
**POLISH ACADEMY OF SCIENCES
SYSTEMS RESEARCH INSTITUTE**

**THE INTERNATIONAL
ECONOMIC COOPERATION**
THEORETICAL FOUNDATIONS

STANISŁAW PIASECKI



**POLISH ACADEMY OF SCIENCES
SYSTEMS RESEARCH INSTITUTE**

**THE INTERNATIONAL
ECONOMIC COOPERATION**

THEORETICAL FOUNDATIONS

STANISŁAW PIASECKI

Warszawa 1992

PREFACE

The main difference between the work here presented and the other studies related to the same, generally speaking, domain, consists in the fact that considerations contained in this book indicate the possibility of resolving questions concerning the choice of the subject and establishment of profitability of international trade and cooperation in conditions when:

- * prices on the internal market do not correspond to social costs,

- * there is lack of conviction as to correctness of exchange rates,

- * prices in international trade are subject to manipulations, resulting from definite interests of some countries, or they simply cannot follow the development of world production system.

As can easily be noticed these are just the conditions in which currently the international trade and cooperation system is being shaped. These particular conditions result, for instance, from governmental subsidies oriented at individual commodities or groups of commodities (e.g. food products), from existing custom tax barriers and from an extremely quick pace of technological progress in the techniques of production.

INTRODUCTION

The problem of international exchange was presented for the first time in precise mathematical terms by Wassily Leontief in his paper entitled "Factor Proportions and the Structure of American Trade", published in *Review of Economics and Statistics* (1956, vol. 38, no. 4).

The first mathematical approach to the problem presented in Poland, was of international industrial cooperation formulated in the Doctoral dissertation of Andrzej Ameljańczyk (Military Technical Academy, 1975), supervised by this author.

Earlier, a similar formulation of the problem of international trade exchange had been forwarded in the Doctoral dissertation of J.Kotyński (Main School of Planning and Statistics, Warsaw, 1968).

If we distinguish the specific problem of international economic cooperation within the broader domain of international trade exchange then the first monograph devoted entirely to economic cooperation is the book in Polish by S.Piasecki, J.Hołuniec and A.Ameljańczyk, entitled "International economic cooperation - Modelling and Optimization" (PWN, Warsaw-Lódź, 1982).

The assumption of complementarity of goods, characteristic for the problem of cooperation, was first introduced by D.Graham in 1923 in his paper "The Theory of International Values Examined" (*Quarterly Journal of Economics*, vol. 38, no.1).

The present publication contains the original results of studies conducted during the years 1982-1985, being a continuation of work started a dozen years before.

Models of international cooperation considered there (see Chapters 1 to 3) were much simpler than in the ones presented here. Still, they are, alas, only theoretical models, which cannot be practically applied in economic activity.

Notwithstanding this situation, the models give certain possibilities with respect to applications. I am convinced that

further in-depth studies in and broadening of the theory presented here will make out of it in the future a perfect instrument for economic practice. I think that conclusions resulting from it may contribute to quicker reequilibration of the international economic system, which has been put so much off the equilibrium by the existing debts.

Against the background of existing numerous publications dealing with international trade and cooperation, as well as international specialization, the theory here presented does not require acceptance of the commonly up to date adopted assumption concerning economic equilibria within the cooperating countries, and, furthermore, this theory has much greater practical potential than the previous theories, in which it has been necessary to assume existence of economic equilibrium prices for comparing profitability of trade.

Since the theory presented in this book is independent of existence of prices, it can also be used in determination of the price structure of goods included in the trade, profitable for the partners in such an international trade deal. Thus, the structure determined ("terms of trade") guarantees stimulation of international cooperation and improvement of international specialization.

On the other hand, the theory can also be used in deciding whether the structure of prices actually existing in the international market is enhancing or, to the contrary, hindering, the development of trade, whether it does not lead to an unsound development of some of the partners at the expense of the other ones. It is not difficult to realize that the theory presented, and especially its results, concern one of the essential economic problems of present time.

The theory has, indeed, its weak points as well. A number of technical simplifying assumptions put aside (their number shall be decreasing as the theory develops), there is one fundamental assumption. It says that every participant of cooperation relation (of international trade) tries to produce the maximum of necessary goods of a given structure, entering the group

considered.

When these ones are consumption goods, we are dealing with the situation, when every partner (every national economy) participating in international exchange, is geared towards maximization of the living standard of own population, given a consumption structure characteristic for this population.

