THE SWEDISH CASE STUDY - A PROGRESS REPORT

Åke E. Andersson

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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

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INTRODUCTION

In April 1979 the problems of western Skåne were discussed in the IIASA working paper, WP-79-23. In that paper, it was concluded that a case study should be undertaken at IIASA and be oriented to problems of water supply and land resources planning. Since then a collaborative team has been established with the participation of different planning agencies in Skåne. The work on creating a system for planning of land use has primarily involved the Local Federation of Southwest Skåne (SSK) in Sweden and the Regional Development Task (within the General Research Area) at IIASA.

This paper gives a comprehensive presentation of the system of models that has been developed during the 12-month period of cooperation, 1979-1980.

DEVELOPMENT PROBLEMS OF THE SKÅNE REGION

The Skåne region constitutes an important part of the Swedish economy. Its current role measured in different ways is indicated by Table 1.

Table 1. Selected Indicators on the Relative Importance of the Skåne Area in the Swedish Economy (Share of National Totals).

	Population	Total land	Agricultural land	Income	Density of population
1960	11.8%	2.7%	15.3%	11.7%	81*
1975	12.3%	2.7%	16.7%	12.1%	93*

*Inhabitants per square kilometer (the density of Sweden was 20 in 1975).

Source: Statistisk Årsbok, 1962 and 1976.

The Skåne region is relatively densely populated. Conflicts on the use of land and other natural resources are serious, especially in the western part of the region. The region has always performed productively in the city industries (transportation, communications, commerce, and manufacturing) while at the same time having the most productive agricultural sector among Swedish regions. As a consequence, serious conflicts on the use of land and water have evolved. Economic statistics indicate that agriculture, transportation, trading activities, and in manufacturing food, chemical and nonmetalic mineral production are sectors of specialization in the region.

In all these sectors of production the Skåne region contributes more than 1/7th of national production. The development of these sectors at the national level is therefore of a great importance for the Skane region.

The south of Sweden has had an extremely stable relative role in the Swedish economy in a long-term perspective. Statistics show that the south of Sweden (Skåne and Blekinge) has had close to 15% of the recorded incomes and population from 1920 till the end of the 1970s. Statistics for larger Swedish geographical areas show that there is a strong tendency in the country to convergance between the regional income shares and population shares.

The pattern of convergance also seems to be rather clear:

A. The network for railroad transportations was already established in its basic structure by the end of the nineteenth century and had already then established the general transportation and communication advantages for the different geographical areas of the country. The main road network which was built in the 1920's and 1930's followed the same pattern as well as the developing network for electricity distribution. This means that the communication and transportation advantage for the different regions established in the beginning of the century has been reinforced by the subsequent investments in other networks.

The investments in the private and public sectors in the nodes of this network tended to follow the relative accessibility differentials and thus created a capital, production, and income structure which was established already by 1920.

B. The population distribution in 1920 was grossly at variance with the allocation of income between the regions. The response to this regional income inequality was heavy migration towards the Stockholm region and away from the northern and inland counties. In this whole migration process, the Skåne region remained undisturbed by this great economic change.

C. The general conclusion is thus that the Skåne region seen as a macro-object, is an extremely stable part of the Swedish economy. It is not be expected that it will lose any of its relative importance in the future. It is rather the case that one could expect certain increases in its relative share of income, employment, population, and capital, especially if its position in the transportation networks would be strengthened by the building of a bridge or tunnel across the strait of Oresund.

The stability of the relative share of the Skane region in the national totals does not imply that the structure of production and employment in the region is stable over time. The industrial structure is changing rather rapidly as can be seen in Table 2.

Table 2. Relative changes in the structure and employment in the industry of Skåne between 1960 and 1975.

