CHAPTER 1

CHARACTERISTICS OF THE ELEMENT OF SPACE

1.1. Categories of Space Units. Order of Subdivision

The larger part of the theory of development planning has been developed without the inclusion of the element of space. The economy of the developing country considered has been subdivided into sectors, and within sectors projects and methods of production have been studied; in addition, for obvious reasons, the element of time plays an important part; but a subdivision into geographical areas has had much less attention. In a way this aspect was even left to other categories of experts, less specialized in economic matters: in such disciplines and activities as town and country planning (French: aménagement du territoire; German: Raumordnung) engineers, architects and sociologists play the predominant roles, certainly not without some justification. Yet, some important aspects of dealing with the element of space are of an economic character. Recently an intensified interest in these economic aspects has been developing and economists are now trying to make their contributions. To be sure, there have been some economists who long ago paid some attention to the spatial aspects of economics; but they have been somewhat isolated and the subject is given little attention either in general economics textbooks or in the theory of development planning.

This book intends to be a contribution from economists – and mathematicians – to this neglected field. It has been formulated in simple language, and concentrates on applications in practical planning, particularly for developing countries.

As soon as one wants to introduce the element of space one is confronted with the task of *defining space units*. In practice, both statistically and with regard to the implementation of development policies, political units are used; the most important category being countries or nations. For several

purposes of economic analysis and development programming this concept has considerable drawbacks, however: the biggest one being that the "size" of nations is so different. It is unsatisfactory to consider as comparable the Soviet Union, the Netherlands and Bahrein or Mauritius. It is also unsatisfactory to take the physical unit of area, say, 10,000 or one million square kilometers. There is a need for a more meaningful economic unit of space. So far, population size and national income have been used in many studies, but again for lack of better data. A fully satisfactory answer to the question of the most appropriate measure may not be possible, simply because it also depends on the type of economic problem one wants to solve. Yet it will be admitted that the most important aspect of space in economic matters is the existence of transportation costs. Therefore, we think the best economic measure of space must be based on the level of transportation costs for a number of commodities.

Transportation costs should be considered, in this context, to represent all obstacles to overcome distance, including a number of cultural ones. Measurement of transportation costs in this widest sense has hardly been undertaken and may have to be based on indirect methods (Cf. KLAASSEN, 1967; LINNEMANN, 1966. See also Section 1.2). These costs determine largely the degree of openness of a space unit which seems, in the opinion of the authors, to be an important and in many cases the most useful single economic characteristic of a space unit. This openness of a space unit may be reflected in the relative importance of that space's interaction with the outside world, for instance its ratio of exports to national product as has been proposed by one of the authors (TINBERGEN, 1965-1). This question has been dealt with in more detail in Appendix I.

We are also in need of some appropriate *terms* to indicate spaces of economically different size, avoiding the use of terms which already have a political or physical meaning. Our proposal based on the reasoning of Appendix I is to use the five terms of Table 1.1, indicating spaces of diminishing size.

Much statistical material has to be analyzed before an exact definition can be given for each of them or before any given space – say, the state of Bihar – can be given its place in the system. Moreover, we are aware of the fact that this classification, useful in the context of this study, may need to be extended and refined for other purposes, while it is quite possible that different classifications apply to different parts of the world.

How the space units have to be chosen in practical planning work will

be discussed in Chapter 4, Section 1. For practical purposes we will in general stick to the existing political terms, in order to be more easily understood. It will also be understood that the largest space, the world as a whole, could have headed the list of Table 1.1, but here there is no danger of confusion.

TABLE 1.1

Proposed names, in English and German,
for spaces of different economic size, with examples.

Category in English	in German	Examples
Mega-space	Grösstraum	U.S.A., E.E.C., India, Soviet Union
Macro-space	Grossraum	France, Germany
Major-space	Mittelraum	a "region"
Minor-space	Kleinraum	a "city"
Micro-space	Kleinstraum	a "village"

An aspect of spatial subdivision not often emphasized but of eminently practical significance and hence given more attention in this book than in most other publications is the *order of subdivision* applied. We will speak of a first-order subdivision if several space units are distinguished, without a hierarchical ordering between them. We will call a second-order subdivision, one where the subdivision of one space into a number of the next smaller units is considered; say, a country, subdivided into regions, or the world, subdivided into continents. A third-order spatial subdivision is then one where the smaller units are again subdivided; for instance, the continents in their turn into some big countries and a remaining few groups of smaller countries. For some purposes a subdivision of higher order will be necessary. The spatial unit of the highest order may be a closed (e.g. the world) or an open economy (e.g. a country), but this is irrelevant for the order of subdivision.

