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Analysis of Foreign Trade Activity With the Aid of Mathematical Models

„Today, in the conditions of the vertiginous development of the forces of production, of modern science and technology, the exchanges of material and spiritual assets are a basic condition for the advance of mankind and for the very flourishing of human civilization."

NICOLAE CEAUȘESCU

One of the characteristics of the contemporary economic development is that the growth of production is surpassed by the increase of the foreign trade activity. Edifying in this connection is that in the 1960—1968 period, the index of the world industrial output[1]) has increased from 100 to 164.2, that is at an average annual rate of 6.4%[2]) whereas the index of foreign trade has increased from 100 to 189.4 corresponding to an average rate of increase of 8.3% and that of imports from 100 to 184.3 corresponding to an average rate of increase of 8%[3]). These data signify a 1.12—1.15 times more rapid increase of foreign trade in comparison with that of the industrial output.

In this connection, it is explainable why, in the last few years, economists have granted and continue to grant special attention to foreign trade analysis, its economic efficiency, the prospects of its development, etc. Worth mentioning among these preoccupations are especially the economic-mathematical models.

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[1]) A comparison was made with the industrial production because it is considered to be more significant. It is well known that generally, its dynamics is more accelerated than that of total production. Hence the powerfully ascending development of foreign trade activity appears more striking.

[2]) Data processed by the author after the Statistical Yearbook of the Socialist Republic of Romania, 1970, tables 309 and 310.

[3]) Data processed by the author after Statistical Yearbook 1968, UNO, New York, 1969 and Monthly Bulletin of Statistics, UNO, New York, November 1969.

1. TYPES OF MATHEMATICAL MODELS USED IN FOREIGN TRADE ANALYSIS

Without having the pretension of a classification, we shall however try to make a somewhat grouped presentation of the types of models more often found in foreign trade analyses, namely models of a book-keeping identity type and econometric models.

1.1. *Models of a book-keeping identity type*

The models of this type are characterized by the fact that they express structurally the total social product from two points of view: on the one hand „the entrance" or source and, on the other hand, „the exits" or destination.

The organization of the total social product from the point of view of entrances usually repeats, in a more or less changed form, the structure of value. For the analysis to include the foreign trade activity, the disintegration of the component means of production into component parts, namely means of production from internal sources and means of production from import, is practised currently.

In this case, the total social product can be written:

$$PST = VN + CPN + CPM \tag{1}$$

where

PST represents the total social product;
VN — the national revenue;
CPN — means of production from national sources for productive consumption;
CPM — idem from import.

From the point of view of exits, the basic component parts of the total social product are the deliveries destined for productive consumption and the final product. For the economic analysis to include foreign trade, the disintegration of the final product into component parts is practised, among which three, namely: the unproductive consumption (by this we mean the individual and social consumption), investments and export, appear more frequently.

A new relation can be written for the total social product:

$$PST = PI + PFC + PFI + PFE \tag{2}$$

where:

PI represents deliveries destined for productive consumption
PFC — the final product destined for unproductive consumption
PFI — the final product destinated for investiments
PFE — the final product destined for exports

The identity

$$VN + CPN + CPM = PI + PFC + PFI + PFE \tag{3}$$

results from the relations (1) and (2), an identity which allows to make certain analyses on various elements reflecting the foreign trade activity.

In order to extend the analysis on certain aspects regarding commercial or financial policy, some authors [4]) complete the identity (3) either with the foreign trade balance or with the foreign payments capacity. Each of these two concepts allows to introduce indicators as to the efficiency of foreign trade activity or indicators characterizing the financial situation. In this way, „the foreign exchanges relation", the flow of long term financial availabilities, balance of short term availabilities, etc. are used.

„The foreign exchanges relation" characterizes the evolution of competitiveness with regard to prices. It is calculated as a relation between the index of the prices of exported products and the index of the prices of imported products. This relation expresses the percentage increase of the prices of exported products which is found again with the one per cent increase of the prices of imported products. In a certain sense, this relation can be interpreted as an index of purchasing power on the world marked of the analysed economy.

There are also other ways of tackling the problems of foreign trade. As an example, we shall dwell on Van Rijckegem's[5]) model which tries to explain the contribution of foreign trade to economic development.

