THE LOCATIONAL DECISION FROM THE POINT OF VIEW OF THE INDIVIDUAL COMPANY[1]

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1. BACKGROUND OF THIS STUDY: A PREVIOUS INVESTIGATION

During 1954 through 1956 the author was working on an investigation of the location of industries. The investigation was so designed that its results could be usable in regional planning. The first stage in regional planning is to draw up broad, general plans, usually based on investigations of conditions in the area concerned. The planners study the character of the land, the various communications (access to harbours, railways or different types of road), the supply of various grades of labor and the composition of the population with regard to age and sex. They then investigate what type of industrial enterprise might be attracted into the area by the existing conditions. In view of this method of approach, it seemed that some information about industry's locational requirements could be valuable to planners at several stages in their work, for instance in deciding which conditions to study in a particular area and in making a first rough selection of the type of enterprise which might be relevant. It was hoped that the investigation would provide a qualitative and in some cases a quantitative specification of some of the locational requirements of enterprises in different industries, for instance regarding building sites, transportation etc.

If the information were used as suggested here, it would constitute an important part of a forecast about the type of enterprise which will be located to a particular area. It should therefore be hedged about with strong reservations. The reservations can be divided into three groups:

(a) In a study of this type it is never possible to foresee the amount of location that is likely in the future. To understand the extent of the difficulties involved, we need only remind ourselves how closely industrial location is connected with, among other things, the birth and death of companies, with expansion and contraction or with the creation of new branches or mergers in different industries. During the 1960's the development of the European markets has become an increasingly important factor. To obtain some idea of the extent of future location, expected developments in these markets will also have to be analyzed.

(b) As a rule a company which is seeking possible areas for location, is faced with several alternatives. An area fulfilling certain minimum requirements thus usually represents only one among many possibilities. The final choice will depend on a number of conditions, e.g. how satisfactorily the different areas fulfil the various requirements. Or if none of the areas concerned fulfil all the conditions completely, the relative importance of the different requirements will have to be considered.

(c) Since the investigation would be concerned with the requirements of existing establishments, a number of reservations of a more special kind would also be necessary. The requirements which a particular existing company makes upon its present location may be in part a result of the considerations mentioned in (b) above. It is also reasonable to suppose that the importance of different factors varies with time as a result of developments in technology, markets, price trends etc. Furthermore we have to remember that presumably in many respects, e.g. with regard to type of production, sales and investment policy, existing companies have continuously accommodated to local conditions regarding labor, wage structure, transportation etc. It is therefore difficult to derive a company's locational requirements from a study of its subsequent utilization of land, trans-

portation, labor and similar factors, long after the location was originally chosen. It would of course be even more problematical to draw conclusions from condensed data for a group of companies.

The outline of an investigation of this type was discussed with a group of regional planners. They were informed of the results that could be expected and of the strong reservations which would have to be made. They showed only slight interest, claiming that, in view of the reservations, application would be limited. The study was abandoned.

Nevertheless the geographical location of economic activity continues to be a much discussed problem. It is studied in many different contexts and from various viewpoints. The reservations which were cited in connection with the above-mentioned investigation are, however, applicable to other studies of industrial location, albeit in varying degrees. It therefore seems essential that these reservations should be examined and defined more precisely and, if possible, that the study of the location problem should be developed so as to include them.

2. THE GENERAL PURPOSE AND PLAN OF THIS STUDY

Since it is difficult to make a complete prediction of the behavior of companies, the design and direction of our investigation have been changed. In this paper we adopt the viewpoint of the individual company as our frame of reference in considering the locational problem. This means that we will study an individual company's choice between alternative locations. As location is usually related to investment, the study will also be concerned with a company's choice between alternative investments.

As a first step in studying a company's choice between locations we might examine ways of incorporating the various factors (which can vary from place to place) into the company's investment calculations. By using this approach we hope particularly to be able to provide a means of shedding some light on the relative importance of different location factors.

Although it is far from certain that the companies use the methods discussed or, if they do, that they base their decision only on such calculations, an examination of the methods might nevertheless provide some insight into the possibilities open to them and thus be of some help in the construction of models of their behavior. A study of the present kind should also be valuable as a base for empirical investigations. These pages can thus be seen as a supplement to investigations of the type mentioned earlier in connection with regional planning, and to more general works concerned with descriptions or explanations of the spatial distribution of industry.

Our interest in providing a link with empirical studies has also influenced our choice of the methods of calculation[1] to be discussed here. Instead of trying to obtain a simultaneous solution of the company's production planning and investment problems, we decided to link together calculi for product mix and investments. In the case of product mix the calculus is based on linear relations only.

The most decisive reason for this is the difficulty of obtaining data. In general the calculations fulfil two functions: to constitute one stage in a prediction of the consequences of certain actions and to provide a base for the preference ordering of these consequences. If the calculation is to be used at all as part of a prediction in an actual situation, it is of course necessary that data be available. It therefore seems just as desirable to examine some aspects of the data used in these simple calculations as it is to try to apply more refined calculi to the locational problem. For this reason much of the following discussion will be concerned with the application of these calculi to the locational decision of an individual company. A list of the works which have most influenced the writer in the areas concerned is supplied at the end of the paper.

We have arranged our material in five parts. First we present a general discussion of the locational problem from the point of view of the individual company. Throughout we attach great importance to the consideration of the total situation by a company involved in

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[1] Following Törnebohm (1957) p. 119, we distinguish between a particular calculation and the methods or rules governing the calculation. The rules of calculation will be designated by the term *calculus*.

a locational decision. With this in mind we have extended somewhat the concept of location and the definition of the company which are usual in studies of this kind. We next make brief mention of some of the location factors presented in the literature. In the third and fourth sections we construct a calculus intended to provide a possible basis for a company's locational decision. It is based on the points put forward in the previous sections. We have in particular taken into account the long-term nature of the locational decision and the company's chances of accommodating to changing conditions in the areas concerned. The fifth section contains a discussion of some other possible uses for the calculus and some suggestions for supplementing the theoretical study by empirical investigations. In this context it might be worth noting that the situation of a company involved in a locational decision seems to provide suitable experimental material, or perhaps we should say study material, for other investigations e.g. of the process of accommodation to changes in the relative prices of the production factors.

3. THE LOCATIONAL PROBLEM FROM THE POINT OF VIEW OF AN INDUSTRIAL COMPANY

What are the Characteristics of a Locational Problem?

Previous studies of the location of economic activity have had many different points of departure and many different purposes in view. As a result the concept of location and locational problem have been assigned more than one meaning. In geographical or economic studies, for example, the purpose is often to describe, explain and predict the spatial distribution of industry. An important part of such studies is concerned with the interplay between various activities, e.g. between the extraction and the subsequent refinement of raw materials, taking into account the transportation facilities, the raw material supplies, population density etc. It is often assumed that the only given factors are certain economic-geographic conditions, such as the position of the various raw material supplies, the climate, the type of vegetation etc. and, sometimes, the location at a certain time as resulting from historical development. The principle governing models of subsequent

locational developments is that the interplay between factors should be as effective as possible. If the study is concerned with the special problem of industrial plant location, the aim will then be to find the most effective spatial distribution of the various types of production, with the existing raw material supplies, consumer markets and production and transportation facilities. One difficulty here is of course that consumer markets—like the intermediate industrial markets—will to some extent be affected by the location of industry.

In a study of the spatial distribution of production it seems natural to regard each separate production unit as a location unit, regardless of whether several units are part of a common industrial enterprise or not. A change in industrial location may then refer to the establishment, the transfer or the discontinuation of a unit. The locational problem will consist of evaluating the advantages of such actions in view of the alternative locations available. The advantages may be looked at from different points of view and evaluated in accordance with different reference systems, e.g. national, regional or company.