For the economics of large spaces, say the first three types defined in Table 1.1, it will often be possible to consider all economic processes as homogeneous or perfectly divisible into small parts. In other words, at this level, the production of any commodity takes place in a large number of

single production units. If we proceed to the smaller spaces, an increasing number of production processes will show indivisibilities, that is, units which cannot be further subdivided, because of economic or technical reasons and can only exist as a whole or not exist at all. This will influence the type of analysis to be used. An example, known to the mathematical specialist is the transition from traditional mathematical programming to mixed integer programming. Planning for such smaller spaces will be considered in Chapter 8. We are aware of the modesty of our contribution to that part of planning.

1.2. Mobility of Factors Products and Consumers

We have already indicated that we consider transportation costs to be the most important economic aspect of space. The concept of transportation costs should be understood in its widest sense, covering all obstacles to mobility of factors of production (land, labour, capital), of products (goods and services) and of consumers of products. These obstacles may take different forms, which we will sum up briefly.

(*a*) Some factors and products are completely immobile, namely land, buildings, highways, railways.

(*b*) Movement of persons, particularly periodical movements, are difficult because of the time and effort needed, causing a high degree of immobility of services such as retail trade, primary schools, domestic services etc.

(*c*) Migration of persons is often severely limited by socio-cultural and political obstacles.

(*d*) The transportation of energy or its raw material oil requires wire or pipeline connections, which are also an impediment to the mobility of these products.

(*e*) More generally there are a number of heavy goods whose transportation over long distances is costly (some agricultural products, fuel, fertilizers, building materials, ores).

(*f*) The movement of products from suppliers to consumers implies not only transportation in the restricted sense of the word but communication as well. This may enlarge the spatial attraction exerted by these consumers considerably beyond what would be suggested by physical transportation costs (KLAASSEN, 1967, p. 43 ff.).

Among the factors of production, land is completely and labour rather immobile; capital in "fluid" form shows considerable mobility, but once it has been invested in buildings or some forms of equipment it becomes immobile; new machines, however, are rather mobile.

Consumers are in general largely immobile, with the obvious exception of the consumers of tourist services. Factories using intermediate products may be rather mobile before the period of construction.

Products are not as mobile as has been suggested for a long time by textbooks on international trade, although some authors have recognized the need to make a distinction between goods of different mobility (LEONTIEF, 1953-1; ISARD, 1960). While this phenomenon might be described with complete accuracy by the explicit introduction of transportation costs for each type of product considered we prefer another approach on which a large part of this book is based. We propose to distinguish as many categories of commodities as we have categories of space, and to assume full mobility of each category of products within a limited space and complete immobility outside that type of space. There exists here some interaction as far as the choice of the categories of space could be partly determined by our knowledge of the degree of mobility of certain goods. E.g. the choice of a nation as a space unit makes economic sense as far as e.g. the services of the national government are by definition largely mobile within the nation and immobile outside of it (cf. also Appendix I). By definition micro-space products cannot be exported from or imported into a micro-space; minor-space goods cannot be traded by a minor space; major-space goods cannot be traded by a major space and so on, the reasons being technical or cultural. Therefore minor-space goods include, micro-space goods, but in addition there are other minor-space goods which are not micro-space goods. Often, for the sake of convenience we will call minor-space goods "local goods"; major-space goods "regional goods"; macro-space goods "national" or "domestic" goods; we will also speak of continental goods. Products which can be transported all over the world will be called world products. In cases where we deal with open models for national economies, we will speak also of international goods if they can cross the national border, leaving it an open question as to whether they are continental or world goods. Table 1.2 contains some examples.

Statistical problems (border trade!) are dealt with in Section 10.3, while a more refined classification can be found in Appendix V.

TABLE 1.2

Examples of types of sectors or products

Local	Regional	Domestic	International
Construction	Secondary education	Higher education	Most agricultural, mining and manufacturing products
Housing	Perishable goods (vegetables)	Central government	
Retail trade	Provincial government	Building materials	
Services	Transportation	Electricity	
Primary education			
Local government			

The concepts approximately cover the concepts of IAN LITTLE (1965) of non-tradables and tradables, with the difference that we make a distinction between several categories, depending on the size of the space considered. We believe that this gives a certain hierarchy and structure to the classification of products which constitutes a useful first approximation to the solution of problems of transportation. In fact, no transportation costs occur explicitly in this treatment; they are e.g. in the case of national goods assumed zero within the nation considered whereas the transport flow of such goods is absent between that space and the rest of the world.