To this purpose. Rijckeghem uses three identities which he calls "equilibrium conditions" one of which expresses the settlement of the balance of payment. Noting with:

Y — internal raw product
C — internal consumption
S — internal savings
I — internal raw investments
X — export
M — import
Tr — the settlement of the balance of payments;

the author forms a relation for the "financing equilibrium" (4), another for "internal equilibrium" (5) and a third one for "external equilibrium"(6).

$$Y = C + S \tag{4}$$

$$Y = C + I + X - M \tag{5}$$

$$S - I = X - M = - Tr \tag{6}$$

The author gives no explanation of the content of the notion "internal savings". It might be understood from (6) that they represent an accumulation fund and that its surplus over its component part — the investment fund — is exclusively destined for the financing of export. In this light, the relations (4) and (5) are superfluous, the analysis being made only on the basis of the "external equilibrium" relation.

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[4]) FERNANDO LLINAS TOLEDO — *Un modèle destiné à l'analyse du secteur extérieur des économies en voie de développement*, Revue économique de Louvain, 1967.

[5]) W. J. van RIJCKEGHEM — *External equilibrium and the economic growth.* Put forward at a seminar of econometry of the Liege University, in May 1970

It also results from (6) that X and M do not represent export and import in the sense known, but an "export" and an "import" in the meaning of all flows of value to and from other countries. In this connection, the export and import of capital are included respectively into X or M and certain aspects of the content of the notion of "internal savings" are also outlined. These savings thus signify the part left from the final product for the enlargening of production and for the export of capital.

Despite the lack of clarity in the presentation of notions, the author comes to an interesting relation as regards the factors explaining the average annual rate of increase of production. From the relation (6), the author deduces a condition for the level of investments, namely

$$I = S + M - X$$

in which if multiplied with the average annual rate of increase of the internal raw product and if some convenient transformations are made:

$$\frac{\Delta Y}{Y} = \frac{\frac{S}{Y} + \frac{M - X}{Y}}{\frac{I}{\Delta Y}}. \tag{7}$$

is found.

The relation (7) shows the link between production and foreign trade, in which the average annual rate of increase is explained through the accumulation rate (S/Y), the share of "import" and „export" in total production (M/Y, respectively X/Y) and the investment efficiency coeficient ($I/\Delta Y$).

Relation (7) has a static character, but, in certain conditions, the influence of the time factor can be included in it. Considering that the average annual rate of increase is given through the plan and that the fixed investment efficiency coeficient is unchanged during the planning, the relation (7) can be written:

$$d(\Delta Y/Y) = kd[(M - X)/Y]$$

where k also represents an investment efficiency coeficient. We consider that relation (8) has the advantage of the analysis of the dynamics of phenomena linked with foreign trade.

The book-keeping identities we have referred to, have nevertheless quite a limited applicability, especially as a result of the fact that they considerably limit the analysis elements and imply the separate calculation of each of them, regardless of the aggregate size and of the other elements of analysis.

In order to surpass these limits, they resorted to the tackling of the main component parts of identity (3) with the "input-output" method, the so-called *gravitational and space economy models* being elaborated.[6]) These models

[6]) There is, at present, a rich literature in this respect, but the fundamental works remain: W. LEONTIEFF and A. STROUT: *Multiregional Input-Output Analysis*, Mc. Millan and Co. Ltd. Publishing House, 1963 and H. LINNEMAN — *An Econometric Study of International Trade Flows*, NHPC, Amsterdam, 1966

represent a network of exchanges among countries and their aim is to explain the cause of the formation and development of the flows of products among countries and the structure of the partner's foreign trade. We consider that such an approach to the problem is much closer to the analysed economic phenomenon because within international exchanges, the imports of a country are the exports of its partners and inversely. The independent analysis of a country's imports and exports brings, in this connection, less precise and even less stable information. By this, we do not mean at all the planning of a country's foreign trade activity from outside, for example, from one or several commercial partners, but only, an approach to the problem in conditions as near to reality as possible. The knowing of the import possibilities of a buying country from a selling country is insufficient as long as it is not completed with the knowing of the export possibilities of a buying country to the selling country, and with the import and export possibilities of the buying country with the rest of its commercial partners.