When, as here, the location problem is examined from the point of view of the individual company, it is no longer so natural to count each separate plant as a location unit. An essential feature of a locational problem from the point of view of one company is that differences stemming from the nature of the locality are taken into account as variables when decisions are made about the extent and/or type of operations. Locational decisions are therefore involved every time a change in the extent or type of operations in one or more localities is being considered although there is not necessarily any question of building a new plant or transferring an old one (for example, a retail company considers which of its existing stores to expand, a manufacturing company wishes to start a new line and has to decide which of its plants can best embrace it, etc.). Any choice between such alternatives must take into account the consequences for a larger unit than the individual plant. It is possible that in an economic study of the spatial distribution of industry, there might be some justification in studying single plants in order to focus attention on the locational aspects. But since we intend to incorporate locational decisions of this type into our study, we must extend the location unit

to include at least those plants in a company which will be directly concerned. Moreover a company may be faced, for example, with the alternative of expanding an existing plant or building a new one. To evaluate the consequences of the first of these alternatives, it is often necessary to study many of the circumstances of the existing plant before expansion, e.g. utilization of capacity in various respects and remaining length of life.

A study of locational decisions from the point of view of one company involves a number of new problems. To begin with, there is some difficulty in delimiting the concept of company. Next, in providing a basis for our analysis we have to decide what factors are determined externally (or are perceived as being so determined). The factors determined by outside circumstances will of course be more numerous in an analysis for a single company than in an analysis concerning a whole industry or the whole of the economy. Thirdly, we must remember that a locational decision is part of a series of decisions in which earlier decisions affect later ones in different ways. It is therefore necessary to discuss the position of the locational decision in the decision sequence (e.g., will decisions concerning the volume of production, product design and production methods come before the locational decision or after) and to study how the different decisions affect each other.

Defining the Concept of Company

One demarcation of the concept of company is to be found in the law concerning legal persons, e.g. limited company, trading company etc. However, from our point of view this delimitation suffers from the disadvantages that we discussed above in connection with the too narrow definition of the location unit. After all a locational decision may well be concerned with results throughout a whole industrial group consisting of several legal persons (i.e. different operational units, geographically separate but interdependent, and formally run as separate companies).

This objection serves to highlight a unit which, in our opinion, is essential to the definition, namely the group of plants which are taken into consideration in an appreciation of the effects of the loca-

tional decision. We could thus provisionally define the company as
the decision unit within which the locational decision is made.[1] A
disadvantage of this definition is that the limits of the company will
vary with the source of decision-making; in other words the lines of
demarcation will depend on the extent to which a particular organiza-
tion is centralized. As a result, two other conditions will be linked with
the delimitation of the company, i.e. the externally determined factors
and the position of the locational decision in the decision sequence.
The definition of the company—the decision unit—will be further
specified by these two conditions.

Rough Classification of Locational Decisions

When locational decisions are placed in a broader framework—as
part of decisions concerning the extent (volume) and type of opera-
tions in different localities—they can no longer necessarily be re-
garded as the key decisions. And even if a locational decision is re-
garded as of primary importance, it cannot be handled without taking
into account any other decisions which may be affected by it in the
future.

We now need a basis on which to study the position of the loca-
tional decisions in the sequence of decisions concerning the extent of
operations. With this end in view, we will collate changes in the
volume of operations with changes in the number of plants. For the
sake of simplicity we limit the possible changes in both cases to three
(increase, no change and decrease), thus obtaining nine groups of
locational decision (see Table 1). It is reasonable to suppose that any
decisions about investment policy, choice of product, production
methods etc. which follow a particular locational decision in an ex-
panding company will deviate from the corresponding decisions in a
stationary or declining company. Similarly we can suppose that the
assumptions on which the decision is based will vary in accordance
with the expected development of the volume of operations. It can

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[1] Cf. Carlson (1939) p. 2. Carlson defines a company as the unit over which
an entrepreneur has financial control. Cf. also Carlson (1945) pp. 10–12, where
a company is defined as the unit in which pricing is independent of any markets
and an independent planned economy obtains.

also be expected that dispersion and concentration are the results of different backgrounds and serve different purposes.

In our definition of a location problem we included decisions concerning changes in the type of operations in different localities. At least some of these decisions can be included in the nine groups shown in Table 1. We may ask ourselves whether the type of operations should be taken into account as a separate classification base; the answer depends on whether the surrounding decisions would be different if the primary decision concerned the type of operations instead of their volume. This question cannot be solved without empirical studies of several circumstances, including the time sequence of decisions. But it serves to show that the specification of locational decisions suggested here is hardly to be regarded as final. Since Table 1 nevertheless provides a more detailed basis than is usual for the discussion of locational decisions we will content ourselves with the help it provides. First we need illustrations of the nine groups of locational decision.

Table 1. Nine groups of locational decision.

| Volume of operations | No. of plants | | |
	Dispersion of operations	No change	Concentration of operations
Increase	I	II	III
No change	IV	V	VI
Decrease	VII	VIII	IX

An increase in the volume of operations can be related to a dispersion of operations, e.g. a subsidiary is established or a new branch of operations started in a new locality. Locational decisions connected with the establishment of a new company can be included in this group. An increase in the volume of operations may also occur without any change in the number of (geographically separate) plants, if one or more of the existing plants is expanded. A decision of this type will be preceded by questions such as: Which plant(s) are to be expanded? Shall we expand an existing plant or would it be more advantageous to establish a subsidiary? Thirdly, an increase in the volume of opera-

tions may be combined with the discontinuation of certain plants, i.e. if technological development favors large-scale production; or if one company buys up its competitors in order to combine production in larger units. In this case, of course, it is not certain that an expansion of the purchasing company will be accompanied by an increase in the volume of operations for the whole industry. This point demonstrates the importance of having a clearly defined point of departure for every analysis of a locational decision: results vary according to the angle from which a problem is regarded.

In the case of our second category—unchanged volume of operations—it is usual to connect locational decisions with transfers or reductions in the number of plants. However, these circumstances can also be linked with dispersion. A topical problem for many Swedish companies concerns the possible establishment of subsidiaries or affiliates in the EEC countries. To judge by the public debate on this question, these considerations are not necessarily the result of an expansion of the company; they can be interpreted as part of an effort to maintain the existing state of affairs. One difficulty here is of course the time element; new facilities may be intended to provide a base for future expansion. This complication will be discussed in the following pages.

Locational decisions without any change in the volume of operations or in the number of plants occur, for example, when a company transfers various sections of its operations between its (existing) plants. ASEA's decision to concentrate its production of electric motors to Västerås and its mechanical engineering products to Hälsingborg provides an example. Locational decisions were then concerned with how the move should be carried out. Lastly, a company which closes down subsidiaries and removes sectors of operations to its central plants illustrates a concentration combined with an unchanged volume of operations.

It is important to note that stagnating companies can be found in an expanding economy. Faced by a decrease in the volume of operations, a company's decision will probably in the first place be concerned with the choice of maintaining all plants or closing down one or more of them.

The Locational Decision

Any decision about the location of a plant, from the establishment of a new company with one plant to changes in a large group with many plants, will always be a long-range decision. The effects of the choice will continue to make themselves felt in various ways for a long time to come. Furthermore the effects may appear at different times according to which alternative is chosen. In most cases the locational decision is of major importance since it involves a relatively large proportion of the company's assets, and because there may be very great differences between the various alternatives. The decision is therefore usually based on a detailed investigation containing attempts to predict and evaluate the effects. In this study we have limited ourselves to the prediction and evaluation of the effects on the company's future payments. Thus we ignore a great many factors which are ordinarily considered of great importance in a locational decision e.g. the supply of schools, theaters etc. in the alternative localities. It is certainly true that the various attractions of alternative districts may indirectly affect a company economically: local drawing power may affect the company's chances of attracting workers and clerical staff, thus influencing its wage structure. We could perhaps reformulate our restriction and say that this study is concerned with all payments which are more directly related to the locational decision. As will be seen in the following pages, considerable difficulties will still arise despite this simplification, one of the greatest being to appreciate the effect of the locational decision on future decisions. How, for instance, will differences in wage level between two localities affect the formulation of future investment policy? And how will this policy influence the choice of products and pricing? It should perhaps be noted here that the predictions have to be based on assumptions concerning the future actions of the company.

