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Methods of Calculating Planned Coefficients of Direct Inputs

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"Opinions Expressed and Positions Taken by Authors are Entirely their Own and do not Necessarily Reflect the Views of the Institute of National planning".

Contents

The elaboration of the coefficients of direct inputs is one of the most significant stages in compiling the planned inter-branch balance.

The coefficients of direct inputs represent the aggregated norms for the utilization of raw materials, materials, semifinished products; fuel, energy per unit of output.

These indicators characterize the inter-industry production relations in the national economy, which arise in the process of reproduction of the social product.

Continuous changes in the inter-branch relations occur under the influence of technological progress.

Those changes is one of the most important factors stipulating the shifts in the branch structure of social production and determining, to a considerable extent, the relationships of growth rates for individual branches and products.

The influence of technological progress over the growth rates and proportions of development in social production are taken into account in the inter-branch balance, first of all, through the system of planned coefficients of direct inputs, which are elaborated in physical and value terms.

The introduction of input coefficients (a_{ij}) into the mathematical model of the planned inter-branch balance $(X_i = \sum_{j=1}^{n} a_{ij} + y_i)$ means the acceptance of a number of essential assumptions, viz.

a) relative invariability of input coefficients in the course of the planned period (t), for which the mathematical model is elaborated

$(a_{ij}^{(t)} \approx \text{const.})$

b) independence of these norms on the production levels Xj in the receiving branches

c) strict proportional inter-dependence of production inputs Xij and outputs Xj

(Xij = a_{ij} Xj, where a_{ij} is the coefficient of proportionality).

These assumptions are the mathematical abstraction. And if they are incorrect, or not quite accurate, the model cannot be applied for the planned economic estimates which require high precision.

The present work treats of practical questions of the methodology for elaborating the coefficients of direct inputs for the purpose of drawing up planned inter-branch balances.

1. METHODS OF CALCULATING THE COEFFICIENTS OF DIRECT INPUTS

IN PHYSICAL TERMS.

The coefficients of direct inputs in physical terms represent the consumption of a certain type of output to produce a unit of another type of output. They are built up in accordance with the nomenclature of the inter-branch balance in physical terms.

So far as the inter-branch balance nomenclature consists of the aggregated items, which combine the types of homogeneous output, e.g. - "ferrous rolled metals, pipes and forgings", "metal cutting lathes", etc. - then the coefficients of direct inputs bear the nature of aggregated norms for the consumption of material resources. Thus, the coefficient of direct inputs of ferrous rolled metals to produce metal cutting lathes combines all the individual norms, which characterize the consumption of concrete types of ferrous rolled metals to produce particular lathes.

Due to the fact that the technical coefficients are, in fact, the aggregated norms, their level depends on a number of factors:

- on the relationships of individual types of output within the given item;
- on the relationship of different types of technique and technology which are applied to manufacture the given output;
- on the relationships of different types of interchangeable material resources.

The level of technical coefficients in mining industry and agriculture differs also according to individual economic territories, in consequence of which fact the level of general coefficients of direct inputs in these branches depends on the territorial distribution of production.

In this way, the direct input coefficients' level is determined, depends and is stipulated by a great many factors.

Inputs of material resources consist of technological inputs, directly connected with the process of manufacturing output and varying direcly as the output and additional inputs, connected with maintenance of basic production and management. The additional inputs depend on the volume of production but do not vary directly as the latter.

The technological inputs of material resources comprise raw, basic and auxilliary materials; technological fuel; electric power for technological requirements; intra-mural semi-finished products (of own make), and the supplementary parts and semifinished products which are bought from the outside.

The additional inputs of material resources comprise the materials, electric power and fuel for current repairs and maintenance of buildings, structures, equipment; and also the materials consumed to manufacture models, appliances, machinery gear, special instruments.

There exist certain relationships between the norms for the utilization of material inputs and the coefficients of direct inputs.

The interrelationship between the individual norms for the consumption of material resources and the coefficients of direct inputs is characterized by the formula:

$$a_{k\ell} = \sum_{p=1}^{m} \sum_{q=1}^{n} a^{1}_{pq} d_q + \sum_{p=1}^{m} S_{p\ell}$$, wherein $a_{k\ell}$ is the coefficient of direct inputs,

a^{1}_{pq} - individual norms for the consumption of product P.

d_q - the specific weight of product q in product ℓ.

$S_{p\ell}$ - relative consumption of product P per product ℓ in the share of general production inputs.

The quantity of the material which is utilized to produce the given product not directly, but through another product available in the nomenclature of the inter-branch balance, is not included into the input coefficient in physical terms. (technical coefficient).

In accordance with the same principle of forming the technical coefficients , the material inputs of the power and the instrument making workshop are not to be related to the inputs of basic production of the enterprise provided that "energy" and "instruments" come under their individual items in the nomenclature of the inter-branch balance.

The inputs of material resources, which are connected with capital construction or capital repairs but not with operation inputs are not also included into the technical coefficients.

The coefficients of direct inputs in physical terms are utilized, firstly, for the purpose of elaborating the inter-branch balance in physical terms, and, secondly, for the purpose of calculating the input coefficients in money terms.

The elaboration of these coefficients can be realized, mainly, by two methods:

a) by the method of direct calculation,
b) by the method of correcting the base coefficient.

The method of direct calculation is the calculation of coefficients on the basis of elaborating the planned individual norms for the consumption of raw materials, material, fuel, electric power, which are worked out in conformity with the functioning methods in each branch, considering the specific share of each product coming under the general item.

When making calculations for the direct inputs of material resources to produce new output, it is necessary to base oneself on the data of designing and technological documents, the characteristics and technical computations checked up experimentally, and on the relative consumption of material resources which level is reached at the advanced enterprises.

The formation of the average branch technical coefficients is effected by way of consistent averaging the individual technical coefficients of those enterprises which produce some type of the output being part of the balance nomenclature, and further averaging those obtained coefficients, proceeding from the specific share of the output, which is to be combined under the aggregated item of the balance nomenclature (classification).

Thus, for example, it is necessary to determine the consumption of oil seeds to produce vegetable oil.