As shown above, the gravitational models are based also on a book-keeping identity, namely:

$$\text{Production} + \text{Import} = \text{Consumption} + \text{Export} \tag{9}$$

The production and consumption of a country can be expressed with the aid of the relations

$$P_i = X_{ii} + \sum_{j \neq i} X_{ij} \tag{10}$$

$$U_i = X_{ii} + \sum_{j \neq i} X_{ji} \tag{11}$$

where

P_i represents the production of the country i;
U_i — consumption in the country i;
X_{ij} — the export from the country i to the country j(the import to the the country j from the country i).

The production for internal needs and the consumption from internal production were made distinctly evident in the relations (10) and (11). Eliminating X_{ii} between (10) and (11), the mathematical expression of the book-keeping identity (9) is obtained:

$$P_i + \sum_{j \neq i} X_{ji} = U_i + \sum_{j \neq i} X_{ij} \tag{9'}$$

We introduce in relation (9') a transformation of import-export flows in keeping with the production of the exporting country and the consumption of the importing country, as follows

$$X_{ij} = \alpha_{ij} P_i U_j \tag{12}$$

where X_{ij} is a so-called "gravitational" parameter. Relation (9') can also be written:

$$P_i + \sum_{\substack{j=1 \\ j \neq i}}^{n} \alpha_{ji} P_j U_i = U_i + \sum_{\substack{j=1 \\ j \neq i}}^{n} \alpha_{ij} P_i U_j \tag{13}$$

which, if written for all i ($i = 1, 2, ..., n$) leads to a system[7] $n \times n$, in which n is the number of the countries considered in the network and the productions and consumption are unknown.

As can be noticed, the import-export X_{ij} flows are explained by a relation of a product type, through production, consumption and a "gravitational" parameter grasping the influence of the two basic factors on foreign trade. As regards the form of the relation, we mention that there are also other proposals, such as the linear dependence:

$$X_{ij} = aP_i + bU_j$$

We have an attitude of reserve as regards this form of dependence. Linear dependence may thus indicate a certain value for X_{ij} even if P_i and U_j are nill; if, for example, $U_j = 0$, then $X_{ij} = aP_i$ which signifies an export from producer i on the market j in the conditions in which consumption on the market j is nill, which is obviously unjustified from the economic point of view. We note that relation (12) excludes the obtaining of such results.

An interesting application of a gravitational type model was achieved for the two European economic blocs: the Common Market and the European Free Trade Association[8]). In order to determine the exchange flows between two countries, the authors solve a system of a (13) type each for estimating the production and consumption on countries of a category of goods, after which they calculate the import-export flow between two countries after the relation:

$$X_{ij} = h e^{F_1} e^{F_2} D_{ij}^{G} M_i^{E_1} N_j^{E_2} P_j^{A} U_j^{B} R_{ij} \qquad (14)$$

in which except for the notations already introduced above appear:

h — scale coeficient;
F_1 and F_2 — coeficients preferably relating to the Common Market or EFTA;

D_{ij} — the distance between the exporter i and importer j;
M_i — the active population in the exporting country i;
N_j — the total population in the importing country j;
R_{ij} — the residual factor;
G, E_1, E_2, A, B — flexibility coefficients.

The aggregation problems in this type of models are playing an important part in establishing the volume and quality of the information to be obtained, but, they equally determine the volume and structure of the input data, in connection with which the problem of the existence and possibility of obtaining them is raised most often. Attempts of great proportion[9]) are known in

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[7]) FROMET and ZIGHERA — *Une méthode de l'analyse de l'évolution et de projection des structures et son application au commerce mondial* — CNRS Cahiers du séminaire d'économétrie, 8/1965.

[8]) HEAN CLAUDE BLUET and YVES SYSTERMANS: *Modèle gravitationnel des échanges internationnaux pour les produits manufacturiers* — Bulletin du CEPREMAP, no. 1, 1968

[9]) YVES LE GO and GERARD LAFAY: *Présentation d'un modèle de projection sur court terme des échanges internationnaux.* Economies et sociétés, P series, no. 13, May 1967.

this connection, in which they have come to about 20 commercial partners and about 15 products and groups of products. The model we refer to has a four-dimensional structure expressed in the individualization of the exporter, importer, the producing and consuming branches. In connection with this analysis, we note the possibility of duplicating the studies in the direction of some in which the analysis should pursue the exchanges among branches on zones (countries) and of others in which the analysis should thoroughly study the exchanges among countries (inter-zonal) on products.

