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INTENSITY OF TRADE AMONG THE CMEA AND THE EEC

1. Introduction

The paper aims to examine the relative intensity of intra-regional trade among seven European member countries of the Council of Mutual Economic Assistance (CMEA) and nine member countries of the European Economic Community (EEC) in the period 1970-1980[1].

The analysis is based on stochastic measures (compatibility and correlation coefficients) defined on the international trade flow matrix. The value of these coefficients depends on the ratio of actual and theoretical trade flows. The latter are derived by use of a probabilistic model[2]. It is assumed that the origin and the destination of the consignments traded internationally are quasi-independent[3].

Methodological concepts are introduced in the Appendix A (Section 5). The SCORE algorithm used for calculation of the parameters S, P_i, Q_j determining the theoretical trade distribution and, subsequently, the bilateral trade intensity indices (compatibility and correlation coefficients) is also provided.

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[1] Complete results of the study are presented in J. K o t y ń s k i (1979) to be published in 1986, Cf. also separate studies on the intra-group trade of the CMEA (J. K o t y ń s k i (1983)) and the EEC (J. K o t y ń s k i (1984)).

[2] The approach proposed by I.R. S a v a g e and K.W. D e u t s c h (1960).

[3] This term was introduced by L. A. G o o d m a n (1968).

In Section 2 the empirical results obtained by application of an open trade model are presented. This approach takes into account not only the intra-group trade but also the CMEA and the EEC dependence on trade with other countries in 1980.

In Section 3 a close group trade model is adopted. In this case the CMEA and the EEC trade links with non-member countries are not taken into consideration.

Respective integrational groupings are subdivided in both Sections 2 and 3 into subsets which agglomerate the partners most strongly linked by trade. For that purpose some taxonomic methods are applied, e.g. dendrite arrangement.

The conclusions on the concentration of the intragroup trade and on the arrangement of countries according to their mutual trade distance are summed up in Section 4. They differ substantially, depending on the trade model selected as a basis. The approaches adopted in Sections 2 (open model) and 3 (closed model) are however complementary. They allow, on the one hand, for evaluation of the tendency towards strong geographical concentration of the CMEA and the EEC global trade on the intra-regional turnover. On the other hand, the tendency towards relatively uniform geographical distribution of the intra-trade of the respective groupings is also revealed and quantified.

2. Application of an open trade model

2.1. Intra-CMEA Trade

Trade intensity indices (correlation and compatibility coefficients)[4] have been computed on the basis of the 1980 world trade matrix (fob, in US dollars), disaggregated by 35 countries or regions, compiled from the UN trade statistics ("Monthly Bulletin..." (1982)). Values of the indices are multiplied by 100. Hence the correlation coefficients are scaled in the interval ⟨ -100, 100 ⟩. The compatibility coefficients corresponding to the quasi-independence level of inter-country trade are equal to

[4] For definitions and methods of calculation of the trade intensity indices see Appendix A.

100. In case of no trade the latter coefficients are equal to 0. Higher values of both kinds of indices reflect higher intensity of bilateral trade links or lower relative trade distance[5].

Both trade intensity measures are closely related. Shares of total exports and imports of partners in the global value of international trade constitute however a special factor influencing the level of correlation coefficients.

