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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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PRODUCTION AND EXPORT PLANNING IN THE ENGINEERING INDUSTRY 1/

by

A. Deák
Economic Department,
Ministry of Finance, Hungary

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

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Contents

Introduction

1. This paper is a survey of macroeconomic methods used in long-term planning (for periods of 5 or 15-20 years) in the Hungarian engineering sector. Only the economic problems of planning are dealt with; the methodology of technical planning is not treated, not even from the aspect of how the technical data used by economists in planning are established. The related problems are touched upon only occasionally.

2. A survey of the traditional, non-mathematical methods will be followed by a description of the main features of the mathematical planning methods worked out in Hungary. The experimental application of these methods in the engineering industry will be reviewed in detail.

3. A few remarks on research work in mathematical planning are appropriate. In Hungary during the last ten years or so, several well-known economists and mathematicians have been engaged in the theoretical and practical problems of the application of mathematics in economics. In this domain, the research devoted to the mathematical methods of long-term planning is particularly outstanding. Beyond disclosing and solving a whole series of theoretical problems, the research workers engaged in this field, while continuously experimenting, also prepare the terrain and press for the practical application of the mathematical methods, performing at the same time extensive educational and training work to foster this end. They rally the economists, technical specialists and mathematicians interested in these methods, acquaint them with the possibilities of the practical application of mathematics and, in the course of the collective practical realization of the theoretically well-founded methods, introduce them to up-to-date and systematic thinking and working methods, rendering thereby great service not only to the specialists, but also to practical planning work in general. These activities contribute greatly to a more efficient solution of the decision problems confronting the planners.

4. The theoretical foundations of programming on a national scale were laid in Hungary by J. Kornai, who also directs the practical works of mathematical programming connected with the long-term national economic plan. The experimental computations were carried out simultaneously in 45 sectors of the economy. Of those, the author of the present paper was engaged, jointly with the mathematician G. Filep, only in the practical organization of the engineering sector computations. The results of the engineering sector computations have been arrived at by the joint efforts of numerous economists, technical planners and

mathematicians. Both the theoretical preparations and practical computations are the subjects of a vast literature[1/]. The present paper cannot be considered as the author's independent work since the methods of traditional and mathematical planning are described mainly on the basis of Kornai's works, and the models for the engineering industry rest on the collective work of the research group. Thus this study does not claim priority of publication; it is merely intended to give a short survey of the work performed.

I. TRADITIONAL PLANNING METHODS IN THE ENGINEERING SECTOR

5. Long-term planning methods are essentially the same in all sectors of the economy, with the same indices worked out everywhere. In traditional planning the aim is to secure equilibrium by drawing up and analysing balances and to safeguard efficiency by performing economic efficiency computations and analysing their results. There is a separate chapter in the official plan for the major investment projects: the plan for the development of fixed assets. In drawing up this part of the official plan, the results of the balances and of the economic efficiency computations are taken into consideration.

a. The balance method

6. The balance method is the planning method most generally applied. In the balances, the sources and allocation of resources or products are taken into account. In planning, the aim is to establish an equilibrium of the balances. In long-term planning, various types of balances are drawn up.

7. The equilibrium of the synthetic or aggregate balances (those of gross social product, national income (net material product), international payments, the state budget, the incomes and expenditures of the population etc.) need be ensured only on the national level. The individual industries, though supplying information for these balances, do not draw up such balances themselves.

8. The specific balances (those of products, and resources, prime costs and profitability, and foreign trade balances) were drawn up till recently for addressees, that is authorities (ministries) in charge of production which are not necessarily identical with the individual industrial sectors. Thus, the Ministry of Metallurgy and Engineering controls about 75 to 80 per cent of all

1/ Especially, J. Kornai, A beruházások matematikai programozása (Mathematical Programming of Investments), Közgazdasági és Jogi Könyvkiadó, Budapest, 1962, pp.323; and Mathematical Planning of Structural Decisions, Akademiai Kiado - North Holland Publishing Co., Budapest/Amsterdam, 1967, pp.526; and several articles, published mainly in Közgazdasági Szemle.

engineering production. But the production of mining equipment, for example, falls under the Ministry of Heavy Industry; there are also engineering co-operatives with a fair share in production. On the other hand, the plan of the Ministry of Metallurgy and Engineering covers not only metallurgy, but the building activities of the Ministry's enterprises, activities which obviously do not fall within the field of engineering.

9. For some years, the specific balances have been drawn up according to addressees and industries. The addressed balances are of a directive character and thus obligatory; those by industries have more of an economic character and give a better indication of the real equilibrium problems. These specific balances, drawn up by the National Planning Offices, contain the allocation of resources and products to addressees and industries. Similar balances are prepared by the addressees who reallocate the quotas and estimates received from the planning centre to their own enterprises, thus ensuring the realization of the plan.

10. As from 1968 - after the introduction of the economic control reform - balances will be drawn up only for industries, since after the abolition of plan instructions the plans will no longer be broken up by enterprises and, therefore, plans for addressees will no longer be necessary.

11. The planned balances cover the most important material supplies, sources and energy, finished products, machinery and transportation services. On the resource side, domestic production, imports and inventory reduction are accounted for; on the utilization side, domestic utilization, exports and inventory increases. In the engineering industry some one hundred products (or rather product groups) are covered by central balances.

12. The resource balances cover investments (not only the global amounts, but the respective quotas for construction, domestic machinery and import machinery) and the allocation of available manpower.

13. The prime cost estimates and those relating to profitability (such as material costs, wage costs, social insurance contributions, various taxes and charges, and profits) are listed in the balances item by item. The foreign trade targets are also worked out according to the principal markets and countries of supply.

14. The balances take shape as a result of extensive discussion and co-ordination. In the course of the co-ordination, individual balances may be modified several times while drawing up the plans. The effect of these modifications usually cannot be traced in the other balances because even if the direct effects could be taken into account, it would in turn modify a series of balances and if these were all followed up, further modifications would become necessary. As

modifications are often made in several different balances simultaneously, the various balances will not be in unequivocal harmony with each other. Nevertheless, owing to the routine and experience of the planners, many contradictions will be revealed in the course of the discussions and co-ordination work, and - particularly since the use of input-output methods has become general - the disequilibrium problems of the major balances will become clear so that the necessary measures can be taken in time.

b. <u>Economic efficiency computations</u>

15. Economic efficiency computations are complementary methods in planning, aimed at determining which of several alternative economic actions having the same objective will yield the highest return with one unit of input or, conversely, which will yield a given return with the least input. In Hungarian planning practice, economic efficiency computations are used mainly in two types of decision problem; in the selection of exports and of investment projects.

16. The aim of the export efficiency computations is to determine which of the domestically produced commodities should be exported. An analogous method has been devised for import efficiency computations. This method aims at determining which essential, but scarce, commodities could be efficiently produced at home and which should be imported. (This method will not be treated here since its application is less general.) These investigations are carried out at a national or sector (branch) level.

17. In export-efficiency computations on a national level, the relation between total domestic labour input into the product in question (in terms of wage costs) and the output of this labour input (in terms of foreign exchange) is examined; in other words, an effort is made to determine the total domestic labour input (in forints) necessary for earning one unit of foreign exchange from the export of the commodity in question. The foreign exchange earned is not the total sales price, for the foreign exchange costs of imported materials or parts have to be deducted. (The methods and basic assumptions of the calculations are beyond the scope of this paper and will not be dealt with here.)

18. The export-efficiency computations performed at the sector level establish the relation between domestic labour input in the last phase of production (of the end product) in terms of wage costs and the output of this labour in terms of foreign exchange. The result of the work performed in an industry is indicated as the difference between the world market price of the product in question and the world market price of all materials and parts used in the industry concerned. It is assumed that the materials and intermediary products turned out by other

industries could be directly exported if they were not used by the industry in question. Thus the total domestic labour input (in forints) required to earn one unit of foreign exchange can be established by means of the individual products in the last phase of production. The sector-level computations can be most useful in determining what to produce for export from given materials.

19. In the engineering industry only branch-level computations are used; the complexity of the products makes the calculation of the foreign exchange yield rather difficult on the national level and involves a great number of conjectural and uncertain factors.

20. Export efficiency computations do not form an organic part of planning or of the plan documents, but the results of the computations are utilised in planning. The purpose of the investment efficiency computations is to prove the expediency and appropriate selection of an investment project.