The treatment of world exchanges with the input-output method can be used at the most for a medium term, that is 1 to 3 years, the displacements in the structure making it unusable for a long period of time. Yet, it has certain advantages as regards data processing and the outlining of some very useful analysis indicators.

2. ECONOMETRIC MODELS

The econometric model is an aggregate of mathematical expression relations reflecting the interaction of various variables which describe or influence the evolution of an economic process or phenomenon and even of an economy as a whole. In the sense of this specification, an econometric model of foreign trade activity aims at the explanation of a country's exports or imports as a whole, or on groups of partners or goods, through the action of one or several production, economic, commercial, economic policy, financial and customs factors.

This type of models is widely used in forecast activities, a double goal being attributed to it.

a) the working out of a forecast by outlining the statistical-economic relations and

b) the achievement of a certain coherence of the forecast values, taking into consideration the economic criteria.

A problem often discussed in connection with the working out of econometric models is the forecast scope. Nevertheless, there is a wide-spread opinion that the medium term is most convenient for a forecast with such models. Several arguments are brought in support of this opinion, arguments which can be summed up as follows:

— the insufficiency of statistical data for a series of variables, which is translated through the existence only of annual statistics for certain variables, which would necessitate the carrying out of interpolations for the formation of quarterly or monthly series, necessary for short term forecasts;

— the forecast capacity for a short term is weaker, deviations going as far as 100%. This is explained through phenomena, such as seasonality, the stronger influence of economic cycles on subannual indicators, etc.

— the necessity of a permanent putting up-to-date of the parameters and coefficients characterizing the influence of variables following the structural displacements, which makes the utilization of these models on a long term difficult and inefficient.

We add to these groups of arguments also the fact which, in our opinion, is not negligible, at all that, in the case of short term forecasts with such models, the grasping of conjunctural influences and oscillations necessitates a big number of variables which excessively makes the working out and manipulation of such models difficult.

The factors influencing the foreign trade activity, which are to be taken into consideration in the elaboration of econometric models may be very much varied as regards their character. The volume, structure and quality of information we can obtain in connection with these factors are playing a decisive role in choosing these models. In this connection, we consider typical Adamst[10]), econometric model concerning the determination and analysis of the import-export flows of the countries, members of the European Organization for Trade and Development (OCDE) in which each country's import and export is explained through 10 variables characterizing the possibilities, tendency and structure of foreign trade in a complex way. The explanatory variables thus include the level of economic development, customs policy, the structure of foreign market, the level and structure and demand of each country and the level of prices. The relations are considered to be linear, a hypothesis which is widely used in econometric analysis, but the information obtained is very useful for estimating the evolution of foreign trade activity in the above-mentioned countries.

Obviously, a careful and thorough analysis is absolutely necessary in choosing the influence factors, since unreal conclusions may be reached. In this way, explaining the foreign trade activity, many bourgeois economists reach the conclusion that the equilibrium of the balance of trade or of payment can be maintained only through the alignement of the rates of development of production. Schematically, this appears from the equality of imports and exports as a result of the following transformations:

$$M = M' \tag{15}$$

$$m\Delta Y = m'(\Delta Y)' \tag{16}$$

$$mtY = m't'Y' \tag{17}$$

$$t = t' \qquad \text{if } mY = m'Y' \tag{18}$$

where

M = the imports of a certain country;
m = the average rate of a country's imports in the increase of its social product;
Y = the internal raw product:
t = the average annual rate of increase of the internal raw product
$'$ = the complementation of the indicator after which it is placed (for example, M' = the import of the other countries from the considered country, consequently the export of the considered country);
Δ = the increase of the indicator before which it is placed.

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[10]) F. G. ADAMS: *Une analyse économetrique du commerce international*, the OCDE Publishing House, Series Etudes économique, 1969.

Condition (15) signifies the equality of a country's import and export These two categories are expressed in (16) through their rate in the increase of the internal raw product and afterwards in (17) through the average annual rate of their increase. The supplementary condition in (18) is achieved when the average and differential rate of import are equal. It results from (18) that the equilibrium of a country's balance of trade is achieved when the rate of increase of the internal raw product in that country is equal to the average rate of increase of the internal raw products of the partner countries in foreign trade. Hence, most bourgeois economists continue to affirm the necessity of "co-ordinating the economic development of the countries". They put forward this necessity as an ultimatum condition of "national expansion" in "an open system".