Unfortunately we know very little about the effect of particular locational decisions on future courses of action. And how do the companies themselves perceive the future significance of their decisions? In view of the uncertainty on these points, we cannot at present construct complete models for predicting the cash flows related to the

different locational alternatives. Instead we will first examine the
prediction in its various shapes as dictated by the external factors
assumed and, secondly, the ways in which different decisions are
interrelated. Since there is a close connection between the choice o
assumptions and the type of calculus which is used, we can procee
from a study of some different calculi in connection with variou
locational alternatives. Before embarking on the main discussion w
will make a brief survey of external factors and of possible interrela
tionships.

In the literature of industrial plant location,[1] the concept of loca
tion factors holds a predominant position. These factors include al
the relevant conditions which differ in the alternative localities. I
seems that the most important—judging by frequent mention in the
literature—are raw material supplies, transport facilities (harbour
railway station etc. and the distances involved), supply of labor
wage level, supply of industrial building land, price of land, buildin
costs and markets. In addition there are several factors, for exampl
water supply and sewage system, which are important to certai
types of industrial enterprise. Most writers assume that a compan
wishing to evaluate the relevant alternatives will introduce as externa
factors in an analysis those conditions which affect their operation
and which differ in the alternative localities.

However, given our present approach to the problem, it is clea
that other external factors, which are common to several possibl
localities, can affect the locational decision. Lundberg (1960), fo
instance, discusses the importance of the rate of interest for the choic
between water and steam power stations. A high rate of interest act
in favor of steam power and a low one in favor of water. The tw
types of power plant will require quite different types of locatio
Even if the rate of interest is ultimately determined within the com
pany, it will be affected by a number of factors outside the contr
of the individual enterprise. Another factor which is quite beyon
the control of the company and which would also affect the choic
of power plant, is the market price for oil. Admittedly in this extrem
case the rate of interest and the price of the raw material are actin

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[1] See e.g. Hoover (1948), Holm (1951), Greenhut (1956).

on the locational decision through the medium of the two quite different production methods. But it is not unusual to find differences in production methods resulting from external circumstances, e.g. different wage levels. There is therefore good reason to include in the analysis certain factors which cannot be influenced by the individual company, although they are common to various locational alternatives.

This brings us to the question of the interdependence of decisions. It is possible to distinguish two main groups of decisions which can be related to locational decisions: (a) those concerning the company as a whole, e.g. overall location structure and overall investment policy and (b) decisions concerning conditions in the branch of operations under consideration, e.g. choice of product mix, methods of production and selling prices. As we mentioned above, the position of the locational decisions in the decision sequence will be of great importance. It must be remembered, however, that once a plant has been assigned to a particular locality, reports of operations there will provide part of the basis on which future action will be decided. This means that a review of earlier decisions may have to accompany the final locational decision. For example, it may not have been taken into account in the preliminary deliberations that, other things being equal, investment in efficiency improvement would be more profitable in combination with a high wage level than with a low one. It might, for example, prove advantageous to establish a plant in a locality with a high wage level if part of the company's investment reserves are earmarked for measures of efficiency improvement which would lead to a decrease in labor requirements.

The immediate decision—the locational decision—concerns as a rule an investment in plant(s) or equipment in one of at least two alternative localities. To put it in very general terms, the choice between two (or more) locational alternatives can be seen as the choice between two investment projects, each with their own prerequisities and consequences. We can therefore conveniently start from the customary method of estimating and evaluating investment projects and afterwards examine how some of the assumptions mentioned above can be included.

4. LOCATION FACTORS

As we have already indicated the various location factors hold a position of primary importance in the general literature of location. It is often the aim of writers in this field to provide a basis for classifying industry according to the factors which are regarded as being of primary, secondary, etc. importance in the choice of location. The well known phrases "an industry which is raw-material oriented, transportation oriented, labor oriented, market oriented" owe their origin to this way of looking at certain production factors. We can see immediately that the approach is similar to that used in the study of the locational requirements of industries mentioned above (cf. pp. 47–49). The objections raised there can also be levelled at any discussion of the location problem which bases itself on the location factors. In this context it is important to note once again that the analytical method chosen will partly decide what are to be regarded as location factors in each particular case (cf. our discussion of the rate of interest pp. 58 f. above).

We have already stated that the location factors will be included among the external circumstances forming the basis of the calculi of a company. In view of this they are best studied together with the calculi since the analytical method will also affect how a particular circumstance influences decisions. If, for example, the ordinary square root formula is used to determine the size of the inventory, such differences in transportation costs as can be referred to the fixed costs for delivery, will affect the inventory. If, instead, a model is used which includes shortage costs, then delivery times, and transportation times too, will become location factors.

Since the question of how particular location factors vary from locality to locality is discussed in detail in the literature, we will content ourselves here with a few comments.

It seems likely that what we could call personal factors are of very great importance, particularly for small companies: people who start companies seem to a very great extent to be attached to their own locality. This may be because it is easier for them to obtain capital and other types of help there or it may be simply from

personal preference. In any case it seems to be very difficult to get any general statements on this type of factor.

A study, based on an earlier draft of this report, has recently been made regarding the significance of the market as a location factor. From a study of micro-economic literature, the writers draw some general conclusions about the influence of other location factors on the company's overall evaluation of the market. Apart from this, their main conclusion to date seems to be that the way is wide open for further research.

It may not always be easy to measure the locational variations in other factors either. For instance, if we try to measure the level of wages in different localities, a complication arises in that location to a particular area can influence the very value that we are hoping to measure. There have been clear examples of this in the American south. Attracted by the lower wage level, industries have moved in; soon afterwards the wage level has risen, although maybe not to the level enjoyed by companies in the same branch located in the industrial north.

Transportation costs—another factor which is generally considered important—has recently been the subject of a penetrating study.[1] The author presents a method of estimating on electronic computers the transportation costs of a plant (for raw materials and finished goods), given alternative locations. He supplements this with a number of estimates for some typical cases. We need only mention here that, to judge from these estimates, transportation costs would be likely to limit the choice of locational alternatives to any noticeable degree in a few types of industry only. The results of the report thus seem to justify the point of departure that we chose for the present study: that in any study of locational decisions, the interplay between a number of factors must be taken into account.

In conclusion we would like to point out that no mention of game theory has so far been made in this paper, despite the fact that a company may well choose a location in order to hinder a competitor. While acknowledging the importance of game theory in this context,

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[1] Törnqvist (1963).

we feel that the type of investigation presented in this study must come first. After that, game theory too might be fruitfully applied.

5. INVESTMENT CALCULI AS THE BASIS FOR LOCATIONAL DECISIONS

In this section we will apply to locational decisions the customary method of evaluating the advantages of an investment project, i.e. of making an investment calculation. Our point of view is still that of the individual company. One of our main purposes is to throw some light on the relation between different decisions (cf. section 3 above) and to show how the time sequence of the decisions can influence the formulation of the calculus and the result of the calculation.

Some Comments on the Structure of an Investment Calculus

We have already mentioned that the basis for decisions of this nature consists most often of detailed investigations containing attempts to predict and evaluate the consequences. The investment calculation constitutes an important part of this basic investigation. The prediction and preference ordering (evaluation) are so intimately linked together in this calculus that the two functions are difficult to distinguish.