Sunflower oil, cotton-seed oil, soy-bean oil, linseed oil and other types are produced. According to each of the types of oil by way of averaging the individual norms for the consumption of oilseeds to produce vegetable oil the corresponding norm (coefficient) for the consumption of oil seeds is determined in terms of enterprises.

Let us suppose, that the norms characterizing the average consumption of oilseeds in tons (per 1 ton of vegetable oil) are obtained:

sunflower oil	-	2;643 tons
cotton-seed oil	-	5,600 tons
soy-bean oil	-	6,000 tons
linseed oil	-	2,800 tons
others	-	3,550 tons

Let us further suppose, that the quota of oil for each type in the general volume of vegetable oil production is estimated at:

sunflower oil	0,333 or 33,3 per cent
cotton seed oil	0,167 or 16,7 per cent
soy-bean oil	0,083 or 8,3 per cent
linseed oil	0,084 or 8,4 per cent
others	0,333 or 33,3 per cent

Then the average consumption of seeds within the branch per 1 ton of vegetable oil will be:

2,643. 0,333 + 5,600. 0,167 + 6,000 . 0,083 + 2,800 . 0,084 + 3,550. 0,333 = 3,730689 ton

So far as the consumption of seeds for the general-production requirements is missing, the technological consumption of oil seeds can be taken as the technical coefficient for oilseeds per 1 ton of vegetable oil.

In case when both the input item and the item of the output, for which the coefficient is calculated, are aggregated, the formation of the coefficient becomes more complicated.

Thus, for example, it is necessary to calculate the input norm of varnishing and dyeing products for the production of electro-insulating materials. Electro-insulating materials combine several groups: getinax, textolite, winding, varnished textiles, and micanite.

The input norms of dissolvent per unit of the mentioned types of electric-insulating materials are:

getinax	-	0,005 ton/ton
textolite	-	0,012 ton/ton
winding	-	0,122 ton/ton
varnished textiles	-	0,276 ton/ton
micanite	-	0,356 ton/ton

It is necessary beforehand to change the available norm per 1 thousand of varnished textiles into by-weight units of measure (tons).

As long as 1 thousand meters of varnished textiles weigh on the average 0,2 ton, then the input norm of dissolvent per 1 ton of varnished textiles will equal to:

0,276 : 0,2 = 1,380 ton.

If we know the specific share of each type of electric insulating materials in their total production, then we can calculate the input norm (norm for consumption) of dissolvent per 1 ton of electric insulating materials.

Let us suppose that in the total production of electric insulating materials getinax makes up 20 per cent,

textolite - 20 per cent,
winding - 40 per cent,
micanite - 10 per cemt,
varnished textiles -10 per cent.

Then the calculated norm will respectively come to:

$$0,005 \cdot 0,2 + 0,012 \cdot 0,20 + 0,122 \cdot 0,4 + 0,36 \cdot 0,1 + 1,38 \cdot 0,1 = 0,226400 \text{ ton/ton.}$$

In the same way they calculate the input norms of other types of varnishing and dyeing products per electro-insulating materials, and, afterwards, by summing up, they calculate the general input norm of these products, per electro-insulating materials.

In a general form, the calculating of the aggregated branch norms for material inputs per unit of output is expressed by the formula:

$$a_{ij} = \sum_{k=1}^{m} \sum_{\ell=1}^{n} a_{k\ell} \cdot d_k + \sum_{k=1}^{m} \sum_{\ell=1}^{n} c_{k\ell} \cdot d_\ell \quad \text{wherein:}$$

a_{ij}- is the aggregated norm for material inputs of the product type i to manufacture the output type j.

m- number of components for the product-type i (i = 1,2 .....);

n-number of components for the product type j (j = 1, 2 ....);

k-any of the m components,

ℓ-any of the n components,

$a_{k\ell}$-the coefficient of the technological inputs of the product type k per unit of the output type ℓ;

$c_{k\ell}$ - the coefficient of the general production inputs of the product type k per unit of the output type ℓ

d_{ℓ} - specific share of the output type ℓ in the general volume of the product type j;

$\sum_{\ell=1}^{n} a_{k\ell} d_{\ell}$ - the average weighted value of technological inputs of the k product per unit of the j output (j = 1,2...,n);

$\sum_{k=1}^{m} \sum_{\ell=1}^{n} a_{k\ell} d_{\ell}$ - the average weighted value of technological inputs of the i product (i = 1,2,...,k, ...,m) per unit of the j output.

$\sum_{\ell=1}^{n} k_{\ell} d_{\ell}$ - the average weighted value of the general production inputs of the k product per unit of the j output.

$\sum_{k=1}^{m} \sum_{\ell=1}^{n} c_{k1} d_{\ell}$ - the average weighted value of the general production inputs of the i product per unit of the j - output.

It should be noted however, that the calculation formula for the branch norms and the calculation itself undergo a modification, subject to the initial data.

It should be also borne in mind, that the inputs of resources are not consumed to manufacture all the output which is aggregated under the item of the inter-branch balance nomenclature. In a case like this, the average input of material resources per the whole volume of output is calculated, but not only per that part of output, which actually consumes the given resources.

Thus, for example, the average input of xylene per the whole output of paper can be shown in the inter-branch balance, although it is actually consumed not for the whole volume of paper, but only for some certain sorts of it.

The problem of setting aside constant and variable inputs of production is related to the category of important problems dealt with when elaborating technical coefficients. Part of inputs is directly connected with the manufacturing of one or another product and is in direct functional dependence on the volume of production. Another part participates indirectly in production, contributing to labour operations and does not vary (within known limits) with a change in the volume of production.

Therefore the subdivision of inputs into variable and constant is of essential significance while studying the relationships of production inputs and the volume of production. At this, variable are the production inputs of raw materials, materials, fuel, etc. - those which are in direct dependence on the volume of production. Under any other equal conditions (under invariable norms of inputs, labour productivity, etc.) the change of these inputs occurs proportionally to the change of the volume of production, e.g. the input of metal to directly manufacture parts and components of machines, and so on.