21. Some statutorily defined investment projects require a centrally authorised permit. As a condition of authorization, the prescribed indices of investment efficiency must be worked out and, by means of these, the inputs and returns of the investment activity are compared. There are several indices which differ in the scope of the inputs and returns investigated, in the period covered, and in the factors (prices, interest rates etc.) on which the computations are based.

22. The numerator of the most generally calculated investment efficiency index contains the estimated returns from one year's operation of the plant that is to be constructed by investment (at world market prices, in forints), while the denominator is composed of 20 per cent of the total investment cost of fixed and current assets (which implies a five-year pay-off period plus the operational costs of the plant including depreciation allowance. The investment is considered advantageous if the value of the index is above unity.

23. Up to now, a value limit has been fixed by decree; all investments above this limit were subject to central authorization. The value limits were not too high; as a matter of fact, all major investment projects (in the engineering industry about 75 per cent of all investments between 1960-1965) had to be centrally authorized and the efficiency indices had to be worked out. The economic control reform foresees a decentralization of investment decisions. Not only will the enterprises have a substantial development fund at their disposal, but they will be able to complement it by raising credit. Investments financed from the enterprises' own funds will not require authorization, nor will the initiator

of the project is obliged to present the efficiency indices in the future. It may, however, be expected that to support their own decisions, the enterprises will use similar computations. Centrally-financed investments - which will be considerably less numerous than before - will continue to have to be authorised by central bodies.

24. Investment-efficiency computations do not form an organic part of long-term planning or of the plan documents, but the results of the computations are utilized in planning.

c. Fixed assets development plan

25. This plan contains a list of the individual investment projects to be realized within the plan period as well as some important technical and cost data such as the total amount to be invested, the production capacities to be created and the initiation and completion dates of the project. This plan chapter is thus not identical with the investment balance, for the latter allocates all resources to users while the fixed assets development plan lists the major investment projects together with their principal data.

26. In principle, account can be taken in these plans of both the disequilibrium of the balances (shortages on the resource side may be compensated or at least reduced by increasing domestic production) and of the results of the efficiency computations (those exports shown by the export efficiency calculations to be profitable can be developed in the way indicated by the investment efficiency computations as the most efficient). The unity of these plans, however, could not be achieved in practice. After an individual investment project is authorized, investment efficiency computations are carried out continuously. The long-term plans are worked out every five years. In the long-term plans, not only the authorized investments are included but also the investments which have not yet been authorized and for which no efficiency calculations have been carried out.

27. However, the reasons for the lack of harmony between the plans and the efficiency computations are related not only to the plan for the development of fixed assets but to the balances and the efficiency computations themselves.

d. The harmony of traditional plans

28. There are several reasons why a harmony of the traditional plans could not be achieved. A number of the causes of disharmony can be eliminated by mathematical planning methods, as indicated below:

Whereas the system of plan indices has developed continuously, the individual balances developed independently of each other. The system of plan indices is not closely co-ordinated. The concepts and categories used in the various chapters of the plan are not identical; often the same processes are characterized by different indices. In several cases, therefore, it could not be established if there was a harmony or lack of harmony between the various balances and separate plan chapters.

Efficiency computations having different objectives were drawn up independently of each other. As they do not operate with identical assumptions, their results cannot be interpreted collectively. The various computations are based on different prices and different calculative factors. The contents of the export efficiency indices (expressed in forints per United States dollar) differ from that of the investment efficiency indices (expressed only in forints).

Efficiency computations are carried out continuously while the plans are drawn up at a given date. Both rely on the latest information (prices, cost estimates etc.) and it may thus easily happen that the expected total cost of an investment project appears in the plan with a higher figure than that shown in the efficiency computations.

The plans comprise a huge amount of data, compiled by several thousand specialists and this quantity makes it practically unfeasible to follow up a modification in one balance through the other balances, as would be desirable.

29. The economists investigating the mathematical methods of planning try to solve the difficulties connected with traditional planning, without sacrificing such advantages of the latter as - to mention only the most important ones - the pooling of planners' experience, the combined processing of available information, the preliminary confrontation of supply and demand, the extensive survey of the equilibrium problems of the economy, and the macro-economic analysis of the advantages of the international division of labour and of the structure of the economy.

2. MATHEMATICAL PROGRAMMING MODELS OF LONG-TERM PLANNING IN THE WHOLE PRODUCTIVE SECTOR

30. After several years of theoretical preparation, the practical experimental computations of mathematical programming were commenced, by means of electronic computer, with a large-size, relatively detailed mathematical programming model, to work out certain targets for the Third Hungarian Five-Year Plan (1966-1970). National economic programming involves not a single operation but a whole series of calculations which are performed in several stages:

(a) In the basic computations on branch level, the programme of the sector in question is worked out separately from the other branches.

(b) In the **branch-level sensitivity** analysis, those changes are examined which occur in the branch programme if the values of some initial data are modified.

(c) The engineering branch models are aggregated into a single engineering sector model and the basic computations and the sensitivity analysis are repeated.

(d) All sector models - a total of [illegible], including the engineering models - are aggregated into a single national economic model and the basic computations and sensitivity **analysis are repeated.**

31. This paper confines itself to the basic computations carried out on the branch level in the engineering sector. In some of the engineering branches sensitivity analysis has also been performed. The preparations for the basic computations on a national level - comprising all sectors in a single large-scale model - have been concluded and the calculations are now being made.

32. The aim of the basic computations on the branch level is to determine a branch programme which can provide an answer to the following questions:

(a) Which of the branch's products should be produced in 1970, and in what volume?

(b) What investments should be made between 1966 and 1970 to secure the capacity needed to achieve the production targets of 1970, specifically -

What should be the fate of old plants, i.e. those in existence on 1st January 1966; should they continue in operation in unchanged form, be remodelled, or closed down?

What new plants should be constructed and of what size? Based on what technology (e.g. whether a cheaper plant should be built with a lower productivity or a more costly one, the productivity of which will be higher)?

(c) What to export of the sector's products in 1970, in which volume and to which countries?

(d) What to import in 1970 of those products which fall within the production line of the branch in question, in which volume and from which countries?

A branch programme will thus constitute the complex production, investment, development and foreign-trade plan of the branch.

33. The basic branch-level computations have been performed with linear programming models, the constraints and the objective function were given in the form of linear equations. No mathematical formulations of the problem are given in this paper.

[illegible]. Engineering models

34. In the course of the experiments, computations eleven engineering models were constructed. An attempt was made to have each branch model conform to some addressees under the Ministry for Metallurgy and Engineering because in this manner the results of the computations could be easily collated with the data of the official (traditional) plan. For example, the shipbuilding branch represents the Hungarian Shipyards and Crane Works, the branch for mass metal products represents all enterprises belonging to the Mass Metal Products Directorate of the Ministry and so on. This principle could not be fully enforced. The range of some branches was so wide that, owing to the limited computer capacity available, two models had to be constructed for them, while in some of the branches the models could embrace only part of the products of the enterprises.

35. As a consequence, the engineering models do not cover the engineering sector as a whole, though they do cover a considerable part of the field. In defining the sphere of the models, the decisions were not made on the basis of economic or technical criteria; the experimental computations were extended to the fields where competent and enterprising specialists could be found to participate in the research work. Some branches of the engineering sector (e.g. the whole of the heavy-current equipment industry) thus had to be neglected in the models.

36. The following engineering models were constructed:

(1) Shipbuilding,
(2) Public road vehicles I,
(3) Public road vehicles II,
(4) Precision engineering I,
(5) Precision engineering II,
(6) Telecommunications I,
(7) Telecommunications II,
(8) Machine tools,
(9) Railway vehicles,
(10) Agricultural machinery,
(11) Metal mass products.

37. As the list indicates, the number of models is higher than that of the branches, i.e. three branches are represented by two models each. The reasons are to be found in computation techniques. With a single model, the dimensions of these branches would have been so large that the available computer could not have performed the programming. The division of the precision engineering and the telecommunications branches into two parts presented no particular difficulties because the products of the two models are not closely related. The division of the public road vehicles branch is rather arbitrary, since there is a close connexion between the products of the two models: Model II uses the products of Model I. The results obtained with the separate models of the branches in

question must be analysed together, account being taken of the inaccuracies caused by the division.