In order to illustrate the twofold function we will try to separate the following elements:

(i) a down payment (capital outlay),
(ii) current receipts (inpayments),
(iii) current disbursements (outpayments),
(iv) the period covered by the investment calculus; this period is divided into a number of subperiods,
(v) length of the subperiods, and
(vi) rate of interest.

When all the elements (i)–(vi) have been specified, it is possible to estimate the present value and the final value etc. of the investment.

If, to begin with, we simply assume that the down payment consists of a bank deposit, that no current payments take place, that the

deposit is made at the beginning of a period, that the period corresponds to the bank's interest term (i.e. six months or, more usually nowadays, one calendar year) and that the interest rate is that for bank deposits, the final value after a number of periods will agree with the credit balance at the same point in time. In other words the final value can be used as a *prediction* of the future size of the credit balance. Changes in interest and current payments in the shape of deposits and withdrawals may complicate the calculations but they will not affect the use of the final value as a prediction, provided that the changes in interest, the size of the payments and the times when they take place have been correctly forecast. If the final value is to provide a meaningful prediction it must of course be determined in a way that matches the growth of a credit balance i.e. the interest that accrues during a certain period is added to the capital at the end of the period and is included in the computation of interest for the next period.

The investments which interest us, however, are of quite another type. For example we can take the acquisition of a machine, where the down payment consists of all the payments connected with the purchase and installation (the acquisition cost). There is in itself nothing to prevent us from following the same procedure here, i.e. computing a compound amount which can be used as a prediction of the future size of the cash funds. However, for various reasons this is not done for investments of this type. Chief among these reasons is of course the fact that payments arise as a result of utilizing the machine, e.g. through the sale of products manufactured by the machine, the employment of labor to run it and the acquisition of the necessary raw materials, oil coolant etc. It is therefore felt that a particular rate of interest cannot supply a satisfactory prediction of the future growth of the cash funds. Instead it is usual to make independent estimates, apart from the investment calculation, predicting the current payments which can be directly related to the acquisition cost. The part played by the investment calculation in the prediction is therefore limited to the growth of the gross surplus as estimated independently (i.e. receipts less disbursements or, in an investment for cost-saving purposes, the reduction in disbursements).

All this may perhaps help to explain why the part played by the investment calculus in the prediction of the consequences of a particular investment has often been overshadowed by its other function, namely to provide a basis for the preference ordering of given series of payments. There is, moreover, a great need for aids in this preference ordering. The difficulties are many. Very often one or more investment projects has to be selected from among a great number of possibilities. The size of the down payment (acquisition cost) as well as the allocation in time of the gross surplus can vary considerably from one project to the other. The various possibilities do not necessarily reveal themselves at the same time and a choice made at a particular moment has to take into account future plans which cannot yet be specified. Thus any aid to the preference ordering will have to fulfil certain important desiderata: the projects must be made comparable with respect to the distribution of payments in time; it must be possible to make the comparison on the basis of one measure for each project; and a comparison between a few projects must suffice. The first of these desiderata could be satisfied by making an estimate of the final value of the current gross surplus, with a rate of interest determined in the light of the expected development of the gross surplus. However, this estimate would provide two values: a down payment and a final value for the gross surplus. These two values can be reduced to one either (i) by finding the final value of the initial down payment and subtracting it from the final value of the gross surplus or (ii) by discounting the final value of the gross surplus to the time the original down payment was made which gives us the present value of the gross surplus. We then subtract the down payment from the present value. By this operation we obtain the *capital value of the investment,* either (i) at the close of the investment period or (ii) at the time when the investment was made. In this way the capital value of the investment will express the difference in the growth of the company's means of payment according to whether a sum corresponding to the original capital outlay accumulates at the rate of interest or whether the sum shows a yield in accordance with the gross surplus obtained by means of independent estimates and this in turn accumulates at the rate of interest.

If the rate of interest has been determined according to the expected development of the gross surplus, it is not necessarily possible to use it in a prediction of the development of a sum corresponding to the original capital outlay in an alternative project. Some idea of the size of the latter development can be obtained with the help of the internal rate of interest[1] for an alternative investment. It is therefore often suggested that the rate of interest be based on the internal rate in the best of the alternative projects which at this point have been rejected. A positive capital value for the investment under consideration will then immediately indicate that it is more favorable than the alternatives. Introducing a subjective rate of interest of this type into the calculation, means, however, that the accumulation of the gross surplus also will be estimated on the same basis as the growth of the whole initial down payment in the alternative project. It is far from certain that this will provide a reliable prediction.

Before we leave this subject we would like to emphasize once more that our main purpose has been to highlight the difficulties of distinguishing between the two functions of the calculi i.e. as a basis of the prediction of the consequences of the execution of a particular project and as part of the basis for the preference ordering of these consequences. We have not therefore discussed any of the other criteria which are used instead of the capital value in determining the profitability of an investment. Nevertheless, some light is shed at the same time on several other questions of importance to locational decisions, in particular on the relation between different decisions. We will return to this question below.

Evaluating Investments on the Basis of an Investment Calculus

For various reasons an investment calculus usually constitutes a part only of the base for evaluating different locational alternatives. In its usual shape the calculation includes only those consequences

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[1] The internal rate of interest (or return) of an investment is usually defined as the rate of interest at which the present value of all receipts is the same as the present value of all disbursements.

which can be measured in receipts and disbursements, while many other consequences, that cannot be exactly measured, such as increases in goodwill or industrial safety must be left out. There are also difficulties with regard to the time span: it is difficult to make a prediction (independent or included in the calculation) of payments which will take place a long time ahead. Moreover, although payments are considered in the calculus, it is really only the overall profitability of the whole series of payments which is taken into account. It may sometimes be necessary to check that at any one moment the company has the means of payment available to meet its obligations, i.e. that its liquid assets are the whole time sufficient.

Our examples may serve to illustrate the necessity of supplementing the decision base. Supplementary investigations could be concerned with the influence of the investment project on the company's liquidity, the reliability of the predictions of future payments or the existence of effects which are difficult to measure in the form of payments. We could also extend the decision base by letting the values of the variables in the calculation vary, thus obtaining critical points at which the preference would switch from one project to another. This technique, known as a sensitivity or parameter analysis, would probably be particularly valuable in the case of the rate of interest with its subjective nature. Other supplementary questions might be concerned with the flexibility of the investment project: for instance, could a machine be used for more than one type of production without extensive alterations; could a plant be easily adapted to take on a different volume of production etc. If we are considering a locational decision, questions such as the following might arise: is it possible to extend existing plants, or to obtain new types of labor (e.g. married women) or to retrain the existing labor force.

While we are aware of all these possible lines of enquiry, we realize that they would necessarily require evaluations based on temporary conditions, varying for each individual case. A detailed illustration would be beyond the bounds that we have set ourselves here. We therefore decided to limit ourselves to a study of the various conditions relating to a company's location which can influence the formulation of the investment calculus.

An Investment Calculus as the Basis for a Locational Decision

According to the approach adopted in this paper, the locational decision is one stage in the evaluation of an investment project. We are considering here investment projects that often constitute major decisions in that they involve a large proportion of the company's plant requirements, particularly, for instance, when alternative locations for the establishment, expansion or retraction of activities are under discussion. The investment project can include subprojects of various types, e.g. procuring building land; constructing buildings for production, storage or administration; acquiring machines, tools and other equipment; laying in stocks of raw materials, finished and semi-finished goods and investing in accounts receivable. We would now like to try to illustrate some of the difficulties that beset investment calculi which have to comprehend projects of such magnitude and subprojects of such variety.