Very many concrete aspects of major importance have been completely neglected in the building of the mathematical model of the problem raised and in the formulation of conclusions. Suffice it to mention the different level of economic development of various countries, the fact that many countries have a rate of development below the world average, that for many countries, a rate of development higher to that obtained by a big industrial power does not mean between certain thresholds, nor, a reduction of the discrepancy between the two countries, but, on, the contrary.

Certain economists put forward even the idea of stades of economic development in keeping with the financial and customs policy of a country. Thus, Maurice Bye[11] considers that there are four stades of development: a new debiting country, a developed debiting country, a new crediting country and a developed crediting country. The passing of a country from one stade to another is made automatically, on the account of "the automatism" of the best repartition of capital in the world, the best increase of production and adaptation of the balance of trade. The author is trying to put forward the idea of a permanent cycle of transition from one stade to another, completely denying the role of the relations of production and of the development of the forces of production of society. The tendency is obvious to wipe the differences between the modes of production, especially between socialism and capitalism and to bring fundamentally different social systems to a common denominator, through financial and trade relations.

The linearity of the relation between the explanatory variables and those to be explained is, however, a hypothesis which considerably simplifies reality. There are attempts concerning the working out of non-linear models, but, they are quite few as a result of the great difficulties implied as regards their solution and the estimation of coeficients.

Such an attempt is Peetersen's[12] forecast model. Elaborating the model for annual forecasts, the author proposes to forecast the development of Belgian economy, in the sense of the establishment of the most probable level of achievement of certain synthetic indicators, such as the volume of the total social product, of industrial production, import and export, the index of prices, etc.The model consists of several groups of equations divided for calcu-

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[11]) MAURICE BYE: *Relations économiques internationalles*, Précis Dallaz, Paris, 1965.

[12]) A. van PEETERSEN: *Quelques prévisions pour l'année 1969*. Cahiers économiques, de Bruxelles, no. 41/1969.

lation needs into three blocks one of which comprises the non-linear equations of the model. The solving of these non-linear equations is made with the aid of the Newton-Raphson iterative methods.

Worth mentioning among other things is that in the equations concerning the volume of import and export-built as non-linear equations — and in the equation concerning the index of the prices of Belgian exports, no explanatory variables appear as regards the volume or price of production. In this way, import is explained only through elements of the final product (individual and social consumption, investments, the increase of stocks) and export only through elements characterizing world trade (its volume and the index of world prices). In our opinion, this is a weak point of the model which, as a matter of fact, is also emphasized by the fact that the tests of verisimilitude of coeficients give values very much near to the inferior limits of the admissibility interval.

A special place among the econometric models for foreign trade analysis is held by the *import or export functions.* Usually, they are not part of a model aiming at analysing the national economy as a whole, but their sole aim is to supply information as regards the dynamics of import or export, their possible level in conditions given.

Formally, such a function can be written:

$$M(\text{or } E) = f(x_1,\ x_2,\ \ldots,\ x_n) \tag{19}$$

where

M = the volume of imports
E = the volume of exports
$x_1,\ x_2,\ \ldots\ x_n$ = the level of achievement of the influence factors.

Such a function might explain, for example, the index of imports ($I_t = M_t/M_0$) in the year t as compared to the basic year through the volume of the total social product in the plan year (P_t) and through the weight, in the plan year, of exports in the total social product (E_t/P_t) — an indicator by which we try to characterize the import financing possibilities. The analytic form of the import function is in this case:

$$I_t = P_t^a(E_t/P_t)^b\ e^{cn} \tag{20}$$

in which we noted with n the number of the years in the considered planing period.

As regards exports, there is quite a wide — spread opinion that their study through a function of the form (19) is less conclusive, because trade relations are better explained through demand than supply.[13]. Nevertheless, export functions of the above-mentioned form have been worked out. The function worked out by Krelle[14], expressing the volume of exports in a certain year through the volume of exports in the basic year, corrected through

[13]) A. BABEAU and P. H. DERYCKE: *Problèmes de planification.* Sirey Publishing House, Paris, 1967.