In an attempt to find a second approximation we will introduce (in Chapters 5 and 6) explicitly the transportation costs (at a finite level) for some "heavy goods", which together account for three quarters or more of all transportation. Apart from this, we will allow for transportation costs for more products, but on the assumption that the location of their production is already determined on the basis of differences in production costs and of income increase targets only (Chapter 4, Section 10).

1.3. Shiftability of Activities (Differences in Production Costs)

A second characteristic of the element of space in economics is the diversity in natural resources and of human (individual and social) conditions among different space units. In some units we find coal deposits, in others not;

in some the climate is hot, in others it is cool; some show heavy rainfalls, others are dry; some are endowed with natural waterways, others not; some are situated close to big markets, others are far away from such markets; in some a high level of economically relevant skill prevails among the population, in others such skill is virtually absent. All such factors bring about differences in production costs, for any given type of good, among these space units. The pattern of economic activity, whether actual or potential, is highly dependent on such differences. As a consequence, some activities can be carried out in a very restricted number of areas only, for instance, the production of soya beans or of copper. Other activities can be carried out virtually everywhere at approximately the same costs. This is more or less true for printing or weaving. For the production of mobile goods – that is, as we defined them, easily transportable goods – there is scope, therefore, to distinguish between non-shiftable and shiftable industries or activities: the former can only be carried out in a few areas and the latter in a large number of areas. Strict non-shiftability in fact exists if some activity can only be carried out in one space unit among those considered (for instance, one region within a country); perfect shiftability exists if an activity can be carried out at the same cost in all the space units considered.

1.4. The Optimal Level of the Use of Means of Economic Policy

In most economies a number of means of economic policy are being applied. Thus, taxes are levied, import or building permits are issued, price controls are exerted, rationing is applied, traffic regulations are carried out and so on. Many of these means of economic policy can be handled by authorities at different levels: by local, provincial, state or federal authorities, or even by supranational authorities. This implies that the space in which they are being applied may differ greatly.

In recent decades the application of the proper means of economic policy to the proper extent has been recognized as a major problem. What is proper evidently depends, first, on the goals set by any government or community and secondly, on the nature of the economic mechanism. In the problem of finding the optimal regime or the optimal socio-economic policy the extent to which a number of instruments have to be used are the unknowns. Thus, it may be discussed whether an import duty on some item should be

5 per cent or 30 per cent or 100 per cent, and so on; and also which taxes should be levied at what rate from whom.

This problem also has a space aspect. A given means may be used either by the authorities of a relatively small area or by the authorities of a big area; in other words, by "lower" or by "higher" authorities. This is the problem of the optimal "level" of application of the means under consideration. Historically we observe a shift from lower to higher authorities. Several types of taxes used to be levied by local authorities and nowadays are under the competence of federal authorities. In Europe, some means of economic policy have deliberately been passed on to supranational authorities. Market regulations were carried out by local or national authorities and are now handled at an international level.

The full solution of the problem of the optimal development policies therefore includes the choice of the level at which the various means of economic policy should be used. An important principle to be applied here is the "principle of small external effects". It says that each means should be used at a level sufficiently high to make the external effects small. This implies that most of the effects are felt in the area whose authorities handle the means. In this way a guarantee exists that the authorities, when deciding on the use of the means, are in a position to take the right decision. This would not be necessarily so if only part of the effects are felt in the areas for which the policy-makers are responsible. Under such circumstances the decisions are likely not to be optimal with regard to all people concerned.

This "principle of small external effects" may be supplemented by the following practical rule. In many cases it turns out to be efficient to handle the instruments of economic policy at the lowest possible level of spatial units which is still compatible with the principle mentioned above. Then the amount of information to be transmitted to and from spatial units of different levels is minimized.

We mention a few examples. Inner city traffic regulations concern the city authorities and not higher authorities unless e.g. uniformity of these regulations at the national level is necessary. Construction of roads, mainly for local or intraregional traffic can be left to local or regional authorities. Highways, mainly for interregional traffic are on the other hand a concern of the national authorities. As far as taxes are used as an instrument of an economic stabilization policy or to cover expenditures of the central government, they should be levied at the national level. Some instruments should

be used even at the world level, e.g. international commodity agreements and decisions on the so-called key currencies.

