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Economic Planning for Regions within Countries: Purposes, Methods, Difficulties, and Results

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1. *Introduction*

1.1. IN the last two decades an increasing interest has arisen in the spatial aspects of planning. This interest seems to stem from two distinct sources. One source is the more micro or project-oriented approach of physical planners, social geographers, architects, and other technicians. The other source is the more macro and sector-oriented approach of economists.

Of these two approaches the one of the physical planners has by far the longest standing. From the original concern with individual projects, like buildings, roads, and other infrastructural projects, interest shifted, via problems of optimal location,[1] to spatial systems of projects covering even regions, in view of the obvious spatial interactions of single activities with each other. A well-known theoretical contribution, central place theory, has been initiated by geographers, Christaller and Lösch,[2] while economists, Tinbergen and Bos[3], have extended this theory to complete hierarchically structured economic systems of centres.[4] Recently the introduction of the concept of growth poles[5] has given rise to a number of primarily economic studies on the dynamics of concentration and interaction of economic activities.[6] In general, one could say that all studies of spatial or regional economics which comprise the phenomenon of spatial concentration of economic activity—mainly due to economies of scale or indivisibilities, and external economies, also called economies of agglomeration and juxtaposition—stem from this source.

The other source of interest in spatial aspects of planning employs the tools of macro-economists and has led to two branches of (applied) research. One branch of this approach is the application of macro-economic concepts like multipliers, balance of trade, and input-output tables, which have hitherto been used for the analysis of national economies, to economies of the size of regions.[7] Of course, the economies of regions differ in several respects from those of nations. This is not primarily due to size differences, as quite a few regions in larger countries may be larger in geographical or population size than small countries, but rather due to the embedding of regional economies into the national economy: regional

[1] The first large publication is Weber (1909).
[2] Christaller (1928); Lösch (1944).
[3] Tinbergen (1961); Tinbergen (1964); Bos (1965).
[4] For a survey of location theory see Alonso (1964); Beckman (1968).
[5] e.g. Perroux (1952); Perroux (1955).
[6] See a.o. Darwent (1969).
[7] e.g. Isard (1960); Klaasen (1967).

economies are generally more open than national economies, and regional authorities generally dispose of less instruments for economic policy than national authorities.

The second branch of research or planning, stemming from a macro-economic approach, focuses its attention precisely on how the economies of regions within a country together constitute the national economy or, viewed the other way round, how the national economy can be disaggregated into the economies of its constituting regions. Planning with this focus is called interregional planning, national planning with regional subdivision, or national-regional planning.[1]. It is in this second branch, rather than in the first branch, that the spatial character of a national economy is accounted for.

1.2 In this paper we will understand the subject 'economic planning for regions within countries' as referring primarily to this second branch of the second source of interest in the spatial aspects of economic planning, that is, we will deal with national-regional planning. It is hoped that in this way the paper serves best its introductory function, offering a general economic planning framework in which agricultural planning has an important place.

Even within the subject of national-regional planning we will not attempt to give a survey of methods and models, which have appeared in the literature, but rather sketch the main points of recent work in this area by a group of people at the Netherlands Economic Institute and the Netherlands School of Economics in Rotterdam, in which this author has taken part.[2] Our approach takes up quite a few points dealt with also in the rest of the literature in this area, so it is hoped that the majority of relevant aspects here are at least touched upon. Nevertheless, we are only too well aware that the subject requires much further elaboration. This approach offers as yet only a basic framework, which needs some further empirical underpinning, refinements according to the particular actual situations to which it may be applied, and testing for its usefulness by more applications than have hitherto been made of only the simplest versions.[3]

1.3. The paper is structured as follows. First the problem and the general principles of the approach are discussed (Section 2). Next the simplest version of the models employing these general principles is sketched (Section 3), followed by versions which comprise some refinements and extensions (Section 4). Then some further problems and limitations of this approach are indicated (Section 5) and finally a few applications, made thus far, are briefly discussed (Section 6).

[1] See for an early publication on it Leontief *et al.* (1953), pp. 93–115.

[2] The main publication is Mennes *et al* (1969). Earlier publications by J. Tinbergen show his main contribution to the development of the basic concepts, see a.o. Tinbergen (1965–1). Similar problems have been dealt with in two clarifying papers by Hermanson (1968) and (1969).

[3] See Section 6 of this paper.

2. *Some general principles for dealing with the problem of national-regional planning.*

2.1. The approach to be outlined is thought to play a role primarily in medium term (e.g. five-year) planning. In this outline we will take planning in the narrowest sense, that is, in the sense of constructing a series of figures for the expansion of production in the widest sense during the planning period, which are consistent and according to one or another criterion optimal, if at least there is room for optimizing at all. In discussing some further problems (Section 5) we will indicate a few aspects of the implementation of these plans. It will then be seen that the method is not thought to be bound for its application to one particular kind of economic system.

It may be useful to sketch briefly as a frame of reference the scheme for medium-term planning disregarding spatial aspects, which the group at Rotterdam had in mind while working on the method for spatial planning and in which scheme the method would fit as an obvious extension. This, however, does not mean that the method could not fit into other planning schemes. In fact, one of the characteristics of the method is that it might be applied on different levels of spatial aggregation at the one extreme at the level of the world subdivided into 'continents',[1] at the other extreme on the level of such small areas, subdivided into still smaller areas, that essentially discrete choice problems do not yet arise in connection with the phenomena of scale economies and concentration. In this last case extensions of the method are necessary which would bring us outside the scope of simple linear programming models into the less tractable area of discrete programming.[2] In this paper the method will only be discussed with respect to national-regional planning.

The above-mentioned scheme for medium-term planning is that of planning-in-stages,[3] consisting of a macro phase, a middle or sector phase, and a micro or project phase. In the macro phase a growth target for the national income is chosen in view of the savings potential, the implications for the balance of trade, the opportunities for the inflow of foreign capital and, in practice, other considerations of a more political nature. In the middle phase the expansion of the production of the sectors is determined, based on the chosen increase in national income, the concomitant increase in demand within the country, and the comparative advantage of the country with regard to the international sectors of which the products can be traded internationally.[4] Finally, in the micro phase, projects are selected in accordance with the planned expansion of their sectors. Normally the more refined information acquired in later

[1] See Mennes *et al.* (1969) and Herman *et al.* (1969). In the last paper four spatial levels are distinguished: world, continents, countries, and regions.

[2] See a.o. Balinski (1965); also Scott (1969–2).

[3] Tinbergen (1962); Tinbergen (1967).

[4] For this problem as well as for project evaluation Tinbergen has developed the semi-input-output method: Tinbergen (1966); Cornelisse and Tilanus (1966); Cornelisse and Versluis (1969).

phases makes a certain revision of earlier phases necessary, which may lead to an iterative process. Here again it should be emphasized that such a planning scheme could be applied irrespectively of the existing economic order or of the type of implementation envisaged, central planning, indicative planning or whatever type. On the other hand, the scheme has been developed primarily for 'developing' economies, that is, for low-income countries, and the same, but to a less degree, is true of the method for national-regional planning.

This method fits into the middle phase, in which the national economy is supposed to be subdivided not only into sectors, but also into regions, and in which the problem posed is not only to indicate how much which sectors should expand, but also in which regions these expansions should take place.

2.2 The extension of the middle phase problem by the regional disaggregation brings *three essential elements* into focus, which will have to be dealt with:

(*a*) Different regions offer different production opportunities for each sector.[1]

(*b*) The movement of products between regions and internationally is not equally possible or equally difficult ('costly') for all products.[1]

(*c*) The interests and prospects of different regions are not the same, some regions may be poorer than others, some regions may be more easily or quickly developed than others.

In the following subsections we will discuss each of these elements, and the way they are dealt with in the method outlined in this paper We assume provisionally that a satisfactory subdivision of the country into regions is given.

2.3. *Interregional differences in productive opportunities.*

It is only too obvious that for each sector the productive opportunities may be quite different between different regions. One may distinguish two different types of causes for these differences:

1. The relative scarcity of factors of production (like labour of various qualities, capital, and land including minerals and climate) may be quite different from region to region.
2. The availability of raw materials or intermediate products as inputs, and the access to a market for the products of a sector may be quite different from region to region, dependent on the presence of other sectors, which either provide inputs or buy the outputs, and on the presence of consumers, but in particular on the transportability of inputs and outputs.

This second type of causes for the differences in productive opportunities for a sector between regions has very much to do with the transportability

[1] In this whole discussion sectors are assumed to produce a homogeneous typical product, so products and sectors can be identified with each other.

of products, which will be dealt with in the next subsection. In addition, the presence or rather expansion of other sectors in the relevant future is not a datum but a variable of the problem itself. Therefore, we will discuss in this section only the first type of cause for the above-mentioned differences: the differences in scarcity of the factors of production.

Interregional differences in the scarcity of the factors of production are due to incomplete mobility of these factors. *Labour* is to a large extent rather immobile.[1] Massive migration is exceptional, and migration, though normally lessening the differences in labour scarcity, appears by no means to wipe them out. In general, the mobility of labour is higher as its quality is higher. Land is completely immobile. Capital, once invested in buildings or some forms of equipment, is immobile; new machines, however, are rather mobile. In 'fluid' form, capital is in principle highly mobile, although in practice severe limitations to this mobility of an institutional and even psychological nature show up. It is a debatable point whether foreign exchange should be counted among the scarce factors of production. Under certain assumptions—which we will not discuss here—it can be argued[2] that imbalances in the balance of trade reflect imbalances in the relation between national income and national expenditure, that it is the task of the authorities in charge of the short-term policy to see to it that such short-term imbalances do not occur, and that, as we are here concerned with medium or even long-term policies, we may assume that these short-term problems, and therefore the scarcity of foreign exchange (as different from that of capital in general), do not concern us here.

The influence of these differences on the interregional differences in productive opportunities for a sector depend on the possibilities for substitution between those factors within the sector concerned. Land can hardly be substituted for, so the opportunities for agriculture and mining are nearly completely determined by the availability of the factor land in the widest sense. Capital and labour of various qualities display a certain substitutability among themselves, allowing for different technologies to be used at different places. This, however, does not eliminate interregional differences in the cost of production in terms of the use of scarce factors.

Thus, interregional differences in productive opportunities for each sector show themselves in two ways: for certain sectors certain regions are simply unsuitable, for other sectors the costs of production in terms of scarce factors of production are different from region to region.

In the method to be outlined in this paper, which method will turn out to take the form of linear programming models, we will represent this situation in two ways. On the one hand we will call those sectors which can exist (or be expanded) in only one region *non-shiftable*, those sectors which can exist in all regions *shiftable*, and those sectors which can exist in some but not all regions *partly shiftable*. Thus, some combinations of sectors and regions are excluded as impossible. On the other hand, we will assume that per sector and per region, in which the sector concerned can be

[1] See, for example, Mennes *et al.* (1969), Section 10.1, and O.E.C.D. (1966).