Constant are the inputs of current repairs and maintenance of equipment, inputs of heating and lighting workshops and intra-mural buildings, maintenance inputs of administrative and management personnel and other intra-mural and workshop inputs of an enterprise.

The change of such inputs does not depend (within known limits) on the increase of the volume of production and they are arbitrarily called CONSTANT.

The stress on these two types of inputs and the calculation on their basis of technical coefficients is of great significance.

In the practice of elaborating technical coefficients of material resources cases happen, when the input of a certain part of these resources appears not to be directly connected with the level of production and is relatively independent on it.

For instance, when calculating the requirement for electric power and fuel at machine-building enterprises, it is considered that their consumption per the general production needs is relatively constant.

Likewise, the inputs to maintain a railway track in railway transport (under its certain length) are rather stable in their amount and cannot be directly proportional to the increase in the freight turnover.

The distribution of the general production inputs of material resources by individual types of products is made on the basis of the methods which exists in the branch under study with account taken of the preformed relationships between direct and indirect inputs of production.

If the input of material per the general production needs is less than 5 per cent of the principal input of the material in question, then, in the calculation of the planned coefficient the general production inputs may not be taken into account.

In other cases, for the purpose of calculating the requirement of production for material resources it is expedient to resort to the construction of the (dynamic) time series for the volumes of production and for the quantity of the respective material inputs in order to reveal correlations between them.

The method of direct calculation to elaborate technical coefficients can be the most successfully applied in such cases when each item of the balance combines a comparatively small number of individual products for which physical norms are available. In other cases the application of other calculation methods seems to be more expedient.

The method of correcting the base coefficients can be realized in accordance with the following stages:

a) determination of the level of the technical coefficient in the base period;

b) study of the factors which have essential effect upon the magnitude of the coefficient under study;

c) evaluation of the most significant factors which influence over the magnitude of the technical coefficient in the planned year.

For the purpose of determining the base level of the technical coefficient it is necessary to make use of the accountancy about the consumption of raw materials, materials, fuel, energy, the available normative data, the data of the estimations for the statistical and estimated calculations and also the data of the statistical inter-branch balance. In some cases it is advisable to arrange a sample survey.*/

In order to determine the level of technical coefficients in the planned period it is necessary to take account of such factors as: the change in the structure of output /e.g., the change in the assortment (range) of rolled metal/;
the shifts in the relationships of different technological methods of production (e.g. the relationships of the output of electric power at the thermo electric power station and the hydro electric power stations);
the shifts in the structure of consumed interchangeable materials;
the implementation of new types of materials (for instance the implementation of plastics in engineering);
the shifts in the distribution of production;
the implementation at the enterprise of the policy of economy and other factors.

With regard to the calculation technique for the planned technical coefficient all the factors can be broken down into 2 groups:

the structural shifts in production and
the change in the technico-economic parameters.

In order to determine the influence of the structural shifts over the magnitude of coefficients it is necessary to single out the basic

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*/ see the work "The Sample Survey of the Inputs of Production".

groups within each item, the relationship of which determines the magnitude of the coefficient.

At this, the groups within each item ought to be combined in such a way as to make it possible to neglect the structural shifts within each group; in other words, so that the input norms for each group can be stable enough.

The general technical coefficient is estimated with account of the change in the specific share of these more detailed groups in the total volume of output.

For the sake of taking into account the influence of the change in technico-economic parameters over the technical coefficient it is necessary to present the coefficient as the function from the technico-economic indicators most essentially influencing over the magnitude of the coefficient. With that end in view, it is necessary, first of all, to reveal the principal technico-economic indicators, determining the coefficient's level and to fix the functional relationship between the factors and the magnitude of the coefficient.

When establishing the functional relationships it is expedient to widely utilize the correlation methods, methods of constructing empirical functions, the method of constructing nomograms which makes it possible to swiftly determine the influence of the change in some factor over the magnitude of the coefficient.

In some cases it is necessary under the elaboration of technical coefficients to study the dependence among principal output parameters on the levels of technical coefficients. This, for instance, when working out the technical coefficient of rolled ferrous metals for electric generators it is possible to reveal the dependence of the average power of the generator on the level of relative consumption of rolled metal per 1000 KW of the generator's power.

The elaboration of technical coefficients enables us to create the necessary foundation for the subsequent elaboration of input coefficients in

value terms and can be also utilized for the purpose of raising the efficiency of the calculations while correcting the coefficients with the aid of other methods.

2. METHODS OF CALCULATING THE COEFFICIENTS OF DIRECT INPUTS IN VALUE TERMS.

The input coefficients in value terms represent the expenditure of gross output (in monetary units) of one branch per value unit of gross output in another branch.

These coefficients are constructed in accordance with the branch nomenclature of the inter-branch balance in money terms.

Input coefficients, if compared to technical coefficients, characterize the production not among individual products in branches, but among the branches as a whole.

There is another essential feature about the input coefficients in money terms. So long as the gross output of branches according to the methods which exists in the USSR is calculated, as a rule, by the enterprise method, i.e., with the deduction of the intra-mural turnover, then the input coefficients reflect only the commodity relations among branches. Thus, for example, the input coefficient for electric power in the production of sugar comprises the bought-in electric-power and does not contain the value of electric power which is received from own (intra-mural) electric power stations.

Those branches, which, in conformity with the practice of planning, deviate from the enterprise method in the calculation of their gross output become an exception. For instance, one input coefficient of textile products per textile output comprises the intra-mural turnover value of yarn and unbleached thread since this intra-mural turnover, according to the existing practice, is incorporated into the gross output of the textile industry.

Hence the input coefficient here will show the input of yarn and unbleached thread per 1 rouble of output of this industry.

Due to the fact that a branch in the inter-branch balance is an aggregate of output corresponding to the primary output of the branch, the coefficients of direct inputs in money terms for this or other branch combine only the inputs of primary output.*/

For instance, the input coefficients of the cotton industry do not combine the inputs of staple fabric production, which refer to the silk fabric production, although a considerable part of staple fabrics is manufactured at the enterprises of the cotton industry.

