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		Building materials	
Services	Provincial government	Electricity	
Primary education			
Local government	Transportation		

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.

CHAPTER 10

PREPARATORY STUDIES; SOME COEFFICIENTS

10.1. Spontaneous Migration

The purpose of this chapter is to provide the reader with some practical information. Population movements; the relative importance of international, national, regional and local sectors; capital-output ratios; international differences in input coefficients and in the average size of plants; these are the subjects on whose order of magnitude we want to give the reader some indication.

In most countries migration is not and has never been an important factor. If we express net immigration or emigration per year as a percentage of population at the beginning of a period, it can be seen that before the Second World War the highest percentage rates of emigration were 1.5 per cent in Ireland in the period 1880-1890, 0.8 per cent in Scotland in the period 1920-1930, 0.5 per cent in Italy and 0.4 per cent in the Balkans, both in the period 1900-1910 (cf. COLIN CLARK, 1944). The highest rate of immigration of 1.8 per cent is found in Canada in the peculiar circumstances of the period 1900-1910. The U.S.A. showed a rate of inflow between 1910 and 1914 of 0.9 per cent. The next highest rates were in Australia and France, both 0.6 per cent in the period 1920-1930. After World War II the highest annual rates of inflow in the period 1954-1966 were in Switzerland and West Germany: 0.9 and 0.7 per cent (cf. O.E.C.D. Observer, December 1966). The highest percentage rates of emigration were again in Ireland – 1.3 per cent – and in Portugal – 0.7 per cent – .

Although the higher yearly percentages of migration are restricted to a small number of countries, they give rise to considerable population movements. For example, since the Second World War the intra-European migratory movements have assumed substantial proportions. Between seven and eight million foreigners are now living in the countries of Western

Europe. In Switzerland 30 per cent of the labour force and 17 per cent of the population consist of foreigners. These migratory movements seem, however, to be of a short-term nature. In Western Germany and Switzerland – two countries where foreign workers make up a high proportion of the total labourforce – the rate of turnover of the foreign labour force, calculated by dividing the yearly number of departures by the total number of foreign workers, is about 30 per cent. This means that roughly one out of every three foreign workers leaves the country every year, which corresponds to an average stay of about three years (cf. United Nations Economic Commission for Europe, 1966). Within a country, however, these migratory movements can certainly be of importance, e.g. California within te U.S.A.

What are the determinants of the geographical mobility of labour? In her study on regional factor mobility, Mrs. Blanco analysed American interstate migration data for the period 1950 to 1957 (cf. BLANCO, 1962). She found the most important determinant of population migration to be the increase in relative unemployment, i.e. the difference between the increase in the population of working age and the increase in employment opportunities in the various regions between which population is free to flow. Although the normal direction of population migration is into the higher income states and away from the lower per capita income states, Mrs. Blanco found no significant direct effect of wage levels on regional differences in migration. This effect could, however, be exerted indirectly through influences on the regional levels of employment and unemployment. The fact that relative unemployment turned out to be the only main determinant of regional labour mobility can be explained by the situation of relatively high unemployment in the U.S.A. during the period considered.

Other studies[1]) show that geographical mobility is associated with changes in earnings. However, what appears to be a response to opportunities to increase earnings turns out to be equally consistent with the attraction of employment opportunities. Probably the best formulation is that in the case of unemployment, job availabilities are the main factor influencing migration, while in a situation of full employment existing earnings differentials have a more important effect.

[1]) For an excellent survey see: O.E.C.D., (1965).

10.2. Optimum Size of Production Units

When in development programming we speak of expanding or establishing an industry in some spatial unit, it means that in that spatial unit new production units have to be established. In some cases, existing plants will be expanded but this possibility will not be considered further here. The production or income target which results from the development plan has to be "filled up" by a number of production units. Given the spatial unit's income or production target for a sector, the number of plants depends on the optimum size of a production unit. This optimum size depends on a number of factors of which the following are the most important:

(1) The extent to which economies of scale exist given the technology chosen; the choice of the technology depends in its turn on the availability of factors of production and on the prevalence of another target, i.e. full employment.
(2) Transportation costs per unit of distance.
(3) The geographical distribution of demand.
(4) The expected future growth of the economy.
(5) The rate of change of the technology.