When, however, these are not consumption goods, but, e.g. semi-products, then this corresponds to the situation in which every participant-producer tries to maximize own production, this production determining the structure of demand for semi-products encompassed by cooperation. From this point of view the theory presented may get applied beyond the domain of international cooperation.

Technical simplifications adopted in the book result from the wish of possibly clear and understandable presentation of the theory. Thus, wanting to show graphically the mechanism of cooperation and to illustrate the results of the theory, the present author emphasizes in the book bilateral cooperation encompassing only two kinds or groups of commodities. Analysis of the thus simplified problem is contained in first seven chapters of the book.

The eighth chapter is in a way a generalization of considerations presented in the previous chapters so as to account for the case of multilateral cooperation, involving multiple goods. This chapter may constitute a separate whole - a summary of the contents of the book.

1. GENERAL PREREQUISITES

The problems of determination of economic cooperation which would be profitable for both sides and of economic specialization related to it are being considered on the example of two goods which are the subject of trade. As partners of the exchange process we can consider both enterprises (large establishments, conglomerates etc.), national or international, and national economies. Consequently, cooperative exchange leading to specialization may both have intra-national and inter-national nature.

Before explaining what is meant by "two kinds of goods" let us establish initially what is the purpose of cooperative exchange or, generally, of trading.

We shall assume that the purpose of cooperation is to increase "consumption" of the goods considered by both partners. Obviously, only such cooperation or trade is advantageous for both sides.

Consumption shall be understood as using up of a good by:

- other technological processes of cooperating enterprises,
- other branches of economy of cooperating countries,
- populations of cooperating countries.

Assume that both partners try to maximize "consumption" thus defined, for it makes possible a growth in production of other goods, bringing in certain advantages, or better satisfaction of population needs. We shall also assume that within the framework

of the expected magnitude of increase in consumption level due to appearance of the cooperation links, we may disregard the fact that in reality the magnitude of these needs is limited, thereby adopting, for calculation purposes, the assumption of the requirement of an unlimited growth of consumption level. This does not signify, though, that the magnitudes of needs in both goods are equal. We assume namely, that we are given a consumption structure of these goods - proportions between consumption levels of particular commodities.

We shall in addition assume that the production scale of the cooperation goods of both sides, together with possibly broadly understood effectiveness of their production, may be different for the sides involved.

In this, production scale is limited by the production potential, different, in principle, for the sides involved, both as to the magnitude and the type of production technology adopted. It is easy to guess that cooperation may bring in advantages only when characteristics of production potentials of both sides are different, at least as to their magnitudes.

In case of enterprises (economies) which are identical as to all their aspects, cooperation has no sense.

Let us pass now to a more precise definition of the assumptions adopted.

First let us explain what we mean by "two goods". We shall refer for this to an example.

Let the object of cooperation between two enterprises (economies) producing - among other goods - trucks, be their engines and chassis. Additionally, one of the partners has greater capacity in production of engines, while the other - in production of chassis. It is obvious that each of the sides wants to produce as many lorries as possible, so that the "structure" of consumption of both types of goods - engines and chassis - is identical in both countries. Thus, for instance, two engines are needed for each chassis, taking into account the fact that the

second engine is needed as a spare one for exchanging the old one, worn out in exploitation, for its durability is twice shorter than that of chassis.

When we consider the needs in element exchange during car use we see that importation of engines must be paralleled by importation of such spare parts as, for instance: valves, bearings, dynamos etc. Similarly, imports of chassis must be paralleled by imports of such elements as: differential gear mechanisms, brakes, bearings etc.

Consequently, the good appearing as "engine" shall in fact comprise a set of products, containing the engine itself, and a number of spare parts for the engine, in the definite proportions. We can define similarly the good called "chassis", i.e. as the set of certain products, in definite proportions, containing, obviously, as the main element - the chassis itself.

Let us turn attention to one aspect yet related to the notion of two goods distinguished. The fact, that we are considering only two distinct goods, thus understood, is not equivalent to consideration of enterprises in which only these two types of goods appear. To the contrary - they were distinguished solely because of the fact that they are (or will be) the subject of exchange, that they are necessary for functioning of the enterprise, that there is demand for them from "other" technological or economic processes, left out of analysis here. These "other" processes are represented in our model by the demand (for the goods distinguished), treated as the consumption needs of the remaining part of the enterprise (economy). Consequently, in the enterprise or the national economy considered we do distinguish two commodities together with the technological processes of their production, understanding that they reflect only a portion of the enterprise - see Fig.1.