Sector	1960-1970				1970-1975			
Agriculture & Forestry	-31	percent	of empl.	1960	-16	percent	of empl.	1970
Manufacturing Industry	- 7	"	"	"	- 1	"	"	"
Construction	+26	"	"	"	-13	"	"	"
Trade, Restaurants, etc.	+18	"	"	"	- 1	"	"	"
Electricity, Gas & Water	+ 3	"	"	"	+19	"	"	"
Transportation	+12	"	"	"	+ 9	"	"	"
Service (Public & Private)	+42	"	"	"	+17	"	"	"
Financial Institutions	+93	"	"	"	+18	"	"	"
Total Change	+ 9	"	"	"	+ 2	"	"	"

Source: SOU 1978:20.

The table indicates that the rate of structural change is related to the general rate of growth. The contraction of the construction industry is a consequence of the decline in the growth rate of the Skåne economy in the 1970s. Industries and their sub-branches have very different requirements of land and other natural resources. Swedish studies of the use of land and water in different sectors have indicated that the demand for land and water differs between and within the different branches within industrial sectors. Many studies from the US, Netherlands, Norway, and other developed countries have also shown that there are great differences in pollution output per unit of production between different sectors of the economy. It is thus necessary to make good predictions of the production growth in different industrial sectors of the Skåne economy in a long-term perspective. There is thus a need for a dynamic model of production to forecast the demands for land, and the consequences of growth for the accumulation of pollutants.

Skane consists of two counties, Kristianstad County and Malmohus County. There are great differences in population density and economic performance of the two counties. The northeastern Kristianstad County has an average density of population of 45 inhabitants per square kilometer, which means that the county has a density close to the densities recorded for most counties south of Stockholm. The southwestern Malmöhus County has a clearly metropolitan character with an average density of population of 150 inhabitants per square kilometer. The density of population of Malmöhus County has increased by 27 inhabitants per square kilometer during the past 25 years, while the population density of Kristianstad County has increased by only 3 inhabitants per square kilometer in the same time period.

Really high population densities are located close to the western coast of Malmöhus County. It is clear that with respect to the conflict on land use planning the analysis must be concentrated on Malmohus County and within that county to the metropolitan planning area of SSK.

The manufacturing industry is rather specialized in the Skane region, and especially in Malmohus County. The over-represented manufacturing sectors are *food and beverages*, *chemicals, rubber, etc.*, and *nonmetalic mineral products*. Recent statistics show that the food and beverages industry in the Malmöhus County has the highest productivity of all regions in the country. More than 40% of the employed in these industries are in production units classified as "high-profit units". The situation in the chemical industry is quite different. More than 60% of the employed are working in units with extremely low or negative profits. It is therefore necessary to forecast the development of chemical industry demand for the country as a whole, as well as productivity development of the chemical industry in the Skane region. It is, as viewed by current statistics, a great possibility that the chemcial industry will undergo a sudden structural change.

Housing is another sector of great interest for long-term planning of land use. Housing policies are intimately related with population distribution policies. Two tendencies are of great importance in this respect. In the Malmohus County (the western part of Skåne) there has been a strong suburbanization tendency during the last 15 years. The large urban municipalities have lost population while the population growth rate has been as large as 7%/year in some coastal and in-land municipalities.

This is probably to a large extent a consequence of the low share of one-family housing units and space per capita in the metropolitan part of the SSK region.

The increasing leisure time causes increases in the demand for weekend houses. The expected demand for such houses is far above the possible capacity in Malmöhus County. With current land use policies this means that the commuting field will continue to develop far beyond the borders of Malmöhus County.

The tendencies in housing construction, recreation, and weekend housing implies an increasing demand for urban land, a widening of the urban influence field quite beyond the planning area of SSK with large consequences both for land use policies and for transportation, investment and administration policies. This interaction between location and transportation policies must be observed in the construction and use of the system of models for regional planning.

In the development of the system of models the potential conflicts of land use have lead to two consequences. The sectoral subdivision has been adapted to the actual and potential sectoral specialization of the Skåne region and its consequences for land use. The focus of conflicts will, with all probability, be in the southern and western parts of Skåne. As a consequence of this the regional subdivision into planning zones is much more dense in those parts of Skåne. The interdependencies between the different parts of Skåne have, however, forced us to have at least a rough picture of the develoment possibilities in the northern and eastern parts of the Skåne region.