This, however, requires careful sector studies which fall outside the scope of this book[2]). We will only try and make some generalizations about the prevailing size of plants – if any – in different countries. Size is not in terms of output, but is measured by the number of workers. This topic comes up mainly in discussions on the question of whether the greater efficiency in the U.S.A. can be accounted for, even to a small extent, by a possible prevalence of large plants in the U.S.A.[3]). One of the most important studies in this field, a comparison of the structure of the different industries in Britain and the United States, concentrating *inter alia* on the prevailing size of their factories has been made by FLORENCE (1962).

In his study Florence first assigned 131 industries, taken from the 1951 UK Census of Production, – covering the whole sector of manufacturing industry together with a few non-manufacturing industries – to grades according to the prevailing size of plant. The prevailing size was determined

[2]) For this purpose see: MANNE (1967) and United Nations (1964).
[3]) For an extensive discussion and many quotations cf. FABRICANT (1960).

according to the proportion of persons employed in establishments of given size. Five main grades of prevailing size of plant were distinguished – small, smallish, medium, largish and large – together with two supplementary grades – bias towards smaller and bias towards larger – with less rigorous requirements. The following table gives the rules for assigning the 131 industries to grades.

TABLE 10.1

Rules for assignment of industries to grades of prevalent size of plant

Grades of size	United Kingdom		U.S.A.	
	Percentage of total persons employed	In establishments employing	Percentage of total wage-earners employed	In establishments employing
Grade 1, or small plant	50 or 60	Less than 50 Less than 100	50 or 60	Less than 50 Less than 100
Grade 2, or smallish plant	50 or 60	50-199 25-199	50 or 60	50-249 20-249
Grade 3, or medium plant	50	100-499	50	100-499
Grade 4, or largish plant	50	500 or more but not qualifying for grade 5	50	500 or more but not qualifying for grade 5
Grade 5, or large plant	50	1,000 or more	50	1,000 or more
Bias towards smaller plant (2)	60	Under 200	60	Under 250
Bias towards larger plant (4)	75	Over 200	75	250 or more

Source: SARGANT FLORENCE (1962, Table 1).

Of these 131 industries 28 did not show a sufficient concentration of employees to fall into any of these grades, and were graded as having no representative or prevailing size of plant, or, in other words, as having all sizes. For all other industries classification was possible.

Next a comparison was made with American industries using the 1954 United States Census of Manufactures. Eighty-one industries appeared to be fairly reliably comparable. Of these 81 industries of similar scope, 48 had a specific prevailing size of plant assignable to them in both countries. Of these 48 corresponding industries 26 were in exactly the same grade of plant size in both countries, which was 2.7 times as much as would be expected in a random distribution.

TABLE 10.2

Prevalent size of plant of American and British industries

Industries	Grade of prevalent size of plant	
	British	American
Footwear	3	3
Bread and flour confectionery	1	2
Tobacco	5	5
Cotton weaving	3	5
Glass	4	4
Furniture	(2)	(2)
Shipbuilding	5	5
Railway carriages	5	5
Textile machinery	4	5
Jute and linen goods	3	3
Woollen and worsted fabrics	3	4
Rayon, nylon, silk	4	5
Soap, candles, glycerine	4	4
Motor and cycle manufacturing	5	5
Oil and greases	(2)	1
Brick and fireclay	2	2
Rubber	5	5
Cotton spinning	3	3
Plastics	4	4
Petroleum refining	5	5
Cement	(4)	3
Iron and steel (melting and rolling)	5	5
Sugar	(4)	4
Paper	(4)	3

Source: SARGANT FLORENCE (1962, Appendix C).

It must be concluded that there is – at least some – evidence that for a given type of industry the size of plant in different countries tends to be much alike. This would justify the use of an average size for development planning purposes as a first approximation.

Finally, a number of industries classified according to their prevailing size of plant can be found in Table 10.2.

10.3. Local, Regional, National and International Industries; A Ten-Country Study

In development planning it is important to know which activities have to be carried out at home irrespective of their costs – the local, regional and national industries – and which sectors produce goods that can be imported and exported – the international industries. In a recent article one of the authors (cf. TINBERGEN, 1965-3) made the following rough classification: most manufacturing industries, mining and agriculture, may be considered international industries; construction, the operation of buildings, transportation, government services, education, electricity, water, wholesale and retail trade may be regarded as national, regional or local industries, where it is often difficult to classify some activity as a local, regional or national industry.