Contrary to the technical coefficients the input coefficients (in money terms) in their composition combine the consumption of bought-in materials connected with the output of the given branch not directly, but through the output of other branches which is produced (manufactured) at the enterprises of the branch under study. For instance, if a metallurgical plant has a coke-chemical workshop, then the INPUT of coal for the production of coke is directly transferred to the ferrous metal production.

At this, into the coefficient is included only that part of coal inputs of the coke-chemical workshop which corresponds to the share of the workshop's output consumed within the metallurgical plant.

Thus, the input coefficients reflect only the commodity inter-branch relations, whereas the technical coefficients show the whole input of material resources, irrespective of whether they are bought-in or produced at the place of consumption.

If product K is not only directly consumed per product ℓ, but also through product r, the latter being manufactured at the same enterprise as product ℓ then for the calculation of the input coefficient (in money terms) it is necessary beforehand to transform the technical coefficient (in physical terms) according to the following formula:

$$\bar{a}_{k\ell} = a_{k\ell} + a_{kr}\, a_{r\ell}\,(1 - w_r)$$

*/ In greater detail the problem is dealt with in the UN periodic publication - Studies in Methods, Ser. F, No. 14, 1966. "Problems of Input-Output Tables and Analysis".

where:

$\bar{a}_{k\ell}$ - the input coefficient of product k per product ℓ in physical terms, which is accepted to calculate the corresponding coefficient in money terms;

$a_{k\ell}$ - the technical coefficient of product k per product ℓ in physical terms;

$a_{r\ell}$ - the technical coefficient of product r per product ℓ (in physical terms);

a_{kr} - the technical coefficient of product k per product r (in physical terms);

w_r - the specific share of product r which is bought in to manufacture product l.

The interrelationship between the coefficients of direct inputs in physical terms and in value terms is characterized by the formula

$$a_{ij} = \sum_{k=1}^{m} \sum_{\ell=1}^{n} a_{k\ell} \frac{p_k}{p_\ell} w_k d\ell$$

where:

a_{ij} - the coefficient of direct inputs of branch i per 1000 roubles gross output of branch j in money terms;

$\bar{a}_{k\ell}$ - the coefficient of direct inputs of product k per product ℓ in physical terms with account taken of the input of product k per product ℓ through other products of own make;

p_k - the price of a unit of product k;

p_ℓ - the price of a unit of product ℓ

w_k - the specific share of product k, which is bought in, in the general input of product k per product ℓ

d_{ej} - the specific share of product e in the gross output of branch j;

m - the number of products k, comprised in branch i;

n - the number of products e comprised in branch j.

For example, the coefficient of direct inputs of iron ore per ferrous metals (in money terms) can be calculated as follows:
(it is supposed that the whole iron ore is bought in)

$$a_{\text{ore metal}} = a_{\text{ore cast iron}} \frac{p_{\text{ore}}}{p_{\text{cast iron}}} d_{\text{cast iron}} + a_{\text{ore cast iron}} a_{\text{cast iron steel}} (1 - w_{\text{cast iron}}) \frac{p_{\text{ore}}}{p_{\text{steel}}} d_{\text{steel}} + a_{\text{ore cast iron}} a_{\text{cast iron steel}} a_{\text{steel rolled stock}} (1 - w_{\text{cast iron}}) (1 - w_{\text{steel}}) \frac{p_{\text{ore}}}{p_{\text{rolled stock}}} d_{\text{rolled stock}}.$$

where:

$a_{\text{ore cast iron}}$ - the coefficient of direct inputs of iron ore per c cast iron (in physical terms);

$a_{\text{cast iron steel}}$ - the coefficient of direct inputs of cast iron per steel (in physical terms);

$a_{\text{steel rolled stock}}$ - the coefficient of direct inputs of steel per rolled stock;

$d_{\text{cast iron}}, d_{\text{steel}}, d_{\text{rolled stock}}$ - the specific shares of commodity output of cast iron, steel and rolled stock in the gross output of ferrous metals;

$w_{\text{cast iron}}$ - the share of commodity cast iron in the general volune of cast iron consumed per steel;

w_{steel} - the share of commodity steel in the general volume of steel consumed per rolled stock;

$P_{ore}, P_{cast\ iron}: P_{steel}, P_{rolled\ stock}$ - the prices for ore, cast iron, steel, rolled stock (metal).

As it can be seen from the formula

$$a_{ij} = \sum_{k=1}^{m} \sum_{\ell=1}^{n} \bar{a}_{k\ell} \frac{P_k}{P_\ell} w_k d_\ell$$

The level of input coefficients (in money terms) depends on the maginitute of the corresponding technical coefficients (in physical terms), on the relationships of prices for materials and products, on the products' structure of gross output of a branch and on the level of combining the branches under study.

If product k is consumed per product ℓ not directly, but through another product of this branch (C), which is manufactured only at the enterprises of the branch in hand, then in the calculation of the coefficient in money terms there can be utilized the technical coefficient of direct inputs of product k per the intermediate product C. At this, the above formula will take the following form:

$$a_{ij} = \sum_{k=1}^{m} \sum_{\ell=1}^{n} a_{kc} \frac{p_k}{P_c} w_k g_c$$

where:

a_{kc} is the coefficient of direct inputs of product k per product C;

g_c - the ratio of the gross output of product C to the gross output of the j-th branch.

The input coefficient of iron ore per ferrous metals can be essentially simplified on the basis of this formula.

$$a_{ore\ metal} = a_{ore\ cast\ iron} \frac{P_{ore}}{P_{cast\ iron}} g_{cast\ iron}$$

where:

$g_{cast\ iron}$ - the ratio of the gross output of cast iron to the gross output of ferrous metals.

An important problem of methods for the calculation of input coefficients (in money terms) is the determination of planned prices for materials and products.*/

The planned input coefficients are estimated in the prices comparable to the prices of the base period, for only under this valuation the analysis of the change in the physical volume of production, growth rates and development proportions becomes possible.

While calculating input coefficients, the average-weighted prices are, as a rule, utilized, those which take into account the structural shifts in the output produced and consumed.