OPTIMALITY AND THE GENERATION OF SCENARIOS IN REGIONAL PLANNING

It is argued in this paper that the creation of different scenarios is a necessary feature of the planning process. Such planning scenarios can be developed through a purely verbal process, but this verbal process can also be aided by sketching as is often done in physical planning. However, experience shows that such a procedure is only viable, if the number of planning variables is extremely small. This implies that computer-assisted planning procedures grow more useful and necessary when the number of fundamental dimensions and their degree of disaggregation increases.

Economic structure can be seen as one dimension of the planning process, the regional structure can be viewed as a second dimension, and the temporal structure of activities form a third dimension. If we were to assume that the economic structure could be represented by 30 production sectors, the regional structure by 10 regions, and the temporal structure by only three time periods, the minimum total size of a model featuring all interdependencies would be 900 variables. Thus, it would be very difficult to construct a plan for such a system without the aid of a formal computer model.

In the early theory of planning, it was often assumed that such a large system must, by necessity, have one and only one, global goal function, which should then be maximized, subject to certain technological constraints. Adopting the same planning paradigm, one should then construct one giant model for the the whole system, and maximize the global goal function subject to the possible variations in the variables, which could be viewed as the instruments of planning.

This approach can be criticized for at least three different reasons:

(a) It is not yet certain that it is possible to construct an empirically reasonable, yet numerically computable economy-wide optimization model containing spatial, sectoral, and dynamic subdivisions.

(b) It is doubtful whether policy makers are willing or able to state their valuations in a form suitable for programming purposes before they have discovered some means of identifying the consequences of their valuations. It is thus disputable if any single goal function can be determined before the start of the planning process. The most appropriate valuation might have to be determined within the planning process, implying that policymakers should really be involved throughout the modeling procedure.

(c) Having introduced a spatial subdivision, it is very likely that the preferable goal functions for each region will not correspond to any single global function for the whole system.

Clearly, the a priori selection of a single global goal function for the planning process is a difficult and dangerous task. A more meaningful approach might be to suggest a number of difficult possible goal functions, and then to study the range of solutions obtained. This could overcome the last two problems [(b) and (c)) mentioned above, but it would still suffer from the first uncertainty. In summary, it is felt that the numerical capacity of any optimization model which contains spatial, sectoral, and temporal dimensions presently remains very limited in the emprical sense.

But a further difficulty is evident. Most planning models can be given quite a concrete and statistically reasonable specification when it comes to those constraints which have a clearly technological background. This is certainly the case with resource use constraints. Most planning models for an economy contain suitably accurate constraints on the use of primary resources, labor, and other factors of production.

The interdependencies between the sectors can also be specified with some degree of precision. It is, however, far more difficult to specify the behavioral constraints which regulate the activities of the households (consumers) and other decision-makers in the economic system. It is thus probably that any optimization model for the planning of an economy will be underdeveloped with respect to the specification of behavioral relationships.

THE CHOICE OF SYSTEMS ANALYSIS APPROACH

Regional systems analysis is an application of systems analysis to policymaking in a dynamic and spatial perspective. Space can be handled in essentially two ways. We can either analyze the problem in continous space as proposed by Martin Beckmann, Tonu Puu, Walter Isard and Edwin Mills, inter alia. The other principle is to subdivide the total space (for instance the nation) into a discrete set of regions. We have in our development of a systems analysis approach to regional development generally chosen the discrete, regional approach to spatial analysis. In most cases, we have also chosen to handle time as a discrete set of time periods.

