INTRODUCTION AND SUMMARY

This study presents some simple methods for dealing with the element of space in medium or long-term economic development planning. The types of problems the authors have in mind range from world planning with a continental subdivision, via planning for a group of countries together and national planning with a regional subdivision, to finding the optimal dispersion of production units resulting in a system of groups of centres of different size and composition. The book is intended in the first place for practical planners who in one way or another have to deal with the element of space, but it may at the same time stimulate further research in this field.

The methods in the form of linear (programming) models are presented at two different levels of mathematical sophistication. The *main text* is intended to be accessible *without any mathematical training beyond high school level.* Only the ability to read mathematical symbols in linear formulas, and (in Chapter 8) to solve systems of linear equations by high school is supposed there. The main text is *supplemented* by *discussions and examples of simple solution methods* of the models suitable for hand calculations, but even these parts do not suppose knowledge of linear programming; they are confined to the transportation- or uv-method and direct generalizations of it which are explained in detail. *These parts*, as well as those in Chapter 7 which use heavily formulas, are *starred* and could be left out in reading the book, although they might contribute to a better understanding of its subject matter. For proofs and more complicated solution methods the reader is referred to the linear programming literature.

In line with an earlier remark by one of the authors (TINBERGEN, 1956, p. VIII) we ought to state which concepts, methods or findings in the book are considered by the authors to be new. For none of the main concepts used may we claim complete originality. The identification of sectors according to the degree of mobility of their products, the subdivision of spaces, the limited shiftability of certain sectors with mobile products, the planning framework used, the decomposition of some of the models, the

idea of a certain hierarchical ordering of centre types, are all concepts which have been examined before. Yet some elements, like e.g. the attempt to characterize spatial units in an economically meaningful way, starting from their degree of interaction with other spatial units, or the extension of the uv-method in Chapter 4, or the decomposition method especially developed for the models of Chapters 5 and 6 and the complete hierarchical system of centres in Chapter 8, may not be found in this form in the literature. However, primarily the combination of these concepts, their systematic use and generalization within the framework of planning for the development of complete economic systems with a spatial character, may be new. They yield a systematic survey of what data should be collected and which decisions should be taken for planning that takes account of space. Moreover, they indicate the ways for further research and refinements.

The *general structure of the book* is as follows.
Chapter 1 introduces the basic concepts related to space to be employed in this study and in possible applications, like the economic characterization, nomenclature and hierarchical ordering of spatial units, the division of products into different categories of mobility, the (non)shiftability of activities and the optimal spatial level for the use of certain instruments of economic policy. *Chapter 2* gives then a birds' eye view of the main concepts and methods used in development planning before the element of space is introduced into it. Next, *Chapters 3-7* present the results of fitting the concepts of Chapter 1 into the planning framework of Chapter 2. They give simple models with solution methods and refinements for planning in spatial units with a second order spatial subdivision. With transportation costs implicit as a first approximation they are presented for a closed economy in Chapter 3 (world-continental planning), and for an open economy in Chapter 4 (national-regional planning and planning for groups of countries). With transportation costs for a few heavy sectors explicit as a second approximation, similar models are dealt with in Chapters 5 and 6 for closed and open economies respectively. Moreover, in Chapter 6 a decomposition method is presented which allows proceeding in a few steps from the first approximate solution (without explicit transport costs) to the second approximate solution (with explicit transport costs for heavy sectors). Chapter 7 gives a survey and generalization of these models by showing their derivation from one general model. Each of these models is meant to constitute the

middle phase of a planning in stages procedure, where fixed income targets for the spatial units are given and should be attained at minimum costs. All of them are only applicable for planning in spatial units which are large enough to make the phenomenon of indivisibilities negligeable. *Chapter 8*, however, deals exactly with these smaller space units and indivisibilities: it offers, in the form of the "hierarchy hypothesis" and several refinements of it, hypothetical solutions to the problem of finding an optimal complete system of industrial centres, specified with regard to size, composition and location. This approach is a more theoretical and hypothetical one and it is not yet fully integrated with the former chapters. Therefore, *Chapter 9* offers a practical addition to the preceding chapters, by referring to already known approaches to a number of partial or incremental spatial planning problems often met in practice, and by attempting to link them to the content of the more general earlier chapters. Finally, *Chapter 10* offers some empirical material which gives an impression of the type of data, their order of magnitude and their variation between countries, which are relevant for the use of the models presented. Two complementary empirical studies, based on these spatial planning and hierarchical models, to be published separately, are summarized briefly at the end of the appropriate Chapters 4 and 8.

A remark may be added on the character and the applicability of these models, especially those of Chapters 3-7. At least three general elements should be accounted for in planning models dealing with the element of space: differences in mobility or transport costs between different products, differences in availability of the production factors (including natural resources) between different spatial units, and differences in (sometimes conflicting) interests of different spatial units. These three general elements are taken account of in this study by the distinction of categories of mobility (and in addition in some models by explicit transport costs), by different incremental production costs (and in addition by non-shiftabilities of some sectors), and by the setting of income increase targets for the spatial units. In addition one might include a number of particular elements of a technical, economic, social or political character, like the impossibility of extending certain sectors in certain spatial units very quickly for technical, economic or social reasons, the desirability of extending certain sectors at least by a certain amount for socio-political reasons, or the impossibility of increasing the exports of certain products very quickly for economic or institutional

reasons. These particular elements can be represented in the models by upper (or lower) bounds on the variables or combinations of variables, as discussed in Section 4.11, while these bounds also allow for calculating the marginal costs of these elements. These bounds lend to the models, whose logic is simple, a considerable flexibility for their practical application.

A warning with regard to the use of the models in this study is in order. The study is by no means intended to present a cookbook of models which are ready to be applied blindly. Instead, all models ought to be seen as "framework models", which should be refined or extended by practical judgment and experience for adjustment to the actual situations before they could be applied, unless they are used for illustrative purposes. In addition, making plans is only one step in the preparation of a development policy; it has to be followed by a careful indication how to implement the plans in view of the already existing trends of development in the economy concerned and of the available direct and indirect instruments to steer the economy from its projected to its planned development. Apart from some remarks in Section 1.4, the problems of implementation of the plans are not considered in this study on purpose, in order not to increase its size considerably. Their consideration, however, constitutes a necessary complement to this study. If the models in this book contribute to the building of practical and useful models and lead to further and more detailed investigations in this field, then the authors will be satisfied.