If the balance is constructed in producers' prices the wholesale prices of the enterprise are utilized without the turnover tax.

The inter-branch balances of production and distribution of output in the USSR have practically been elaborated hitherto in users' prices. In this case the price of consumed materials included the sale and transportation margins and the turnover tax with account taken of the specific share of the output which is realized through trade and on which the turnover tax is imposed.

In order to valuate output in user's prices the tranformation coefficients were widely utilized to transform the enterprise wholesale prices into the prices of final consumption.

The elaboration of input coefficients is carried out in accordance with the above formulas in those cases, when a branch turns out a small number of products. Besides, the given method is applicable when the input structure of individual products of the branch is homogeneous enough.

If the direct calculation for input coefficients (in money terms) is impossible the coefficients must be elaborated in the same sequence as the technical coefficients, viz.:

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*/ Questions on determining planned prices is dealt with in a special memorandum according to the approved work-programme.

a) establishment of the input coefficients' level in the base period;

b) determination of the most significant factors;
influencing over the input coefficients and their change in the planned year versus the base year;

c) estimation of the influence of the change in the factors over the magnitude of input coefficients and the determination of the input coefficient's level in the planned year.

The influence of the factors' change over the magnitude of the input coefficient can be taken into consideration with the aid of the following formula:

$$a^1_{ij} = \frac{a^\circ_{ij} - a^\circ_{k\ell} \frac{P^\circ k}{P^\circ \ell} \frac{Ki}{kj} w^\circ_k d^\circ \ell \,(1 - d^1 \ell)}{1 - d^\circ \ell} + a^1_{k\ell} \frac{P^1 k}{P^1 \ell} \frac{Ki}{Kj} w^1_k d^1 \ell$$

where:

a^1_{ij}, a°_{ij} - the coefficients of direct inputs of the i-th branch per the output of the j-th branch in money terms in the planned and base periods.

$a^1_{k\ell} a^\circ_{k\ell}$ - the coefficients of direct inputs of product k per product ℓ in physical terms in the planned and base periods;

$P^1 k$, $P^1 \ell$ $P^\circ k$, $P^\circ \ell$ - average wholesale prices for product k and ℓ in the planned and base periods;

$W^1 k$, $W^\circ k$ - specific share of product k which is bought in, in the general input of product k per product 1 in the planned and base period;

$d^\circ \ell d^1 \ell$ - specific share of the gross output of product ℓ in the gross output of the j-th branch in the planned and base periods.

Ki, kj - the transformation coefficients of wholesale prices into the prices of final consumption.

3. PROBLEMS OF CORRECTING THE COEFFICIENTS OF DIRECT INPUTS.

An important methodical principle in the elaboration of planned coefficients is the principle of differentiation for the method of determining one or another coefficient in the planned period subject to the economic significance of the corresponding inter-branch flow of products in the system of inter-production relations.

The coefficients of direct inputs which characterize the most significant inter-branch relationships must be elaborated for the planned period through the medium of concrete calculations, considering the basic technico-economic factors which have effect upon one or another coefficient. As for the remaining coefficients, they can be taken for the planned period at the level of statistical (base) coefficients or with some deviation from those, the deviation resting upon the experienced evaluation of the tendency in the measurement of inter-branch relationships in one or another branch.

Such division of coefficients is based on the account taken of the influence of the change in each coefficient of direct inputs over the coefficients of direct and indirect requirements per unit of final demand. Those coefficients of direct inputs, the change in which within certain limits causes some insignificant change in the corresponding coefficients of direct and indirect requirements per unit of final demand are said to be secondary. The rest of the coefficients are said to be primary.

The analysis of the statistical inter-branch balance of the USSR for the year 1959 showed that each branch has a certain number of coefficients which are of primary importance in production, which characterize the economic structure and predetermine the technological progress and the development direction of the branch. It is estimated that out of 4260 input coefficients of the statistical inter-branch balance for 1959 in money terms, 550-600 input coefficients are vitally important.

These very coefficients determine the national economic branch structure and comprise over 90 per cent of all the material-production inputs.

The analogous conclusion was obtained by another method. The investigation of the coefficients of the statistical inter-branch balance at the Scientific Research Economic Institute of the USSR State Planning Committee was carried out from the following point of view - what is the magnitude of the maximum permissible deviation of each individual coefficient under which the output volume of the branch changes by more than 1 per cent.

As a result there was obtained the following distribution of coefficients.

Distribution of the coefficients of direct inputs according to the permissible limits of deviation in the statical inter-branch balance for 1959.

Groups of Coefficients of direct inputs with the Permissible Limit of Deviation (Per cent)	Number of Coefficients in The Group	Specific share of the Group According to the Number of Coefficients (Per cent)	
		In the Total Number of coefficients	In the Number of the coefficients with the Permissible limit of Deviation Up to 100 per cent
From 0 to 10	98	2,3	14,8
From 10 to 20	85	2,0	14,6
From 20 to 30	82	1,9	14,1
From 30 to 40	61	1,4	10,5
From 40 to 50	58	1,4	9,9
From 50 to 60	40	0,9	6,9
From 60 to 70	37	0,9	6,3
From 70 to 80	38	0,9	6,5
From 80 to 90	42	1,0	7,2
From 90 to 100	42	1,0	7,2
Total	583	13,7	100
Over 100	3677	86,3	-
Grand Total	4260	100,0	-

In our opinion such evaluation of the coefficients' significance is somewhat cumbersome, because the deviations by one per cent in the gross outputs in respect to different branches are not of equal significance. It would be more expedient to break down the branches into several groups stemming from their significance and to set for each group its own permissible percentage of variation in the gross outputs.

It should be also borne in mind, that the permissible variations (deviations) characterize the influence of an isolated change in the coefficients over the branch structure of social production. It is natural, that such variations in a number of interdependent coefficients will cause variations in the volume of production by far more than 1 per cent. Nevertheless thus given indicators of permissible variations are an important characeteristic for the coefficients of direct inputs and can serve the purpose of determining the range of principal coefficients which are to be worked out for the planned period.