This section deals with an investigation that has been made in order to arrive at a somewhat more precise classification of activities into these three categories: international, national and local industries. Our procedure has been as follows. Using the list of industries appearing in the International Standard Industrial Classification (1958), we divided the industries first into two groups: international industries on the one hand, national and local industries together on the other hand, where we based the division on the transportability of their products. This classification can be found in Appendix V. Next, some supporting empirical evidence for this classification had to be found. In trying to do so for a developed country, one would see that for most industries the products are exported or imported even if they clearly have to be classified as national or local products. The reason is, of course, that in the neighbourhood of the frontier local and national goods do cross the border. Consequently, we have chosen for this empirical investigation of our theoretical classification a more or less isolated country for

which we could, in addition, make use of a very detailed input-output table and therefore of trade figures corresponding to an industrial sector classification, i.e. Japan. The Japanese 1951 input-output table contains 182 sectors which seemed precise enough for our purpose, except for the sector "Transport" which had to be divided into an international and national part.

The data turned out to fit in very well with our theoretical classification which therefore has been accepted as a basis for further research on this subject. Of course this is only true for the distinction between international products on the one hand and national and local products together on the other hand. The distinction between local and national sectors is completely on an apriori basis and has not been examined empirically[4]). Another result was that the general classification mentioned at the beginning of this section could very well serve as a rough approximation.

The next step was to apply our detailed classification to a number of countries in order to find out which part of production is accounted for by the local, national and international industries respectively. This was done in two different ways. Using a sample of ten countries for which census data were available, we have first calculated the distribution of the economically active population over our three categories of industries. By

TABLE 10.3

Percentages of economically active population by country and by sector

Country	International industries	National industries	Local industries
U.S.A.	40	14	46
West Germany	50	20	30
Sweden	39	16	45
France	53	17	30
Netherlands	37	21	42
India	36	12	52
U.A.R.	58	5	37
Japan	58	14	28
Brazil	88	4	8
Argentina	49	16	35

[4]) For a summary of some attempts cf. CHENERY *et al.* (1959, p. 311 ff.).

assuming that total production in terms of value added is, roughly speaking, proportional to the number of workers, we obtained a crude indication of the distribution of production over the three sectors. The result of this sample can be found in Table 10.3.

From this table the following tentative distribution can be derived:

International sectors	40-60%
National sectors	10-20%
Local sectors	30-45%

The table shows a few exceptional cases, such as Brazil and India; but these deviations can easily be explained. In the case of Brazil, many part-time workers work in the agricultural sector (coffee). In the census data, however, they have been counted as fully employed persons. Since agriculture is an international industry, the percentage of the economically active population working in the international sector has been overestimated. In the case of India we could expect an equally high percentage of the economically active population working in the agricultural sector but here the Census only takes account of persons employed in commercial agricultural activities. Obviously, this reduces the percentage of national product produced in the international sectors when calculated in this way.

More or less as a check on our results we made another set of calculations. For five developed countries (U.S.A., West Germany, France, Italy and the Netherlands) and three less developed economies (Pakistan, Mexico and Iraq) we calculated – using input-output tables – the percentages of total gross value added which come from the international sectors on the one hand, and from the local and national sectors together on the other hand. The result was that we found for the five developed countries and Mexico a percentage distribution of gross value added between these two categories of sectors which was remarkably stable as is shown in Table 10.4.

For Pakistan and Iraq we obtained different results: in both countries the percentage of the international sectors was much higher, i.e. 65 per cent. However, this was due to the fact that the input-output tables for these countries were much less detailed; e.g. the agricultural sector contains many activities which should be counted as national or local industries. It seems reasonable therefore to conclude that our second set of calculations fits in with the tentative frequency distribution derived from the ten-country sample.

TABLE 10.4

Percentage distribution of gross value added by country and by sector

Country	International sectors	National and local sectors
U.S.A.	42	58
West Germany	46	54
France	43	57
Italy	45	55
Netherlands	44	56
Mexico	43	57

10.4. International Comparability of Input-Output Tables

In the sector stage, as well as in the project stage of development planning, the use of input-output tables is by and large indispensable. If we want to determine the rates of growth of the individual sectors of the economy, it is almost essential to know the demand caused by interindustry relationships. In industrial countries this intermediate demand takes account of about 50 per cent of total domestic demands for goods and services. As for the project stage, if we want to apply the semi-input-output method in order to calculate the bunch of investments belonging to some international project, the "local and national" part of the input-output table, i.e. the rows corresponding to the local and national sectors, must be known. This leads automatically to the question of whether it is permissible, when making a development plan for some country, to use an existing input-output table of some other country. Two important studies on this inter-country comparability of input-output tables have been made: one by CHENERY and WATANABE (1958), the other by SIMPSON and TSUKUI (1965).