In case when we analyse exchange on the level of national economies, "other" processes encompass the "rest" of economy (i.e. besides the distinguished processes of production of the goods

considered), including also the population of the country. In particular when the products distinguished are two sets of consumer goods, the consumption needs have a simple interpretation of consumption demand of the population.

It would be a more general - a weaker - assumption to admit as the object of exchange a set of distinct goods with cardinality greater than two, but thereby our further considerations would be made much more complex. If there exists a need of analysing cooperation exchange when cardinality of the set of commodities is greater than two (and we cannot aggregate these goods to just two, assuming that definite proportions among them must be kept to, exactly as we did for the case of exchange of engines and chassis) then we can apply the methodology here described by "breaking down" the set of goods considered into a family of all pairs. This operation, though, is somewhat artificial, and that is why the assumption of trading two goods is essential.

Now, let us explain what we understand by the level (magnitude) and structure of consumption.

Let us for this purpose denote by β_i^k the magnitude (level) of consumption of the good i in the enterprise (economy) k , expressed in natural units (tons, cu. meters, kilometers, sq. meters etc.) per unit of time - usually one year. Thus, the vector

$$\hat{\beta}^I = \langle \beta_1^I, \beta_2^I \rangle$$

defines the level of consumption of goods indexed $i=1,2$, for the side $k=I$, while the vector

$$\hat{\beta}^{II} = \langle \beta_1^{II}, \beta_2^{II} \rangle$$

defines the level of consumption of goods indexed $i=1,2$, for the second side, $k=II$.

The structure of consumption, determining the required

proportions among the quantities of goods consumed, shall be denoted by the vector

$$\hat{\gamma}^k = \langle \gamma_1^k, \gamma_2^k, \dots, \gamma_1^k, \dots, \gamma_J^k \rangle$$

where $\gamma_1^k = \frac{\beta_1^k}{\beta_{i_0}^k}$

with i_0 denoting the index of the selected (distinguished) kind of commodity. Since in our case $J=2$, then by taking for further considerations $i_0=1$ we obtain

$$\hat{\gamma}^k = \langle 1, \gamma_2^k \rangle, \text{ for } k=I, II$$

so that the structure of consumption of both sides is determined by the numbers γ_2^I and γ_2^{II} .

It is assumed further on in this book, for simplicity, that the structures of consumption of both cooperating sides are identical, that is, that the equality

$$\gamma_2^I = \gamma_2^{II} = \gamma$$

holds. Thus, the purpose of cooperation is the maximum increase of consumption of the goods distinguished, under the predefined consumption structure. It is essential here that we assume identity of the structures of needs of both cooperating sides.

An example of adequacy of the assumption made above is provided by the case in which the objects of exchange are two semi-products, of which the same final product (e.g. a car) is put together in both countries. It is in this case obvious that the structures of demand of the processes of mounting of the cars are identical in both countries.

The above reasoning is of course valid also in the case of two

cooperating enterprises. Another example can be provided by two food products (e.g. meat and cereals) whose consumption structure could be assumed identical for the two countries.

Then, it is necessary to explain the notion of "productive potential" for a given kind of commodities (products). Assume for a while that in a given country (enterprise) we decided to produce uniquely the product number 1 (without a change in production levels of other goods), with simultaneous purchase of the good number 2 and that we shall then attain the maximum production of the commodity 1, namely A_1^I . Lack of possibility of further increase of production results from the fact that there is, in the production process, some technological subprocess which constitutes a "bottleneck", limiting the output capacity, so that any additional increase of production capacities would require, of necessity, an investment input into machines and equipment - an investment-bound growth of production capacities. The quantity A_1^I shall be called characteristics of production potential for the commodity "1", and the technological process being the bottleneck of production shall be referred to as the critical process.

Consider now the second possibility, that is - production of the good "2" exclusively (in conjunction with the purchase of product "1"). We obtain in this situation the second magnitude, A_2^I , defining the maximum production capacities for product "2" in country (or enterprise) I. The couple (A_1^I, A_2^I) fully characterizes the production potential of an enterprise - or a country - I from the point of view of exchange of goods which are of interest for us. Both magnitudes of the couple are expressed in natural units, corresponding to goods "1" and "2", respectively, per unit of time - one year.