The policymaking problems are mostly in regional development analysis of a long-term nature. This means that uncertainties are a rule rather than an exception. Furthermore, we cannot expect these uncertainties to be well-structured in the sense that one can apply stochastic theory to the handling of them. It is rather the case that the uncertainties are of a more fundamental and ill-structured nature. For a region, the development of certain crucial national or international parameters (like the price of oil) is impossible to forecast in a more or less reliable way. We have found development scenarios for such external important parameters to be a much more promising approach.

Principles of Regional Decomposition

In a purely theoretical general equilibrium analysis of the kind proposed by Debreu (1959)[1], each decision variable, for instance the quantity to be produced, is indicated by time, decision maker, type of commodity and region. To prove the existence of a solution to such an interregional equilibrium problem, even with an infinitely large number of consumers and producers, is not impossible in a static situation. However, this approach requires a large number of simplifying and not very realistic assumptions about convexity of preference and production sets. Such assumptions are normally not valid in the real world.

The extension of this approach to realistic transportation-communication technologies and situations of growth and development has never been possible as an extension of the basic static theory. To cope with policymaking problems in such a dynamic, interdependent regional production and consumption system, decomposition and simplification is necessary. Simplification through decomposition and structuring of the regional development problems has been proposed by many analysts in the market-and plan-oriented economies. Some prominent names in thie field are Walter Isard, Vasilii Leontief, Abel Aganbegyan and Alexander Granberg. Common to the approaches of these scientists is simplification through linearization of technologies for production, transportation and consumption of commodities. With linearization, it is mostly possible to solve problems with hundreds of regions and a rather large number of production sectors and different categories of households.

Two types of criticisms can be raised against the linearized approach proposed by Leontief and others. The first criticism concerns economies of scale in production and transportation of commodities. Economies of scale in production leads to non-linearities, which however, for sufficiently large regions are of limited importance. Leontief and similar world regional modelers can thus claim that linearization is of no real importance for their regional policy problems. In a national regional

[1] Debreu, G. Theory of Value. Cowles Foundation Monograph, 17. New York: John Wiley and Sons Inc., 1959.

problem fomulation, one must however take this criticism seriously. The regions which form a part of a nation are normally rather small and economies of scale cannot be disregarded in the model formulation.

Furthermore, transportation and communication are phenomena which cannot, according to modern transportation-communication theory, be linearized but are non-linear on any scale of aggregation. It can, in fact, be argued that the higher the level of aggregation, the more non-linear it becomes.

From this point of view our approach to regional systems analysis has not been limited to simplification by linearization but in the cases where the linearization was justified, it was widely used.

We have rather chosen to simplify the long-term regional policymaking problems through decomposition of the total problems into a set of interlinked models. These submodels are linear, non-linear, integer or real-valued in accordance with the best formulation of the problem and the technologies and behaviors reflected by the models.

Decomposition and Structuing of the Regional Policy System

In decomposing a regional policy problem, there are basically two principles.

A. A procedure based on successively constraining policy actions from an international through a national, down to the regional level (Top-down approach).

B. Another approach is to start with the planning of the individual region, aggregating those plans up to a national level, and then confronting the regional and national aggregates with the world markets. (Bottom-up approach).

At the same time, a third approach can be mentioned which is in fact the further development of A with respect to mutual regional interdependence.

It has often been assumed that these approaches are related to different institutional frameworks. This is only partially true. It is true that international organizations tend to prefer the interdependency approach. It is also true that planning in some fairly decentralized countries like the Scandinavian, has been more oriented to the "bottom-up" approach. In reality, the scale of the region is more important for the choice of approach. A relatively large region cannot disregard the impact of its policies on other regions and even on the nation as a whole. In such a case, it is fairly natural to use the interdependency approach in which the policies of the large regions are considered simultaneously in its natural context. In the case of small regions, one can safely disregard the effect of each one of the small regions on other, larger regions and the nation as a whole. In these cases causality tends to go in a one-way direction. International and national technological and market development determine the action possibilities for the regions, while it can be safely assumed that the actions taken in any single region will not influence national and international development to any significant degree.

Since the SSK region is relatively small, the first hierarchical "top-down" approach was used to date in the IIASA study.