Besides these economic investigations of the problem in hand, some mathematical methods are also elaborated and utilized. [1]/

It goes without saying that it is impossible to determine the range of these coefficients only on the basis of the analysis for the statistical inter-branch balances.

The significance of individual coefficients for the planned balance may undergo radical modifications as a consequence of the technological progress. This concerns, for example, the coefficients for the consumption of plastics in a number of engineering branches.

On the other hand, a certain number of significant coefficients can be taken for the planned balance at the level of statistical data or else with slight amendments in case if it is known beforehand, that the basic directions of technological progress and the structural shifts

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1/ Yershov E.B., "Mathematical Methods in the Static Model of the Inter-Branch Balance". The report at the scientific discussion on the problems of the inter-branch balance, Moscow 1963."

2/ V.V. Kosov "The Inter-Branch Balance". The Publishing House "Economy", Moscow, 1966.

of the given branch will not have significant effect upon the coefficient's magnitude and if, consequently, it will not undergo essential modifications in the planned period.

The principle of elaborating only the significant coefficients for the planned period, those which determine the major economic relationships of a branch, enables us to reduce considerably the volume of the work on forming the normative basis for the inter-branch balance.

The above given methods to elaborate planned coefficients of direct inputs do not comprise and exhaust all the problems arising in some concrete calculation for one or another coefficient. It is necessary to work out concrete methods to calculate these indicators, those which may take into account the technico-economical specific features of a branch.

Concentration of efforts, in the calculation of coefficients for the planned period, upon setting accurate figures only for the significant (primary) coefficients leads to the application of various iterative methods for the purpose of determining the secondary (less significant) coefficients of direct inputs.

Extrapolation of coefficients on the basis of the time-series is the best known method among them.

The method of iterative computation of coefficients - the so-called "RAS" method, offered by the English scientist R. Stone[1/] is of great interest, as well as other investigations and works in this direction in a number of countries.

However, in most of the given methods, in our opinion, the efficiency in correcting the coefficients can be reached in conjunction with other methods and, first of all, with direct methods of calculation, which enable us to correct a great number of inaccuracies.

Comprehensive and efficient studies and recommendations on the problems in hand are given in the UN publication - Studies in Methods, Ser. F, No. 14, 1966, "Problems of Input-Output Tables and Analysis."

1/ R. Stone "Input-Output and National Accounts."

4. FORMATION OF THE INITIAL ECONOMIC INFORMATION AND ORGANIZATION OF CALCULATIONS.

The availability of the appropriate initial data in forming the coefficients of direct inputs is one of the most complicated and labour consuming parts of the work. Inconsistency of the existing system of information in order to obtain the all-round data makes the work costly and more difficult.

The coefficients of direct inputs differ in their content from ordinary production norms. The coefficients do not only show the technological inputs of the given material (resource) per unit of output, but also the inputs connected with general production requirements. At this, in the elaboration of a planned inter-branch balance of production and consumption, the coefficients characterize the average branch level of the inputs of production per unit of output in terms of a "pure" branch.

The character of the coefficients of direct inputs is determined by the objectives set in the calculations of the inter-branch balance.

The extent of differentiation in the coefficients depends on the accepted classification of branches or products which are taken in the scheme of the planned inter-branch balance.

The coefficients' stability is determined by the growth rate of technological progress and by the extent of aggregating branches and products.

The utilization of coefficients of direct inputs in calculations can be characterized by two main features. In the first place the coefficients are comparatively stable in time. In the second place, the essential fact in the utilization of coefficients is that particular coefficients may be repeatedly utilized while solving different problems, although for the solution of each concrete problem its own, specific set of coefficients (norms) is necessary.

Considering the above main features characterizing the utilization of coefficients, and taking into account the technical reasons aimed at providing the appropriate easiness for their preparation and inversion, it is possible to formulate the principal requirements, to which, in our mind, the process of preparing the aggregates of coefficients for the planned inter-branch balances must correspond:

- the introduction of initial coefficients must be effected through the minimum number of entries of this information in the established forms, so that the work on subsequent utilization of the information can possibly be done without resorting to rewriting or retyping the documents.

- fixed on special information bearers, the data must be given together with the characteristic indicators which by means of a one-digit number should ensure the connection of these bearers with a certain aggregate and their definite place in it.

- the utilized system of devices and methods of coding must provide for the possibility to change any figure (datum) in the formerly prepared aggregate of information.

The organization of working out the coefficients of direct inputs is stipulated mainly, by the adopted system of economic management and by the organization of elaborating inter-branch balances.

While elaborating inter-branch balances at all levels of management, a pyramidal system is created, as a rule, in which the data for the coefficients of direct inputs coupled with other components of the economic information for the inter-branch balance, are aggregated at each following level from "below".

Other systems and variants exist for the purpose of constructing the information system to elaborate the coefficients for the planned inter-branch balances.

It seems advantageous, considering a number of specific conditions, to examine in greater detail the possible organization of elaborating the planned coefficients of direct inputs on the basis of the data obtained from statistical inter-branch balances with an all-round utilization of the necessary materials in order to correct the coefficients. In this case it seems expedient to consider the following general provisions on the elaboration of the coefficients.

In the first place, the coefficients of direct inputs derived from the statistical inter-branch balance of the nearest base period serve as the basis for the calculation.

In the second place, the most significant coefficients, determining the structure of the production relationships in the national economy, are to be picked out. Further work must, chiefly, go in the direction of correcting these coefficients. The correcting work ought to be based on taking into account their most significant modifications, structural shifts and other factors.

Ministries and their subordinated departments, the branch scientific research and designing institutes and organizations must directly take part in the work on correcting the coefficients of direct inputs.

The correction of the coefficients must be made with account taken of their specific features and through the medium of the most efficient methods.

In certain cases, when the analysis for the coefficients of the statistical balance reveals their insufficient representativity, or else when new coefficients of direct inputs are introduced, they can be defined by way of direct calculation.