Even though these points are important for the implementation of plans, we will nevertheless not deal with them any further in this study.

However, we mention finally a particular aspect of the models which this study is dealing with. Most of these models aim at a certain distribution of income between spatial units by setting specific income increase targets for these units. This distribution of income has to be achieved by a distribution of production. The really crucial variables of the models are therefore the investment figures for each sector in each region. Since domestic saving is possibly not equal to investment, the results of the model might imply some capital flows between the spatial units. This will certainly be true if the model refers to the world as a whole (cf. Chapter 3). As capital is assumed to be largely mobile, it is implicitly assumed that the authorities of the spatial unit of the highest level control instruments which are able to influence the spatial distribution of investments. In general one would expect that the authorities of spatial units of lower level do not themselves control instruments powerful enough to direct the necessary capital flows.

1.5. Space Economics of the First Order; without Prices

In the remainder of this chapter, in order to illustrate the role of space in economics, we will describe briefly some examples of space economics. The examples have been drawn from existing literature and therefore show that the element of space has not been neglected completely. We will divide our examples according to two criteria : (i) whether a spatial subdivision of the first order or of higher order has been applied; (ii) whether prices have been mentioned explicitly or not. While it is more exact to introduce prices into the analysis, it is, at the same time, more cumbersome, since it increases the number of variables. Hence we start out with some examples in which prices have not been mentioned explicitly.

As a first example in the category of a first-order spatial subdivision without the use of prices, a model is taken in which only one country and the rest of the world is considered (TINBERGEN, 1965-2). The model is a Keynesian model of the simplest type but it makes a distinction between domestic and international goods. The country considered is assumed to

show a deficit on the balance of payments in the initial period and in a subsequent period to reduce its national expenditure sufficiently to restore balance of payments equilibrium. It is shown that the mere existence of domestic goods (or non-tradables, cf. Section 1.2) explains why, under these circumstances, balance of payments equilibrium can only be attained at a lower level of national income than prevailed in the initial period.

As a second example an empirical model may be quoted (LINNEMANN, 1966), explaining the volume of trade between any pair of a large number of countries with the aid of the national incomes of each of the two, their populations, their distance and some more factors. This model constitutes an interesting example of an explicit treatment of the distance factor in economics. Granted that the explanatory variables are the correct ones, it is shown that the volume of trade is close to being inversely proportional to the distance between the partners. Distance may, however, represent factors other than physical distance only, including "distance" in culture or lack of information about the partner if he is farther apart.

1.6. Space Economics of the First Order; with Prices

In this category a model may be quoted (BOS *et al.*, 1961) in which a limited number of centres and of goods is considered with the explicit introduction of their prices. The prices in different centres for the same commodity are different and transportation from one centre to the other will be more intensive the higher the differences in prices are in comparison to the transportation costs between the centres considered. The model is used to appraise road projects, that is, projects tending to reduce the transportation costs between any two centres. As a consequence, there will be not only more transportation, but a complete change in production and income and hence consumption patterns, in other words the equilibrium values of most or all variables of the economy may change. The value of the road can only be ascertained by estimating the change in total national income which it brings about and this change may be much bigger than that which is usually estimated with the aid of simpler methods of road project appraisal. On the other hand it will be clear that this type of model in which all prices and transportation costs are considered will soon become very difficult to manage if the number of commodities and of centres is increased. This is

why in the remainder of this book (from Chapter 2 on) various types of simplifications are considered which may help to make easier the problem of planning of a set of space units and of sectors.

One of the most important consequences of the explicit introduction of transportation costs into economics is the change in character of the cost function for many types of products it entails. The widely held belief that larger production plants are working at lower unit cost is often based on a consideration of production costs in the narrow sense, that is, the costs of producing a unit of product on the spot of the plant. What is more relevant, however, is the cost at which the user of the product can be supplied with additional quantities. And on increasing the size of the plant one has to look for more distant users, that is, transportation costs have to be added to production costs proper. These transportation costs induce an element of increasing marginal cost. With a given density of the distribution of demand over space there is an optimum volume of production of finite size, corresponding to an optimum market size beyond which the total costs of production and transportation will be higher (LÖSCH, 1944; BOS, 1965). These market areas are related to but not identical with the space categories discussed in Section 1.1. A fundamental difficulty is that, in the same area, they are different for different goods. For a large number of goods they are relatively small. One of the conclusions to be drawn from this fact is that for a densely populated relatively prosperous continent such as Europe the economic gain from integration is probably limited.