To recapitulate from the earlier part of this section: according to the calculus the calculation contains, among other things, a down payment, current receipts and disbursements for each subperiod (possibly combined into a gross surplus) and a rate of interest. The rate of interest, regardless of how it is determined, will forecast the accumulation of the gross surplus. Since we can assume that the subprojects have different life-spans while the current receipts are probably determined for the whole project, the payments for the continual replacement of obsolete parts must be included in the current disbursements. Otherwise an accumulation corresponding to the rate of interest will be presumed throughout the calculation for these replacements too. If the locational decision concerns the whole company, the gross surplus will furthermore correspond to the company's total profit. In this case the rate of interest employed will express the future accumulation of this profit. We may reasonably suppose that the replacements will correspond in size at least to ordinary machine investments. It is worth noting the difference in treatment of machine investments according to whether they are part of a reinvestment project or whether they are evaluated by means of a separate calculation: in a separate machine investment calculation

the current receipts and disbursements are estimated independently because it is thought that the rate of interest implies too simplified an assumption of the future development of the payments; but when equally large investments appear as reinvestments in a more comprehensive calculation the rate of interest is accepted. To some extent this difference reflects differences in the temporal perspective. The accumulation of the gross surplus is always further removed from the moment of decision than are the expected payments connected with the capital outlay in an independent calculation.

This naturally leads us to consider several related problems: how shall we determine the receipts and disbursements and the rate of interest? How can we decide which parts of the future development are to be estimated in an independent calculation and which by the rate of interest? Before going any further we might mention that it is these very difficulties which necessitate the introduction of some sort of stereotype, e.g. an investment calculus in which the expected direct consequences of the investment are distinguished from consequences relating to the reinvestment of the gross surplus.

We argue the whole time on the assumption that the rate of interest is determined in accordance either with the expected yield from investing the gross surplus or with the yield from investing a sum corresponding to the original capital outlay in an alternative project. The main idea behind this argument is that the company has at its command a given amount of cash to allocate in the most favorable way, and that the total number of projects would require greater resources than exist. We also suppose that the yield from the completed projects would be greater than the financing costs. Otherwise it would have been more advantageous to refrain, thus decreasing the company's debts or equity. These assumptions are probably reasonable in an evaluation of relatively small investments, in which the receipts and disbursements are estimated more or less on the fringe of the company's activities (i.e. in a kind of marginal analysis). Whether it is equally reasonable to make these assumptions in the case of such important investments as those involved in locational decisions is quite another matter. Furthermore there may be items contained in these big investments which influence the type of financing—for in-

stance it may be possible in such circumstances to obtain a mortgage on some property. When the rate of interest is determined in accordance with the cost of financing, it will agree with the expected yield of the new investment of the gross surplus in so far as the new investment constitutes repayment of loans. In this light the difficulties arising from the size of the investment seem somewhat less formidable.

The situation is further simplified by the fact that we evaluate the differences between two locational alternatives only. This evaluation will be a variant of the type discussed above, differing chiefly in that it can answer the question: which of two locational alternatives is the more favorable? but not the question: shall the investment project, of which they form a part, be carried out? This reduces the compass of the calculus and the number of assumptions necessary, since both the original capital outlay and the current payments are smaller and can be regarded as somewhat marginal.

In conclusion we would simply mention that for our purpose—to illustrate some economic calculi and their formulation, taking into account the interdependence of decisions—there is no particular disadvantage in a calculus where the accumulation of the gross surplus appears only via the rate of interest. We can therefore leave any further discussion of this subject.

6. INDEPENDENT PREDICTIONS OF PAYMENTS

We will now turn to the separate prediction of the series of receipts and disbursements. We have already mentioned how important it is— and how difficult—to distinguish between the accumulation which is considered in the independent prediction and that which is determined by the rate of interest. In the first place we will try to gather into the independent prediction all the payments which are expected to arise from the original capital outlay. To begin with we can distinguish between three groups: (a) the capital outlay, (b) the contribution for each period obtained from sales of each of the company's products and (c) the disbursements in each period for administration etc., which are common for several products and which are not included in the estimate of the contribution. This grouping may need some comment. Group (a) includes not only the disburse-

ments which are made at the time of the original capital outlay, but also the present value of disbursements for the replacement of obsolete equipment and the salvage value at the end of the investment period. In group (b) we have included the total estimated contributions, i.e. sales receipts for a period minus the total separable costs for production units sold. For example, they may include disbursements for raw materials, wages and sales commission. This means that not all disbursements for the period are included in group (b). We have therefore added a further group (c) which will include the current disbursements for, e.g. remuneration of foremen and clerks, insurance premiums, telephone charges, advertizing etc. Groups (b) and (c) represent an attempt to provide some measure of the current payments connected with the running of the plant concerned.

First of all we will present a calculation of the payments in group (b) without taking the time element into consideration. Afterwards we will discuss the prediction of the capital outlay and of group (c) and, finally, try to illustrate how the future development of the total contribution can be dealt with.

Determination of the Contribution from Sales of the Company's Products

We can start from the formulation of a product mix problem. This does not mean that the company necessarily wishes to fix or change its product mix in connection with the locational decisions; but it can be shown that a product mix calculus can be dependent on location. In somewhat more general terms we can say that we are seeking grounds to demonstrate how the decision sequences discussed above in section 3 can influence the formulation of the calculus. The formulation of the product mix will be as follows:[1]

find
$$\max z = \sum_j c_j x_j$$

with the following restrictions:

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[1] In view of the fact that programs exist for the solution of linear programming problems in different data processing machines, we will not discuss methods of solution here. Nor will we examine other formulations of the product mix problem which would be possible with different methods of mathematical programming.

$$\sum_{j} a_{ij} x_j \leqslant b_i (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n)$$

$$x_j \geqslant 0,$$

where

z = total contribution from all products, which are included in the investment calculus,

c_j = contribution per unit of product j,

x_j = amount (e.g. number of units) of product j per period,

a_{ij} = resource requirements in operation i for each unit of product j (e.g. production time in operation i for each unit of product j),

b_i = available resources per period for operation i (e.g. available production time in operation i).

We must now find specific values for the coefficients a_{ij}, b_i and c_j. But first we would like to observe that, if the product mix is taken as given, the calculus will be reduced to an evaluation of z, given x_j, i.e. to a determination of the value of the coefficients c_j and the quantities of every product x_j. The quantity manufactured and sold will have to be estimated with reference to the size of the demand etc. and the capacity of the plant concerned. Since such estimates are a part of the product mix calculation in the determination of the value of the coefficients b_i, the product mix formulation will contain the simpler estimate as a special case.

Some Uses of the Product Mix Calculus

We indicated above that to solve the product mix problem we need specific values for the coefficients a_{ij}, b_i and c_j. It is also necessary of course that the possible types of product have been specified. This need for specification is at the same time one of the bases for the usefulness of mathematical programming. If we distinguish between products fulfilling the same functions but differing in design or between products sold on different markets, the formulation we suggest can be used to determine product design and market specialization. That such decisions can affect the locational decision is revealed in the following examples:

(a) A company is faced with the choice between two locations which differ as to wage level. At the same time there exist two pos-

sible types of design for one of the company's main products. The two designs, which can be regarded as equivalent from the point of view of the buyer, require different methods of production and different amounts of handling by men and machines. The effect of the wage difference will obviously depend on the choice of product design. The difference in total receipts can be computed from two product mix calculations, one for each of the alternative locations, in which the two designs are treated as separate product types. It is important to note that the differences between the product programs in the two alternatives may well apply to several types of product and are thus not necessarily limited to these designs. In this case, however, a further evaluation can be made. In transferring to a design which requires more machine handling, is it profitable to extend machine capacity? As a basis for this evaluation a product mix calculation can be applied to each alternative, incorporating the possible increase in capacity (i.e. the greater value of the relevant coefficient(s) b_i). The evaluation will then have to be extended to include the investment calculation, since the down payment has been changed. One of the alternatives "capacity-increase" or "no-capacity-increase"—whichever provides, for instance, the highest capital value—is applied to each of the locations, and these are then compared.