Thus, the first stage is to obtain the coefficients on the basis of the statistical inter-branch balance's data. Therefore the obtaining of the coefficients of direct inputs is one of the most significant results of elaborating the statistical inter-branch balance. The input and the

technical coefficients are calculated by deviding the total amount of inputs of each product by the total volume of production for the given product.

$$a_{ij} = \frac{Xij}{Xj}$$

Accurate and precise data about the coefficients of direct inputs on the basis of the statistical inter-branch balance acquire especial significance as a statistical basis for planning.

Special attention in the elaboration of the statistical inter-branch balance must be concentrated upon the objective authentic information, obtained on the basis of precisely and concretely determined methodological regulations (provisions).

To obtain the appropriate data for the purpose of forming the coefficients of direct inputs is a rather complicated work. The existing system of accountancy and elaboration for the initial documents does not, as a rule, secure the possibility of obtaining ready data about the inputs of production according to the classification accepted for the elaboration of the inter-branch balance.

To obtain such data considerable additional work must be done together with a number of rather complicated calculations. Taking into consideration the complicacy and labour-consuming nature of this work and also the necessity to preliminarily process a number of methodological regulations it seems reasonable to carry out a sample survey of a number of enterprises and organizations, so that the data thus collected can be transferred to the remaining enterprises and organizations. In this case, the significant task for the sample survey could be to obtain from the enterprises and organizations, according to a certain (rather detailed) nomenclature, the data about the inputs of various types of raw materials, fuel and electric power to produce individual types of products. In greater detail this question is touched upon in the work "The Sample Survey of the Inputs of Production".

The coefficients of direct inputs obtained as a result of elaborating the statistical inter-branch balance are analyzed (the most significant coefficients and materials are determined) and given over to the respective ministries and their subordinated departments. The ministries and their subordinated departments pass over the received coefficients for a deeper and more detailed analysis to the branch designing and scientific research institutes. The planned and statistical norms for the utilization of material resources, and also the possible structural shifts in production are simultaneously sent over to these institutes.

The branch (sectoral) designing and scientific research institutes following the advice of the corresponding ministries and their subordinated departments, make the complex elaboration for the problems of inter-branch relationships and structural shifts during the planned period. As a result of this work, the coefficients of direct inputs of raw materials, fuel and semi-finished products per unit of output must be defined. The coefficients are to be elaborated with account taken of the circumstances of production which will be characteristic for the planned period. At this one takes into consideration the development of technique and technology of production, the implementation of new, more economical raw materials, materials and designs for machines, and also the progressive changes in the structure of production and its better organization.

The data, elaborated by the branch scientific research institutes are considered by specialists of the ministries, according to the established form (see the form) and sent over to the Computation Centre.

FORM

CLASSIFICATION ITEM OF THE PLANNED
INTER-BRANCH BALANCE

NAME ———————————————————————————

SPECIFIC SHARE OF THE GIVEN PRODUCT WITHIN THE CORRESPONDING ITEM OF THE INTER-BRANCH BALANCE (OR THE ANNUAL VOLUME OF PRODUCTION)

Item No.	Name of the Products of the inter-branch balance consumed per unit of output	Unit of measure	Coefficients of direct inputs			
			Statistical (Base) Period	Planned Period		
1	2	3	4	5	6	7

The Computation Centre makes the primary analysis of the data obtained, defines more exactly with the specialists of Ministries and Institutes the appropriate regulations and gets ready the obtained materials to be examined by the Central Planning Agency. At this, the elaboration of the coefficients and the preparation of the data to be examined and subsequently computed is made according to the columns of the nomenclature of products for the planned inter-branch balance, i.e. each economist has definitely demarkated items j (columns).

It is only natural that if the branch is complicated enough and the elaboration of coefficients offers some difficulties due to the great volume of work or their specific nature and complicacy, then the branch may be broken down into parts.

The elaboration and preparation of the initial data by columns with the division of labour according to the branch principle is of certain significance.

The work by columns means that each economist of the branch builds up and presents the data about all types of inputs per each type of the output (column) coming under his authority. Such division makes it possible to see the structural shifts of the physical inputs by columns, to have a certain idea about the technology of production, to feel the place of each type of output in the state development plan.

This circumstance concretizes the work on the coefficients of direct inputs, makes it easier to collect and build up the initial data, to check them up within the competent organization.

We shall take, as an example, the column coefficients of direct inputs for 2 types of products - power cable and control cable.

(arbitrary figures)

Columns: Name of the j-th output / rows: Name of the i-th consumed materials per unit of the j-th ouput	Unit of measure	Power cable		Control cable	
		Statistical (base) period	Planned period	Statistical (base) period	Planned period
Copper	Ton/KM	0,048100	0,047030	0,108120	0,107430
Aluminium	Ton/KM	0,038890	0,043830	0,045000	0,048420
Lead	Ton/KM	0,79770	0,74740	0,88010	0,6200
Plastics and Synthetic resins	Ton/KM	0,35470	0,42450	0,54650	1,15400

The table gives the characteristic for material inputs and their structural changes. It enables us to see regular shifts in the structure of material inputs per unit of output in the planned period versus the statistical (base) period. As it can be seen from the example, the input of copper slightly decreases, the input of aluminium increases, the input of lead decreases and the input of plastics and synthetic resins increases.

Owing to the fact that the work within the planning bodies and also at the ministries, scientific research and designing institutes is carried on in terms of branches (industries), the coefficients of direct inputs thus obtained can be easier examined and subsequently corrected.

There exist several ways and methods for the analysis of the coefficients.

The method of direct measurement which presupposes the comparison of the input coefficients for several periods, is the one most frequently utilized in practice.

Another method is based on the comparison between the actual gross output and the gross output for the same period having been calculated on the basis of the inter-branch balance.

Other methods of the analysis for the coefficients are also widely utilized and dealt with in a number of works, viz. in the UN periodic publication - Studies in Methods, Ser.F, NI4, 1966, "Problems of Input-Output Tables and Analysis".

The presented materials are studied and consequently corrected within the departments of the planning authority. In order to carry out such an examination, if necessary, some additional calculations and specifications are made ready. The examination is usually carried out with the workers of ministries and their subordinated departments, scientific-research institutes and enterprises taking part in it.

The initial data about the coefficients of direct inputs, having been previously tested, are given back to the Computation Centre to perform the computations.