THE HIERARCHICAL APPROACH TO REGIONAL SYSTEMS ANALYSIS

The SSK area, and even Skåne is, in comparison with Sweden as a whole, small in terms of employment, capital, land use, and production. This means that decisions taken at an international or national level on the development of technology trade patterns and specialization of production will be important constraints for the decision maker at the local, Skane and SSK level. This implies that it becomes extremely important to predict economic development at a national level and its regional consequences in order to use these development scenarios as constraints external to Skane planning.

It must be stressed that the construction of such national and international scenarios do not necessarily have to be developed by central research and policymaking institutions. In theory, and very often in practice, such scenarios can be developed within a region of the size of Skåne.

The hierarchical approach to regional systems analysis means that the research starts at the international level to generate some constraints on national development. The national development is then analyzed with some emphasis on sectors of production of especially large importance in the context of Skåne. The national scenarios should be oriented to possible development of prices, commodity production and investments in machinery and construction capital. These national scenarios should reflect consequences of different situations of energy supply, public sector and private consumption, expansion alternatives.

A national scenario provides the *interregional location analysis* with its most important development constraints. Another type of development constraint for the region comes from the population and labor forecasting activity. A third type of constraints comes from the development of local resources like water, land, mineral resources, etc. At the interregional stage of analysis, the locational possibilities for the Skane region as a whole is determined by a consistent procedure for calculating sectoral development in all the Swedish regions. The results of this analysis can then be used for the really policy-oriented analysis for Skane--the problem of allocation of land use to industrial, agricultural, service, and housing activities. The outline of this hierarchical planning method is given in the flow chart on the following page (Figure 1).

1. Technological Development

Reasonable economic development forecasts must be built on some ideas of develoment of technology. In a country like Sweden with a fairly small total research and development sector, most of the technological advances are imported from other countries. This means that the technological analysis must be focused on diffusion of technology and its innovation in the Swedish industry. A model for analysis of these problems has been developed in 1979 and is presented in working paper WP-79-12.

