This seems to have been the case particularly in the United States, and the widely fluctuating waves in house

building since 1830 should partly be ascribed to this mechanism.*

The considerations given above have been treated without any formula, for the benefit of the nonmathematical readers. It could be asked, therefore, whether they are examples of econometric research. They are, because their exact treatment is only possible with the help of formulas, and because the conclusions have only been found by exact treatment. These conclusions actually go considerably further into detail than has been possible within the scope of this chapter, precisely as a consequence of its nonmathematical treatment. For this, however, we again refer to the literature cited.

§ 41. The General Business-Cycle Movement

The tendencies to cyclic movements appearing in separate markets have relatively little to do with the general business-cycle movement in economic life which has been observed for years. The examples cited are more or less special cases, the importance of which is methodologic rather than real. We see from them in how many different ways cyclic movements not only may, but also actually do, come into being.

Econometrics, however, has also contributed to our knowledge concerning the causation of the general business-cycle phenomenon. By its exact way of describing a causal structure and by the possibility of measuring the different influences at least approximately, it has provided more insight in the business-cycle mechanism than verbal treatment alone can do. It has achieved this by creating a number of models of the business-cycle mechanism, which by statistical measurements have been adapted to reality as closely as possible.

The first few of these models—e.g., Frisch's†—have been set up mathematically and are consequently sharply outlined, but they are still rather distant from reality, as they are only based on measurement of a few magnitudes. Kalečki's model,‡ like-

* J. B. D. Derksen: Long cycles in residential building: an explanation, Econometrica 8 (1940) p. 97.

† In the volume: "Essays in Honour of Gustav Cassel," London 1933.

‡ "Essays in the Theory of Economic Fluctuations," London 1939.

wise, although adapted to reality to a greater extent, is still relatively simple in its assumptions, nor is it based on elementary equations which have all been tested statistically. Nevertheless, it is very instructive.

Radice's model* is entirely based on elementary equations which have been tested against reality. The same applies to Colin Clark's calculations,† who in 1937 predicted the turning point in the English business cycle, on the basis of the relations by which he described the business-cycle mechanism of that country.

In this connection we may go somewhat further into the results of two attempts by the present author to set up models for the United States‡ in the period 1919 to 1932 and for England in the period 1870 to 1914.§ In these models, in order to make them as realistic as possible, 30 to 40 variables have been included: two or three income categories, separate production (and for England import and export) indices for consumption goods and means of production, separate price indices for these two sorts of goods and their raw materials, and a number of variables from the financial sphere, etc. An equal number of elementary equations (§ 11) was set up and tested statistically. By this testing, of course, their correctness has not been proved (see § 26), but it was at least established that they were not in conflict with the data. The most interesting equations among these 30 or 40 are the demand and supply relations for the various markets included in the model. A final equation was obtained for one of the variables in the way described in § 12, from which equation the movements of the model can be derived. Nonlabor income, Z, was taken as the variable appearing in this final equation. This variable is approximately equal to the profits figure. With the help of a number of appropriate approximations a final equation in three terms was

* A dynamic scheme for the British trade cycle, 1929-1937, Econometrica **7** (1939), p. 47.

† National income at its climax, Economic Journal 47 (1937) p. 308.

‡ See Note * on page 130.

§ In a forthcoming study.

obtained, for instance, for England (where the time unit is eight months):

$$Z_t = 1.27\, Z_{t-1} - 0.60\, Z_{t-2} \qquad (41.1)$$

Z here indicates the deviation from trend. The equation, consequently, only describes the movements around the trend, which is considered as given.

The reader will remember that the systematic movements are indicated in this way; as soon as a new change of data appears, a "disturbance term" should be added. We shall first consider only the systematic movements.

The coefficients 1.27 and 0.60, which, as will become clear later, determine the movements of the system, have been obtained from a great number of coefficients from elementary equations, having the significance of elasticities, marginal propensities to consume, labor quota, etc. If we consider the origin of the final equation (41.1), we might wonder how it will ever be possible to describe such a process in words alone, and without the help of symbols. We shall nevertheless try this in the following, but it can only be done approximately and very roughly. We fear, however, that no literary theory will ever be able to overcome this defect.

The way in which the numbers 1.27 and 0.60 have been obtained also entails that they are rather uncertain. This problem has been fully discussed in the publication mentioned in note * on page 138.

The character of the final equation determines the systematic movements which the system can perform, as we have already explained by a simple example in § 12. We shall clarify this further with our new case of (41.1). If only the first term would be present on the right-hand side of (41.1), the movement would show an ever-growing deviation from the trend. A cumulative process without end would appear; every deviation would be 1.27 times as great as the preceding one, either negatively or positively. A turning point would not appear, except by exogenous disturbances. It is not impossible, now, that the business-cycle movement should be regarded as caused by ex-

ogenous disturbances alone. As has become apparent from Slutzky's* studies, a system like the one under discussion may show movements of a quasi-periodic character, as a consequence of random shocks. The most important economic interpretation conceivable is that these shocks are the changing crop yields and a few very important political events (e.g., wars). The majority of business cycle theorists, however, will be of the opinion that also more systematic causes of turning points should be assumed.