[2] e.g. in Tinbergen (1965–1) and Mennes *et al.* (1969), pp. 22, 23, 26.

expanded, a figure can be determined, which is the *unit cost (in terms of the use of scarce factors of production) of expansion of that sector in that region.* In determining this unit cost it is supposed that the expansion takes place in production units of optimal size, using the optimal technology, and that the use of the scarce factors of production is expressed using scarcity prices.[1] If for a sector those figures are the same for all regions, then such a sector is called *completely shiftable.*

2.4. *Differences in transportability of the products*

The second essential element to be dealt with, if the national economy is spatially disaggregated, is the different transportability of the products. In fact, transportation of products[2] is the way to overcome distances between the points of production and those of use of the products (by consumers or by other producers), and obstacles to the mobility of products (in the widest sense) express essentially (geographical) space as extensiveness.

Such obstacles to the mobility of products may take different forms, e.g. the following:

(*a*) Some products are completely immobile, like building, highways, and railways.

(*b*) Many services such as retail trade, primary schools, domestic services, etc., are highly immobile due to the difficulty of periodical movement of persons in view of the time and effort needed for it.

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

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

(*e*) The movement of products from suppliers to users (consumers or factories) implies not only transportation in the restricted sense of the word, but communication as well. This may enlarge the spatial attraction between the suppliers and users of products considerably beyond what would be suggested by physical transportation costs.[3]

Due to such obstacles products are not as mobile as has been suggested for a long time by many textbooks on international trade. In principle one could represent these obstacles rather completely by introducing for each product the costs of transportation from any region to any region, including the international market. However, this would introduce into the problem, and into the models which deal with it, an enormous amount of variables and it would require a similarly enormous amount of detailed information on such transportation costs. A large part of these variables and the information would be actually irrelevant, however.

[1] Cf. Section 5.1 of this paper.

[2] In this whole discussion sectors are assumed to produce a homogeneous typical product, so products and sectors can be identified with each other.

[3] Cf. Klaassen (1967), pp. 43 ff.

Therefore, we propose another way of representing these obstacles to mobility, namely by *distinguishing products qualitatively, according to classes of mobility, as regional, national, or international products.*[1] Regional products are defined as those products which (for technical or economic reasons) cannot be transported to outside the region where they are produced; national products are defined as those products which cannot be transported internationally (they comprise therefore the regional products, but comprise also 'other national products' which are not regional ones; for simplicity we will sometimes call 'other national products' simply national, if no confusion is possible); finally, international products are defined as those products which can be traded internationally.

As a first approximation we will assume that this distinction of the products into categories of mobility is a sufficiently complete description of the obstacles to mobility as far as the optimal regional distribution of the expansion of production is concerned. That is, we will assume that (other) national and international products can be transported interregionally without cost. As a second approximation, however, we will introduce explicitly the transportation costs for a few, so-called *heavy* products, mentioned already earlier, which in probably many countries comprise 65–85 per cent of the total transportation system (see Section 4.3).[2]

The characteristic implication of the definition of the categories of mobility is, that *production and use of regional products must balance per region, those of (other) national products need only to balance per country, and those of international products do not need to balance for each sector even on the level of each country*, but together as a group they balance on the national level if national income balances with national expenditure.

A rough empirical investigation[3] has shown that international sectors comprise 40–60 per cent, (other) national sectors 10–20 per cent, and regional (or local) sectors 30–45 per cent of the production in many countries. Table 1 gives by way of example a rough indication of the classification of sectors in general. Even local sectors are distinguished there, which, however, in the models presented here play the same role as regional sectors.

TABLE 1. *Example of mobility classes of sectors or products*

Local	Regional	National	International
Construction	Secondary education	Higher education	Most agricultural,
Housing	Perishable goods	Central government	mining, and manu-
Retail trade	(vegetables)	Building materials	facturing products
Service	Provincial govern-	Electricity	
Primary education	ment		
Local government	Intraregional trans-		
	portation		

[1] This distinction goes back to Leontief (1953) and Isard (1960). See also Tinbergen (1965–2).

[2] A. Kuyvenhoven contributed some empirical research on this point to Mennes *et al.* (1969), Appendix IV.

[3] This investigation has been made by B. Herman, see Mennes *et al.* (1960), Section 10.4.

2.5. *Regional interests*

In discussing the third element to be introduced if we distinguish regions, regional interests (and prospects), we should say first a few words about the aims of planning. The aims of economic planning are the economic aspects of the aims of policy in general, which we take here as the increase in welfare. For simplicity we assume that the economic aspect of the increase in welfare is expressed as the increase in national income, leaving aside other economic policy aims, e.g. with regard to personal income distribution, to economic independence, etc. Even then there remains the problem of the optimum growth path of the national income (or of consumption), which is a subject of deep theoretical investigations and discussion,[1] but which we will not discuss here, as it appears only implicitly in the method outlined in this paper. In fact we will assume that the government, on the basis of political and economic considerations, is able to choose a growth target for the national income over the planning period.

Then the recognition of the existence of regions brings the question of the regional income distribution into focus. Without putting this question explicitly a planning method which takes account only of the production opportunities during the planning period will locate the expansion of each sector as far as possible always in its most attractive region. There are two possible objections against such a solution:

(*a*) If there are considerable differences between the regions with regard to income level and its growth, it may be expected that in the medium term the poorer and/or slow-growing regions tend to appear rather unattractive for the expansion of sectors, while in the long-run view their attractiveness or prospects might be relatively good after a certain breakthrough period. Such regions might be wrongly neglected. How valid this objection is, or how general the sketched situation, is difficult to assess on *a priori* grounds, as it may differ from case to case.[2]

(*b*) There is, however, another objection, which seems anyway valid. There may be a socio-political preference for as little interregional *per capita* income differences as possible, already on the basis of the consideration that marginal utilities of income are higher in poorer than in richer regions, whichever theoretical and empirical difficulties such a consideration carries with it.

For these two reasons we will also assume that it is possible to distribute the target for the increase of the national income into targets for the increases of the regional incomes separately. We are aware that at least as many difficulties are involved here as with the determination of a national income increase target. In addition it should be clear that studies on population growth and population movements between regions should precede the choice of these regional income increase targets. Here an

[1] See especially Chakravarty (1969).

[2] See a.o. the clear exposition of the different arguments by Hermanson (1968).

additional difficulty is, that the population movement might be influenced by the implementation of the plan, which may lead to a revision of the projections of these population movements.

2.6. *The problem and the approach to its solution*

On the basis of the foregoing discussion we can now formulate the problem to be dealt with in this paper, which we will call the *national-regional and transport planning problem: determine the feasible and optimal increases in production per sector and per region and the corresponding optimal inter-regional (and international) transport system*, feasible in the sense that production and use of regional products balance at the regional level, and those of national products balance at the national level, and that the income increase targets for each region are attained, and optimal in the sense that the total costs in terms of the increased use of scarce resources are at a minimum.

In dealing with this problem we aim at extreme simplicity in order to keep the logic of the problem clear and to make it understandable also for those not accustomed to working with models. Naturally some costs are involved, this time in realism, but the realism can be increased, as will be discussed in Section 4. In fact we will outline in Section 3 the simplest model expressing our general approach, and in Section 4 some extensions and refinements of it.

One of the simplifications, stuck to in the whole paper, is that we use only comparative static models, not dealing with intertemporal distribution of the expansion of production during the planning period, nor after it. A second simplification, used throughout, is that we assume full capacity use at the beginning and the end of the planning period, the problem of unused capacities being assumed to be rather of a short-term nature.

Before closing this section we should make a brief remark on the proper choice of regions and of sectors. The proper choice of regions will always constitute a compromise between several conflicting criteria. Too much refinement in this case may lead to the distinction of many regions, while it is felt that a maximum number of around 12 is most appropriate. Otherwise the models become very large and difficult to handle, and the insight into their results may be lost. Apart from this criterion, the main principle appears to be that the regions should be as homogeneous (economically, but also socio-culturally) as possible, should have preferably real obstacles to transportation at their frontiers, should coincide with (groups of) administrative units both for data collection and for implementation, should be of comparable importance, and should differ in openness from the national economy. For the sectors, in addition to the criteria for sector disaggregation usually applied in input-output theory,[1] new principles of disaggregation are that they should be as homogeneous as possible with regard to the mobility of their products and their cost differences between regions. However, a practical choice for the total number of sectors may be around 25.

[1] See Chenery and Clark (1959), pp. 34–9.

3. *The simplest version of the approach.*

3.1. In the simplest version of our approach to the national-regional and transport planning problem, as defined in Section 2.5, we make the following *assumptions*.

Assumption 1. Sectors and products can be distinguished into the categories regional, national, and international, and transportation[1] costs of national and international products can be neglected.

The second part of this assumption constitutes the essential part of what we call the first approximation of our problem. It implies that we assume that taking explicit account of transportation costs does not influence the spatial distribution of the increases in the production. Once this spatial distribution has been determined, however, transport cost figures can be used to find the optimal transport system, given this distribution.

Assumption 2. All production processes can be described by linear relationships between outputs and inputs of all kinds.

This assumption is well known from input-output theory. As for the factors of production, however, it is only used to have fixed unit cost coefficients for the expansion of production, which does not exclude technical substitution possibilities. The assumption does exclude, however, economies of scale and external economies as irrelevant at this level of aggregation.

Assumption 3. For each sector the ratio between income to output is the same in all regions.

This assumption is very near to assuming that there are no interregional differences in the technical coefficients of the sectors and it is related to Assumption 5. A somewhat weaker form of the assumption would be possible.

Assumption 4. For each national or regional product the increase in demand is proportional to the increase in national or regional income respectively.

This assumption implies a constant demand coefficient for all products. However, it would be sufficient to assume that the increase in demand is fully determined by the increase in income. Anyway it implies that the increase in (also intermediate) demand does not depend on which sectors are expanded in each region or in the country. This assumption, therefore, allows for the extremely simple form of the problem to be presented in this section.
section.

Assumption 5. For all products prices are given and interregional differences in prices can be neglected.

This assumption makes it possible to measure production in income (or value added) units, which are the same throughout the country, as prices are no variables in the problem. It excludes in particular transportation as an income-producing activity.

Accordingly, the following data for this simplest model are supposed to be known:

[1] From here on we mean by transport(ation) always interregional and international transportation.

(*a*) Target values of the increases in income for each region;
(*b*) Classification of products (and sectors) into the categories regional, national, and international;
(*c*) Unit cost/output figures for the expansion of production per sector and per region;
(*d*) Income/output ratios for each sector and each region;
(*e*) Ratios between the increases in demand (in terms of value added) per (regional and national respectively) product and the increase in (regional and national respectively) income.