(b) A company has to choose between expanding its plants in Sweden or establishing a new plant in one of the EEC countries. An important factor in the choice of location in this case will be the effect of customs duties. If the company assumes that the selling price and the sales potential within the EEC area are independent of the location of production,[1] they can obtain some idea of the differences in total contributions for the two alternatives by defining sales to EEC and sales within Sweden as different product types. Differences in customs duties (including transportation costs etc.) will appear in the product mix calculation as differences in the contribution per product (i.e. coefficients c_j). In this case the significance of the product mix calculus does not lie only in the fact that the company can compare the profitability of EEC sales in the two alternatives.

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[1] These assumptions are not essential. They can be replaced by specific values for the selling price and the sales potential.

Perhaps more importantly, the calculation can also show that the allocation between sales on the home market and to the EEC countries can depend on the location.

These two examples should also have shown that the choice of product in its more usual sense can affect a locational decision. We will therefore turn now to the determination of the value of the coefficients a_{ij}, b_i and c_j. In the case of the coefficients a_{ij} and b_i we will also try to show how various problems can be considered by the introduction of various restrictions.

Determining the Coefficients a_{ij} and b_i

Any estimate of the amount of resources available and the resource requirements of the different product types will be closely related to the design of the plants concerned. Since the aim of the product mix calculation is to discover how the available resources can be utilized so that the total contribution, z, will be as large as possible, we need consider only such resources as might be scarce in the case of a particular combination of product types. The diversified usefulness of the product mix calculus is already obvious in the determination of resources to be incorporated in it. The different markets can, as we illustrated above, play a part in the locational decisions. If it is considered that sales potential in one or more of the company's markets is limited, the size of the market concerned can be introduced as a restriction. The geographical distribution of the raw material supplies, can be treated similarly. For example, we can assume that the price of raw materials varies according to the conditions of procurement etc. at the sources of supply, and that transport costs for raw materials from the same source to different locations will also vary. Thus the contribution per unit of a particular product type, c_j, will depend partly on which source of raw materials is used. Provided that the supply of raw materials from each source is sufficient for the volume of production possible for that type of product, the company will simply have to determine the best source of raw materials for each locational alternative and use the resulting raw material price in the estimate of the contribution per unit. If raw material requirements

exceed the possible supplies from the best source, it will be necessary to define the products manufactured from raw materials from the next most favorable source as a special product type with a lower contribution per unit and then to introduce raw material supplies from the best source as one of the restrictions, b_i. Whether the company will then use more than one source of raw materials will depend among other things on what other resources are required by the relevant product types and on the resource requirements and the contributions of other product types.

As regards resource requirements in the various operations for each unit of the different product types, i.e. the coefficients a_{ij}, writers usually indicate a number of conditions which accompany a linear programming approach, e.g. it is assumed that the value of a particular coefficient does not depend on the number of units of one product type which undergo the operation. This means among other things that setting-up times are not taken into consideration.

Instead of discussing questions of this kind which are common to all product mix calculi, we are going to try to exemplify here some problems which may be of interest to the locational decisions.

We illustrated above how wage differences between locational alternatives can be incorporated into a product mix calculation. It is often claimed moreover that the labor and the degree of skill available can vary between different locational alternatives. We note in the first place that labor shortage is implicitly included in certain of the restrictions already discussed, particularly in the restrictions regarding capital resources. It is clear, for example, that a limitation in the number of machine hours available will also apply to the number of working hours in the relevant engineering departments. In itself, however, a shortage of labor can mean that further restrictions, b_i, can be introduced for departments which require relatively small investments, e.g. assembly departments, and that the company will to some extent have to use other means in adapting to conditions in the relevant locality. For instance, with a fixed supply of labor, the company cannot increase production by increasing the number of machine hours available. Instead it will have to increase the capacity of the plant by raising production per working hour or, in other

words, by reducing the resource requirements per unit produced (a decrease in the value of some of the coefficients a_{ij}). This may be done by a change-over to machines requiring less labor (possibly preceded by a change in product design), by investments in efficiency improvement etc. or by other similar methods.

Differences in the skill of the labor force in the alternative localities is often exemplified as follows: the labor force in one area with industrial traditions is accustomed to industrial work, perhaps even of a particular kind, while the workers in areas without this tradition are not. We are not going to discuss here whether in fact such differences exist at all nor whether they exist between the actual alternatives under consideration. If they do exist, they can be expressed in the calculation as differences between the values of certain coefficients a_{ij} in the alternative locations. Here, too, it may be a question of trying to influence certain of the coefficients a_{ij}, although the methods employed may be somewhat different.

The measures of accommodation outlined here, intended to alter resource requirements, are very similar to the substitution of factors as discussed in classical production theory.[1]

But, in the present context, we have to ask ourselves whether it is reasonable that such measures be considered in connection with a locational decision. In certain situations they might even involve the company in alternative plans for plant design for each of the alternative locations. Since the planning and designing of a plant can also be regarded as an investment with certain profitability requirements to fulfil, and since the yield from such an investment is very difficult to forecast, a point will soon be reached where certain decisions concerning the design of the plant will have to be made independently of

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[1] One important deviation from classical production theory must be noted. If we assume our present formulation of the overall evaluation, a measure of accommodation requiring capital, cannot be undertaken until the increase in the total receipts, z, has been compared in an investment calculation with the increased capital input. The overall evaluation which we are discussing here should therefore be linked to a combination of production theory and capital theory. For other ways of incorporating short-term estimates into long-term evaluations the reader is referred to Lindbeck (1963) pp. 66–98 and to the references there indicated.

the location. Thus, once more, we have come up against the im
portance of the time sequence of the decisions.

Estimating Contributions per Unit

Contributions per unit of a product type, c_j, are estimated by sub
tracting the separable costs for the unit from the selling price. Thi
is done regularly and as a matter of routine using data from pric
lists, accounts and budgets. In the case of a prediction as basis for
locational decision, it is less usual that such data is available. Bot
the selling price and the expenses included in the separable costs mus
themselves be based on predictions. In the following pages we wi
illustrate some of the expenses which may be of importance to th
locational decision.

When the product mix calculus has been formulated with the ai
of linear programming, receipts per unit of a product type are dea
with as though they were independent of the manufacture and sellin
of the product. This conflicts with experience and with economi
theory. There now exist other forms of mathematical programmin
in which the relation between, for example, selling price and sale
volume can be taken into account. It is also possible to include suc
relations to some extent within the bounds of linear programming
we define one product, sold at several prices, as several product type
(one type for each price). We would then have to introduce restri
tions, b_i, to express possible sales at each price level. In this cas
however, we would be forced to make a prediction of the future sellin
price and the possible sales at that price.

Several writers have studied the shifting of a company's deman
curve as a result of variations in transportation costs between th
company and the market. They assume that the purchaser pays fo
the transport and that the total price he has to pay is decisive fo
his making the purchase. If such an analysis is to be applicable to
company choosing between alternative locations, it must be furth
assumed that the purchaser is the same regardless of location.
several sellers supply several purchasers, however, a simple analysi
e.g. with the aid of the special linear program for the transportatic
problem, shows that if one seller is removed, then some accommod

tion will be possible between the remaining sellers and the purchasers. The total increase in transportation costs will be less than if the ex-seller was still delivering to his old customers. Thus a company obtains some idea of the relative competitive situations in the alternative localities. At the same time it is obvious that many other considerations must be included if we are to have an adequate basis for determining the selling price and the possible volume of sales. Here we can only point to the implications of the competitive situation: Is it monopolistic? Is it oligopolistic? Is the company able to influence product design (cf. above)? Nor should we forget that other differences in costs between the alternative locations will also affect the company's pricing policy.