38. To each of the branches belong 6 to 12 product groups which, for the sake of simplicity, will be called products. In some cases these are individual products (e.g. a 40-hp tractor or a 100-ton floating crane), but generally they constitute a group of several products (e.g. TV receiving sets, high-precision machine tools, farm machinery etc.). In delimiting the models, serious problems were caused by the great diversity of the engineering products. The higher the degree of aggregation, the easier it is to survey and handle the models, but the characterization of the products by reliable data becomes more difficult. Efforts were made to find the highest aggregate where the per unit data are still relatively acceptable and interpretable, but this could not always be achieved. This accounts, for example, for the absence of a foundry model. It must be pointed out, however, that a suitable aggregation of foundry products would not have been impossible, but would have necessitated a large-scale regroupong of the data and this was not warranted by the purpose of these experimental computations.

39. The products in a branch model do not represent the entire production of the branch. The products which were not taken into account in the mathematical programme form the sphere of the branch outside the model. However, efforts were made to include in the model all major products, particularly those representing the highest export volume.

40. In the engineering models precisely one hundred products were dealt with. They are listed in table 1 below.

Table 1

Over-all review of the branch models

Branch	Products
Shipbuilding	Portal cranes
	Floating cranes (16-ton)
	Floating cranes (100-ton)
	Seagoing cargo ships
	Boilers for power stations
	Tugboats
	Cargo ships for inland waters
Public road vehicles	"Csepel" engines and spare parts
	Other engines and spare parts
	Front axle housings
	Rear axle housings and driven front axles
	Auxiliary gearboxes for change-speed gear
	Power-steering units
	Lorries (5 t capacity)
	Lorries (8 t capacity)
	Lorries (12 t capacity)
	Buses (up to 11 m. in length)
	Buses (longer than 11 m.)
	Dumpers (3.5 cu.m.)
	Dumpers (6 cu.m.)
	Tractors (40 h.p.)
	Tractors (90 h.p.)
	Electrical material for automobile manufacturing
	Structural spare parts (without dumper)
	Spare parts for tractors and dumpers
Precision engineering	Automation devices
	Electronic measuring instruments
	Office machines and management devices
	Material testing instruments
	Geodetic instruments
	Optical devices
	Optician's products
	Electric instruments
	Electro-mechanical parts
	Electric installation material
	Medical apparatuses
	X-ray apparatuses
	Steel medical instruments
	Laboratory equipment and implements
	Geophysical instruments
	Fuel pumps
	Other precision engineering products

Table 1 (continued)

Branch	Products
Telecommunications	Incandescent lamps
	Fluorescent tubes
	Receiver tubes
	Transmitter tubes
	TV picture tubes
	Other electronic tubes
	Semi-conductors
	Vacuum engineering machines
	Machines for telecommunication
	Telephone apparatuses
	Telephone exchanges
	Transmission equipment
	Radio transmitter-receivers
	Microwave equipment
	Radio home receivers
	TV home receivers
	Amplifier studio equipment
	Tape recorders
	Electric railway safety appliances
	Electric spare parts for telecommunication
Machine tools	Universal precision lathes
	Special precision lathes
	Medium-size lathes
	Grinding machines
	Knee-type milling machines I
	Shaping machines
	Special purpose machines
	Drilling machines
	Knee-type milling machines II
	Special milling machines
	High precision machine tools
	Semi-automatic disc lathes
	Production lines
	Machine tools operating on special principle
	Metal-working machine tools
Railway vehicles	Diesel engines
	Electric locomotives
	Diesel locomotives
	Electric power cars for tramways and suburban railways
	Multiple unit diesel trains
	Railway passenger coaches
	Railway freight wagons
	Railway tank wagons
	Spare parts for railway vehicles
	Wheel sets

Table 1 (continued)

Branch	Products
Agricultural machinery	Tilling machines
	Seeding and manure-spreading machines
	Plant protection machines
	Harvesting machines
	Machines for stock-breeding
	Loaders
	Fruit and vegetable cultivating machines
Metal mass products	Aluminium kitchen pans
	Enamelled ware
	Bolts and nuts
	Padlocks
	Hand-tools
	Industrial armatures

b. **Variables of the models**

41. Several of the following activities may be attached to each of the products:

(a) Domestic production in old plants;
(b) Domestic production in remodelled plants;
(c) Domestic production in new plants;
(d) Imports from socialist countries;
(e) Imports from capitalist countries;
(f) Exports to socialist countries;
(g) Exports to capitalist countries.

Activities (b) and (c) may be of several kinds, according to the technological variants. Only as many activities as are admissible from the technological and marketing points of view are attached to any given product. The extents of the various activities are not defined; they are the unknowns, the variables in the computations. It is the extent or volume of the activities belonging to the individual products that must be determined. The quantitative targets of the variables taken together constitute the programme of the branch.

42. The plan based on the traditional methods is also a branch programme which we shall call the official programme. All activities foreseen in the official programme in connexion with the products of the branch also figure in the models, which contain, however, additional activities as further alternatives. The mathematical programme can thus be identical with the official programme substantiating, as it were, the latter one; it may, on the other hand, deviate from the official programme and yield different proposals. Thus, the model makes its own choice from among the possible activites.

43. Each model has 50 to 60 activities and the same number of variables. The engineering models contain a total of about 700 variables which are not listed here. They can be worked out indirectly from tables 4 and 9.

c. The constraints of the models

44. Obviously, the variables of the models could not be given arbitrary values. Several realistic situations - limits and obligations - had to be taken into account. The most important constraints are the following:

(a) The branch cannot claim more of the resources (investments, manpower, wage fund, specified materials) than that allocated to it in the official plan. The resources are bounded from above, as the claim of the branch on the resources may not exceed the volume available on the basis of the resource balance of the national economic plan. This constraint on the individual branches will be removed in the national economic programming computations, as the resources are actually restricted only on the national level. In the computations on the national level, a reallocation of resources may thus be made.

(b) The branch's output for domestic consumption and for meeting obligations under international agreements may not be lower than that specified in the official plan. The obligations are thus bounded from below.

(c) The branch must not produce more than the quota set by the capacity constraints. The capacities are generally bounded from above.

(d) The branch can export only that quantity of each product which can be sold in the foreign markets.

(e) The balance of socialist foreign exchange must reach at least the level specified in the official plan. In national economic computations this constraint will be prescribed only as a total and not for the individual branches.

45. The constraints were not worked out in the course of the computations, but were brought into the programme from outside. In determining the constraints, the allocations to the branches were reduced by the quotas falling into the sphere outside the branch model, so that the models use only the allocations to the products within the programme.

46. Quantification of the constraints was sometimes a highly difficult task in the engineering models. In order to determine the domestic demand for machinery in 1970, it would be necessary to draw up the investment plan for the years after 1970. To do this, however, the other interrelations of the plan ought to be known. Indeed, to assess correctly the five-year demand for machinery, the outlines of a ten-year plan ought to be drawn up.

47. Part of the engineering capacity is convertible. The determination of the capacity constraints is dependent upon the knowledge of the product pattern; yet the capacity constraint was introduced in the model as a constant.

48. In traditional planning, several data which must be quantified for the purposes of the mathematical model are not established. Thus, for example, the market limitations on exports are usually not fixed. In the course of drawing up the official programme, the planners would work out the export plan on the basis of their experience and would take into consideration both production and market possibilities. Thus, for the purposes of programming, the foreign-trade market constraints had to be established separately for each product. For each model 80 to 120 constraints were fixed - a total of about one thousand constraints.

49. The coefficients of the individual activities in the constraint equations also had to be worked out and this presented many additional difficulties. A considerable number of the coefficients hold only for a given production pattern; it was nevertheless assumed that the coefficients would not be affected by changes in this pattern. On the other hand, the specific material and labour input requirements of the products are strongly influenced by the degree of subcontracting among enterprises. Changes in subcontracting could not be fitted into the model in the course of the experimental computations, and the amount of subcontracting was considered constant. This assumption may not be permissible because it could also have consequences for the subcontracting enterprises; but this aspect could not be accounted for in the model either. These factors had to be considered when evaluating the programme.

d. The objective function

50. In the experimental computations, the objective function of the branch models usually became the maximization of the balance of capitalist foreign exchange for 1970. The balance represents the difference between export returns and import expenditures in terms of foreign exchange.

51. Import expenditures consist of two items. The first item is composed of competitive imports, i.e. imports of those products which fall within the branch's scope and which usually compete with similar domestic products (e.g. in the railway vehicle model, the imports of Diesel engines which are also produced domestically). The second item consists of the direct requirements in import materials and productive components for a branch's production. These requirements do not compete directly with domestic production in the branch model since they represent the cost of import materials necessary for the domestic production of products belonging to the scope of the branch (non-competitive imports). By way of example, the costs of some imported materials and accessories indispensable for the production of railway vehicles may be mentioned.