3.2. The *algebraic formulation of the simplest model* for the national-regional planning problem[1] is given for a particular example of a country with 3 regions and 5 sectors, with the following characteristics:

Sector 1: regional;
Sector 2: national, nonshiftable, only expandable in region 1;
Sector 3: national, shiftable;
Sector 4: international, shiftable;
Sector 5: international, partly shiftable, not expandable in region 1.

The following symbols are used:[2]

Variables $^{r}y^{h}$: the increase in income or value added of sector h in region r.
Targets y : the increase in income created in the country.
^{r}y : the increase in income created in region r.
Coefficients $^{r}\tilde{c}^{h}$: the total costs (of scarce resources) per unit increase in income of sector h in region r.
$^{r}\tilde{n}^{h}$: the increase in total demand for product h in region r, measured in value added, per unit increase of region r's income.
$\tilde{n}^{h}$: the increase in total demand for product h in the country, measured in value added, per unit increase of the country's income.
Special sign $\sim$: this symbol is used to remind the reader that all units of measurement in this simple model are in income or value added terms.

The model can then be written as follows:[3]

Minimize
$$\sum_{r=1}^{3}\sum_{h=1}^{5} {}^{r}\tilde{c}^{h}\,{}^{r}y^{h} \tag{3.1}$$

(the total cost of expanding the production is minimized)

subject to
$$^{1}y^{1} = {}^{1}\tilde{\eta}^{1}\,.^{1}y \tag{3.2}$$
$$^{2}y^{1} = {}^{2}\tilde{\eta}^{1}\,.^{2}y \tag{3.3}$$
$$^{3}y^{1} = {}^{3}\tilde{\eta}^{1}\,.^{3}y \tag{3.4}$$

[1] The transport planning problem has been separated from it by virtue of Assumption 1, so we could call this left over problem the 'main body' of the model.
[2] All increases refer to increases over the planning period.
[3] Variables which do not occur in the models due to non-shiftabilities are nevertheless kept in some formulae in order to keep the notation simple (symmetric).

(the expansion of production of each regional sector should equal the increase in demand for its products per region)

$$ {}^{1}y^{2} = \tilde{\eta}^{2}.y \qquad (3.5) $$

$$ {}^{1}y^{3}+{}^{2}y^{3}+{}^{3}y^{3} = \tilde{\eta}^{3}.y \qquad (3.6) $$

(the expansion of production in each national sector should equal the increase in demand for its products in the country as a whole)

$$ {}^{1}y^{1}+{}^{1}y^{2}+{}^{1}y^{3}+{}^{1}y^{4} = {}^{1}y \qquad (3.7) $$

$$ {}^{2}y^{1}+{}^{2}y^{3}+{}^{2}y^{4}+{}^{2}y^{5} = {}^{2}y \qquad (3.8) $$

$$ {}^{3}y^{1}+{}^{3}y^{3}+{}^{3}y^{4}+{}^{3}y^{5} = {}^{3}y \qquad (3.9) $$

(the total increase in income from all sectors in each region should equal the regional income increase target)

$$ {}^{r}y^{h} \geqslant 0 \qquad (r = 1,\ldots, 3;\ h = 1,\ldots, 5) \qquad (3.10) $$

(it is supposed that no sector will decrease its production in any region).[1]

Equations (3.2)–(3.6) are balance equations, equations (3.7)–(3.9) are definition equations. For the international sectors characteristically for these models no balance equations appear (cf. Section 2.3); the balance equation for all international sectors together is redundant and follows by deducting equations (3.2)–(3.6) from the sum of equations (3.7)–(3.9). Balance of payments is assured if the demand/income coefficients $\tilde{\eta}^{1},\ldots, \tilde{\eta}^{5}$, in which also the demand for investment goods is included, sum to unity.

3.3. The same model can be represented conveniently in *tabular form*, with the regions and sectors as entries. For concreteness' sake we use rather arbitrary numerical values for the data of the problem, leaving open, however, their real magnitudes.

In particular we suppose:

$$ {}^{1}y = {}^{2}y = {}^{3}y = 10;\ {}^{1}\tilde{\eta}^{1} = {}^{2}\tilde{\eta}^{1} = {}^{3}\tilde{\eta}^{1} = 0{\cdot}2;\ \tilde{\eta}^{2} = 0{\cdot}1;\ \tilde{\eta}^{3} = 0{\cdot}2; $$

$$ (\tilde{\eta}^{4} = 0{\cdot}3;\ \tilde{\eta}^{5} = 0{\cdot}2), $$

and the cost/value added ratios to be given by Table 2.

TABLE 2. *Cost/income ratios of the numerical example (the* ${}^{r}\tilde{c}^{h}$*)**

Sectors	Regions 1	2	3
1	3	3	3
2	3	..	..
3	3·1	2·8	3
4	3·5	3	3·3
5	..	2·3	2

* .. Indicates (partly) non-shiftability.

[1] This assumption is made in order to arrive at a normal linear programming problem. It is not an unreasonable assumption in a growing economy, but one could also allow for a certain limited decrease in production by redefining the variables concerned so as to be measured from a maximum decrease on upward.

Table 3 gives the tabular representation of the model of this section.

TABLE 3. *Programme of income increases*

Sectors		Regions 1	2	3	Sectoral demand increase totals
Regional	1	${}^1y^1$	${}^2y^1$	${}^3y^1$	$\left[\sum_{r=1}^{3} {}^r\hat{\eta}^1 . {}^r y = 6\right]$
National	2	${}^1y^2$	..	..	$\hat{\eta}^2 . y = 3$
National	3	${}^1y^3$	${}^2y^3$	${}^3y^3$	$\hat{\eta}^3 . y = 6$
International	4	${}^1y^4$	${}^2y^4$	${}^3y^4$	$\left[(\hat{\eta}^4 + \hat{\eta}^5) . y = 15\right]$
International	5	..	${}^2y^5$	${}^3y^5$	
Regional income increase targets		10	10	10	Total 30

Table 3 should be so interpreted that the variables should add up row-wise to the row totals, and column-wise to the column totals, while minimizing (3.1) for the data in Table 2, and being non-negative. However, in fact for the variables in the rows of the regional sector(s) we know more than only each row total; their individual values are determined fully by equations (3.2)–(3.4). Also, for the variables in the rows of the international sectors only their sum total is given, and even that can be derived from the total (30) after deduction of the other sector totals in the last column.

3.4. *Calculating the solution* of this simplest model is extremely easy and can be done by hand even for large models, with many more regions and sectors than in the simplified example given here.

The mathematical form of the optimization problem, that is left after fixing the values of ${}^1y^1$, ${}^2y^1$, ${}^3y^1$, and ${}^1y^2$, which are determined already, is nearly that of the classical transportation—or Hitchcock–Koopmans–Kantorovich-problem, dealt with in any textbook on linear programming.[1] It can be solved by a slight extension of the standard transportation or *uv*-method for such problem, which is considerably simpler than the simplex method for general linear programming problems. We will not discuss this well-known solution method here.[2] It may suffice to mention that the slight extension of the solution method consists in noticing that, as the variables in the rows for the international sectors all have to satisfy only one row constraint, which is in addition redundant, the multipliers (u's) corresponding to these rows should be all equal, and can be chosen conveniently = 0.

The *optimal solution of the numerical example* is given in Table 4. In it also the u and v values, used in checking the optimality of the solution, are given, as well as the total costs for each sector and each region, while the cost coefficients are placed in the upper left-hand corner of their corresponding cells, and the increases in demand per sector and per region (assuming no interregional differences in demand coefficients) are placed in the lower left-hand corner of the corresponding cells.

[1] See, for example, Dantzig (1963). [2] See Mennes, *et al.* (1969), Section 4.4.

TABLE 4. *Optimal solution and other data of the numerical example*

u^h	Sectors	^ry: 2·6 / 2.3 / 2 — Regions 1	2	3	Sectoral totals	Costs
..	Reg. 1	3 / 2 / 2	3 / 2 / 2	3 / 2 / 2	[6]	18
..	Nat. 2	3 / 3 / 1	.. / .. / 1	.. / .. / 1	3	9
0·5	Nat. 3	3·1 / 5 / 0·2	2·8 / 1 / 0·2	3 / 0 / 0·2	6	18·3
0	Int. 4	3·5 / 0 / 3	3 / 0 / 3	3·3 / 0 / 3	[15]	0
0	Int. 5	.. / .. / 2	2·3 / 7 / 2	2 / 8 / 2		32·1
Regional totals		10	10	10	Total 30	Total costs
Costs		30·5	24·9	22		77·4

3.5. From the solution it is clear that not each non-regional sector is expanded in its cheapest region, as would be the case if there were no regional income increase targets. In this last case sector 2 would again be expanded by 3 units in region 1, sector 3 by 6 units in region 2, sector 4 not at all, sector 5 by 15 units in region 3, and sector 1 by 0·75, 1·5, and 3·75 units in regions 1, 2, and 3 respectively. The regional income increases would then be 3·75, 7·5, and 18·75 in regions 1, 2, and 3 respectively and total costs would be 73·8 units. Within the assumptions of this simplest version of the model one may conclude from this that the regional income distribution policy gives an extra cost of $77{\cdot}4-73{\cdot}8 = 3{\cdot}6$ units.

However, a policy-maker might be more interested to know what the increase (positive or negative) in total costs would be for *small* changes in the regional income increase targets, while the national income increase is kept at the same value. This information can easily be derived from the figures in Table 4, as anyone familiar with linear programming will know. The small changes in the regional targets (increases positive, decreases negative) are simply multiplied by the corresponding figures for ^ry at the top of the table and the results are added up to give the desired figure. For example, increasing ^3y by 1 and decreasing ^2y by 1 decreases the cost by $-\{(+1)(2)+(-1)(2{\cdot}3)\} = 0{\cdot}3$ units. Thus such sensitivity analysis for the regional income increase targets can easily be carried out, without much extra calculation.

4. *Some refinements and extensions of the approach*

4.1. The solution in Table 4 expresses only increases in the production and therefore does not give a picture of the situation at the end of the planning period. In addition, the values of the variables depend strongly on the numerical data used in the model. Yet we will use the figures in this solution as an illustration to discuss some less realistic features of this solution, which are thought to be more or less representative for the results of any application of this simplest version of the approach. In the next subsections we will discuss some refinements and extensions of this model, which can redress to a certain extent these less realistic features, without bringing us outside the framework of linear programming.

In discussing the solution in Table 4 we may imagine for concreteness' sake the sectors, 1,..., 5 to be, for example, most services, national government, power, industry, and agriculture respectively. We notice the following less realistic features of this solution.