Both studies are concerned with the general character of inter-dependence in production. So their aim is to ascertain the extent to which this structure of production is similar in different countries. Moreover, Chenery and Watanabe make an industry by industry comparison of the input coefficients.

The countries which are compared in both studies are the U.S.A., Japan, Norway and Italy, while Simpson and Tsukui deal with Spain in addition. All are more or less developed economies. There are two reasons why it is better to base such an international comparison on input-output tables of developed countries. First, in developed countries there is generally more and better statistical information available. Secondly, if we had to calculate the inputs necessary for the development of some sector it would be wrong to base our estimates on an input-output table of an underdeveloped country because the inputs of many international sectors are imported and do not appear in the interindustry bloc of the input-output table.

As for the general structure of production, both studies show that for the countries considered the pattern of interdependence among sectors is rather similar. All matrices turn out to have the property of being largely triangular. In other words, the sectors can be arranged in such a way that the elements above the main diagonal consist mainly of zeros while the ordering of sectors is about the same in each country. Simpson and Tsukui even show that the sectors can be grouped into four blocs (metal, non-metal, energy and services) and that the matrices can be arranged in such a way that the blocs follow a triangular order with respect to each other, i.e. they are bloc-triangular. However, the matrices of the sectors grouped in this way are not only bloc-triangular, with the exception of the services bloc they even show the still stronger property of "bloc-diagonality". In other words: no sector in these blocs is related to any other sector in another of these blocs.

The main conclusion is that there seems to exist a common fundamental structure of production in different countries. This common structure has the form of an almost triangular (or even bloc-diagonal) input-output table while the ordering of sectors is about the same in the different countries. If we try and apply our mobility criterion to the industry classification used in the two studies it must first be mentioned that this is only partly possible. For instance, construction – an important national industry – is not a separate sector but is included in final demand. Nevertheless it turns out that the national and local industries are placed at the bottom of the matrices. This means that the property of triangularity applies mainly to the international industries but that each sector – international, national or local – needs inputs of the national and local industries.

The industry by industry comparison of input coefficients has been done in two ways: by columns and by rows. As for the column comparisons which

TABLE 10.5

Mean inequality coefficients by sector

Sectors	Mean inequality coefficient
A. International industries	
I. Manufacturing:	
1. Apparel	0.545
2. Shipbuilding	0.795
3. Leather	0.401
4. Processed Foods	0.625
5. Grain Mill Products	0.482
6. Transport Equipment	0.751
7. Rubber Products	0.657
8. Textiles	0.388
9. Machinery	0.399
10. Iron and Steel	0.614
11. Non-metallic Mineral Products	0.579
12. Lumber and Wood Products	0.730
13. Chemicals	0.650
14. Printing and Publishing	0.356
15. Non-ferrous Metals	0.479
16. Petroleum Products	0.621
17. Coal Products	0.881
18. Paper and Products	0.783
19. Industry n.e.c.	0.872
II. Mining:	
1. Coal Mining	1.253
2. Metal Mining	1.138
3. Non-metallic Minerals	1.175
4. Petroleum	1.558
III. Agricultural activities:	
1. Agriculture and Forestry	0.985
2. Fishing	0.897
B. National and local industries	
1. Electric Power	1.342
2. Transport	1.002
3. Trade	0.875
4. Services	0.956

Source: CHENERY *et al.* (1958, table V).