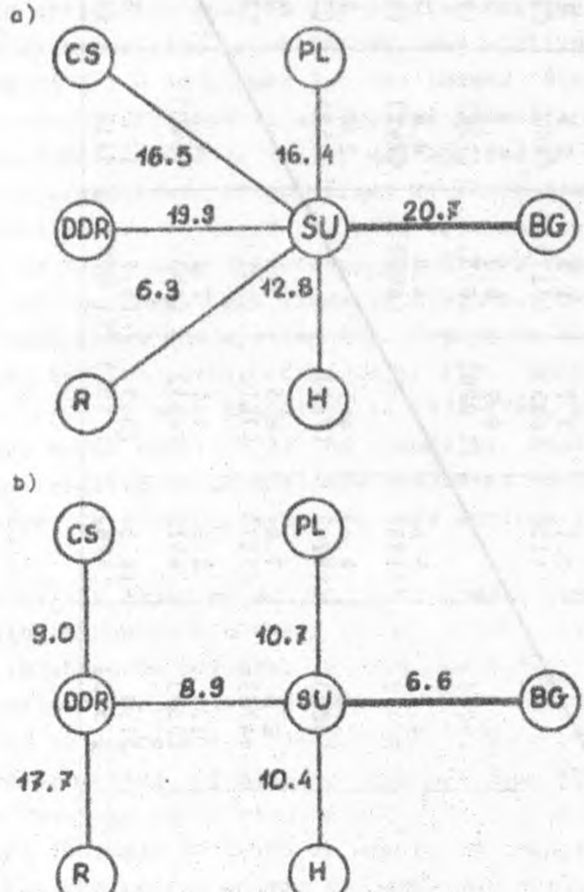

Fig. 1. Dendrite arrangement of the European CMEA member countries by distance in their intra-trade in 1980 (open model) a) taxonomic distance estimated as an arithemetic average of correlation coefficients, b) taxonomic distance estimated as an inverse geometric average of compatibility coefficients

[5] Cf. K. W. Deutsch, W. Isard (1961).

Table 1

Intensity of intra-CMEA trade in 1980 measured by correlation and compatibility[a] coefficients (open model)

x100

Exporter \ Importer	Bulgaria	Czecho-slovakia	GDR	Hungary	Poland	Rumania	USSR
Bulgaria		2.1 (412)	3.7 (605)	1.3 (317)	2.3 (403)	1.5 (341)	20.0 (1 490)
Czechoslovakia	2.7 (521)		8.2 (1 020)	5.7 (695)	6.2 (774)	2.7 (463)	16.4 (1 047)
GDR	4.5 (741)	9.6 (1193)		4.0 (608)	6.4 (741)	3.4 (514)	19.5 (1133)
Hungary	1.0 (307)	4.4 (826)	4.5 (767)		2.4 (455)	1.6 (381)	10.3 (889)
Poland	2.6 (476)	7.0 (917)	6.3 (761)	3.0 (491)		2.8 (328)	15.3 (929)
Rumania	1.5 (363)	2.6 (451)	4.1 (613)	2.3 (453)	2.0 (340)		7.0 (548)
USSR	21.3 (1 543)	16.5 (998)	20.3 (1 106)	15.2 (1 029)	17.5 (941)	5.6 (428)	

[a] In parentheses.

Source: Calculations based on the UN trade series "Monthly Bulletin..." (1982).

Estimates of the intensity indices obtained from an open trade model for the intra-CMEA turnover in 1980 are shown in Table 1. Main conclusions can be drawn easier if the results are presented graphically (Figure 1.) For each country of the group a closest (nearest) trade partner was selected. For this purpose two alternative trade distance measures were computed as transforms of the trade intensity indices. The first (inverse) measure, defined as an arithmetic mean of correlation coefficients related to bilateral export and import flows, was utilized for construction of the dendrite in Figure 1a. The second (direct) trade distance measure, determined as an inverse geometric mean of respective compatibility coefficients, was applied in Figure 1b[6].

Graphic arrangement of countries by their trade distance might be different if two criteria are used alternatively as distance measures. In fact, some differences in graphs representing the intensity of the intra-CMEA trade in 1980 have been found when an open trade model was applied (cf. Figure 1a and 1b). On the other hand, for the intra-EEC trade in 1980 (open model) and for the intra-trade of both groupings in 1970-1980, examined by use of a closed model (Section 3), no essential, qualitative differences in relative trade distance estimates have been revealed when alternative distance measures were applied (cf. Figure 3 and 4).

The analysis based on an open trade model confirmed that the Soviet Union occupied a central place in the intra-CMEA trade, not only in absolute but also in relative terms. The USSR is the nearest partner for all other CMEA countries if the trade distance is measured by correlation coefficients (Table 1, Figure 1a), though the estimates of distance between the USSR and other countries (average correlation coefficients x 100 vary from about 6 (Rumania) to about 20 (GDR) or nearly 21 (Bulgaria). In terms of both open and closed models Bulgaria and the USSR have mutually been the nearest partners for the whole 1970-1980 period, i.e. they have constituted a first - order conglomeration[7].

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[6] Values of both distance measures are multiplied by 100.

[7] Connection between respective models of dendrites for first-order conglomerations are distinguished by a bold line. On the other hand a broken line joins separate subsets of countries.

A dendrite built on the basis of compatibility coefficients (Figure 1b) is more diversified than that corresponding to the correlation coefficients matrix (Figure 1a). Compatibility coefficients are not weighted by trade shares, hence they are not influenced by a major trade share of the USSR. Nevertheless, even in terms of compatibility coefficients and derived taxonomic distance indices the USSR was in 1980 the nearest partner for all other CMEA countries but Czechoslovakia and Rumania, linked relatively closer to the GDR (Figure 1b).