A The country is strongly specialized with regard to the expansion of international sectors. As a result:

A_1 A considerable change occurs in international trade (and international transportation); whether this is an increase or a decrease, however, depends on the trade pattern at the beginning of the planning period. It is doubtful whether such a change is possible, organizationally, economically, and politically.[1]

A_2 A considerable expansion of the production in a few sectors takes place, which may influence the unit costs of these expansions, or simply be technically infeasible.

A_3 The big change in international transportation may cause the change in transportation costs, at least for some products, no longer to be negligible.

B The same feature of specialization can be observed for the regions separately with respect to the expansion of national and international sectors. The implications of this feature at the regional level run parallel to those at the national level (A^1–A^3), though with different relevance:

B_1 The change in interregional trade might create less doubts and difficulties.

B_2 The strong increase in production of a few sectors in one region may have, however, more probably an influence on the unit costs and run more clearly against technical limitations.

B_3 The change in interregional transportation may also have no longer for all sectors negligible cost implications. In general, the increase in production of a national or international sector is not directly related to the increase in demand in that region, in the same way as this is not the case for international sectors at the national level.

[1] The world market prices are assumed to be known, to remain the same for any quantity bought or sold, and to be the basis for the prices for international products on the home market.

C The increase in production of a regional sector in a region is independent of which other sectors are expanded in that region as much as the increase in production of a national sector in the country as a whole is independent of the expansion of the international sectors.

D This simplest version does not allow for other economic policy goals, e.g. with respect to employment.

The following devices can partly counteract these less realistic features:

(*a*) The introduction of upper or lower bounds on variables or combinations of variables (counteracts A_1, A_2, B_1, B_2 and partly A_3, B_3, and D).

(*b*) The introduction of explicit transportation costs for a few heavy sectors (counteracts A_3 and B_3).

(*c*) The introduction of explicit input-output relations (counteracts C).

(*d*) The introduction of explicit employment targets (counteracts D).

We will briefly discuss each of these devices.

4.2. *The introduction of bounds*

Upper bounds can be introduced on, for example:

1. The expansion of the production of a sector in a region:

$$ {}^{r}y^{h} \leqslant {}^{r}\tilde{A}^{h} \qquad (r = 1,\ldots, R;\ h = H_1+1,\ldots, H) \tag{4.1} $$

${}^{r}\tilde{A}^{h}$: upper bound, chosen in one or another way
H_1: number of regional sectors (= 1 in the example of Section 3)
H: total number of sectors (= 5 in the example of Section 3)
R: total number of regions (= 3 in the example of Section 3)

2. The increase in exports of a product from a region:

$$ {}^{r}y^{h} - {}^{r}\tilde{\eta}^{h}.{}^{r}y \leqslant {}^{r}\tilde{B}^{h} \qquad (r = 1,\ldots, R;\ h = H_1+1,\ldots, H) \tag{4.2} $$

${}^{r}\tilde{B}^{h}$: upper bound, chosen in one or another way

3. The increase in exports of a product from the country:

$$ \sum_{r=1}^{R} {}^{r}y^{h} - \tilde{\eta}^{h}.y \leqslant \tilde{D}^{h} \qquad (h = H_1+H_2+1,\ldots, H) \tag{4.3} $$

H_2: the number of (other) national sectors

In a similar way one can introduce lower bounds to the items mentioned, as well as upper or lower bounds to changes in imports.

In all these cases the resulting model can still be handled by hand computations.[1] The values of the simplex multipliers (or the values of the dual variables) corresponding to these extra restrictions can be used to estimate the effect on the total costs of a small change in the value of the bounds, which therefore can be revised if this influence turns out to be large.

4.3. *The introduction of explicit transportation costs for heavy sectors*

In Section 3.1, when discussing Assumption 1, we argued that the costs of transportation were not neglected altogether, but were used only in

[1] See Dantzig (1963), Chapter 18.

determining the optimal transportation system after the regional distribution of production had been determined. However, for a few sectors the transportation costs (per unit distance and per unit of product) may be so high that taking account of them while determining the regional distribution of the production of those sectors would lead, it is true, to higher costs for the expansion of production but at the same time to so much lower costs for transportation that the over-all costs of production and transportation nevertheless are lower.

Now, introducing explicit transportation costs into the main body of the model for all national and international sectors would largely do away with the advantages of introducing mobility classes. It appears, however, to be sufficient to do so only for a few 'heavy' sectors. We will not define these sectors precisely here, but empirically they may be found by investigating which minimum number of products the transportation occupies together around 70–80 per cent of the total transportation in a country. Taking account of their transportation costs in the main body of the model may be sufficient as a *second approximation* of the national-regional and transportation planning problem, including a rough picture of the main transport arteries in the country. It implies that the second part of Assumption 1 is given up with respect to heavy sectors.

We will not deal with all the technical details of the introduction of explicit transportation costs for heavy sectors into the main body of the model, nor with the method of solution for such a model. We may refer for that to the original publication on it.[1] Here we mention only that such an introduction requires also inserting into the model data on the total production and on total demand at the beginning of the planning period (cf. p. 18, n. 2.)

As for the method of solution of the extended model, two methods are described in the original publication. One is the so-called revised simplex method, of which the application can be made still by hand. However, also a second, decomposition, method is developed especially for this problem, called the 'iterative improvement method'. There the main idea is that one may start with the first approximation solution, solve then the resulting problem of finding the optimal transport system, but then, by switching between the two problems and using information acquired already when solving the problems separately, one can see whether the second approximation solution may be better than that of the first approximation, and, if so, calculate the solution. Also this second method can still be used by hand calculations. The reasons for developing this second method are the following ones. Computationally it may be easier to deal with a few smaller problems than with one larger problem, also if the problems are too complicated to be solved by hand (see Section 4.4). Organizationally it may be attractive to have separate departments dealing with the increases in production and with the transportation system, each employing their own expertise. Didactically, a decomposition of the problem may be attractive for discussions about the results of the model.

[1] Mennes *et al.* (1969), Chapters 5 and 7.

As an *illustrative example* we will take the same numerical example as that in Section 3, but consider in addition sector 4 to be heavy. The additional information to be used is that the transport costs of one unit of product 4 transported between the regions and the outside world are as given in Table 5.

TABLE 5. *Cost coefficients for interregional and international transport of product 4.*

	From region			Outside world
To region	1	2	3	
1	..	0·5	0·5	..*
2	0·5	..	0·7	0·6
3	0·5	0·7	..	0·5
Outside world	..	0·6	0·5	..

* It is supposed that no direct international import or export to or from region 1 is possible, because of its geographical position.

In addition it is supposed that at the beginning of the planning period the following surpluses (of product 4) of production over demand exist in the regions:

$$\text{region 1: } {}^{1}\bar{y}^{4} - {}^{1}\bar{d}^{4} = -1$$
$$\text{region 2: } {}^{2}\bar{y}^{4} - {}^{2}\bar{d}^{4} = 1$$
$$\text{region 3: } {}^{3}\bar{y}^{4} - {}^{3}\bar{d}^{4} = 0$$

The following equations are added to the model of Section 3:

$${}^{1}y^{4} - {}^{12}\tilde{t}^{4} - {}^{13}\tilde{t}^{4} + {}^{21}\tilde{t}^{4} + {}^{31}\tilde{t}^{4} = {}^{1}\tilde{\eta}^{4}\,{}^{1}y - ({}^{1}\bar{y}^{4} - {}^{1}\bar{d}^{4}) \tag{4.4}$$

$${}^{2}y^{4} - {}^{21}\tilde{t}^{4} - {}^{23}\tilde{t}^{4} + {}^{12}\tilde{t}^{4} + {}^{32}\tilde{t}^{4} - {}^{2}\tilde{e}^{4} + {}^{2}\tilde{m}^{4} = {}^{2}\tilde{\eta}^{4}\,{}^{2}y - ({}^{2}\bar{y}^{4} - {}^{2}\bar{d}^{4}) \tag{4.5}$$

$${}^{3}y^{4} - {}^{31}\tilde{t}^{4} - {}^{32}\tilde{t}^{4} + {}^{13}\tilde{t}^{4} + {}^{23}\tilde{t}^{4} - {}^{3}\tilde{e}^{4} + {}^{3}\tilde{m}^{4} = {}^{3}\tilde{\eta}^{4}\,{}^{3}y - ({}^{3}\bar{y}^{4} - {}^{3}\bar{d}^{4}) \tag{4.6}$$

Here, ${}^{rr'}\tilde{t}^{4}$: the total[1] transport of product 4 from region r to region r'

${}^{r}\tilde{e}^{4}$ and ${}^{r}\tilde{m}^{4}$: (international) export from and import to region r.

To the objective function (3.1) the total cost of transport is added:

$$\sum_{r=1}^{3}\sum_{r'=1}^{3} {}^{rr'}\tilde{\tau}^{4}\,{}^{rr'}\tilde{t}^{4} + {}^{2}\tilde{\epsilon}^{4}\,{}^{2}\tilde{e}^{4} + {}^{2}\tilde{\mu}^{4}\,{}^{2}\tilde{m}^{4} + {}^{3}\tilde{\epsilon}^{4}\,{}^{3}\tilde{e}^{4} + {}^{3}\tilde{\mu}^{4}\,{}^{3}\tilde{m}^{4} \tag{4.7}$$

Here, the τ's, ϵ's, and μ's are transport cost coefficients per unit (of value added) of product 4 transported.

We give in Table 6 the solution of the first approximation (called the successive solution, as we calculate successively the national-regional planning problem and the transport planning problem) together with the solution of the second approximation, called the simultaneous solution, as we take simultaneously into account the increase in production costs and the total[1] transport costs.

[1] Total in the sense of not only the increase over the planning period. To a certain extent it is necessary to work with such total values for transport, as in a growing economy a decrease of transport of certain goods along certain routes is quite well possible (e.g. import substitution).

TABLE 6. *Comparison of the successive and the simultaneous solution of the numerical example**

The successive solution

Sectors	Regions 1	Regions 2	Regions 3	Outside world	Sector totals	Costs of the solution per sector
1	3 / 2	3 / 2	3 / 2		[6]	18
2	3 / 3	..	..		3	9
3	3·1 / 5	2·8 / 1	3 / 0		6	18·3
4	3·5 / 0	3 / 0	3·3 / 0		[15]	0
Transport flows	← 4 —(0·5) ← 7 —(0·5) ← 2 —(0·6)					6·7
5	..	2·3 / 7	2 / 8			32·1
Regional targets	10	10	10	Total costs: 84·1		

The simultaneous solution

Sectors	Regions 1	Regions 2	Regions 3	Outside world	Sector totals	Regions solution per sector
1	3 / 2	3 / 2	3 / 2		[6]	18
2	3 / 3	..	..		3	9
3	3·1 / 1	2·8 / 5	3 / 0		6	17·1
4	3·5 / 4	3 / 0	3·3 / 0		[15]	14
Transport flows	← 2 —(0·6)		← 3 —(0·5			2·7
5	..	2·3 / 3	2 / 8			22·9
Regional targets	10	10	10	Total costs: 83·7		

* In the upper left-hand corner of each cell in the centre part of the table the corresponding cost coefficient is given; in the centre of each cell one finds the value of the corresponding variable in the respective solutions. At the bottom of the row corresponding to the heavy sectors the arrows indicate the resulting transport flows. Their volume is placed in the midst of the arrows, while their cost coefficients (between brackets) are at the beginning of the arrows.