TABLE 10.6 Input coefficients of nation

Inputs from into → ↓		A. International industries											
		I. Manufacturing											
		1	2	3	4	5	6	7	8	9	10	11	1
Electric Power	USA	22	75	24	24	33	33	89	72	47	87	136	
	Japan	33	70	22	49	31	55	47	40	54	93	176	1
	Italy	9	194	14	15	49	107	92	85	86	325	286	
	Norway	24	72	36	57		69	68	38	47	189	217	
Transport	USA	67	126	152	213	570	170	154	177	131	344	547	4
	Japan	36	103	226	150	101	120	184	40	101	79	346	4
	Italy	20	101	15	42	90	88	38	47	62	142	275	2
	Norway	43	102	78	25	4	52	97	39	73	68	97	1
Trade	USA	279	200	159	136	112	70	225	302	203	519	171	1
	Japan	328	302	338	190	347	460	359	166	294	93	235	1
	Italy	275	171	265	350	408	181	239	255	136	52	223	2
	Norway	226	357	406	136	20	271	509	205	380	314	507	2
Services	USA	216	291	243	282	219	147	204	146	201	147	236	3
	Japan	261	283	189	138	98	282	255	329	283	131	179	2
	Italy	115	90	171	278	241	90	129	114	68	77	222	2
	Norway	161	97	298	94	37	209	597	265	86	114	103	

Source: CHENERY *et al.* (1958).

are of special interest for the sector stage, one of the results of Chenery and Watanabe is that a much greater similarity exists among coefficients for purchases of the manufacturing sectors than for the other sectors of the economy. In other words: the columns of the input-output tables corresponding to the local and national sectors show much more dispersion among different countries than the columns corresponding to an important part of the international sectors, i.e. the manufacturing industries. The same is true for the two other main international sectors: agriculture and mining. This may best be illustrated by means of Table 10.5 which shows the mean inequality coefficients. The inequality coefficient is defined as

sectors: $\varphi_{h_ih} = x^{h_ih}/x^h$; all figures $\varphi_{h_ih} \times 10^4$

							B. National and local industries									
							II. Mining				III. Agriculture					
13	14	15	16	17	18	19	1	2	3	4	1	2	1	2	3	4
66	37	101	31	76	71	78	183	358	209	24	14		887	52	91	79
198	50	117	30	40	146	57	372	259	88	266	17		119	102	10	45
401	114	977	6	77	419	79	535	224	68	578	8			378	48	60
158	31	203	23	60	160	46		323	127		47			13		64
279	132	202	679	887	160	110	31	111	86	3	238	79	339	536	101	56
172	88	120	37	498	297	114	183	89	114	61	54	57	302	206	98	71
112	39	235	35	470	80	80	62	14	7	5	19	38	46	125	3	6
56	32	101	104		64	99	2600	18	35		132	246	4	286		273
225	48	1051	9	50	588	229	65	151	142	5	347	118	22	159	145	112
268	329	166	47	151	193	267	94	171	161	100	183	165	198	136	59	211
216	257	42	44	368	171	82	91	87	24	10	120	101	44	240	24	26
296	167	338	539		204	518	53	97	184		190	155	25	254	244	161
417	379	103	192	121	141	412	160	151	548	198	747	333	163	506	1472	1022
511	982	173	265	79	255	348	296	511	220	625	193	245	610	729	1054	708
373	211	52	231	101	78	263	101			100	203	160	107	263	415	414
84	777	115	39	239	140	778	316		12		112	229	446	388	535	1909

follows:

$$\gamma_j^{\alpha\beta} = \frac{\sum |a_{ij}^{\alpha} - a_{ij}^{\beta}|}{\frac{1}{2}\sum (a_{ij}^{\alpha} + a_{ij}^{\beta})}$$

where a_{ij} is the input-coefficient and α and β refer to different countries. This coefficient was calculated for each pair of countries; then the mean was taken. The more similar the structure of production in the countries compared, the smaller will be the ratios obtained. If the inputs are completely uncorrelated, the measure has a value of 2.0. Chenery and Watanabe take 0.80 to be a critical value.

The authors mention several factors which contribute to the greater comparability in manufacturing industries, like the greater degree of aggregation in agriculture and services, the greater similarity of technology in manufacturing and the greater accuracy of the statistical sources for manufacturing. We may add that differences in price structure should be eliminated before comparing input-output tables internationally.

However, our conclusion must be that the greater dispersion among countries of input-output coefficients of the national and local sectors which are of particular importance if we apply the semi-input-output method, renders the use of uniform input-output tables a rather critical matter.

Nevertheless, we give in Table 10.6 a number of coefficients for the national and local sectors, i.e. they represent the inputs of each national sector per unit of output of each of the international and national sectors. This is done for each of the four countries dealt with by Chenery and Watanabe so that the reader may judge on the comparability himself. The column numbers refer to the sector classification of Table 10.5.