We shall express in identical units the intensity (or scale) of production of good "1" - α_1^I , and of good "2" - α_2^I (for enterprise or country I). There is, obviously, $\alpha_1^I = A_1^I$ and $\alpha_2^I = A_2^I$. An essential assumption that we are making here is the one which says that the critical technological processes being "bottlenecks" in production

of goods "1" and "2" are the same. The case, when the critical processes for the two goods are different, was described in [***]. The consequence of such an assumption is that the production intensities α_1^I and α_2^I shall be limited by the common inequality:

$$\frac{\alpha_1^I}{A_1^I} + \frac{\alpha_2^I}{A_2^I} \leq 1$$

Similarly, we shall assume that the productive potential of the enterprise (or country) II is characterized by the quantities A_1^{II} and A_2^{II} , and that the quantities α_1^{II} and α_2^{II} , corresponding to production intensities of goods "1" and "2", respectively, in enterprise (country) II, are constrained by the common inequality, similar to the one presented before:

$$\frac{\alpha_1^{II}}{A_1^{II}} + \frac{\alpha_2^{II}}{A_2^{II}} \leq 1$$

This inequality results from the limited output capacity of the technological process being the bottleneck from the point of view of turning out products "1" and "2" in country (enterprise) II.

Note that the kinds of critical technological processes which are the bottlenecks in countries I and II do not have to be identical. Thus, for instance, for the enterprise (country) I the critical process may be the process of machining, while for the enterprise (country) II the critical process may be the casting process (in case when cooperation encompasses two products of metal industries, say - engines and gears). This results from the fact that production of the commodity "1" requires work defined in technological normatives, both for the casting and for the machining tools. Then, the numerical values of quantities A_1 and A_2 result from the numbers of casting and machining equipment and from the mentioned technological normatives.

If the goods considered were plants (e.g. wheat and corn) then for the given surfaces of cultivation of both these cereals the magnitudes A_1^I and A_2^I would be defined as the products of crop yields per surface unit and the surfaces S_1^I and S_2^I . The role of the bottleneck is played by the limited cultivation surface.

Having explained the assumptions adopted for further considerations, let us pass over now to a more detailed characterization of a single enterprise (or country) from the point of view of production and exchange of both distinguished products (raw materials, semi-products and final products). In considerations concerning single enterprises (countries) we shall be omitting indices I and II, assuming, that the reasonings presented would equally concern both partners.

2. THE MODEL OF ECONOMIC ACTIVITY

If we understand by α_j (the intensity of global output) the magnitude of production in a given year (or the so called scale of production), that is the quantity of the good "j" expressed in natural units proper for this good over a unit of time, one year, then net output of this product, c_j , is defined by equation

$$c_j = \alpha_j - \sum_{i=1}^J \alpha_i b_{ij}, \quad j=1,2$$

constituting a known model linear with respect to α_i . In our considerations this model shall be valid within the boundaries of variability of α_i determined by the inequality

$$\sum_{i=1}^J \frac{\alpha_i}{A_i} \leq 1$$

These two relations define therefore together a nonlinear model

BIBLIOGRAPHY

1. Aganbegyan, A., Bagrinovski, K., Granberg, A.: Modele matematyczne w planowaniu gospodarczym (mathematical models in economic planning, in Polish). PWE, Warszawa 1974.
2. Ameljańczyk, A.: Niefinansowy model sterowania współpracą międzynarodową (A non-financial model of controlling the international cooperation, in Polish). *Organizacja i Kierowanie*, No. 3/1976.
3. Ameljańczyk, A., Hołubiec, J., Piasecki, S.: Optimisation of international economic cooperation. *Ricerche Economiche*, no.1, 1978.
4. Ameljańczyk, A., Hołubiec, J.: Optimal international economic cooperation and solution of a multi-person cooperative game. *Ricerche Economiche*, no.1/2, 1981.
5. Ameljańczyk, A.: Multicriterial optimisation of international economic cooperation. Vth International Conference on Systems Science, Wrocław (Poland), 1978. *Prace Naukowe ICT Politechniki Wrocławskiej*, no.39, 1978.
6. Ameljańczyk, A., Hołubiec, J.: Modelling of international cooperation in energy by multiperson cooperative game. *Proc. of the First International Conference on Applied Modelling and Simulation*, AMSE, Lyon, 1981 (vol.V).
7. Ameljańczyk, A., Hołubiec, J.: Compromise solution of multiperson cooperative game and its application to international energy consumption. *Large Scale systems, Theory and Applications*. Pergamon Press, London, 1983.
8. Ameljańczyk, A., Hołubiec, J.: The influence of political conditions on the international economic cooperation. *Proc. of SWISS Workshop: Supplemental Ways for Improving International Stability*. Pergamon Press, Oxford, 1984.
9. Ameljańczyk, A., Hołubiec, J.: Modelling of economic cooperation among blocks of countries with different politico-economic objectives. *9th World Congress of IFAC*. Pergamon Press (IFAC Proc. Series, no.6), Oxford 1985.