From Table 6 it can be seen that the simultaneous solution has indeed a lower total cost figure than the successive solution, although the increase in production costs is higher in the simultaneous solution, which, however, is more than offset by the lower transport costs.

4.4. *The introduction of explicit input-output relations*

Obviously in many cases, especially if structural changes take place, a separation of final and intermediate demand will give a more accurate projection of the increase in total demand for the product of a sector. This separation can be made if explicitly input-output relations between the various sectors in the model are introduced, that is, if Assumption 4 is changed to apply only to final demand. If that is done, there is no longer any special reason to use income or value added for the unit of measurement. In the simplest version (Section 3) this lent to the problem its especially easy form of a Hitchcock–Koopmans–Kantorovich problem, but this simple quality is anyway lost if input-output relations are introduced. It is also no longer possible to calculate the optimal solution by hand.

We will give the more refined form of the model with input-output relations—but without heavy products—of the same example of Section 3.

Minimize
$$\sum_{r=1}^{3}\sum_{h=1}^{5} {}^{r}c^{h}\,{}^{r}x^{h} \quad {}^{1)} \tag{4.8}$$

subject to

$${}^{r}x^{1} = \sum_{h'=1}^{5} {}^{r}\phi^{1h'}\,{}^{r}x^{h'} + {}^{r}\gamma^{1r}y \quad {}^{1)}\ (r = 1,\ldots, 3) \tag{4.9}$$

(the increase in production of a regional sector in a region should equal the increase in intermediate and final demand for its products in that region)

$$\sum_{r=1}^{3} {}^{r}x^{h_2} = \sum_{h'=1}^{5}\sum_{r=1}^{3} {}^{r}\varphi_{h_2h'}\,{}^{r}x^{h'} + \gamma^{h_2}y \quad {}^{1)}\ (h_2 = 2, 3) \tag{4.10}$$

(the increase in production of a national sector in the country should equal the increase in intermediate and final demand for its products in the country)

$$\sum_{h=1}^{5} {}^{r}\phi_{0h}\,{}^{r}x^{h} = {}^{r}y \quad {}^{1)}\ (r = 1,\ldots, 3) \tag{4.11}$$

(the sum of the increases in income created in all sectors in a region should equal the target for the regional income increase)

$${}^{r}x^{h} \geqslant 0 \quad {}^{1)}\ \ (r = 1,\ldots, 3;\ h = 1,\ldots, 5) \tag{4.12}$$

(no decrease in production in any region)

Here: x: increases in production, measured in output terms
y: income increase targets
c: cost coefficients
γ: (incremental) final demand coefficients

[1] *See p. 76, n.3*

$^{r}\phi_{hh'}$: input-output coefficients in region r

$^{r}\phi_{oh'} = 1 - \sum_{h=1}^{5} {}^{r}\phi_{hh'}$: value added coefficients.

A few remarks on this model are in order.

Characteristically balance equations for international sectors are missing. One may add bound and transport variables for heavy sectors like those discussed in Sections 4.2 and 4.3. Both such additions for exports and imports of international sectors will necessarily introduce expressions for exports and imports of a similar complexity as that of equations (4.10). In practice in most cases no regional input-output tables will be known; then one may work with national input-output tables nearly as well.

The calculation of the solution of these models can no longer be made by hand. Real size problems could be dealt with by the simplex method on a computer, but lend themselves also well for the application of decomposition methods[1] in view of the special structure of the coefficient matrix. The discussion of these well-established methods is outside the scope of this paper. We will rather draw attention to two approximative solution methods.

The first approximative solution method[2] proceeds in two steps; first national sector-planning is carried out disregarding the regional subdivision of the economy, next the sector increases are distributed over the regions in such a way that the regional income increase targets are met at minimal cost. This method leads only to a feasible or consistent solution if interregional differences in (incremental) input-output and final demand coefficients can be neglected, as well as the differences in the increase in intermediate demand for regional products by different national and international sectors. Even then, however, optimality of the solution is not ascertained, as in calculating the sector increases at the national level no account is taken of interregional differences in cost-coefficients. Yet it is believed that the considerable computational simplification—the second step can be carried out by hand calculations—makes the method interesting for reaching a first rough and approximate impression of the optimal solution of the whole model.

The second approximative solution method consists in a repeated application of the idea of Tinbergen's semi-input-output method at different levels of spatial aggregation.[3] First at the national level the bunches of all international sectors, which contain also the horizontally and vertically indirect effects (on the national and regional sectors),[4] are determined together with the contribution of the increase in national income and their (national) unit cost requirements. Next the optimal bunch or combination

[1] See a.o. Dantzig (1963); Kornai (1967); Künzi and Tan (1966).

[2] See Mennes *et al.* (1969), Section 4.9 and Appendix 3; Herman *et al.* (1969).

[3] See p. 68, n. 4, and Herman *et al.* (1969).

[4] The expression bunch is introduced in the literature on the semi-input-output method.

of bunches is determined,[1] which determines the national expansion of all sectors. Then for each region separately for each national or international sector the bunches in terms of indirect effects on the regional sectors are determined, together with their regional income increase contributions and regional unit cost requirements. A simple Hitchcock–Koopmans–Kantorovich problem can solve then the optimal distribution of these bunches—of which the total expansion is given now—over the regions, which solves the problem. Again, the solution is feasible only under similar, but fewer, extra assumptions as for the first solution method,[2] and need not be optimal in general, as the national cost coefficients do not reflect interregional cost differences.

4.5. *The introduction of employment targets*

The objection that the models thus far discussed neglect a number of important practical, economic, or political considerations, in particular employment aspects, can be met by essentially the same device as discussed in Section 4.2. If creating employment is a consideration, additional to or even superior to creating income, this may be expressed by extra constraints, which use employment/income or employment/output ratios per region for all sectors. They may express fixed employment increases, maximum employment figures (in view of the available labour force of varied qualities)—upper bounds—or minimum employment goals—lower bounds. Other considerations, like a political preference for certain sector expansions in certain regions or the necessity to complete projects which are already under way, can be expressed by extra constraints as well. Again, it is interesting that the dual variables or simplex multipliers corresponding to these contraints in the optimal solution express the marginal costs of these extra constraints.

5. *Some further problems*

5.1. *Statistical problems*

It may be observed that even the simplest model requires a not inconsiderable amount of data. To a large extent this is a general problem in planning, and in particular with national-regional planning; the data problems are not especially related to the use of these models. In fact, one of the reasons to display a series of models of increasing complexity—which all embody, however, the same logic—is precisely that one may like to choose a model in correspondence with the availability of data. It is our contention that presenting concisely a logical framework for data collection and decision making is at least as important a function of working

[1] This optimization problem is extremely simple, and can be solved by hand, as all interindustry effects are taken account of by the concept of bunches, the computation of which requires the inversion of matrices of the order equal to the number of national and regional sectors; complications arise only in cases where bounds are present: see Cornelisse and Versluis (1969) and Waardenburg (1966).

[2] Differences in increases in intermediate demand for regional products by different national or international sectors need not be negligible in this case.

with models as presenting a precise quantitative answer to precise quantitative questions.

If necessary data fail to be available they may often be 'borrowed' from other areas with similar circumstances. We noticed already (Section 4.4) that national input-output tables instead of regional ones may be used, but even demand increase coefficients can be derived sometimes in an approximative way from statistics of other countries with a comparable income level. The choice of regional income increase targets as well as that of several upper and lower bounds mentioned may seem to display a more arbitrary nature, but precisely they require a rather intimate knowledge of the existing situation and prospects in the regions and on the international market.

One type of figure may be most difficult to acquire: the cost coefficients. At the very minimum one should be able to acquire a rough idea of them, be it even only in qualitative terms of cheap-intermediate-expensive. Information about cost differences[1] may be acquired from price differences, data on duties and subsidies and on indirect taxes, and data on freight rates. A useful first attempt in using these models may consist in considering only capital as a scarce factor, and hence in working with capital coefficients for sectors. A more sophisticated way, however, is to identify all scarce factors of production and estimate for each sector their unit requirements. Then shadow prices, as a corrected version of existing (market) prices, may be used to weigh these factors and to get one cost figure.

A general theoretical objection against the use of shadow prices may be made that they themselves depend on the outcome of the model. To a certain extent this is a valid objection. In cases where this is felt to be relevant one may use a more aggregated model of the reversal of our problem to estimate roughly these shadow prices. The model would specify fixed available amounts of scarce factors of production per region or in the country during the planning period, and maximize the increase of national income over the planning period, subject to the balance equations and the extra constraints that not more than the available scarce resources can be used, and that the regional income increases should occur in fixed proportions among themselves. As it appears that the shadow rates for the scarce resources estimated in this way are rather insensitive to the degree of aggregation of the sectors, one may use in this model only very few sectors. In fact such a model might also be used for national-regional planning, but it appears to be somewhat more complicated. This is the reason that we recommend it provisionally only for estimating the shadow rates with a high aggregation of sectors.

5.2. *Economies of scale or indivisibilities*

If the expansion of sectors in a region in our models were so small that even for one technical unit no optimal size of production would be

[1] For the simplest model only the differences in costs play a role in determining the optimal solution; for other models full costs should be known.

reached, then the models need to be adjusted to this situation. The unit cost of production would itself become dependent on the expansion of the sectors and an essentially different kind of choice would arise: whether not at all to expand a sector in a certain region, or to do so at least to a minimum efficient amount. These problems occur in practice in various sectors (e.g. chemicals, steel) and increasingly so as the regions considered become smaller. In principle one can construct models (with 0 or 1 variables) for such situations as well,[1] but they are of the discrete programming type and available solution methods for them are by no means as powerful as those for, for example, linear programming. In practice more than around fifty 0–1 variables pose serious computational problems even for the largest and fastest computers available today.[2] Numerous articles both with models of this type and of algorithms to solve them are appearing in the literature, but,as far as we are aware of, little general and systematic insight into these problems has been gained which would allow us to use some hand rules for cutting through the wood of details and reaching a first approximative view of the optimal solution. One example of such a general insight would be the hierarchy hypothesis, worked out by Tinbergen and Bos, about the optimal system of industrial centres, but the assumptions of the model for which this hypothesis is suggested to be the optimal solution are still quite restrictive (a.o. closedness of the economy).[3]

Given this completely open situation, there is enough reason to look for more partial approaches. In the introduction we mentioned as examples already Klaassen's work on the 'attraction-model' and the growing literature on growth poles.