52. In the model, competitive imports within a branch are represented by separate "import activities" and "import variables", while the import costs of production are expressed by the coefficients in the foreign exchange balances belonging to the production activities and production variables.

53. The foreign exchange balances of the objective function do not contain the foreign exchange expenditures necessary for investments and replacements from 1966 to 1970 within the individual sectors. In the model, these expenditures are governed by separate constraints. It is assumed, however, that every time a branch economizes on the import quota set for machinery between 1966 and 1970, the savings can be used to pay off debts. This will save interest (in this connexion, a 10 per cent rate of interest was assumed in the case of capitalist countries) and this saving can then be accounted for as an item improving the commodity balances.

54. In addition to maximizing the balance of foreign exchange with capitalist countries, other objective function criteria, such as the following, were applied in non-engineering sectors.

(a) Maximization of production, with a fixed commodity pattern;

(b) Minimization of production costs;

(c) Maximization of the combined amount of the rouble and dollar balances.

In the engineering industry, no other objective function has been used as yet for working out the programmes.

e. Comparison between the official plan and the mathematical programme

55. Since the objective function of the models was the improvement of the foreign exchange balance with capitalist countries, the problem of how the mathematical programme modified the targets of the official plan in respect to the objective function was examined first. This is shown in table 2 below.

Table 2

Mathematically programmed balance of foreign exchange with capitalist countries (expressed as percentages of the official plan)

Branch	Percentage[a/]
Shipbuilding	157.1
Public road vehicles	177.2
Precision engineering	166.3
Telecommunications	153.5
Machine tools	105.3
Railway vehicles	110.1
Agricultural machinery	b/
Metal mass products	156.1
Engineering, total	204.5

a/ Official plan = 100 per cent.

b/ The official plan did not provide for exports to capitalist countries.

56. The balance of foreign exchange with capitalist countries is considerably more favourable in the mathematical programme than in the official plan: for all engineering branches taken together, the computed balance is double that of the official plan. The fact that the percentage of the improved total is higher than any percentage given for the individual branches is due to the circumstance that some branches had a negative balance (deficit) in both types of programme. In these branches the improvement means a lower deficit.

57. This important improvement in the balance of foreign exchange with capitalist countries has come about without a deterioration in the balance of foreign exchange with socialist countries; the level set for the latter in the official plan was maintained. It must be emphasized that this improvement does not require any additional input; it even encourages the economizing of some resources, an aspect which will be dealt with later. It must be noted, however, that in the official plan several factors have been neglected which, if taken into account, could have had a detrimental effect on the foreign exchange balance of the mathematical programme. These factors include regional employment problems, certain conditions of trade policy and consequences of bilateral clearings.

Table 3

Production and foreign trade (expressed as percentages of the official plan[a/])

Branch	Product	Production	Imports from capitalist countries [b/]	Imports from socialist countries	Exports to capitalist countries [c/]	Exports to socialist countries [d/]
Shipbuilding	Portal cranes	100	-	-	120	-
	Floating cranes (16 ton)	111	-	-		
	Floating cranes (100 ton)	137	-	-	.	300
	Seagoing cargo ships	100	-	-	100	.
	Boilers for power stations	100	-	-	-	100
	Tugboats	100	-	-	-	100
	Cargo ships for inland waters	100	-	-	145	0
Public road vehicles	"Csepel" engines and spare parts	100	-	-	100	100
	Other engines and spare parts	99	.	.	.	50
	Front axle housings	100	.	100	-	-
	Rear axle housings and driven front axles	101	.	-	.	101
	Auxiliary gearboxes for change-speed gear	98	-	123	-	150
	Power-steering units	112	.	-	-	.
	Lorries (5 t capacity)	100	-	.	-	100
	Lorries (6 t capacity)	122	-	.	150	133
	Lorries (12 t capacity)	100	-	.	-	100
	Buses (up to 11 m. in length)	100	.	.	-	100
	Buses (longer than 11 m.)	101	-	-	150	100
	Dumpers (3.5 cu.m.)	100	-	-	150	83
	Dumpers (6 cu.m.)	77	.	-	150	46
	Tractors (40 h.p.)	94	.	-	.	.
	Tractors (90 h.p.)	108	.	-	200	104
	Electrical material for automobile manufacturing	110	.	0	120	120
	Structural spare parts (without dumper)	101	.	.	150	101
	Spare parts for tractors and dumpers	98	.	-	165	78

a/ Official plan = 100%.
b/ The sign "-" indicates that the activity is not represented in the model.
c/ The sign "." indicates that the activity is represented by a variable, but as its value in the official plan is zero, the quotient is meaningless.
d/ The sign "=" indicates that the value of the variable is zero in both the official and the mathematical programme.

Table 3 (continued)

Branch	Product	Production	Imports from capitalist countries	Imports from socialist countries	Exports to capitalist countries	Exports to socialist countries
Precision engineering	Automation devices	113	0	35	.	0
	Electronic measuring instruments	92	0	117	139	91
	Office machines and management devices	104	0	196	400	107
	Material testing instruments	72	0	106	425	0
	Geodetic instruments	100	0	0	166	100
	Optical devices	53	433	76	0	122
	Optician's products	100	.	0	75	110
	Electric instruments	100	0	0	28	124
	Electro-mechanical parts	108	0	154	-	.
	Electric installation material	80	-	0	0	.
	Medical apparatuses	100	0	0	135	84
	X-ray apparatuses	100	0	0	100	97
	Steel medical instruments	100	0	0	160	91
	Laboratory equipment and implements	96	0	0	127	92
	Geophysical instruments	100	-	0	-	94
	Fuel pumps	84	-	830	-	100
	Other precision engineering products	97	0	111	103	50
Telecommunications	Incandescent lamps	101	-	-	112	85
	Fluorescent tubes	84	-	-	100	50
	Receiver tubes	100	-	.	114	70
	Transmitter tubes	100	-	-	125	97
	TV picture tubes	68	-	.	.	0
	Other electronic tubes	95	-	-	111	95
	Semi-conductors	116	-	-	.	120
	Vacuum engineering machines	100	-	-	333	87
	Machines for telecommunication	15	.	-	.	0
	Telephone apparatus	66	.	-	200	0
	Telephone exchanges	107	.	-	121	105
	Transmission equipment	80	.	-	.	80
	Radio transmitter-receivers	22	.	-	.	0
	Microwave equipment	100	.	-	117	90
	Radio home receivers	94	.	.	0	110
	TV home receivers	100	.	-	56	119

Table 3 (continued)

Branch	Product	Production	Imports from capitalist countries	Imports from socialist countries	Exports to capitalist countries	Exports to socialist countries
Telecommunications (cont.)	Amplifier studio equipment	65	.	-	0	133
	Tape recorders	118	.	.	.	0
	Electric railway safety appliances	94	-	-	.	0
	Electric spare parts for telecommunication	160	.	.	.	.
Machine tools	Universal precision lathes	100	.	0	0	238
	Special precision lathes	100	.	1300	100	0
	Medium size lathes	100	.	0	100	90
	Grinding machines	100	.	0	121	86
	Knee-type milling machines I	100	.	0	114	83
	Shaping machines	100	.	0	150	66
	Special purpose machines	100	98	.	.	-
	Drilling machines	100	.	0	129	69
	Knee-type milling machine II	100	.	0	125	80
	Special milling machines	100	.	.	100	100
	High precision machine tools	100	0	0	133	67
	Semi-automatic disc lathes	100	.	0	117	62
	Production lines	100	.	.	.	100
	Machine-tools operating on special principle	100	0	160	.	0
	Metal-working machine-tools	100	.	.	100	100
Railway Vehicles	Diesel engines	97	.	.	100	82
	Electric locomotives	100	.	-	-	-
	Diesel locomotives	109	-	-	.	82
	Electric power cars for tramways and suburban railways	100	.	.	-	-
	Multiple unit diesel trains	[illegible]	-	-	.	.
	Railway passenger coaches	106	-	-	200	.
	Railway freight wagons	80	109	100	.	.
	Railway tank wagons	100	.	-	-	-
	Spare parts for railway vehicles	100	-	-	153	81
	Wheel sets	96	.	-	20	217

Table 3 (continued)

Branch	Product	Production	Imports to capitalist countries	Imports to socialist countries	Exports to capitalist countries	Exports to socialist countries
Agricultural machinery	Tilling machines	100	.	8	.	0
	Seeding and manure-spreading machines	100	.	78	-	0
	Plant protection machines	97	.	98	.	.
	Harvesting machines	100	.	97	.	0
	Machines for stock-breeding	154	.	0	-	127
	Loaders	100	-	-	-	-
	Fruit and vegetable cultivating machines	0	.	570	-	0
Metal mass products	Aluminium kitchen pans	121	.	-	218	386
	Enamelled ware	106	.	100	143	.
	Bolts and nuts	105	.	0	179	.
	Padlocks	118	.	-	124	120
	Hand-tools	74	.	-	46	108
	Industrial armatures	96	.	100	0	-

58. The next problem concerns deciding how much of what products should be produced, exported or imported according to the two types of programme.