10. Aumann, R.J.: Existence of competitive equilibria in markets with a continuum of traders. *Econometrica*, 34/1966.
11. Bondareva, O.N.: O teoretiko-igrovyykh model'akh v ekonomik'e (On game theoretical models in economics, in Russian). *Izd. Leningradskogo Universiteta*, Leningrad 1974.
12. Czerwiński, Z.: Problematyka planowania cen w ujęciu matematycznym (The problem of price planning in the mathematical perspective, in Polish). PTPN PAN, Poznań 1963.
13. Czerwiński, Z.: Podstawowe problemy konstrukcji racjonalnego systemu cen. *Poznańskie Roczniki Ekonomiczne*. Poznań 1969.
14. Debreu, G.: Economies with a finite set of equilibria. *Econometrica*, 38, 1970.
15. Debreu, G., Scarf, H.: A limit theorem on the core of an economy. *Internat. Econ. Rev.*, 4, no.3, 1963.
16. Gale, D.: On optimal development in a multi-sector economy. *Review of Economic Studies*, 34/1, no.97, 1976.
17. Gale, D.: *The Theory of Linear Economic Models*. McGraw-Hill, New York 1960.
18. Gale, D.: On optimal development in a multi-sector economy. *Rev. Econ. Studies*, 34, no.1, 1967.
19. Georgesen-Roegen, N.: Some properties of a generalized Leontief model. *Activity Analysis of Production and Allocation*, T.C.Koopmans, ed., New York 1951.
20. Gambarelli, G., Hołubiec, J.: Modelling and optimization of international economic cooperation via fuzzy mathematical programming and cooperative games. *Control and Cybernetics*, no.4, 1988
21. Graham, D.: The theory of international values examined. *Quarterly Journal of Economics*, 38, no.1.
22. Hahn, F., Matthews, R.C.O.: The theory of economic growth. A survey. *Economic Journal*, 74, 1964.
23. Hołubiec, J., Piasecki, S.: La collaborazione economica internazionale e la uniformità dei prezzi internazionali (International economic cooperation and the uniformity of

international prices, in Italian). *Rivista di Politica Economica*, no. 12, 1978.

24. Holubiec, J.: Modelling of the International Economic Cooperation. *System Theory and Mathematical Economics*. Pitagora Ed., Bologna, 1986.

25. Intriligator, M.: *Mathematical Optimization and Economic Theory*. Prentice Hall, New York 1971.

26. Kemeny, J.G., Morgenstern, O., Thompson, G.L.: A generalization of the von Neumann model of an expanding economy. *Econometrica*, 24, no.2, 1956.

27. Kotyński, J.: *Teoria wymiany międzynarodowej a programowanie liniowe*. PWE, Warszawa 1970.

28. Kulikowski, R., ed.: *Modelowanie systemowe społeczno gospodarczego rozwoju kraju (Systems modelling of the socioeconomic development of a country, in Polish)*. PWN, Warszawa 1979.

29. Leontief, W.: Factor proportion and the structure of American trade. Further theoretical and empirical analysis. *Review of Economics and Statistics*, 38, no.4.

30. Leontief, W.: *Structure of American economy 1919-1929* Cambridge-Massachusetts, Harvard Univ. Press 1941.

31. Leontief, W., Carter A.P., Petri P.A.: *The Future of the World Economy*. New York 1977, Oxford Univ. Press.

32. Luce R.D., Reiffa H.: *Games and Decisions*.

Wiley and Sons, New York 1957.

33. Maciejewski, W.: *Algorytmy optymalizacji struktury handlu zagranicznego i kursów kierunkowych (Algorithms of optimization of the structure of foreign trade and the directional rates, in Polish)*. *Zastosowanie metod matematycznych do analizy ekonomicznej*. ZBKS HZ, Warszawa, 1968.