5.3. *On instruments in national-regional planning*

One of the reasons for planning is that the preferred situations or solutions may or will not come forth only by the working of 'automatic economic forces', e.g. of a market mechanism. This is particularly true for the national-regional planning problem, if this does not follow simply historical lines of development and of retardation of regions within a country.[4]

It is outside the scope of this paper to discuss generally the problems of implementation of the type of plans envisaged thus far, nor even of the organizational problems of national-regional planning. We just want to add a few remarks in the direction of these subjects, which rather indicate problems than present ready-made answers to them.

First there is the general distinction of 'planning from below' to 'planning from above'. In the context of our problem this is related to the question whether planning should start at the regional level, with regional plans, which are then co-ordinated and possibly adjusted at the national level,

[1] See in addition to the literature mentioned in p. 15, n. 2, e.g. Bos (1965), Chapter 6; Kendrick (1967); Cornelisse (1969); Mennes (1970); Scott (1969–1); and Vietorisz (1964).

[2] See p. 68, n. 2. [3] See p. 66, n.3. [4] Cf. Williamson (1965)

or whether from the national level national-regional planning should start, which then is worked out into more concrete details at the regional level.[1] We have no definite scheme to present on this question but we will only point out a few aspects in the light of our foregoing discussion.

This distinction has at least a decisional aspect and an informational aspect. In the models presented above the decision on the regional income increase targets is an important distributional decision which logically precedes the planning outlined by the models. Whatever purely economic arguments, e.g. on far away future prospects, are involved, the decision appears to be essentially one of a political character, in which opposing interests of regions are harmonized and which essentially constitutes a political compromise. As realistic as the opposition between these interests is, as important is it to settle this compromise in advance. Otherwise, during the course of the planning period or in general when concrete projects are selected at certain locations, these opposing interests may time and again play a role in the process of locational decisions of the projects; although the final outcome of such a process might reflect the same weighting of the opposing interests against each other as would show up in the compromise on regional income increase targets, it is hardly to be expected that such a result would be as efficient in terms of total costs or, however measured, as if the compromise is settled in advance. This argument favours involvement of a national planning agency at an early stage.

If the distinction of regional, national, and international sectors is a useful one, then the primary attention of a national planning agency should go to indicating appropriate international sectors for the country and to the regional distribution of the international and national sectors together over the regions. The expansion of the regional sectors could be rather left to regional planning agencies, as soon as the regional profile of the expansion of the other sectors is more clear.

Full information on the particular situation in each region can never be expected to be available at the national level. As far as such information is relevant for the regional distribution of the expansion of the national and international sectors it should be sent to the national level. An example of such information would be that about lower or upper bounds to the regional expansion of these sectors. Such information may be more important for planning at the national level than the proposal of a full regional plan. On the other hand, information about bounds on international trade should typically be collected at the national level.

A *second* general question is at which spatial level certain instruments of economic policy should be handled. We mention here only a general principle. In general, instruments should be handled at such a high level that the external effects of the use of an instrument occur fully or for the large majority in the area for which the agency concerned has responsibility. In addition, efficiency seems to be served best by decision taken at the lowest level compatible with this minimization of external effects outside the

[1] Hermansen (1969) points out this problem clearly.

area of responsibility. We mention just a few examples. For a number of instruments (like the setting of international tariffs) this principle indicates that even the national level is too low for the decision. Taxes as an instrument of an economic stabilization policy or to cover expenditures of the central government should be levied at the national level. Inner city traffic regulations or the location of housing projects can be left, however, to regional or local authorities, unless national uniformity in the regulations is required.

Finally, it is assumed in the models that capital is mobile throughout the country to such a degree that the central government can influence directly or indirectly the location where it is invested. This will be necessary especially if there are definitely extra costs connected with a regional distribution policy. Instruments to direct these interregional capital flows may, however, selectively be applied for investments into certain sectors, rather than to all sectors, as we will see in the discussion of the application of one of these models to Mexico, in the last section of this paper.

6. *Applications*

6.1. Thus far applications of this approach have been made—as far as the author is aware of—for three countries: Chile, Italy, and Mexico. We will briefly mention the first two applications and discuss the third one somewhat more extensively, although in neither case do we attempt to give an evaluation of the studies.

6.2. The application to *Chile*[1] (for the period 1967–71) uses eleven regions and nine sectors, of which four sectors are considered regional and five national. Among the national sectors three sectors (agriculture, mining, industry) appear which in our paper would be called international, but as also for these sectors the model starts with a given total increase of their production—determined at the national level, taking input-output relations into account—they play indeed the same role as the national sectors. In the remaining problem input-output coefficients for estimating the increase in demand for regional products are used. As cost coefficients incremental capital coefficients are used and sensitivity analysis is used to find out for which of these coefficients the optimal solution (the optimal basis) is particularly sensitive; thus special attention to a correct estimate of these coefficients can be given.

In a further application, which is only announced in the paper, a slightly changed version of the model is employed, sixteen sectors (of which six regional, five national, and five international) are distinguished, and the concepts of shiftability, semi-shiftability, and non-shiftability are used. In neither application are explicit transport costs for heavy sectors introduced. The regional differentiation of the cost coefficients is a serious statistical problem.

6.3. The application to *Italy*[2] (for the period 1968–72) uses two regions and eleven 'mobile' sectors, of which also the total national increases are

[1] Boissier (1968). [2] d'Antonio (1969).

determined in advance by an econometric investigation. The increases in production of 'local' and 'autonomously growing' sectors (among which agriculture) within the regions are also determined before the model is applied. Again capital coefficients are used for the cost coefficients. After the simplest model has been solved several other exercises are made: sensitivity analysis on the cost coefficients is used, upper bounds on production within the regions are introduced, an alternative estimate of the growth of the autonomous sector agriculture is made and its consequences for the model are calculated. Finally, the same type of model is used for a model which uses increases in employment, instead of income, as variables, maximizes total production provided employment totals for each of eight sectors and also for each of four regions are reached.

In the models themselves neither input-output relations nor explicit transport costs for heavy sectors are used.

6.4. The application to *Mexico*[1] (for the period 1961–5) uses ten regions and thirty-one sectors, of which six are regional, six national, and nineteen international. Again capital coefficients are used as cost coefficients, alongside the recognition of (partly) non-shiftabilities. Interestingly all calculations have been carried out for two different sets of regional income increase targets. One set distributes the national income increase over the regions in accordance with recent historical trends, leading to the 'historical model'. The other set aims at a faster than 'historical' growth of the four poorest regions, at the cost of the richest region: the 'social model'. No inter-industry relations nor transport costs for heavy sectors are introduced. Four different versions of the models were considered:

(*a*) without bounds;
(*b*) with fixed national totals for twelve of the nineteen international sectors, which were called 'traditional sectors';
(*c*) with fixed national totals for all international sectors;
(*d*) with upper bounds for all national and international sectors in each region, limiting the increase in production of a sector in a region to 100 per cent of its 1960 level.

The successive versions of the model are introduced in order to avoid too strong a specialization of the solutions. In fact the first version (*a*) shows in both models the increase of only one international sector, the second version (*b*) shows in both models the increase of only two of the non-traditional sectors and so only in five respectively three regions, while the third version (*c*) has still some variables increasing 500–1,000 per cent over their 1960 levels.

In this study also a comparison is made of the total capital costs of the solutions of both models for the four versions. In addition, it has been calculated for each version which percentage of total production was differently located in the social model as compared with the historical model, and this percentage is split into a part belonging to sectors which

[1] Carillo-Arronte (1968).

completely change their location—falling to or rising from a zero level in the region concerned—(A) and a part belonging to sectors which change their location only partly (B). The results show that only a part of the production is sensitive to the differences in regional income increase targets, indicating that only for a part of production expansion special instruments for implementing a regional income-distribution policy need to be used, although a further analysis would be required here. The results of the computations are given in Table 7.

TABLE 7. *Comparison of the capital costs and the percentage of production increase strongly* (A) *and weakly* (B) *sensitive to regional income increase targets in the four versions of the 'historical'* (H) *and the 'social'* (S) *model of the Mexican economy**

	Version 1	Version 2	Version 3	Version 4
Capitals costs: H	979	1,095	1,158	1,333
(10^8 pesos) : S	1,000	1,184	1,247	.. †
Percentage of:				
production: A	11·2	20·4	21·1	.. †
sensitive*: B	26·8	23·9	22·6	.. †

* For explanation see text.
† Not available.

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L. Folkesson, *Sweden*

The topic of Prof. Waardenburg's paper is 'ECONOMIC PLANNING FOR REGIONS WITHIN COUNTRIES'. He has then chosen to present the methodological work done in this area in Rotterdam. He has also based his presentation on a book published last year, which he wrote together with Prof. Tinbergen and Prof. Mennes entitled *The element of space in development planning*. I will deal mainly with the work of the Rotterdam group, in line with Prof. Waardenburg's paper. I do hope, however, that later in the conference we will also get presentations of research efforts and practical experiences from other countries as well.

From a methodological point of view we can think of two different approaches to economic planning for regions of a country. One approach takes the national development plan as a starting point. It then proceeds to construct development plans for individual regions, in such a way that these plans are consistent with the national plan. In order to ensure such consistency, all regions and the corresponding interdependencies have, in principle, to be considered simultaneously. It is then often necessary to treat the economic structure of each region in a relatively schematic fashion, in order to reduce data collecting and computational problems, and in order not to lose the understanding of how the plans have been derived.

Economic development plans are also drawn up for individual regions in many countries, by regional authorities who often have intimate knowledge about their own areas. The economic structure of each region can then be treated in a more detailed way. It then becomes, however, more difficult to take inter-regional interdependencies, and also the national targets for economic development, explicitly into account.

During recent years, there has been a growing interest among economists about how the two approaches I have mentioned can be united. I can here refer to various formal planning procedures suggested by researchers such as Danzig and Wolfe in the United States, Malinvaud in France and Kornai in Hungary. Much further work seems, however, to be needed in order to make these procedures truly operational.

The researches of the Rotterdam group seem to be especially concerned with the first of the two approaches. This approach is referred to by Prof. Waardenburg as 'THE NATIONAL-REGIONAL PLANNING PROBLEM .

The group has then discussed *why* it is necessary to consider the spatial

element in the national development planning. It has also proposed *how* it should be done, by the use of various former models. It may therefore be argued that the title of the book, '*The Element of Space in Development Planning*', gives a better description of their work than the title of the present paper.