[14]) W. KRELLE: *Prévisions pour les exportations.* Cahiers de l'ISEA, serie AC, no. 3, 1963.

the relative index of the price and through the incomes index of the commercial partners, is better known. The analytic form of the model is:

$$X_t = X_0\left(1 + e_1 \frac{\Delta P_2}{P_r} + e_2 \frac{\Delta Y_{ext}}{Y_{ext}}\right) \qquad (21)$$

where

X_t represents the volume of exports in the year t;
X_0 — idem in the basic year;
e_1 and e_2 — the flexibility of exports in comparison with the relative price, respectively with the partners' income;
$\frac{\Delta P_r}{P_r}$ = relative variation of the relative price in the examined period
$\frac{\Delta Y_{ext}}{Y_{ext}}$ = idem of the partners' income.

We consider that the model is less operative because of the "partners income" factor, for which statistical information is insufficient and has a rather high degree of approximation.

3. A MODEL OF MACROECONOMIC GROWTH OUTLINING THE INFLUENCE OF FOREIGN TRADE

Rijckeghem's [15] model tackles with the aid of the "input-output" method the main flows — incomes and expenses — in economy and between the economy studied and the foreign commercial partners. The balance between the flows is:

Expenses / Incomes	Enterprises	Population	Investments	Foreign Partners	Total
Enterprises	—	C°	I°	X	P
Population	Y	—	—	—	Y
Foreign Partners	M_1	M_2	M_3	—	M
Total	P	C	I	X	—

[15] W. J. van RIJCKEGHEM: *L'équilibre extérieur et la croissance économique.* Cahiers économiques de Bruxelles, 1968

in which the following notations were used:

C° — sales of consumer goods by enterprises to the population (purchases of consumer goods by the population from enterprises);
I° — the receipts of the enterprises from the sales of means of production destined for internal investments;
X — the receipts of the enterprises from exports;
P — internal raw product;
Y — the incomes of the population from enterprises;
M_1 — the incomes of the foreign partners from enterprises (the imports of means of production for current production)
M_2 — the incomes of the foreign partners from the population (the imports of consumer goods);
M_3 — the imports of means of production for internal investments;
M — total imports;
C — total consumption of the population;
I — total internal investments.

It results from the list that there are four groups of factors for expenditure flows and three for income flows. Obviously, in connection with the working out of these groups, certain remarks can be made and counter-proposals may exist, but, in certain limits, the group proposed may be accepted as a working hypothesis.

Nevertheless, we appreciate that Rijckeghem has excluded a number of elements the absence of which is felt in the subsequent analysis. The internal productive consumption of the enterprises, the social consumption and the flows inside the group "population" were also left aside.

From the list of the incomes and expenses flows, van Rijckeghem builds four book-keeping equalities:

$$C^\circ + I^\circ + X = P \tag{22}$$

$$Y + M_1 = P \tag{23}$$

$$M_1 + M_2 + M_3 = M \tag{24}$$

$$I^\circ + M_3 = I \tag{25}$$

which reflects the structure of some aggregate sizes, such as the internal raw product, imports and investments.

These equalities are completed by another 5 "conduct" equations, reflecting certain relations between the main component parts of the incomes and expenses flows:

$$C^\circ = c^\circ Y \tag{26}$$

$$M_2 = m_2 Y \tag{27}$$

$$M_1 = m_1 P \tag{28}$$

$$\dot{P} = pI \tag{29}$$

$$\frac{I^\circ}{M_3} = \frac{g}{m_3} \tag{30}$$

where

c° — represents the share of the population's consumption from home-made goods in the total incomes of the population from enterprises;

m_1 — the share of the imports of means of production for current production in the total internal raw product;

m_2 — the share of the imports of goods for the population in the total internal raw product;

m_3 — $\frac{M_3}{P}$ = the efficiency coefficient of the imports of means of production for investments, reflecting the value of the imports of such means for increasing the internal raw product by one monetary unit;

g — $\frac{I^\circ}{\dot{P}}$ = efficiency coeficient of investments from internal resources reflecting the value of the means of production of home-make destined for current production necessary for the increase of the internal raw product by one monetary unit;

p = efficiency coefficient of total investments[16]

In connection with the efficiency coefficient of total investments, we note the following relation:

$$g + m_3 = \frac{I^\circ}{\dot{P}} + \frac{M_3}{\dot{P}} = \frac{I}{\dot{P}}$$

so that we have

$$p = \frac{1}{g + m_3}. \tag{31}$$

The introduction of a parameter of this form is required by the fact that in all the situations of the solving of the model, van Rijckeghem supposes investments as an exclusively exogenic variable. It results from (31) that with regard to the content, the coefficients p, g and m_3 are different: p is an efficiency coefficient in the sense of production at an invested monetary unit; g and m_3 are efficiency coefficients in the sense of consumption of investments in means of production for a production monetary unit.