59. Table 3 shows whether the indications of the mathematical programme for all products of each branch are identical with those of the official plan or, if not, to what extent the mathematical programme modifies the official one.

60. Table 4 shows the changes in the share of the individual branches in total engineering production. Here, the total of the production value (in United States dollars) of the eight branches was taken as one hundred and the percentage share of the individual branches was examined on this basis.

Table 4

Branch changes in the percentage shares of production in 1970 as compared to the official plan

Branch	Percentage
Shipbuilding	+ 0.2
Public road vehicles	+ 0.5
Precision engineering	- 0.4
Telecommunications	- 0.5
Machine tools	-
Railway vehicles	-
Agricultural machinery	+ 0.1
Metal mass products	+ 0.1
Engineering, total	-

61. Tables 5a - 5e show the extent to which the individual targets in the mathematical programme deviate from those in the official plan; i.e. the dispersion of the former around the latter. The first step was to work out the percentage deviations by individual items. A deviation is derived by dividing the estimate of the mathematical programme by the estimate of official plan, minus one, and is expressed in a percentage. This percentual deviation can be established only where the estimate concerned has either a positive value or is zero in both programmes (i.e. a directly comparable estimate). It will not be possible, therefore, to compute the percentual deviation where one of the estimates is positive and the other is zero as these estimates are not directly comparable.

62. In tables 5a - 5e the deviation frequencies for the directly comparable estimates are shown in various class intervals (e.g. the number of deviations between ± 2.1 and ± 5 per cent).

Table 5a

Frequency distribution of directly comparable deviations - production

Branch	Number of directly comparable forecasts	Number of forecasts in class intervals of: 0 to ± 0.1%	± 0.11 to ± 2%	± 2.1 to ± 5%	± 5.1 to ± 10%	± 10.1 to ± 20%	more than ± 20.1%	Number of directly incomparable forecasts
Shipbuilding	7	5				1	1	
Public road vehicles	18	7	3	2	3	1	2	
Precision engineering	17	6		4	2	2	3	
Telecommunications	20	5	1	1	3	4	6	
Machine tools	15	15						
Railway vehicles	10	4		2	3		1	
Agricultural machinery	6	4		1			1	1
Metal mass products	6			1	2	1	2	
Engineering, total	99	46	4	11	13	9	16	1

Table 5b

Frequency distribution of directly comparable deviations - imports from capitalist countries

Branch	Number of directly comparable forecasts	Number of forecasts in class intervals of: 0 to ± 0.1%	± 0.11 to ± 2%	± 2.1 to ± 5%	± 5.1 to ± 10%	± 10.1 to ± 20%	more than ± 20.1%	Number of directly incomparable forecasts
Shipbuilding	-							2
Public road vehicles	-						1	13
Precision engineering	1							3
Telecommunications	-							3
Machine tools	1			1				1
Railway vehicles	9	8			1			2
Agricultural machinery	-							1
Metal mass products	-							25
Engineering, total	11	8		1	1		1	

Table 5c

Frequency distribution of directly comparable deviations - imports from socialist countries

Branch	Number of directly comparable forecasts	Number of forecast in class intervals of: 0 to ± 0.1%	± 0.11 to ± 2%	± 2.1 to ± 5%	± 5.1 to ± 10%	± 10.1 to ± 20%	more than ± 20.1%	Number of directly incomparable forecasts
Shipbuilding	-							
Public road vehicles	2	1					1	1
Precision engineering	8				1	2	5	9
Telecommunications	-							1
Machine tools	2						2	
Railway vehicles	2	2						3
Agricultural machinery	5		1	1			3	1
Metal mass products	2	2						1
Engineering, total	21	5	1	1	1	2	11	21

Table 5d

Frequency distribution of directly comparable deviations - exports to capitalist countries

Branch	Number of directly comparable forecasts	Number of forecast in class intervals of: 0 to ± 0.1%	± 0.11 to ± 2%	± 2.1 to ± 5%	± 5.1 to ± 10%	± 10.1 to ± 20%	more than ± 20.1%	Number of directly incomparable forecasts
Shipbuilding	3	1				1	1	2
Public road vehicles	9	1				1	7	2
Precision engineering	11	1		1			9	3
Telecommunications	10	1				3	6	6
Machine tools	11	3				2	6	1
Railway vehicles	5	2					3	5
Agricultural machinery								3
Metal mass products	5						5	1
Engineering, total	54	9		1		7	37	23

Table 5e

Frequency distribution of directly comparable deviations - exports to socialist countries

Branch	Number of directly comparable forecasts	Number of forecast in class intervals of: 0 to ± 0.1%	± 0.11 to ± 2%	± 2.1 to ± 5%	± 5.1 to ± 10%	± 10.1 to ± 20%	more than ± 20.1%	Number of directly incomparable forecasts
Shipbuilding	3	2					1	2
Public road vehicles	15	5	2	1		2	5	1
Precision engineering	13	2		1	5	1	4	4
Telecommunications	14			3	1	4	6	5
Machine tools	12	3			1	2	6	2
Railway vehicles	6	2				2	2	4
Agricultural machinery	1						1	4
Metal mass products	3						3	2
Engineering, total	67	14	2	5	7	11	28	24

63. A number of important conclusions can be drawn from these tables. The total production volume of the branches is approximately the same in the mathematical programme as in the official plan; the pattern of foreign trade, however, undergoes a considerable change in the mathematical programme. The total volume of exports to, and imports from, capitalist countries is significantly higher here, while that of exports to and imports from socialist countries diminishes slightly. This follows from the choice of the objective function which maximizes the balance of foreign exchange with capitalist countries while keeping the balance of foreign exchange with socialist countries at the level prescribed by the official plan.

64. The production and import tendencies in the engineering sector as a whole do not manifest themselves uniformly, but show rather important differences by branches.

65. For all eight branches examined, the volume of production is approximately the same in both programmes, though in the mathematical programme it is slightly higher for shipbuilding and metal mass products and somewhat lower for precision engineering and the telecommunications.

66. The official plan forecasts competitive imports from capitalist countries only for three of the branches concerned. From these three branches the mathematical programme proposed to import more in two branches and less in only one. The mathematical programme envisages imports from capitalist countries in four branches for which the official plan contains no such figure (public road vehicles, agricultural machinery, metal mass products and telecommunications). There is only one engineering branch (shipbuilding) for which neither programme proposes imports from capitalist countries. Out of a total of eight engineering branches, there are six for which the mathematical programme envisages higher imports from capitalist countries than the official plan. This is worth noting since it contradicts the rather widespread belief that the most natural way to improve the balance of payments with capitalist countries is to cut imports.

67. Exports to capitalist countries show a considerable increase in seven branches of the engineering sector - even in agricultural machinery, where the official plan did not provide for exports. There is only one branch - precision engineering - where exports are reduced by the mathematical programme.

68. As regards competitive imports from socialist countries, the character of the changes in the mathematical programme is different; in five branches they are lower, in two (railway vehicles and telecommunications) they are higher than in the official plan. For the telecommunications branch no imports of this type were foreseen in the official plan and for shipbuilding neither programme envisages imports. The reduction of imports called for by the mathematical programme is particularly significant in the machine-tool industry; in this industry competitive imports were reduced by 75 per cent and even non-competitive imports were cut back to less than half the figure given in the official plan. In precision engineering the situation is similar, with competitive imports reduced by one half, and non-competitive imports cut back to less than three quarters of the official plan figures.

69. Exports to socialist countries are lower in six branches, but the reduction is significant only in precision engineering and agricultural machinery; in one branch exports to socialist countries are essentially unchanged and in another branch they are slightly increased.

70. Almost half the improvement in the balance of capitalist foreign exchange is accounted for by the public road vehicles branch and more than one quarter by telecommunications. The shares of precision engineering (15 per cent) and of shipbuilding (more than 11 per cent) are also significant.