Not only products but also production factors may have different prices at different places, as a consequence of their limited mobility, already discussed in Section 1.2. These differences may be reduced in two different ways. One is to increase the mobility of the factors themselves, by the elimination of some of the obstacles, whether natural or artificial. A number of empirical studies have been made informing us about the extent of the influence of the most important obstacles (E.g. BLANCO, 1962; CHAKRAVARTY, 1960). Generally speaking the forces causing mobility are too weak even to reduce the differences in factor prices between countries; these differences are increasing rather than decreasing. The other way to reduce factor price differences is to choose industries which use as much as possible of the abundant factors. It is an open question whether the two methods together will suffice to reduce factor price differences.

1.7. Space Economics of Higher Order; Without Prices

This type of economic analysis is in its infancy only. Yet a number of practical decisions are currently taken which are in need of a basic analysis of this type. It is precisely one of the objectives of this book to offer a start to such an analysis; this will be done in Chapters 3-7 for a second-order spatial subdivision in case indivisibilities are irrelevant[1]), and in Chapter 8 for higher order subdivisions in case indivisibilities play an essential role. For the moment this latter problem may be introduced by reminding the reader of the optimal market area that can be defined for each product, having in mind its production and transport cost function and, provisionnally, some demand density per space unit. The question may then be asked what constitutes the "best" distribution over the surface of some large space of the necessary plants of each of the industries that the space needs. As a first step one may think of dividing up that space in market areas for each product individually – somewhat like the hexagons suggested by Lösch – and placing one enterprise in the centre of each hexagon. Since the hexagons are of very different size for different industries, the surface considered would be covered by enterprises in an "unorganized" way; for some industries the enterprises would be placed at long distances from each other and for other industries at short distances. As a second step one may then ask the question whether it is not better to combine a number of neighbouring enterprises into "agglomerations" or "centres" these being names for what in real life we call villages, towns and cities. This introduces the idea that the dispersion of economic activity may have to take the form of a hierarchical system characterized by large centres at longer distances from each other, with smaller centres in between, themselves of different size and in numbers which are larger the smaller the centres are. Such a configuration would constitute a higher-order subdivision of the space considered. The first subdivision consists of the market areas served by some industries in the biggest centres and each of these contains one such big centre and a number of smaller centres with their market areas. The next level consists of the smaller market areas served by the next smaller centres; each of them is part of an area served by one of the biggest centres. Again, the smaller

[1]) An example of a fourth order spatial subdivision model without indivisibilities is discussed in HERMAN *et al.* (1969).

market area served by such a smaller centre consists of a number of still smaller market areas, each of which surrounding a still smaller centre. Thus, a hierarchy of areas may be thought of, which at each level of the hierarchy fill up the total surface. Correspondingly, the industries can also be seen as a hierarchy: those serving the biggest areas being of highest rank, and those serving smaller and smaller areas being of lower and lower rank. The system just described may, or may not exist and it may or may not be optimal. Some attempts at analyzing its properties will be made in Chapter 8.

1.8. Space Economics of Higher Order; with Prices

This type of space economics represents the most sophisticated stage of analysis conceivable in the framework of the concepts offered in this chapter. At the same time it also constitutes the most complicated version and as far as the authors are aware no examples of it have been elaborated yet, at least not in a systematic hierarchical framework. The only reason why some attention will be devoted to this type of space economics is that clearly the real world shows the features characteristic of it. Indeed, the world is subdivided into spaces of various order and prices do play their part to regulate, to some extent, the distribution of economic activities over these various spaces and sub-spaces. Also planning activities in large countries, such as the Soviet Union and India are conducted within a framework of the same nature. There are various levels at which decisions are taken, both with regard to the use of the means of economic policy and with regard to productive activity. If these decisions must be optimal, and that is what the politicians responsible are aiming at, a type of economic model will be needed which satisfies the characteristics mentioned in the title of this section.

If, moreover, once we hope to arrive at a world economic policy, with a corresponding type of planning, an additional level of decision making, and hence of planning, will be needed. While the complexity of such a system of decision making is clear enough, we shall need it nevertheless and we must try our best to make the system optimal. It is with this perspective in mind that the authors of this book have tried to penetrate into the subject. They have made a few steps only and are aware of their shortcomings. Yet they want to point out to the reader and to future contributors to the subject what the aim of their endeavours could and should be.