If the coefficient of the term with Z_{t-1} were negative and if the one with Z_{t-2} still were absent, fluctuations would also have appeared, but only very short ones. After two time units (16 months) the picture would repeat itself: positive and negative values of Z would constantly alternate.

Only because there are two terms, is it possible that fluctuations of longer duration appear. This can only happen, however, if the values of the coefficients satisfy certain requirements. If, for instance, both coefficients are positive, no fluctuations can appear. Even if the second coefficient is smaller than the square of half the first one (in this case, smaller than 0.635^2 or approximately 0.4), no fluctuations can appear. The following example deals with the two cases:

Numerical values of Z with different t and for $Z_1 = 0$, $Z_2 = 10$: (A), if formula (41.1) applies, and (B), if in that formula the coefficient 0.60 is replaced by 0.30:

t	= 1	2	3	4	5	6	7	8	9
(A) Z =	0	10	12.7	10.1	5.2	0.5	−2.5	−3.5	−2.9
(B) Z =	0	10	12.7	13.1	12.8	12.4	12.0	11.5	11.0

This example makes it clear that a theory in words alone cannot be sufficient. It is conceivable that two theories are qualitatively the same—i.e., assume the same causes for the movements in all variables—but are only different as regards the size of the influencing coefficients. Then it is entirely possible

* The summation of random causes as the source of cyclic processes, Econometrica 5 (1937) p. 105.

that the one theory results in a movement like (A), and another theory in one like (B). In the case of (A), the theory also explains the lower turning point, with (B) it does not.

The question, now, is of great importance, which of the economic relations have mainly contributed to the presence and size of the coefficients + 1.27 and − 0.60. Only the most important outline of the complicated origin of these figures can be given here. In the coefficient 1.27, among other things, the "propensity to consume" and the investment incentive manifest themselves. If at a certain moment, profits are high, this will lead to higher expenditures for consumption and investment some time later. The lag is a consequence of the time elapsing between the reaping of the profit and its paying out, and between the receipt of the income and its spending; a consequence, also, of the duration of investment processes. The high expenditures for consumption and investment, however, will after a short time again give rise to higher profits. This manifests itself in the coefficient 1.27. It lies above 1, among other things, because prices will also have risen, as a consequence of the higher demand for goods. This price rise, moreover, often influences the profit calculation—perhaps unjustly. A sort of acceleration principle is at work here: the profit depends on the price rise and as the price level itself is also determined by earlier profits (and the demand resulting from it), the profit indirectly depends on the rise in profits at some time earlier.

This is important enough to set forth in a formula:

$$Z_t = a\,(Z_{t-1} - Z_{t-2}) + b \qquad (41.2)$$

Within brackets we have the increase of profits at some time before (namely, between $t-2$ and $t-1$); this increase exerts its influence—in addition to another factor, b—on Z_t by means of the coefficient a. Part of the coefficient 1.27 is formed by the a standing before Z_{t-1}. At the same time we see that part of the negative coefficient − 0.60 is formed by the term $-aZ_{t-2}$, which also appears in (41.2). We have just called the type of relation laid down in (41.2) a sort of acceleration principle, because, just as with Clark's principle, the level of Z_t is deter-

mined by the speed by which a certain magnitude increases. As the presence of a negative term with Z_{t-2} is of decisive importance for the appearance of a turning point, the appearance of such acceleration principles is also very important for the explanation of turning points. Although, as our investigations indicate (§ 37), it seems that no great importance should be assigned to Clark's acceleration principle for the explanation of the course of the business cycle, there are a few other relations which give rise to the mathematical form of (41.2). In addition to the aforementioned influence of price increases on the profit calculation, there is an influence—important in the United States in 1929—of share-price rises on consumption, and a tendency to keep stocks proportionate to the size of production. Production for the increase of stocks, consequently, shows a tendency to have a course parallel to the increase of production.

The negative term $-0.60\ Z_{t-2}$ should also be partly ascribed to the restrictive influence of the interest rate and of the prices of securities (see § 37). The interest rate and the prices themselves depend indirectly on Z, with a small lag; through their influence on investments and consequently indirectly on profits, the profits made some time ago work negatively on the profits of this moment. These influences, which are mentioned in several theories, however, would, according to our results, be quantitatively too weak to result in a term -0.60. They would not even reach -0.40 and therefore could not explain the two turning points of the business cycle. Together with the acceleration influences mentioned, however, they can.

If such relations appear in the mechanism, it is not necessary (contrary to general opinion) to explain the turning point by changes in the elasticity of certain markets. The changes usually thought of are rigidities in the neighborhood of full employment of productive capacity: the so-called *bottle-necks*. In mathematical language these mean a *nonlinear relation* and we have seen from the above that they are not necessary to explain turning points. They may appear in certain situations and have been noticed, for instance, in many crises before 1914. On the other hand, they need not start a declining movement. It is also

conceivable that production, after having reached full capacity, stays there. Whether a reaction follows depends on the other relations in the model.