These data are recorded at the Computation Centre on special forms. The below given form can be also valid for the purpose.

Problem No.			Sheet No.	
Code-number of the consuming product		on the sheet		

code number of the input product	norm	control sum	code number of the input product	norm	control sum

												Made up by Checked up By Summed up By Perforated By	
amend ments	total sum	Source N	date	filled in by	date	summed up by	date	perforated by	date	controlled by	date	Controlled By	

In the cell "problem No" is put down the number of the problem for the computation centre, next to it by a two-digit figure is put down the year, for which the balance is drawn up.

In the cell "Code number of the consuming product" the nomenclatural number of the j-th position (column) with the category is put down.

The column number (in our example of filling in the form) consists of four digits, of which the first denotes the number of the category in our example number 3) the three others - the number of the column. If the number is less than a four-digit one then before it, after the category, zeros are put down.

In the cell "Code number of the input product" is put down the number of the input materials of the i-th position (row) per unit of the j-th position (column). The raw number is put down in the same way as that of the column.

In the column "norm", which is broken down into 3 cells, the coefficients of direct inputs are put down. Each of the three cells is destined for filling in 3 digit-numbers. The first cell is for whole numbers, the rest (remaining) - for fractional numbers. Only the significant numbers are put down. The coefficients of direct inputs may contain about 9 decimal digit-numbers.

If in the course of forming or filling in the forms there appears a coefficient containing (in round numbers) less than one decimal number (sign) it is considered that it equals to 0 (zero) and it is not put down.

If the coefficient consists of more than 9 decimal numbers (in the units of the nomenclature classification for the inter-branch balance), then the units of measuring the products undergo some changes by columns or by rows.

The question of what to change - the row or the column - depends on which of the changes causes less changes in other positions.

for instance, below we have nine types (varieties) of the coefficients of direct inputs.	In the column "norm" only the significant numbers are to be put down as (follows):
999,900 000	999 900 000
12,163 230	12 163 230
1,150 100	1 150 100
0,112 500	112 500
0,013 500	13 500
0,001 460	1 460
0,000 167	167
0,000 067	67
0,000 001	1

The column "Control Sum" is destined for summing up the indicators for the purposes of control, which will be mentioned later. Here is an example of filling in the form:

Problem N			Year	

code number of the consuming product	3373	on one page

Code number of the input product	Norm	Control sum	Code number of the input product	Norm	Control sum
1007	2 358 000	2 362 380	1075	1 575	6 023
1008	91	4 472	1081	6 340	10 794
1009	1 070	5 452	1092	85 090	89 555
1013	546	4 932	1095	4	4 472
1010	41 000	45 383	1111	503 000	507 484
1014	37 230	41 617	1118	1 830	6 321
1017	1 090	5 480	1119	8 940	13 432
1036	6 450	10 859	1131	6 005	10 509
1037	7 204	11 614	1198	356	4 927
1039	960	5 372	1208	512	5 098
1041	105 000	109 414	1295	11 100	15 768
1042	18 270	22 685	1296	51 030	55 699
1043	360	5 276	1328	1 004	5 705
1044	9 350	13 767	1361	272 200	276 934
1046	420	4 839	1362	102 800	107 535

(continued)

Problem N			Year	
code number of the consuming product			3373	on one page

Code number of the input product	Norm			Control sum			Code number of the input product	Norm			Control sum		
1047			79	4	499		1385			150	4	908	
1049			5	4	427		1386		7	040	11	799	
1051		7	580	12	004		1388		7	100	11	861	
1052			460	4	885		1389		11	100	15	862	
1053		10	310	14	736		1395		27	180	31	948	
1060		1	268	5	701		1416		15	680	20	469	
1064			374	4	811		1421		72	220	77	014	
1065	3	183	000	187	438								
1066	1	366	500	370	939								
											8	557	094

To gain greater efficiency in the utilization of these aggregates of information it is necessary to have a possibility to change partially the information. Corrections can be also made before the aggregate is introduced into the electronic computer. The form of amendments (corrections), (see the scheme), is subdivided into 2 parts. The positions (position numbers) which are to be corrected are put down on the left hand side "The data before the amendments". The corresponding positions (position-numbers) are put down on the right hand side "The data amended".

In the row of the first column the positions are put down in the form of a fraction: the numerator is the number of the column to which the amendments (corrections) are referred; the denominator is the number of the row to which the row taken refers. If per one column there should be made several amendments in the rows, then the denominator (the number of the column) is put down once.

When making amendments (corrections) in such a form designed for the final demand, the code number of the work in question is put down in parentheses. In the row of the first column the economic numeration of the position is recorded with the categories. The rest is done in the above given order.

The Form of Amendments

Problem No. Year Page No.

the data before the amendments							the data after the amendments						
Code-number of the columns / Code-number of the raw	Norm			Control sum			Code-number of the columns / Code-number of the raw	Norm			Control sum		
3373							3373						
1007	2	358	000				1007	2	305	000			
1065	3	183	000				1065	3	110	100			
1417							1417						
1009							1009			120			
2020		1	740				1020		1	740			
1027			350				1027						
1031			150				1029			150			

The information thus given is utilized further as the initial document in the work (activities) connected with making changes (amendments).

Thus, the calculations of proportionality in social production imply the availability of the respective normative basis. In the circumstances of state economic managementthe planned norm grows to be the most significant factor in the organization of social production.

As long as the methods of production are continuously improved, the norm must reflect these changes and therefore must undergo a constant modification.

The approach to the calculations of proportionality for the plan with the aid of planned inter-branch balances requires the availability of a certain system of normative data which in turn serve as the objective basis for working out and correcting the planned coefficients of direct inputs. The coefficients of direct inputs represent complicated in their structure indicators which take shape under the influence of many factors. The evaluation of these coefficients is one of the most significant stages in the elaboration of the planned inter-branch balances.

The change in the coefficients of direct inputs, reflecting the shifts in the inter-branch relationships due to the technological progress and intra-branch structural changes, has essential effect upon the growth rates of particular branches of social production and, consequently, upon its branch structure.