10.5. Capital-Output Ratios

In Chapters 3 and 4 it was stated that the cost figures entering into our problems should represent the increase in the use of scarce factors per unit increase of value added in each sector. As the main factors determining costs, we mentioned the availability of natural resources, the degree of skill of the labour force and the availability of capital. However, in practice it may often be assumed that capital is the only scarce factor of production, and this is a useful first approximation. Then we have a situation where our cost coefficients become equal to a well known concept in development planning: capital coefficients.

We will not engage in a theoretical discussion of this concept but only deal with it in a more practical way. Then, the first thing to be mentioned is that the capital coefficients here should be thought of as incremental capital-output ratios (ICOR), the variables of the relevant models being in terms of increases. For a detailed discussion on this incremental capital-output ratio and the factors which have to be taken into account when calculating it, the reader is referred to a recent United Nations study (cf. United Nations, 1964). In this study an alternative capital coefficient is also discussed where

TABLE 10.7

Incremental capital-output ratios. India, 1964

Sector	ICOR
1. Construction, industrial and urban	0.153
2. Construction, rural	—
3. Electrical equipment	0.695
4. Transport equipment	0.752
5. Non-electrical equipment	1.072
6. Iron and steel	2.252
7. Iron ore	1.993
8. Cement	1.788
9. Other metals	2.825
10. Other minerals	2.673
11. Plantations	1.586
12. Leather and leather products	0.369
13. Animal husbandry and fishery	1.591
14. Food industries	0.412
15. Food grains	1.591
16. Cotton and other textiles	0.964
17. Jute textiles	1.051
18. Other agriculture	1.591
19. Chemical fertilizers	1.565
20. Glass, wooden and non-metallic mineral products	0.689
21. Forestry products	1.591
22. Motor transport	1.356
23. Petroleum products	0.475
24. Crude oil	7.137
25. Rubber products	0.539
26. Synthetic rubber	1.621
27. Chemicals	0.892
28. Railways	2.599
29a. Thermal electricity	6.133
29b. Hydro electricity	6.947
30. Coal	2.117
31. Housing	10.000
32. Others and margin	0.157

Source: ECKHAUS *et al.* (1966).

account is taken of contributions to the growth of production by the growth of the labour force: ICOR (L). This coefficient gives a better representation of capital productivity than the ICOR. Nevertheless, for our models the

ICOR's are the correct cost coefficients because we assume that labour is not a scarce factor of production. Obviously, this is not a realistic assumption for skilled labour. We may, therefore, run into trouble if our models yield the result that those sectors which have large skilled labour inputs should be developed most. Of course, one can add restrictions with regard to the labour force. Then account must be taken of what was said in Sections 3.1, 4.7 and 4.11 on increasing the number of restrictions and on reversing the planning problem.

Next, we want to mention a striking feature of the sectoral capital coefficients which are particularly interesting for our models. It is well known that the sectoral capital coefficients show large differences between sectors, or in other words, that their values are spread over a wide range. Now, a striking phenomenon is that the international sectors have capital coefficients which are more or less in the middle of this range (cf. Table 10.7 and TINBERGEN, 1967, p. 105 ff.). So these coefficients have much less variation than the coefficients of the national sectors. Since each country has to develop its own national industries, this means that they have relatively little opportunity of reducing their overall capital-output ratios by an appropriate choice of international sectors. Nevertheless there remains the possibility of choosing the "cheapest" international sectors.

It will be clear that the sectoral capital coefficients vary from country to country and that consequently they have to be calculated separately for each country. Nevertheless we give in Table 10.7 – just for illustrative purposes – a set of sectoral incremental capital-output ratios which were recently (1964) calculated for India.

Finally, we remind the reader that if such coefficients are used in a model like the one in Section 4.3, they should be multiplied by the output-income ratios in order to arrive at the capital-income ratios. Moreover, they remain only a first approximation to the real costs of increasing production in a sector in terms of scarce resources. In particular they might differ from the cost figures calculated for individual projects both because the cost of a specific project may deviate from what was assumed to be the cost of expanding the sector and because such project cost calculations should work with discounted flows of costs and benefits (cf. Section 2.6). This last, conceptual, deviation would only create difficulties if there were systematic differences in these deviations between sectors, e.g. because of systematic differences in the life-time of projects in different sectors (see appendix VI).