The Rotterdam group has taken Prof. Tinbergen's well known scheme for medium-term development planning–the so-called 'PLANNING-IN-STAGES SCHEME'–as a starting point. The group claims that this scheme is not bound for its application to any particular type of economic system. I am sure that this hypothesis will be extensively discussed during the conference. The Rotterdam group now proposes that the spatial element should be explicitly considered during the middle phase of the planning-in-stages scheme. Three different types of arguments are used to support this proposal.

One argument is that different regions offer different production opportunities for different sectors due to available natural resources. This argument is obviously valid in many cases. I find it an open question, however, if it alone justifies the suggested procedure. In many cases it should thus be possible to interpret a sectoral expansion plan in terms of regional use of natural resources, even if regions are not explicitly considered when the plan is drawn up.

The same question can be raised in relation to products that can only be sold on local markets and, in certain cases, also in relation to the transport costs.

The argument for a spatial subdivision becomes more interesting when it refers to the limited mobility of resources, especially labour. Prof. Waardenburg here argues that the inter-regional mobility of labour is much less than what has been traditionally assumed in economic theory. I share this view. I also think that the inter-sectoral mobility of labour, even between sectors within the same regions, in many cases has been over estimated.

In several countries, my own country included, inter-regional labour mobility has traditionally been regarded as a pre-requisite for economic growth. A number of policy instruments have therefore been used to improve this mobility.

There is now, however, at least in Sweden, a growing feeling that this policy can have a number of negative side-effects. The question is then whether or not these negative side-effects will outweigh the advantages of a rapid economic growth.

General equilibrium theory tells us that we should use different costs for the same production factor in different regions, in order to account for inter-regional differences in the relative scarcity of production factors. We should then invest in capital-intensive technologies in regions where labour is scarce and in labour-intensive technologies in regions where labour is abundant.

A problem is then that the wage level tends to be highest in the capital-intensive sectors. Such differences may, as the Rotterdam group has pointed out, be difficult to even out by fiscal and income-redistribution methods.

The investment programme derived from equilibrium theory may then, in

a long term perspective, tend to perpetuate the inter-regional income differences. This policy can thus come into conflict with the goal to reduce such differences, which I feel is very important for the welfare of a country.

In the paper, Prof. Waardenburg has discussed similar problems under the heading of so-called 'REGIONAL INTERESTS'. In my opinion, his arguments on this issue are strong enough to justify the proposal that a regional subdivision should be explicitly considered in the development planning.

He also makes it clear that in many cases it is necessary to establish explicit targets for the development of each region, even if this approach can lead to certain losses in overall efficiency or to increases of the costs for the development programmes.

Prof. Waardenburg then proposes that the choice of sectors and regions should be mutually dependent. He thus defines regional, national and international sectors. National and international sectors are further subdivided into non-shiftable and shiftable sectors. This approach is quite appealing.

Rather little is said in the paper about how the sectoral and regional subdivision should be made in practise. One problem seems to be that it is necessary to relate the regional division to the administrative structure of the country, in order to make it possible to implement the regional programmes. This requirement may come into conflict with some of the criteria for subdivision mentioned in the paper.

Another argument in this context is that the subdivision should stop at the level where economics of scale and indivisibilities must be taken explicitly into account. The question is then at what level this becomes important. According to certain research work, such as that by Manne and others for the Indian economy and by Kendrik for Brazil, economics of scale and indivisibilities have to be considered already at the sectoral level.

I am sure that the Rotterdam group will devote much attention to these problems in the future, even if it is true that the now available computational algorithms do not take us very far into this area at the present time.

I have only few comments on the formal planning models presented in the paper. The first model, which is called the 'FIRST APPROXIMATION', shows that under certain assumptions the development planning problem can be formulated as a classical Hitchcock-Koopmans-Kantorovich transport model.

As it is clear to everybody, the assumptions behind this approach must be very strong and probably also unrealistic in many cases. The model is therefore mainly useful for illustrative purposes.

Some of the assumptions are relaxed in the further presentation. I would, however, like to hear more–from Prof. Waardenburg and from the audience–about problems such as:

- how to define in a more rigorous way the cost concepts to be used, in view of the fact that several goals or targets may have to be considered.
- how various employment targets could be explicitly included in the models.
- how various intersectoral interdependencies should be taken into

account and
- which assumptions should be made about international sectors and foreign trade.

Finally I would like to congratulate Prof. Waardenburg for a very stimulating paper. He has introduced us to a subject that is very important for all countries, irrespective of economic system and stage of development.

N. Vasyljev, *U.S.S.R.*

The four minutes which I have been given is not enough time to discuss such interesting and, from our Soviet side, very important questions, questions concerning planning, questions of distribution of productive forces in our large country, including agriculture production. I will touch upon only the problems and questions which are from my point of view, most important but the role of planning in the economy was founded from the beginning of Soviet power. It was founded at the time of Lenin in the first five year plan of development, when our country was divided into special economic regions. Now, in the Soviet Union we undertake a great volume of work on the regional division of our country in order to arrange better connections between different sectors of production, between agricultural production and other sectors of our economy. This problem has very great importance now when all over the world a high tempo of scientific progress is developing and it leads to many features of agriculture being put on industrial basis. This is why in the economically developed countries still more and more links are developed between agriculture and other sectors of our economy. In this respect the distribution of economic regions allows us not only to control the balance all over the country in general between agriculture and other sectors of the economy but even to create agrarian industrial complexes linked to natural and other features of the region and the country.

Now we have 18 special economic regions and in the light of their specific features we conduct special development. This work is being conducted in every national republic; therefore the regional planning which has found reflection in the first speaker's paper is of great importance and is well developed in our country.

What is especially important from the point of view of agriculture? From this point of view we consider the most important problem is to determine correctly where to locate production. For this we would take into consideration the special natural resources, transport, and labour resources and the possibilities of every region. We take into consideration some factors which have a great influence for rational distribution. First of all we take into consideration that achievements of agricultural and scientific progress must be in full conformity with the interests of industries which supplies to agriculture the necessary implements and equipment and of the processing agricultural enterprises. We take into consideration of course, transport—the availability of roads. This last factor is especially important because our country is large and in some areas we have low density of population and in

some places we have very few roads. Transport possibilities are of a limiting character. We have to take into consideration the consuming centres of agricultural produce; this factor is of especial importance as regards transport. We take into consideration other factors which I cannot list in detail.

The planning system enables us to improve the distribution of agricultural production in our country and improve the links between different branches of industry and agriculture. In this problem of regional planning great importance is being paid to economic stimuli for development of agriculture and agricultural production. In some regions of our country there are great variations in the development of production, and of course the problem is how to discern and to determine how to distribute the agricultural industry so as to take cost elements into consideration so that final costs of agricultural produce should be cheaper for the society. The volume of labour and other inputs used for a given output are obviously of critical importance.

Gerhard Jannermann, *German Democratic Republic*

In the Socialist states it was very interesting to consider how and in what ways the capitalist countries use planning. Regional planning is a very important part of the planning of the socialist economy. The main idea of planning lies in the fact that the central planning and the guidance of the economy and the co-operative farms are very well connected within the national plan. We have many models in order to organise optimal planning to determine co-efficients of development for local planning and to link with the central planning and with the planning of different enterprises. To solve this problem in our opinion, we must try to get co-ordination between the central planning and the planning of local organisations. As Mr Waardenburg said, we must have both the upper circle planning organizations and the lower circle ones co-ordinated—and here contradictions can arise. Here we need political compromise in order to get better results. Planning must take into account different political situations, and conditions. And planning must take into consideration public interest; it corresponds to objective needs and it can be solved practically.

It is in the common interests of society that every stage of the develop ment and planning be improved considerably in order to raise the production of food stuffs. So the task of the planning agencies is the projection of a more rational production and distribution of agricultural products and especially of the processing industry. Here we must take into account also the important part played by science. These prognoses or projections are consistent with the tasks of the planning agencies. So on the basis of the information so obtained linear and optimal models are formulated with structural variants for various branches of agriculture. Here we must take into account also the inter-relations of various branches of the processing industry. The various models are then evaluated; in order to have a clear picture we must have models that will enable us to take some preliminary decisions. Then we must also remember that this is closely connected with the territorial structure. That

will help us to decide optimally many questions, taking into account the transportation problems and the production resources and, of course, labour supply in the territory of the German Democratic Republic. All the results must be set out because radical changes may be made by the representatives of the people's chamber before the convocation of the conferences of farmers. The interests of individual farmers may be taken into account and correlated with the interests of the majority.

F. Kord, *Czechoslovakia*

I want to say something about the influence of the social planning in the development of agriculture. Czechoslovakia, as you know is in the heart of Europe. Already in 1918 there was a ramified network of developed agriculture in the country. However, there existed considerable variation in the level of economic development of various branches. In parts of the country there was well developed industry but at the same time the development of agriculture was insignificant. During the twenty years of the existence of the capitalist system in Czechoslovakia, with the abundance of marketable agricultural produce, it was not possible to achieve something better; these disproportions in the distribution even got worse. We understand now that only the better utilisation of resources under socialist planning and concern for the equal and just distribution of the national income, has enabled us within two decades to largely solve this problem

Let me give you some data: *Slovakia* (for example); the national income per capita in 1949 was 40 per cent lower than in the other part of Czechoslovakia. At present the difference is less than 20 per cent and the distribution of the national income in both parts of the country, per capita, is nearly equal. In agriculture, for example, the level of production in Slovakia has increased two-fold and the productivity of labour in Czechoslovakia has increased more than three-fold. On the basis of these concrete data which have been achieved in socialist Czechoslovakia, we can reach the following conclusions—with the utilisation of the central planning agencies and the re-organization of agriculture on the basis of collective farms, the Slovak people will be successful in the planning of development to solve other problems.

P. Mastikov, *Bulgaria*

In the report of Prof. Waardenburg some methodological problems have been examined on a high scientific level. Different possibilities have been examined for overcoming of difficulties of achieving the aims for national planning. The speaker does not solve problems concerning the sub-divisions of the country. He recommends a very aggregated model of regional planning using hand machines. Such an approach is not very good when we have a very highly developed computing technology; these machines can include different

elements in a system. It has been proved that optimal solution of individual tasks are not always in conformity with other solutions; it is a question whether the optimal solution of a task is in conformity with maximal economy. To my mind, the perfection of the planning system in agriculture depends first of all on the successful solution of the problem of the optimal planning task for a target within the framework of the national economy. With this model it will be possible to do everything. In order to solve this task it is necessary to fix the possible volume and structure of the production and value for five years. For this purpose we must project the growth of labour productivity, of the national income and an increase of the well-being of the population in future. By means of a dual modelling of the production process we must plan a transition from the present stage to the future stage and here we make this transition to the future economic condition of the country. At this stage we must fix the method by which we can optimise the production costs. The common task of this sub-model is to fix the planned norms and the distribution among the agricultural regions according to their resources. The solution of this task requires a preliminary optimisation taking into account the regional structure. Every agricultural region must include the whole of the territory of farmsteads irrespective of the fact that there may exist such conditions in some other regions too. The solution of this dual problem will enable us to plan the purchase prices that will enable us to minimise the costs of production at farmsteads and will achieve the necessary efficiency of the farmsteads. With such an approach to planning there will be a complete correlation of the interests of individual farms and the national economy.