We have now given a few examples of the sort of conclusions which may be drawn from macroeconomic models regarding the generation of general business cycle waves. Besides—and this is a great difference from the old "barometers" (see § 2) based on a rough empiricism—the structure of these models can be changed in order to study in which way the movements they may show will also change. In other words, with these models it is possible to study the consequences of certain measures of economic policy.

Similarly by way of an example, we mention here the conclusions in the field of business-cycle policy (see § 13) drawn from the American model. In the first place, it has become evident that the fluctuations would be much narrower if it would be possible to curb speculation in shares. Further, a stabilization of total consumption expenditures would have particularly favorable consequences for the business-cycle movement: the movement would be considerably more damped. Stabilization of investment expenditures would help much less, on account of the fact that the absolute fluctuations in investment expenditures are smaller than those in consumption expenditures.

We only give these conclusions to arouse the reader's curiosity. It is out of the question that the whole problem of business-cycle policy could be treated satisfactorily within the scope of this book.

Model construction has been practiced intensively during the last five years in the United States; among other things, in aid of business-cycle forecasting in relation to employment policy. In particular, we mention the work of L. R. Klein, which has brought a considerable extension, especially of the income formation relation and of the relation concerning investment activity.*

* The use of econometric models as a guide to economic policy, Econometrica 15 (1947) p. 111.

Further, we refer to the investigation by M. A. Girshick and T. Haavelmo cited above (see § 27), in which a very simple dynamic model is presented which has been tested statistically with the help of the method of simultaneous equations. In this model the attention has been focused on the market for agricultural products in its relation to the economy as a whole.

§ 42. Comparative-Static Systems

In addition to models intended to analyze short-term movements (business-cycle models), comparative-static models have also been developed since the Second World War, with the purpose of estimating either the influence of certain forms of economic policy or the long-term development. Two most outstanding attempts may briefly be mentioned here; an elaborate treatment is outside the scope of this book.

In Appendix C of Sir William Beveridge's book: "Full Employment in a Free Society," N. Kaldor* has constructed a model of the English economy, with a view to estimating the influence of a few alternative methods of employment policy (additional government expenditures, financed either by loans or by direct or indirect taxes). The system, consisting of 37 equations, is relatively simple in its setup; the various income categories depend linearly on total national income and their savings, likewise, linearly on income after payment of taxes. Prices are not introduced as variables.

Colin Clark, in his "Economies of 1960,"† has made an attempt to describe the world economy in that year on the basis of an econometric model in which more than 30 countries are distinguished. The production and the population have been subdivided into primary (agriculture, fisheries, etc.), secondary (manufacturing industry and mining), and tertiary (all other) branches of industry. The system is based, among other things, on the following relations:

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* An econometric analysis of the model is given by R. Stone and E. F. Jackson in: Economic models with special reference to Mr. Kaldor's system, The Economic Journal 56 (1946) p. 554.

† London 1942; subsequently reprinted.

1. the population is distributed over the branches of industry in such a way that the wages (equal to the marginal productivity of labor) have a fixed mutual relation;

2. the productivity in agriculture depends on the density of the agrarian population; moreover, it has a trend;

3. the productivity in the secondary and tertiary branches of industry only shows a trend;

4. the demand for agricultural products depends on the height of national income and on the price level of agricultural products.

The coefficients of these relations are determined from international statistical material. In a number of cases, certain limits of validity are assumed, outside of which other relations are valid; it is assumed, for instance, that at most 35 per cent of the agrarian population will disappear between 1935/38 and 1960.

On the basis of these relations Clark comes to an evaluation of the agrarian price level in comparison to that of products of manufacturing industry, and to an estimation of world trade in agricultural products, subdivided according to countries.

§ 43. Concluding Remarks

In this book we have tried to make the reader acquainted with the way of thinking, the methods, and the results of econometric research. We have made it our task to do this without calling into use what is sometimes called higher mathematics. It goes without saying, therefore, that only the contours of econometrics could be indicated. We have only gone very briefly into the most important investigations: insofar as possible only the principle has been discussed in every instance, together with the most important results.

Econometrics as a scientific method is so young that very much remains to be done. Moreover, we are always dependent on the statistical data which will become available.

In the field of long-term reactions, i.e., in the field of the explanation of the trend movement and of structural economic

policy, very little has as yet been undertaken.* Also here, we have a vast unexplored territory for scientific work. That work is not only theoretically important. It may render good service in the search after a better economic policy or even other forms of society. It should, above all, not be inferred that this type of research only has sense in a "free" society; and that it is not necessary in a more or less "planned" economy. Also in a "planned" economy many reactions remain which are entirely or partly free, and the particulars of which should be known for an adequate influencing of the course of events. Measurement will always remain a useful activity if applied with intelligence and without bias. The comparison with what happens in a "free" economy may also be useful. Econometric methods may render many services in this field.

* Some important considerations can be found in Kalecki: "Essays in the Theory of Economic Fluctuations," London 1939.