Among the separable costs per unit of a particular product type, raw materials and wages are of particular importance. When there are locational variations in the acquisition cost (i.e. raw material price + transport + handling costs) of a certain raw material, an analysis of the type mentioned above in connection with the transportation problem can provide some guidance. This time, however, we must remember that it may be possible to change not only supplier but also raw material. Such a possibility is intimately related to innumerable decisions regarding e.g. product design and production techniques, and so we are yet again faced with the problem of the order of events in the decision sequence.

The differences in labor force between alternative locations will probably all be expressed in wages per unit manufactured. Their development and relative importance will, however, depend entirely on the measures of accommodation which are taken. The estimate of wages will therefore have to be made together with the estimate of the coefficients a_{ij} and b_i, and be based on the technical structure of production.

Estimating the Size of the Initial Down Payment

Under this heading we include the remainder of the payments which will be subjected to independent predictions. These will include, apart from the initial down payment, disbursements for the replacement of obsolete equipment, the salvage value at the end of the investment

period and any current disbursements which are not included in the total contributions.

The size of the initial down payment can be influenced by a great number of factors, of which we have already mentioned some connected with the composition of the machines and equipment. Otherwise it is differences in the price of land and building costs in the different localities that usually attract the greatest interest in connection with the locational decisions. Here again the question arises of the company's ability to accommodate. But now there is reason to consider economic factors as well. For example, will differences in the price of land influence the size of the site? Will differences in the total disbursements for land affect the size of the other sums in the initial down payment, e.g. the amount of machines and equipment. Of course there is some reflection of the company's economic situation in the rate of interest but, since this must serve many other purposes also, it is probably too arbitrary a measure to be the sole base for a decision in such questions. Instead, the company's chances of raising loans in the different localities will have to be investigated, also the technical possibilities of varying the plant design and, where it is relevant, investment needs in other parts of the company.

The determination of payments for the replacement of obsolete equipment, like the determination of the salvage value, is linked with the length of the investment period. In any case these values will probably lie so far off in time that an exact prediction will be impossible and we will have to content ourselves with some simpler type of forecast. In the case of disbursements for the acquisition of replacements there will be the added difficulty of deciding whether, in the economic sense, it is a question of a reinvestment or a new investment.

As examples of current disbursements which are not included in the total contributions we have previously mentioned the remuneration of foremen and clerks, advertizing expenses etc. It is difficult to make any general statement as to whether these payments can vary to any great extent from location to location. On the other hand it is often observed that a company's disbursements for certain indirect forms of remuneration, such as staff housing, recreational facilities,

staff dining-room etc. can vary from locality to locality. In so far as payments for such purposes exist, and are not regarded as investments, they will be included, as are payments for staff training, in this group.

Development of Contributions over a Period of Time

We have already discussed ways of determining the total contributions for one of the subperiods covered by the investment calculation. The simplest way of completing the calculation—and a way which is in fact used—is to take this as a prediction for all the subperiods. However, since several changes can be expected during the investment period, this method is rather unsatisfactory. There has been some discussion in the literature about the possibility of allowing for various changes in the prediction. We will content ourselves here with a glance at some of the observations which are of special interest to our subject.

To begin with it is clear that we are interested here in the relative transposition of factors, rather than in absolute changes (e.g. in the value of money) affecting all payments in every period.[1] As an illustration we can cite the example already mentioned above: wages in a geographical area with a low wage level may rise as a result of location in that area. We assume a company that has to choose between two locations with, among other things, different levels of wages; the company expects that the wage level which is initially low will rise more than the higher one; with given plant design and given production techniques, i.e. given values for the coefficients a_{ij} and b_i, it is possible to calculate the change in, first, contributions per unit manufactured, c_j and secondly, with the aid of the product mix calculus, the total contributions, z.

An estimate of this type raises many questions. Is a more or less continuous change in the type of production compatible with the company's policy? If not, which wage level shall be used in determin-

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[1] This does not mean that there is no interest in studying the effects of change in the value of money on different payments in an investment process (e.g. tax payments). However, the subject belongs in the wider field of investment calculi.

ing the type of production? Moreover, it has to be remembered that once plant design and production techniques are fixed, it is going to be less easy to accommodate to external circumstances. Future developments have to be taken into account already at the planning stage. We discussed above[1] the example of a combined calculus of product mix and investments as the basis for a comparison between a locality with high wages and a shortage of labor and a locality with lower wages and a larger available labor force. We suggested that total contributions, z, be calculated, given various technological conditions, i.e. with different values for the coefficients a_{ij} and b_i and for the working hours in the separable cost calculations. The different total contributions and their corresponding down payments could then each be incorporated into an investment calculation. We could discover, for each location, which solution gave the highest capital value. The same approach is theoretically possible here, e.g. if we wish to consider the development of wages over a period of time. The main difficulty lies in obtaining the technical data on which the calculations must be based. These data will be needed for each of the periods in which wage differences appear. In practice we would probably have to be satisfied with a few technical solutions—plant design and production technique—and calculate total contributions in all periods for each of these solutions. The total contributions thus obtained would then be incorporated into an investment calculation together with the corresponding down payment.

In the original example there were initial wage differences which were going to be levelled out in the expected course of events. In a case of this kind, it is probable that a calculation paying explicit attention to development over a period of time, such as we illustrated in the paragraph above, will lead to smaller differences in plant design. It might seem desirable to generalize the calculation so as to include the future development of other factors, e.g. raw material supplies, raw material prices, markets and selling prices. However, apart from the difficulties already mentioned, we must also remember the various restrictions that we have introduced. There thus seems

[1] Under the headings "Some Uses of the Product Mix Calculus" and "Determining the Coefficients a_{ij} and b_i".

every reason to limit ourselves to a few comparatively rough calculations, given alternative conditions.

7. STUDIES OF INDUSTRIAL LOCATION: A SUMMARY AND SOME POINTERS FOR EMPIRICAL RESEARCH

Summary

This paper has been intended as the basis for an empirical study of the locational decisions of a number of industrial enterprises. In many ways the possibility of empirical studies has dictated the shape of the present work. It should be possible to relate the essence of our thesis here to company behavior, although the companies concerned may not make any direct use of the calculi that we have presented. This means that we can pose our various questions concerning company behavior in such a way that the answers will serve as a pointer for the further development of calculi and possibly even for the construction of models of company behavior.

From the point of view of the individual company, a locational decision can generally be regarded as one of the steps in a broader decision. In this broader framework it is usually possible to discern decisions concerning the volume or type of activities, e.g. the establishment of a new branch of operations. A number of other decisions will also arise which—whether they are regarded by the company as prior or subsequent to the locational decision—can affect the economic significance to the company of the latter, e.g. decisions about product design, plant design, production techniques, type of raw material, choice of raw material supplier and markets.

The location problem is usually studied in connection with the location of the place for operations. However, if all the above types of decision are to be examined, a different unit will be needed. Unfortunately any attempt to distinguish between decision units involves us in complex problems of demarcation. Provisionally we have chosen the company in its economic sense as the unit to be studied.

How many of these problems will be considered by a company making a locational decision will probably depend on the sequence

of events. A decision made earlier will be included in the frame of reference for the choice of location. For example, a company which has already decided on its volume of production, its product design and its production techniques, will seek the most favorable location, given the values of these variables, e.g. a locality offering the lowest total cost after taking into account transportation charges, supply of labor and level of wages. However, if it is possible for the company to change, for example, its production technique by means of further mechanization, the chosen locality may not necessarily be the most favorable any longer. Another locality with an inferior supply of labor and possibly with a higher wage level but with lower transportation costs may promise lower total costs, given the altered production technique.