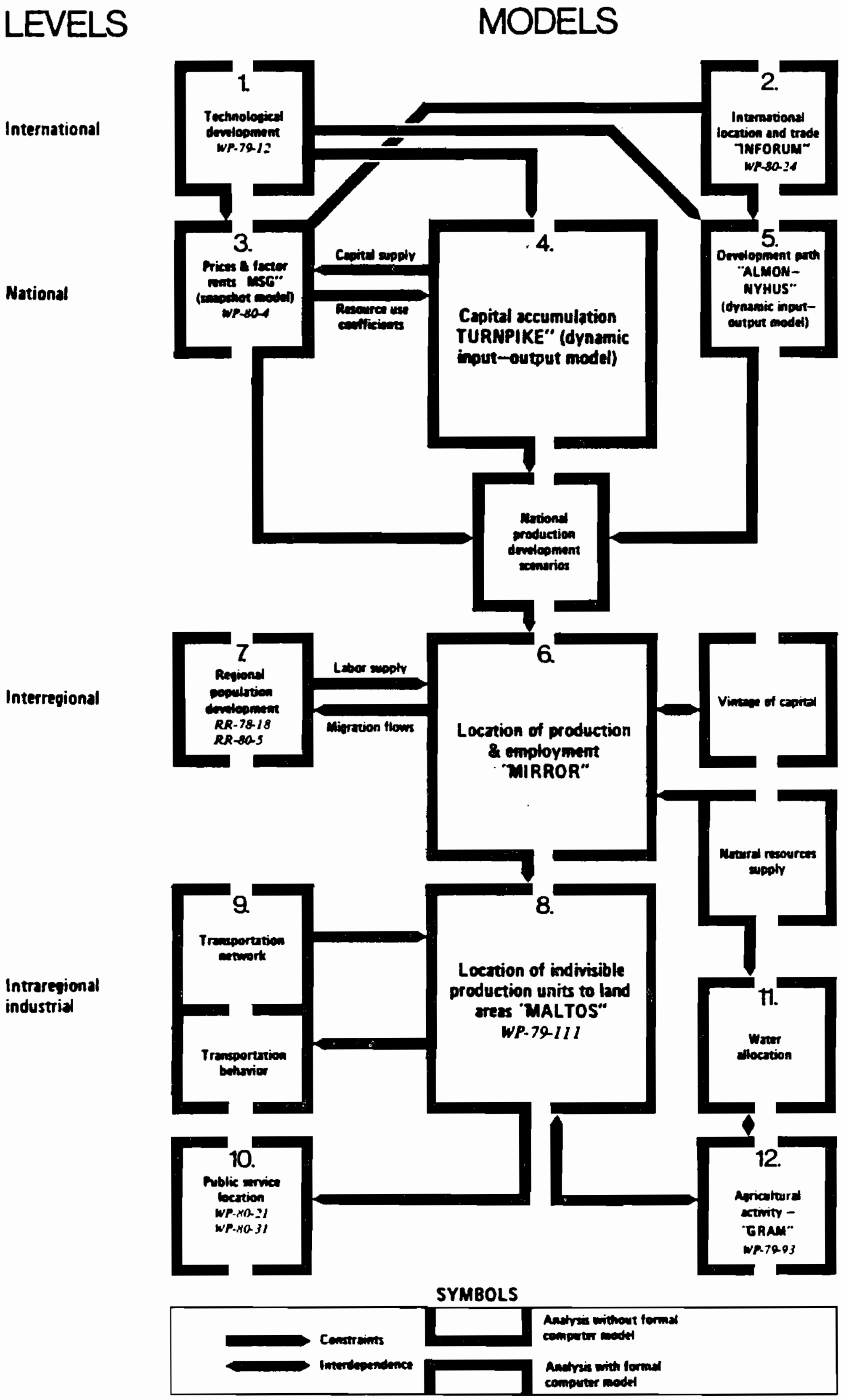

Figure 1. Method C - the Top-Down approach to regional systems analysis.

2. *International Location and Trade*

A fairly extensive work on an international trade model has been developed in cooperation between the Systems and Decision Sciences Area of IIASA and the University of Maryland. This model is built on an assumption of slowly changing trade shares which are moderated by the development of prices of traded commodities in countries of production and on the world market. The development of production potentials and prices in the countries analyzed in the trade model is given by dynamic input-output models of the type constructed by Clopper Almon and Douglas Nyhus. These models are based on dynamic input-output theory. *(5)*.

In the Skåne case study it is obvious that the international location of trade analysis must be focussed on food products industry and agriculture, chemical industry, and mechanical engineering products. The development of the food industry and agriculture is to a large extent determined by Swedish protectionist policies which can be assumed to remain unchanged at a high level of protection. Some preliminary scnearios for world market development indicate that in the chemical industry, demand will be developing quickly for certain chemicals like

- o drugs and other health care chemicals;
- o plastic products;
- o organic chemicals, and
- o paints.

where the world market demand increase can be estimated to be around eight percent per year in the 1980s.

The picture is fairly mixed for the mechanical engineering sectors. A quickly expanding market can be expected for

- o telecomminications equipment
- o electronic components
- o industrial machinery and industrial robots

while a slowly expanding world market can be expected for

- o cars
- o agricultural machines

- o airplane production
- o ship building

Available world market scenarios indicate that demand for these products will not expand faster than approximately 3% per year.