71. In the public road vehicles branch, the total volume of production and total exports to and imports from socialist countries remained essentially unchanged, but the commodity pattern of both production and exports changed considerably and exports to, as well as imports from, capitalist countries increased. With one third of the production estimates, the deviation between the two programmes amounts to more than 5 per cent. Some 90 per cent of the directly comparable estimates of exports to capitalist countries show a deviation higher than 10 per cent from the official estimates, and with half of the estimates on exports to socialist countries, the deviation exceeds 10 per cent.

72. The mathematical programme proposes, among other things, to:

- Produce more lorries (8-ton) and to increase their export to socialist and capitalist countries;
- Reduce the production and export of dumpers (6 cu.m.) to both socialist and capitalist countries;
- Increase the production of power-steering units beyond domestic requirements and to export the surplus in socialist countries;
- Sell in capitalist markets part of the newly designed engines originally destined for socialist markets;
- Increase the exports of dumpers (3.5 cu.m.) to capitalist countries.

73. It should be noted that there was no choice but to include the official plan figures for public road vehicle production into the mathematical programming model. The official plan contained these production figures and forecast in this connexion considerable socialist foreign exchange returns. This was made obligatory for the mathematical programme. It was, however, not possible to build into the programme an alternative variable which could have produced the foreign exchange returns prescribed for this industry. The model's choice was thus restricted to detail problems of the public road vehicle programme and to alternative technological solutions. Future computations, to be performed at the Ministry and national levels, will enable the efficiency of this programme to be re-examined.

74. The structural changes in the programming of the telecommunications branch are extremely significant. Production is lower in the mathematical programme; with about two thirds of the items the deviation exceeds five per cent. Only the mathematical programme provides for imports from both socialist and capitalist countries. The deviations of comparable export estimates exceed 10 per cent, with 90 and 70 per cent of exports to capitalist and socialist countries respectively.

75. As against the official plan, the mathematical programme proposes to:

- Reduce the volume of domestically produced TV picture tubes and to meet the demand by socialist imports;
- Increase the production of semi-conductors to a considerable extent and to increase their export to socialist countries, with some export also to capitalist countries;
- Produce considerably less telecommunication equipment and radio transmitter-receiver sets at home, and to meet the excess demand by imports from capitalist countries, while cancelling the export of this equipment to socialist countries;
- Reduce both production of telephone exchanges and their export to socialist countries;
- Reduce slightly the production of transmission equipment, and to export less to socialist countries while attempting some export to capitalist countries;
- Reduce the domestic production of radio receiver sets, and to cancel their export to capitalist countries, perhaps even importing some from capitalist countries;
- Shift part of the export of TV receiver sets to socialist rather than capitalist countries;
- Reduce slightly the production of studio amplifier equipment eliminating its export to capitalist countries while increasing its export to socialist countries;
- Produce more electric telecommunication spare parts than domestically required, and to export the surplus to capitalist markets;

- Reduce the production of tape recorders to the level of home demand and to eliminate their export to socialist countries.

76. The most conspicuous difference between the official plan and the mathematical programme in the precision engineering branch is that all aggregate estimates of the mathematical programme are lower than those in the official plan, and all activities - production, exports and imports to socialist and capitalist countries - are on a lower level in the mathematical programme. The deviation between the plan and the programme exceeds 5 per cent in more than a third of the production estimates pertaining to competitive imports from socialist countries. The same degree of deviation obtains with 80 per cent of the estimated exports to socialist countries. In 90 per cent of the export estimates to capitalist countries, the deviations are more than 20 per cent.

77. The mathematical programme proposed the following major structural changes in the official plan for the precision engineering branch:

- A considerable reduction of the domestic production of automation devices and of exports to and imports from socialist countries, and the elimination of imports from capitalist countries while increasing exports to capitalist markets;
- A reduction in the exports of electric instruments to capitalist countries in favour of exports to socialist countries;
- A reduction in the domestic production of fuel pumps and an increased import of them from socialist countries.

78. With more than a quarter of production targets (two thirds of the comparable estimates of exports to capitalist countries), the deviations of the mathematical programme from the official plan in the shipbuilding branch are higher than 10 per cent; with a third of the exports to socialist countries the deviation is higher than 20 per cent. The following major changes are proposed in the mathematical programme as against the official plan:

Elimination of the export of portal cranes to socialist countries;

Inclusion in the plan of the export of 16-ton floating cranes to capitalist countries;

Production of more 100-ton floating cranes and an increase in their export to socialist countries, extending their export also to capitalist markets;

Increase in the export of cargo ships for inland navigation to capitalist countries and a suspension of this export to socialist countries.

79. The contribution of the other branches to increased foreign-exchange earnings was lower. Of the proposed structural changes in these branches only a few are mentioned here.

Railway vehicles

80. In the railway vehicles branch, the mathematical programme proposed:

> To cut back the production of Diesel engines and increase imports from socialist countries;
>
> To increase the domestic production of Diesel locomotives and extend their export to capitalist markets, even if this entails a reduction of socialist exports;
>
> To reduce the domestic production of multiple-unit Diesel trains to the level required by socialist export obligations, and to eliminate exports to capitalist markets;
>
> To increase the production of railway passenger coaches and their export to capitalist markets;
>
> To reduce the domestic production of railway freight wagons and to import them from capitalist countries;
>
> To reduce both the domestic production and the export to capitalist countries of wheel sets, and to increase their export to socialist markets.

It should be noted that in the railway vehicles branch - contrary to precision engineering - the estimates of the mathematical programme are higher for all activities than those in the official plan.

81. In the machine tools branch the mathematical programme proposed:

> To cut back the export of shaping machines to socialist countries in favour of exports to capitalist countries;
>
> To eliminate import of drilling machines from socialist countries and to reduce the exports of these machines to socialist countries in favour of exports to capitalist markets;
>
> To increase imports of special-principle machine tools to socialist countries, with a simultaneous export increase to capitalist countries.

82. The mathematical programme proposed the following changes in the agricultural machinery branch:

> To import tilling machines from and to export such machines to capitalist instead of socialist countries;
>
> To eliminate the export of sowing and manure-spreading machines to socialist countries and to reduce correspondingly the import of these machines from socialist countries;
>
> To increase the domestic production of plant protection machines, and to step up their export to capitalist countries;
>
> To replace the imports from socialist countries of stock-breeding machinery by increased domestic production;

> To substitute for the domestic production and the export to socialist countries of fruit and vegetable cultivation machinery, socialist and, to a lesser extent, capitalist imports to meet home demand.

83. In the metal mass products branch the mathematical programme proposes:

> To increase the domestic production of aluminium kitchenware and to increase considerably their export to capitalist countries, even at the price of reducing exports to socialist countries;
>
> To increase the domestic production and export to capitalist countries of enamel-ware;
>
> To increase the production and export to capitalist countries of screw-nuts, to eliminate their import from socialist countries, and even to include in the plan their export to socialist countries;
>
> To increase the production of locks and padlocks and to step up their export to both socialist and capitalist markets;
>
> To reduce the domestic production of industrial armatures, to eliminate their export altogether and even to import them from capitalist countries in order to meet home demand.

84. The proposed structural changes would increase exports to capitalist countries and at the same time would improve the balance of capitalist foreign exchange. This could be achieved at an unchanged level of production and with a considerable increase in imports from capitalist countries, with a hardly diminished total volume of exports to and imports from socialist countries.

85. It should be pointed out - although it logically follows from what has been said - that the model also proposes to carry out the investment modifications corresponding to production, without overstepping the allocated investment limits. Attention should again be called to the fact that in the branch-level computations, structural changes could be made only within a single model. Any reallocation and re-grouping between branches will be possible only in the course of linking the branches.

86. In connexion with the domestic production of individual products, there were three main alternatives in the models for production and investments:

> Variant A: Production in an old plant at the January 1, 1966 technological level.
>
> Variant B: Production in an old plant which had been technically remodelled in the period 1966-1970.
>
> Variant C: Production in a new plant with up-to-date technology.

The relative proportions of the three variants are presented in table 6 below.