In order to provide a base for studying a company's powers of accommodation to varying location factors, we have presented a calculus for use in locational decisions. An essential point here has been the fact that every locational decision has far-reaching, long-term consequences. It is therefore reasonable to regard these decisions as investment decisions and to study them with the aid of an investment calculus. But before an investment calculus can be used, it is necessary to make a separate prediction of the payments which are expected to arise during the relevant period. At this stage the company's powers of accommodation must be taken into account, for instance by formulating a linear programming model of the company's activities and, with its help, estimating the size of the payments for each subperiod. In a linear programming model it is relatively easy to allow for variations in markets (e.g. EEC versus EFTA), product design, type of product etc. by varying the respective coefficients.

Some Fields in which the Calculus can be Applied

Our type of calculus can be used for various purposes. We have regarded the locational decision throughout from the point of view of the individual company and have tried to arrive at the economic significance for the company of the different locational possibilities. One clear purpose of the calculus is thus that it should be an aid to the company in its choice of the most favorable location.

As we mentioned before, in indicating the general purpose of this study, the calculus can also provide some insight into the companies' action alternatives. Thereby it becomes a stage in an explanation (prediction) of the locational decisions of the company. It is not far from this to an attempt to use the calculus as one stage in the construction of a larger model, intended for explanations (predictions) of the spatial extension of the company.

We could mention in passing that a study of locational decisions, embodying a calculus of the present type, might serve to throw some light on the company's opportunities for substitution, e.g. of production factors. Although it is very important to know something of substitution and the possibility of substituting various production factors if we are to determine the effects—in particular the long-term effects—of changes in wages or working hours etc., it is nevertheless extremely difficult to discover the extent of the substitution by making an empirical study of, for example, changes in wages.[1] Perhaps the main reason for this is that substitution requires the replacement of plant and equipment, further investments, revision of production processes, changes in product type etc. and this kind of change really comes under the heading of investment. Because such changes take a great deal of time, because the decision whether to invest—and, if so, when—also depends on alternative investment opportunities, and for other similar reasons, it is probable that there will be a time lag between any major change in wages or working hours and the substitution of production factors thus entailed. In these respects most companies find themselves in a favorable situation when they face a locational decision. Plant and equipment, production methods etc. are still at the planning stage. They can be altered and replaced by plans to suit the locations available. Cost relations between, for example, labor and other production factors in the different localities can be taken into account.

The usefulness of the explanations or predictions drawn from models based on the type of calculus suggested here, will depend in part on the adequacy of the model. To determine the adequacy of a model can be a very extensive business. Here we need only point out

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[1] Cf. Nabseth (1961).

the need for a frequent comparison with empirical observations.[1]
Since models based on the present type of calculus will probably
differ from other models of locational decisions suggested in the
literature, any appreciation of their adequacy will depend to a great
extent on empirical investigation. Added to this, for each of the
purposes indicated the calculus will be used in slightly different ver-
sions of the model. Since we must keep this study within reasonable
limits, we cannot examine this aspect of our subject in full. We will
limit ourselves to a discussion of the use of the calculus (a) as a
managerial aid in the choice of the most favorable location and (b)
as a stage in an explanation (prediction) of the locational decisions
of the individual company.

The Choice of Location

As an aid in choosing the most favorable location, the calculus
provides predictions of the company's economic development for each
locational solution. We have already indicated that it can be used
simultaneously for an evaluation of the different alternatives. It thus
fulfills the dual function that we mentioned above (in particular pp.
63–66 and 68 f.)—to act as one stage in a prediction and as an aid
to preference ordering. This dual characteristic, which we have dis-
cussed only in connection with locational decisions, is probably com-
mon to all investment calculi. Any further study of this aspect of our
subject would thus be outside the bounds of the present article. In-
stead we will look a little more closely at the predictions and discuss
some of the possible ways of testing them.

One problem which always faces any attempt to test a prediction
of the results of several alternatives, is that data is available only
from the alternative which was finally chosen and carried through.
Consequently, in every decision situation the empirical test can com-
prise only part of the prediction. If every alternative were unique
this would imply insuperable problems for the testing of our predic-
tions and thus, our models. A choice between locational alternatives

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[1] For a more complete treatment of the problem of adequacy the reader is
referred to Törnebohm (1957). Cf. also the discussion of the adequacy of a model
in Danielsson (1963) e.g. pp. 96 f.

can be regarded as a choice between possible future flows of activities. Every flow in a series of such flows is presumably unique if the flow is taken as a whole. This means that our choice has to be based on predictions which we have never been able to test. There is therefore every reason to investigate whether or not the flows contain sub-sequences which can be regarded as recurrent or repeatable.[1] The occurrence of such repeatable sub-sequences would mean that parts of the prediction could be based on previously tested predictions. It is important to note that in this study—as in other studies—we assume that some of the sub-sequences arising in connection with a locational decision can be regarded as recurrent, e.g. the transportation of goods and parts of (or sometimes even whole) production processes.

Explanation (Prediction) of the Locational Decisions of the Individual Company

An explanation (prediction) of a locational decision, using the calculus suggested here, can be divided into three stages: (i) a specification of the locational alternatives to be covered by the calculations (i.e. the alternatives under consideration); (ii) estimates, according to the calculations, for each of the alternatives. This stage corresponds to the prediction of the company's economic development which we discussed above; (iii) statements of the alternative chosen. The explanation (prediction) is thus composed on the same pattern as explanations based on price and production theory.

There is an almost total lack of methods which can be used as a basis for determining the alternatives which are under consideration.[2] If, in view of this, it is assumed that the alternatives are given (and can be specified in each situation), then two ways of interpreting stages (ii) and (iii) can be distinguished: (a) it is assumed that the company uses the model as the basis for its prediction and that it chooses the alternative offering the most favorable results, or (b) in view of the fact that the explanation (prediction) is concerned with the company's actions regarding the locational decision, and not with

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[1] It is not possible to discuss here the intricate problems involved in defining the concept of *repeatability* nor in determining when a recurrent sequence of events arises. The problem is discussed from various angles in Danielsson (1963).

[2] Cf. Danielsson (1963) pp. 68 f.

the way in which it makes decisions, it is assumed that an acceptable prediction of the locational decision can be obtained and the question of how the company reaches the decision is disregarded. Case (*a*) seems hardly suitable, to judge from some preliminary interviews with representatives of business and industry. In the second case, (*b*) the combined investment and linear programming model seems to be regarded almost as a *rule*. It would be extremely difficult to try to judge the adequacy of an explanation of this type. Empirical studies alone hardly suffice, as we can see if we look at the similar, though less complex, assumptions concerning the maximization of profit, etc. which are to be found in economic theory.[1]

Some Tasks for Empirical Research

Despite the difficulties stated or implied above, we have intended these pages as a basis for empirical investigations. We claim certain justifications: the formulation of our explanation (prediction) is similar to that employed in capital theory and production theory; also calculations based on the calculus can provide grounds for certain conclusions regarding a company's choice of the most favorable location and for an explanation of a company's locational decisions. We have mentioned for example, the importance of the decision sequence and the rate of interest (which is otherwise rarely considered in this context).

In the course of this study we have been prepared to forego any claim to complete explanations (predictions) and have been content merely to illustrate some questions relating to locational decisions. In the same way in the empirical investigations there should be no attempt to test the predictions; instead such questions as the importance of the decisions sequence, the possibility of accommodating production to varying production factor costs, the existence of calculi etc. could be illustrated.

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[1] Ibid. pp. 69 f.