3. Prices and Factor Rents

It is important to generate the scenarios for the development of relative prices of different industrial inputs and outputs and of factors of production like energy, capital, and labor. For price scenarios, a model has been developed in the Systems and Decision Sciences Area by Lars Bergman and Andras Por. This model which must be fed by external assumptions about the availability of capital and labor, equilibrium prices for future years can be calculated. This model has been used for generation of scenarios for the Swedish nuclear moratorium consequence investigation. As an example of its use, one can cite the result from the imbalance study with the models for the 1970s. In order to establish an equilibrium of the Swedish economy, the model's results indicated that energy use should be contracted with approximately 10% with an increase in the price with approximately 20%. According to the calculations, employment should be reduced in shipyards to 2/3 of its 1975 values. The calculations also showed that housing services should be contracted with 10% of its 1975 volume. To achieve this, an increase of the real price of housing with 15% was warranted.

This model should be run for different possible economic situations in 1990 and 2000.

The main drawback of this model is its need for externally calculated capital and labor supply.

4. Capital Accumulation

To get capital accumulation scenarios a dynamic input-output model has been constructed which includes endogenous generation of capital stocks and thus also investments in all the sectors of the economy. This dynamic input-output model also generates growth of production scenarios, which can be compared with the production scenarios implied in the Bergman-Por SNAPSHOT model. Production scenarios are also generated in the "ALMON-NYHUS" model mentioned in Section *2*.

The result of the models *3.*, *4.* and *5.* must be summarized in national production develoment scenarios.

6. Location of Production and Employment - the MIRROR Model

At the next stage of analysis the interregional location of employment, investments and production for which a model called MIRROR is used. This model uses as initial information the national sectoral scenarios as well as regional information about population growth and regional employment policies. Availability of natural resources in the region are also used. The fact that all changes in location patterns must be slow because of the already invested material and human capital is reflected in the goal function which minimizes the restructuring or spatial reorganization of production or employment.

The accepted growth scenarios in terms of sectoral production and investments can be used as constraints on the aggregated regional development in the 25 Swedish regions, of which the Skåne regions are three. The population development as projected by the HSS model which has recently been adapted to Sweden can give labor supply scenarios for the 25 regions. Sectoral production for the nation as a whole and employment scenarios for the region are then used as constraints on the interregional location models, MIRROR. The natural inertia to relocation of production is built into the goal function of the model. The essential idea is to search for a location of production that can fulfill the sectoral production scenarios and the regional employment goals together with sectoral and regional resource constraints, while at the same time, it minimizes the restructuring of employment in the Swedish economy.

8., 9., 10., 11,. 12. Intraregional Analysis

The allocation of activities with the help of the MIRROR model creates the basis for the next step - the analysis of intraregional problems. For this purpose a model for intra-regional dynamic location of indivisible units of production has been developed in cooperation with the Systems and Decision Sciences Area. This model, MALTOS, allocates indivisible areas of land to the different production sectors over a discrete set of time periods.

This model is a multi-objective quadratic integer programming model with a set of different evaluation criteria:

- o investment, demolition and operating costs (linear);
- o accessibility of sectors of production and consumption to other activities and prelocated resources (quadratic);
- o node congestion costs (quadratic); and
- o environmental synergism costs (quadratic).

In this model which can also be classified as a combinatorial design model, patterns of land use can be generated.

Because of the non-convexity of this problem, the need for a large number of scenarios must be stressed more than in connection with any other model of this package. As a rule, we can expect to have many local optima, where each one of the local optima can have fairly similar values of the goal function.

The results of MALTOS can be used to generate constraints for land use in the more detailed analysis of service location, detailed industry location, transportation behavior, etc.

CONCLUDING COMMENTS

The system of models described above has recently been transfered to Sweden. Its implementation on Swedish computers is slightly complicated but will be completed in the Summer 1980. Data collection is underway and has turned out to be especially complicated in the case of the MALTOS model. The demographic model developed in the Human Settlements and Services Area of IIASA has been successfully implemented with Swedish data and scenarios for population development in Skåne, subdivided into three parts will be reported on in June 1980.

Dissemination of the work can take place during Fall 1980. This dissemination must be directed to four target groups:

1. regional and planning scientists;
2. planners in Skane and other regions;
3. policymakers, and
4. the general public.

It is obvious that dissemination to these four groups must be adapted to their different frames of reference.