In the system (22)—(30), the variables C°, I°, M, P, Y, M_1, M_2 and M_3 are endogenic and the rest exogenic. The system is outsized so that one of the exogenic variables may be turned into an endogenic variable. Van Rijckeghem solved the model in the hypothesis that the incomes of the enterprises from export constitute an endogenic variable. In this hypothesis, he explains the relation between the settlement of the balance of trade and the incomes of the population, on the one hand, and the efficiency coefficient of

[16] Notation introduced by us for simplifying the presentation

total investments, the rate of increase of the internal raw product and the structure of the population s incomes, on the other hand.

The introduction of these parameters enables a thorough analysis as regards investments, especially in the sense of the structure, on purveyors, of the means of production necessary for investments. These efficiency parameters are established, in the socialist countries, for the level of the national economy, so that they belong to the economic policy. In certain conditions, one of them may be considered endogenic, so that by solving the model extremely valuable information concerning the orientation of economic policy decisions may be obtained.

For a thorough analysis especially as regards foreign trade activity, van Rijckeghem considers, in addition, the hypothesis of a foreign balance of trade in equilibrium, which means another equation in the (22)—(23) system, namely:

$$X - M = 0 \tag{32}$$

In the new system, one of the exogenic variables can also be made endogenic. Van Rijckeghem inclines towards the parameter m_2, underlining that the domain of economic policy is approached in this way. This possibility is tempting, but we cannot overlook the fact that the efficiency parameters of investments (m_3 and g) have a dynamic character and that the hypothesis of their exogenic determination raises serious methodological problems, many of them still unsolved. Taking this into account, we consider more useful the exogenic establishment of other variables and the determination of these parameters through the model.

The present article proposes to describe some of the main types of models used at present in the study of foreign trade activity in various countries. The choice of one or another for a study of our country's foreign trade requires a thorough analysis of the peculiarities and specific character of exports, imports and even of our national economy, surpassing the limits of the present study.

L'ANALYSE DE L'ACTIVITE DE COMMERCE EXTERIEUR AU MOYEN DES MODELES MATHEMATIQUES

L'auteur expose quelques types de modèles utilisés dans l'analyse du commerce extérieur, avec les caractéristiques principales et certains résultats obtenus. On présente des modèles du type prévision, de modèles économétriques, modèles du type croissance.

Tenant compte des l'expérience acquise dans l'utilisation de ces modèles, appliqués à l'analyse du commerce extérieur,l'on présente, aussi, quelques uns des plus importants facteurs d'influence de cette activité.

On relève quelques aspects de l'accroissement dans une économie ouverte.

La partie finale de l'article contient la présentation d'un modèle sur le problème d'équilibre d'une balance extérieure de payements (tout particulièrement de commerce extérieur) dans une économie en plein essor, ainsi que l'influence de cette balance sur le développement économique.

АНАЛИЗ ВНЕШНЕТОРГОВОЙ ДЕЯТЕЛЬНОСТИ ПРИ ПОМОЩИ МАТЕМАТИЧЕСКИХ МОДЕЛЕЙ

В настоящей статье приводится несколько типов моделей, применяемых при анализе деятельности внешней торговли, с их основными характеристиками, а также некоторые достигнутые результаты. Указываются модели прогнозного типа, экономические модели и модели типа роста.

В свете опыта применения этих моделей при анализе деятельности внешней торговли выявляются отдельные наиболее важные факторы влияния этой деятельности.

Указываются некоторые аспекты роста в «незамкнутой экономике».

Статья заканчивается представлением модели, касающейся задачи уравновешивания внешнеплатежного баланса (в частности, внешней торговли) в народном хозяйстве в процессе роста, а также влияния этого баланса на экономическое развитие.