B. I. Poshkus, *U.S.S.R.*

I would say a few words about our experience in the planning of agriculture. The common aim is the maximisation of the national income and the application of the advantages of Soviet power to small Republics–Lithuania is a very small republic and the population is only 1.5 per cent of the total population of the U.S.S.R. We solved this problem of the right relation between the centralised and the state planning with the development of the agricultural incentives of enterprises in order to achieve very stable balance of forward production. When we speak about such a production we take into account the ever growing quality of the land and the production of all the farms and resources we can see that only in proper proportions between the sectors they give the maximum effect. That is why we will try to evaluate the meaning of this and we have worked out plans for it.

The most suitable form of the realization of the optimal plans is the optimisation of the state purchase plan. The economic mathematical model helps to define the most rational specialisation of single regions in the complexity of development. Another side of the optimisation of the perspective plan is that the distribution of the factors is optimised to help us to fulfil or implement these plans, namely the distribution of the fertilizers and the mixed foods among the regions.

Some regions and some enterprises do not have one and the same conditions for the efficiency of their enterprises. In this case I do not agree with Mr. Waardenburg who says that some regions can be poorer than others and their prospects are not the same. I would like to say that this problem is solved by our differentiation of the state purchase prices. The purchase prices are differentiated by regions and later on by groups of enterprises; in one and the same region there can be four categories of prices. Some collective farms and state farms have advantages over some others though they are in one and the same group but so the differentiation of the prices will solve economic and social problems of the countryside. With the help of these measures we seek other resources to increase production and they do exist. The differentiation of prices show the advantages of centralised planning.

Among other problems is the system of handling data that we get from industry and agriculture so that they can be utilised or applied in planning to the best advantage.

A. T. Birowo, *Indonesia*

The problem of national-regional planning is complex, and the body of knowledge is not established yet.

Consequently, to explain such a complex problem involves an element of priority and choice. Prof. Waardenburg has chosen to use a transport model to describe the various aspects of national-regional model and for the following reasons: (a) simplicity (b) importance of space and transport element in such a model.

I argue that straightforward linear programming will be better suited because (a) it is pedagogically simpler than transport model and (b) it has the advantage of being able to include more aspects in the national-regional model. What are more relevant in many developing countries are the structural aspects of production, regional resource endowments as well as regional technologies. Straightforward simplex-programming (Dantzig-type) will be more suited than Hitchcock-Kantorovich-Koopmans model.

V. A. Nazarov, *U.S.S.R.*

I have some reservations as regards the very interesting report of Prof. Waardenburg but due to lack of time I would like to express one only of my thoughts. For every research worker fruitful co-operation is possible only if we have an exact definition of the terms which we use during our scientific researches. In his report, Prof. Waardenburg gives a definition of planning.– You know that planning is one of the main aspects and problems which we deal with at this conference. We shall use this term very often in a broad sense. It is very necessary to have an identical idea of the content of this term. The content of this term which Prof. Waardenburg puts into the work plan does not correspond to the content which we Soviet economists use. Permit me to cite the definition of 'planning'. I shall cite in accordance with

his report. The term 'planning' is considered in effect to be the calculation of certain costs. In our estimation such a definition of planning is not sufficient. If we just base our concepts on such a definition of planning. Planning exists in any developed countries both socialist and capitalist. In our opinion, planning is a special means of determining the proportional development of the economy, proportional development of different branches of the economy and different regions of the economy. If under capitalist conditions this proportionality is being maintained by means of competition through the media of the capitalist market, under socialism such a proportionality of the branches of the economy is made by special planning organisation. Planning is especially difficult when we go on to the fulfilment of the plan and ensuring this fulfilment. The development of the economy should be of such character that it should be in full conformity with the plans which have been made out by the special organising bodies. Therefore I think to that definition of planning we should add some other clause. It is not enough to make calculations in this respect when we speak of planning. It is necessary to maintain such developments as will be aimed at the fulfilment of these calculations. I consider that today the work of our Conference, after we have heard the very interesting report of Professor Waardenburg has entered another stage. Yesterday we heard a general survey of all the broad problems of agriculture. Today we are already dealing with separate and narrow problems. I consider that during this discussion and process of the work of the discussion groups we shall go further in scrutinising closely specific problems.

Delbert A. Filchett, *Argentine*

I am sympathetic to Dr. Waardenburg's model. Perhaps my reservations lie in its specification, in terms of the resources we have available and probably from in my experiences in Latin America. I am speaking mostly of trained human resources and financial resources. To a large extent these studies will have to be carried out within government planning offices. I see this as a problem. Most of my work has been within the universities, within private research institutions. I can see that with the greater sophistication of these models that we will have neither the available manpower nor the financial resources to carry them out. We are forming cadres of trained economists in the universities in several countries in Latin America.

I find interesting the author's attempt to 'compatabilise' regional conflicts of interest through meeting regional targets at minimum cost constraints, and I think that if we would be able to solve the model without these target constraints we would have a chance to compare the results with the constrained model results. We would then have an idea of the cost of attempting to 'compatabilise' regional conflicts of interest and thus we could see if we were willing to pay these costs in order to maintain some kind of harmonized regional growth.

Finally, there is an interesting store of experience in Latin America in

regional development authorities, in Colombia, and Venezuela, that have had considerable success in developing their own regions. In pursuing our regional model building, I would not like to see us throw out the baby with the bath water here by not continuing to promote regional development for some of these countries.

Francisco Gomez, *Spain*

Prof. Waardenburg's model is very complicated; the difficulty is just to define the parameters. For our second plan of development we have found a great many variants and have met difficulties in calculating parameters. We have used the data of the census of population and experience showed that if there are inequalities in parameters the results may be different. These models were, of course, the linear programming models and I am now going to make a more dynamic model in order to find a plan which can be applied to the vegetable market. I think that there is another model and my colleague will speak about it after me.

Harry C. Trelogan, *U.S.A.*

As one concerned with the acquisition of data, I am disturbed at some of the evident assumptions in these papers and discussions with respect to source data.

Computers cannot originate or improve upon primary data for planning. Computers might help in the fabrication of data to rationalise plans after plans are formulated; I don't know, since I have had no experience with this.

I am also impressed to note the suggestion that more localized planning is recommended as a means to facilitate the data problem. My observation is that the opinions of county agents are a poor substitute for hard survey data. Neither is it efficient to conduct one-time surveys, even for small areas. It is more economical to obtain such data from widespread surveys standardized over time and space. I should like to have an elaboration of this recommendation.

Dr. Waardenburg, *in reply*

It is not an easy task in ten minutes to refer to the many questions you have done me the honour to put from the floor. On the other hand, there are so many that I can apologise in advance that I cannot do justice to all of them. I will refer only to Mr Trelogan's last point on the data problem. It is very well taken and if we had elaborated more on it we would have been clearer. The reason for advocating attention to local participation in planning in reference to the data problem is especially to minimise the amount of information going up and down from the low levels to the high levels; it is not concerned with the collection of data which might be less efficiently done by local people.

There is a general discussion, I think, on whether the models should not be more complicated. Some people, as I am myself, are mathematicians by origin; they like more complicated models and if they are able to handle the mathematics and if the computers are available to handle these models, then it is O.K. with me. But then a large part of our study does not apply because you are able to do the work yourself. What we did is only to point out a few elementary features which might be included in any model, be it simple one or a more complicated one. Again I would like to emphasise that for any situation none of the models outlined can be applied as it is; it should be elaborated and expanded to the degree that is suitable for the culture, mathematical capacities, computational capacities and the problems it is aimed to deal with. That brings me also to our friend from Indonesia. He said that in developing countries transport is usually 'given', using natural resources in the most efficient way is the primary problem. That may be true and it may be that the models will have to be adjusted a little to take account of this situation. However, there is not all that much stress on the transportation system, as such, in our approach—only in the second approximation do we introduce explicit transport costs. So I think, that even if you emphasise using initial resources most efficiently, it is useful to work with the distinction between regional, national and international sectors, for instance. A lot of speakers have come from socialist countries and as I said earlier this morning, I am well aware that in socialist countries a lot of valuable experience has been gathered and that I have still to learn a lot from them. I think the emphasis put by my distinguished colleague from the German Democratic Republic, and it was also stressed by, I think Mr. Nazarov, is on the point that the implementation in planning, cannot be separated from the planning itself. I think that it is in principle true. Certainly all planning must be directed towards the implementation. It seems only a question of practical strategy whether one breaks down the whole problem of planning into trying to find the optimal plan in terms of plan figures and then trying to find the instruments to implement such a plan, or whether one deals in planning in the narrow sense. I excuse myself for the use again of the word planning in the sense which Mr. Nazarov does not like but I do not find another word. Whether it is good strategy to do simultaneously the planning for the figures which are the target and the plan for implementation, I have no very strong view. My idea would be that as much breaking down as possible is preferable but I understand that some other people have other views on this, and they may be right. One interesting point which I would like afterwards to discuss with my colleague from the German Democratic Republic is this question whether there are opposing regional interests. I think there are still decisions to be taken, which funds are given by the central state to which regions and behind these decisions there is an implicit question of the interests of the different regions. Now I think the great advantage of a centrally planned economy is that the different interests can be harmonised within the system while if there is no such system of central planning probably one gets a kind of fight between the regions. What we have emphasised in this study is that if such a fight is probable, then have the fight first and plan afterwards rather

than plan first and fight it out afterwards, because that is contradictory to planning.

I must pass over the important points made by my colleague from Bulgaria who indicated the complications of elaboration of these models. Let me just say a few words in answer to Dr. Folkesson. I think it very likely that the cost figures are one of the final and most difficult points in these models. In principle we think that one should get out these figures and they should reflect both relative scarcities in the sectors of production which are available within the regions concerned and the technical necessities of the sector to use these scarce resources, in certain amounts. In general, one would have to use shadow prices here but one could find these shadow prices by setting up a simplified model with given resources within the region and maximising the income of the different regions given certain definite proportions for the incomes of these regions. We have said a few things about that in our study. I think income targets can be treated on the same basis. You can put employment targets in a similar way but you can also get employment targets in terms of minimum values to be attained and therefore you can avoid infeasibilities.

The international sectors and the handling of international trade is indeed a good example that very specific studies must be made before one can apply these models because the answer of the models is a fantastic expansion of one international sector and no expansion of other international sectors. Finally I want to say that disaggregation of these models is probably one of the most fruitful directions for research in the future.