Table 6

Production in old, remodelled, and new plants, expressed as percentages of the total production

Branch	Product	Old plants official plan	Old plants math. prog.	Remodelled plants official plan	Remodelled plants math. prog.	New plants official plan	New plants math. prog.
Shipbuilding, total		72.9	79.9	0.1	19.4	27.2	0.7
	Portal cranes	78.1	78.1	21.9	17.1	0 b/	4.8
	Floating cranes (16 ton)	0	100.0	100.0	-	- a/	-
	Floating cranes (100 ton)	75.0	54.5	25.0	45.5	-	-
	Seagoing cargo ships	87.5	87.5	12.5	12.5	-	-
	Boilers for power stations	100.0	100.0	-	-	-	-
	Tugboats	76.0	76.0	24.0	24.0	-	-
	Cargo ships for inland waters	72.0	72.0	28.0	28.0	-	-
Public road vehicles, total		33.0	37.4	9.0	7.5	58.0	55.1
	"Csepel" engines and spare parts	61.3	61.3	38.7	38.7	-	-
	Other engines and spare parts	-	-	-	-	100.0	100.0
	Front axle housings	100.0	100.0	-	-	-	-
	Rear axle housings and driven front axles	28.6	28.4	4.8	4.7	66.6	66.9
	Auxiliary gearboxes for change-speed gear	56.0	57.3	19.0	19.4	25.0	23.3
	Power-steering units	-	-	-	-	100.0	100.0
	Lorries (5 t capacity)	100.0	100.0	-	-	-	-
	Lorries (8 t capacity)	38.8	31.8	11.2	0	50.0	68.2
	Lorries (12 t capacity)	-	-	-	-	100.0	100.0
	Buses (up to 11 m. in length)	100.0	100.0	-	-	-	-
	Buses (longer than 11 m.)	17.1	16.9	10.5	0	72.4	83.1
	Dumpers (3.5 cu.m.)	100.0	100.0	-	-	-	-
	Dumpers (6 cu.m.)	-	-	-	-	100.0	100.0
	Tractors (40 h.p.)	71.4	76.2	28.6	23.8	-	-
	Tractors (90 h.p.)	42.9	39.8	5.7	0	51.4	60.2
	Electrical material for automobile manufacturing	42.8	38.9	7.5	0	49.7	61.1
	Structural spare parts (without dumper)	48.0	42.0	12.0	17.5	40.0	40.5
	Spare parts for tractors and dumpers	30.9	31.7	18.2	18.6	50.9	49.7

a/ The sign "-" indicates that the activity is not represented in the model by a variable.

b/ The sign "0" indicates that the activity is represented by a variable, but its value is zero.

Table 6 (continued)

Branch	Product	Old plants official plan	Old plants math. prog.	Remodelled plants official plan	Remodelled plants math. prog.	New plants official plan	New plants math. prog.
Precision engineering, total		82.0	83.5	11.0	11.5	7.0	5.0
	Automation devices	94.0	92.0	0	8.0	5.4	0
	Electronic measuring instruments	87.7	76.7	7.7	8.4	4.6	14.9
	Office machines and management devices	50.6	40.8	35.1	59.2	14.3	0
	Material testing instruments	58.3	80.8	41.7	19.2	-	-
	Geodetic instruments	78.9	93.0	21.1	7.0	-	-
	Optical devices	100.0	100.0	-	-	-	-
	Optician's products	100.0	100.0	0	0	0	0
	Electric instruments	100.0	100.0	-	-	-	-
	Electro-mechanical parts	38.1	22.6	-	-	60.9	77.4
	Electric installation material	77.7	100.0	-	-	22.3	0
	Medical apparatuses	100.0	100.0	-	-	-	-
	X-ray apparatuses	100.0	100.0	-	-	-	-
	Steel medical instruments	100.0	100.0	-	-	-	-
	Laboratory equipment and implements	95.7	100.0	4.3	0	-	-
	Geophysical instruments	100.0	100.0	-	-	-	-
	Fuel pumps	51.1	60.6	48.9	39.4	-	-
	Other precision engineering products	97.1	100.0	2.9	0	-	-
Telecommunications, total		61.0	10.5	4.5	7.3	34.5	82.2
	Incandescent lamps	51.4	0	0	0	48.6	100.0
	Fluorescent tubes	52.6	0	0	0	47.4	100.0
	Receiver tubes	66.6	0	33.4	100.0	-	-
	Transmitter tubes	58.0	0	42.0	100.0	-	-
	TV picture tubes	75.0	0	25.0	100.0	-	-
	Other electronic tubes	16.4	0	83.6	100.0	-	-
	Semi-conductors	31.6	0	68.4	12.1	0	87.9
	Vacuum engineering machines	69.1	0	0	0	30.9	100.0
	Machines for telecommunication	100.0	100.0	-	-	-	-
	Telephone apparatuses	100.0	100.0	-	-	-	-
	Telephone exchanges	62.0	0	-	-	38.0	100.0
	Transmission equipment	100.0	100.0	-	-	-	-
	Radio transmitter-receivers	100.0	100.0	-	-	-	-

Table 6 (continued)

Branch	Product	Old plants official plan	Old plants math. prog.	Remodelled plants official plan	Remodelled plants math. prog.	New plants official plan	New plants math. prog.
Telecommunications (continued)							
	Microwave equipment	18.0	3.3	-	-	82.0	96.7
	Radio home receivers	31.0	0	-	-	69.0	100.0
	TV home receivers	67.4	0	-	-	32.6	100.0
	Amplifier studio equipment	41.0	63.0	-	-	59.0	37.0
	Tape recorders	54.6	0	-	-	45.4	100.0
	Electric railway safety appliances	100.0	100.0	-	-	-	-
	Electric spare parts for telecommunication	49.8	29.6	-	-	50.2	70.4
Machine tools, total		93.0	92.0	7.0	8.0	-	-
	Universal precision lathes	100.0	100.0	-	-	-	-
	Special precision lathes	87.5	87.5	12.5	12.5	-	-
	Medium size lathes	100.0	100.0	-	-	-	-
	Grinding machines	76.2	76.2	23.8	23.8	-	-
	Knee-type milling machines I	100.0	100.0	-	-	-	-
	Shaping machines	53.3	37.5	46.7	62.5	-	-
	Special purpose machines	100.0	100.0	0	0	-	-
	Drilling machines	100.0	100.0	-	-	-	-
	Knee-type milling machines II	100.0	100.0	-	-	-	-
	Special milling machines	100.0	100.0	-	-	-	-
	High precision machine-tools	100.0	100.0	-	-	-	-
	Semi-automatic disc lathes	100.0	100.0	-	-	-	-
	Production lines	100.0	100.0	-	-	-	-
	Machine-tools operating on special principle	100.0	100.0	-	-	-	-
	Metal-working machine tools	100.0	100.0	-	-	-	-
Railway vehicles, total		72.2	72.2	22.2	23.4	5.6	4.4
	Diesel engines	92.5	95.1	7.5	4.9	-	-
	Electric locomotives	57.7	57.7	42.3	42.3	-	-
	Diesel locomotives	89.7	82.4	10.3	17.6	-	-
	Electric power cars for tramways and suburban railways	66.7	66.7	33.3	33.3	-	-
	Multiple unit diesel trains	75.0	81.8	25.0	18.2	-	-

Table 6 (continued)

Branch	Product	Old plants official plan	Old plants math. prog.	Remodelled plants official plan	Remodelled plants math. prog.	New plants official plan	New plants math. prog.
Railway vehicles (continued)							
	Railway passenger coaches	72.7	67.6	27.3	32.4	-	-
	Railway freight wagons	-	-	0	0	100.0	100.0
	Railway tank wagons	100.0	100.0	-	-	-	-
	Spare parts for railway vehicles	87.4	87.4	12.6	12.6	-	-
	Wheel sets	53.5	55.6	46.5	44.2	-	-
Agricultural machinery, total		57 -	52.6	43.-	47.4	-	-
	Tilling machines	69.0	69.0	31.0	31.0	-	-
	Seeding and manure-spreading machines	100.0	100.0	-	-	-	-
	Plant protection machines	54.0	52.0	46.0	48.0	-	-
	Harvesting machines	55.0	55.0	45.0	45.0	-	-
	Machines for stock-breeding	42.0	28.0	58.0	72.0	-	-
	Loaders	38.0	38.0	62.0	62.0	-	-
	Fruit and vegetable cultivating machines	62.0	0	38.0	0	-	-
Metal mass products, total		86.0	82.0	14.0	18.0	-	-
	Aluminium kitchen pans	83.0	69.0	17.0	31.0	-	-
	Enamelled ware	94.0	89.0	6.0	11.0	-	-
	Bolts and nuts	100.0	95.0	0	5.0	-	-
	Padlocks	76.0	65.0	24.0	35.0	-	-
	Hand-tools	74.0	99.0	26.0	1.0	-	-
	Industrial armatures	63.0	66.0	37.0	34.0	-	-
GRAND TOTAL FOR ENGINEERING		55.0	46.7	12.0	11.3	33.0	42.0

87. The proportions of the three variants have been worked out on the basis of production volumes at import prices in United States dollars. The main results are shown in table 7 below.