34. Maciejewski, W.: *Ekonometryczne modele wymiany międzynarodowej (Econometric models of international trade, in Polish)*. PWN, Warszawa 1981.

35. Mycielski, J., Trzeciakowski, W.: *Critères du choix des investissements rapidement rentables (Criteria of choice of quick*

repayment investments, in French). *Economies and Societies*, no.1, 1970.

36. Mycielski, J., Rey, K., Trzeciakowski, W.: *Decomposition and Optimization of Short-Run Planning in a Planned Economy* (T. Barna, ed.). London 1963.

37. Nash, J.F.: Equilibrium points in n -person games. *Proc. Nat. Acad. Sciences, USA*, 36, 1950.

38. von Neumann, J., Morgenstern, O.: *Theory of Games and Economic Behaviour*. Princeton 1974.

39. Nikaido, H.: *Convex Structures and Economic Theory*. Academic Press, New York - London 1968.

40. Pawłowski, Z.: *Ekonometria (Econometrics, in Polish)* PWN, Warszawa 1978 (fifth edition).

41. Piasecki, St., Ameljańczyk, A.: A control of international economic cooperation. IVth International Conference on Systems Science, Wrocław, Poland, 1977. *Prace Naukowe ICT Politechniki Wrocławskiej*, no.47, 1977.

42. Piasecki, St., Hołubiec, J.: Sterowanie wymianą gospodarczą (Controlling the economic exchange, in Polish) *Prace IBS PAN*, no.32, Warszawa 1979.

43. Piasecki, St., Hołubiec, J.: Wieloletnia koordynacja międzynarodowego rozwoju gospodarczego (Multiannual coordination of the international economic development, in Polish). *Prace IBS PAN*, no.52, Warszawa 1980.

44. Piasecki, St., Hołubiec J.: International economic cooperation and the uniform international prices (in Polish). *Prace IBS PAN Nr 52*, Warszawa 1980.

45. Piasecki, St., Hołubiec, J.: Pewne zagadnienie międzynarodowej współpracy gospodarczej (On a certain problem in international economic cooperation, in Polish). *Prace IBS PAN*, no.77, 1981.

46. Piasecki, St., Hołubiec, J., Ameljańczyk, A.: Międzynarodowa kooperacja gospodarcza (The International Economic Cooperation, in Polish). PWN, Łódź - Warszawa 1982.

47. Piasecki S.: *Model of Socio-Economic National Development*

(in polish). Prace IBS PAN, No 164 Warszawa 1988.

48. Piaszczyński, W.: Matematyczne modele teorii handlu międzynarodowego (Mathematical Models of the Theory of International Trade, in Polish). PWE, Warszawa 1974.

49. Rosati, D.: Polityka eksportowa. PWE, Warszawa 1990.

50. Rosenmüller, J.: Kooperative Spiele und Market (Cooperative Games and Market, in German). Springer Verlag, Berlin - Heidelberg - New York 1971.

51. Roth, A.E.: Subsolutions and supercore of cooperative games. *Mathematics of Operations Research*, vol.1, no.1, 1976.

52. Shapley, L.S., Shubik, M.: On market games. *J.Economic Theory* 1, no.1, 1969.

53. Shubik, M.: Edgeworth market games. *Annals of Math. Studies*, vol.IV, no.40, 1959.

54. Solow, R.M.: A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70, 1956.

55. Shagalov, G.L.: Problemy optimalnogo planirovaniya vneshe-ekonomicheskikh svyazey (Problems of optimum planning of external economic relations, in Russian). Izd. Moskva 1973

56. Trzeciakowski, W.: Modele pośredniego kierowania gospodarką planową w sterowaniu handlem zagranicznym (Models of indirect management of a planned economy in the control of foreign trade, in Polish). PWE, Warszawa 1975.

57. Tsukui, J.: Turnpike theorem in a generalized dynamic input-output system. *Econometrica*, 34, no.2, 1966.

58. Uzawa, H.: Optimal growth in a two-sector model of capital accumulation. *Review of Economic Studies*, 31, 1964.

For order and other information, please write to:

**Systems Research Institute, Polish Academy of Sciences
ul. Newelska 6, 01-447 Warsaw, Poland
Fax: +4822/37 27 72**

ISBN 83-90-00412-5-1