Table 7

Production shares, for all engineering branches, of old, remodelled and new plants (percentage)

	Official plan	Mathematical programme
Old plants	55.0	46.7
Remodelled plants	12.0	11.3
New plants	33.0	42.0

88. In engineering, as a whole, a radical change may be observed between the production shares of old and new plants, while the production share of remodelled plants remains essentially the same. Table 6 shows, however, that this tendency is not uniform. The share of old plants with unchanged technology diminishes in three of the branches while that of remodelled plants diminishes only in one. Moreover, the branches with a high share in production are the ones that deviate from the general tendency and thus determine the aggregate data. In table 8, therefore, the production shares of six engineering branches are summed up (excluding the public road vehicles and telecommunications branches).

Table 8

Production shares in six engineering branches of old, remodelled and new plants (percentage)

	Official plan	Mathematical programme
Old plants	78.6	78.0
Remodelled plants	18.2	19.3
New plants	3.2	2.7

In these six branches, the proportions of production shares hardly change. The small increase of the shares of remodelled plants occurs in two branches to the detriment of unchanged old plants, and in one to that of new plants.

89. The public road vehicles and the telecommunications branches contribute more than two thirds of the total output of the engineering sector covered in the programme and utilize more than two thirds of the investment allocations. The changes in the production shares of old, remodelled and new plants are not uniform in

these two branches either. In the public road vehicles branch, the production shares of old unchanged plants increase, but in the telecommunications branch they decrease.

90. An analysis of inputs has been performed on the basis of table 9. This table presents by branches the changes proposed by the mathematical programme - as against the official plan - in priority inputs (1970) and in gross investment (1966 - 1970).

Table 9

Mathematical programming data by branch on major inputs for the period 1966 - 1970[a]

(expressed as percentages of the official plan)

	Employment	Wages	Gross investment	Machinery imports from Capitalist countries	Machinery imports from Socialist countries	Domestic machinery production	Construction
Shipbuilding	107.0	106.0	100.0	100.0	100.0	92.0	100.0
Public road vehicles	100.1	100.1	100.0	100.0	100.0	100.0	99.0
Precision engineering	98.2	97.5	92.0	64.6	100.0	90.6	96.6
Telecommunications	100.0	99.8	92.8	85.0	35.0	35.0	95.0
Machine tools	100.0	100.0	93.0	59.6	100.0	86.0	77.0
Railway vehicles	100.0	100.0	100.0	99.5	100.0	100.0	100.0
Agricultural machinery	99.0	99.0	100.0	-	101.0	106.0	100.0
Metal mass products	102.0	102.0	100.0	100.0	100.0	100.0	100.0
Engineering, total	100.1	100.0	97.6	98.6	97.4	96.2	98.2

a/ **Data for employment and wages refer to 1970 only.**

91. The data of priority inputs are summarized in table 10, below.

Table 10

Estimates of the mathematical programme as percentages of the official plan

	All engineering branches
Manpower, 1970	100.1
Wages, 1970	100.0
Electric energy, 1970	92.2
Coal, 1970	93.2
Gross investment, 1966-1970	97.6
Machinery imported from capitalist countries, 1966-1970	98.6
Machinery imported from socialist countries, 1966-1970	97.4
Domestically produced machinery, 1966-1970	96.2
Construction, 1966-1970	98.2

The mathematical programme uses the same labour and wage inputs as the official plan, but achieves savings in other operational and investment inputs. This shows that in developing the engineering industries, manpower constitutes a bottleneck - a fact that calls attention to the necessities of raising the level of technology and of making highly productive investments.

92. The savings proposed in the mathematical programme are not evenly distributed among the branches. The precision engineering and the machine tools branches achieve savings in construction and in the import of machinery from capitalist countries. The telecommunications branch saves in gross investment and in machinery imported from socialist countries; the public road vehicles branch saves coal and so on. The limits for construction and domestically produced machinery are reached by half of the branches only, according to the mathematical programme. Once the branch models are linked up, it should be possible to utilize these savings in other branches and to bring about a further improvement of the foreign exchange returns.

93. The utilization of the import machinery quotas has been analysed separately. The purchase of imported machinery was limited in our models by special constraints. It was found that in the mathematical programme, the following branches fully utilized their import quotas of machinery from capitalist and socialist countries:

shipbuilding, public road vehicles I and II, precision engineering I and II, and metal mass products. Quotas of imports from socialist countries only were utilized by the machine tools, railway vehicles and agricultural machinery branches (the latter branch had no quota of imports from capitalist countries). The telecommunications branches I and II did not utilize either of their machinery-import quotas.

94. Thus, though the volume of production remained unchanged, some branches did not fully utilize their quotas for machinery imports. In other branches where the quotas were fully utilized, it may be assumed that the machinery imports constituted one of the most important scarce resources. In linking up the branch models, the reallocation of unused quotas for import machinery may bring about a further improvement in the objective function.

95. With few exceptions, all export activities in the model were bounded by marketing constraints specifying the upper limits of the quantities exportable at the prices taken into account in the model. These constraints were carefully reviewed by the foreign-trade and industrial experts participating in the research project. (In some of the branches the revision of these constraints made new computations necessary.) Perfect accuracy cannot be claimed for these constraints, as the magnitudes in question are difficult to assess. The decisive factor is not the absolute magnitude of the constraints but the observation whether the exports foreseen in the mathematical programme have reached the upper limits. If these upper limits are reached, exports are advantageous and their volume should be expanded. If exports do not reach the upper limits, the export of other products should be fostered.

96. Beside the constraints on imported machinery, the export constraints constitute the main scarcity in the model, i.e. the factor which limits the possibility of choice to the greatest extent. It is important, however, to stress that this holds only for the advantageous exports. Despite the fact that the objective function of the model is the maximization of the favourable balance of payments, it will not pay to press all exports. From among the 64 constraints on exports to capitalist countries in the model, only 52 are fully utilized.

97. The summarized data on the utilization of the export constraints were examined by converting the constraints originally given in physical units (forints, roubles, etc.) into United States dollars and by adding them up. The results are given in the table 11 below.

Table 11

Utilization of export constraints (in percentages)

Exports to	Official plan	Mathematical programme
Socialist countries	76.8	71.7
Capitalist countries	54.1	73.2

98. From table 11 it may be seen that, in the final analysis, the mathematical programme utilizes the assumed possibilities of exports to capitalist countries to a much greater extent than the official plan (73 as against 54 per cent). Obviously, the mathematical programme does not fully utilize all market possibilities, either because of limited domestic resources or because of the lack of economically efficient possibilities.

3. EVALUATION OF THE CURRENT RESULTS OF MATHEMATICAL PROGRAMMING

99. The main task of the project was the application of a general method known to the engineering industry. The specific problems of the individual branches of the engineering industry were given but little space in the models up to now. Thus, the wide scope of co-operation within the industry was not specially dealt with, nor was any other than the traditional method of assessing the demand for engineering products considered. The models cover only part of the engineering industry. The experiments started in the least intricate spheres, and it is assumed that in the non-programmed sphere further problems will present themselves.

100. The economists and mathematicians participating in the research project believe that their work has proved the construction of such mathematical programming models to be both possible and useful in the engineering industry. They are aware, however, that it is possible and necessary to develop and to refine the applied methods in several respects.

101. The models were constructed in 1966, the first year of the Third Five-Year Plan. Accordingly, they constituted, first of all, a methodological experiment. Practical planners were advised, however, to study extensively the numerical results. This should not be taken as meaning that where the mathematical programme foresees a production of 689 tons of product "A", precisely this quantity should be adopted by the plan. But it is worthwhile to consider the characteristic tendencies indicated by the mathematical programme. Nor does it seem justified to draw too far-reaching conclusions. It has not been advocated that

wherever results of the mathematical programme deviate from the figures obtained in the traditional way, the latter should be discarded and the former accepted. Caution is called for by the following considerations:

Despite all the care taken, the mathematical data contain many uncertainties.

The computations are still in their first or second stage of development. The results now obtained may be modified by later computations which will link the branch models together.

Several methodological problems and difficulties have not yet been solved (e.g. those in connexion with the linearity of the input function, the short-time horizon).

102. In view of these considerations, it is deemed indispensible that all practical lessons drawn from the branch level computations should be critically revised and confronted with the results obtained by other methods, and that they should be accepted or refuted only after due deliberation.

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