More detailed analysis of inter-country links within the CMEA can be made on the basis of the matrix of trade intensity coefficients reproduced in Table 1.

2.2. Intra-EEC Trade

Analogous calculations have been made for the intra-EEC trade (open model) in 1980. The results are provided in a matrix form (Table 2) and they are summed up graphically in a dendrite (Fi-

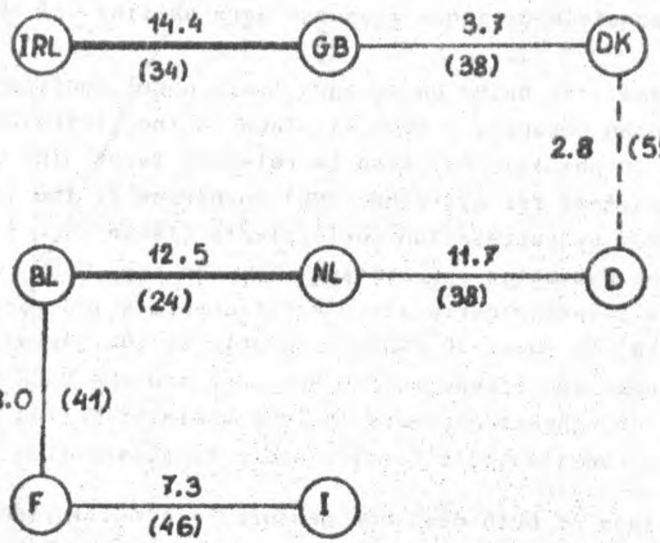

Fig. 2. Dendrite arrangement of the EEC member countries by distance in their intra-trade in 1980 (open model)

Table 2

Intensity of intra-EEC trade in 1980 measured by correlation and compatibility[a] coefficients (open model)

x 100

Exporter \ Importer	Belgium-Luxemburg	Denmark	FRG	France	Ireland	Italy	The Netherlands	United Kingdom
Belgium-Luxemburg		0.5 (124)	7.2 (210)	9.3 (271)	-0.7 (54)	0.4 (109)	10.8 (368)	2.7 (160)
Denmark	-0.9 (55)		2.8 (188)	-0.7 (72)	-0.1 (87)	0.0 (102)	-0.2 (90)	4.0 (279)
FRG	5.9 (182)	2.8 (179)		7.4 (173)	-0.9 (66)	4.8 (157)	8.6 (215)	1.4 (116)
France	6.6 (221)	-0.9 (69)	3.8 (141)		-0.4 (83)	7.6 (219)	0.2 (103)	1.3 (120)
Ireland	0.5 (136)	-0.2 (77)	-0.1 (98)	0.2 (109)		-0.6 (62)	0.5 (134)	11.9 (839)
Italy	0.4 (92)	-0.5 (77)	6.2 (207)	7.0 (218)	-0.6 (64)		-0.3 (92)	-2.9 (40)
The Netherlands	14.1 (453)	2.1 (205)	14.7 (317)	3.2 (158)	-0.3 (81)	1.0 (122)		-3.7 (21)
United Kingdom	2.7 (156)	3.4 (243)	1.6 (119)	1.4 (120)	16.9 (1 025)	-0.7 (88)	2.8 (155)	

[a] In parentheses.

Source: Calculations based on the UN trade series "Monthly Bulletin..." (1982).

gure 2)[8]. In this case the use of two types of trade distance indices resulted in identical dendrite arrangement of countries. Two subsets of the EEC countries have been distinguished. The first one is composed of six original member countries of the Common Market. Among them the Benelux countries constitute a first-order conglomeration. The second subset comprises the United Kingdom linked closely with Ireland (first-order conglomeration) and Denmark. The shortest trade distance between two subsets corresponds to the trade connection between Denmark and the Federal Republic of Germany.

A linear ranking of countries by trade distance is characteristic of the EEC (Figure 2). On the other hand, the pattern of the intra-CMEA trade (Figure 1) is characterized by a distinct, concentric arrangement if an open model is applied.

3. Application of a closed trade model

3.1. Intra-CMEA Trade

A closed model, applied for a specific group of countries, implies the use of a regional trade matrix as a basis for calculation of trade intensity indices. Thus the trade links of the selected group of countries with outside trade partners are not taken into consideration.

Correlation and compatibility coefficients derived from the intra-CMEA trade matrices for 1970, 1975 and 1980 are specified in Table 3. Main trade links among the CMEA, resulting from the closed model, are illustrated graphically in Figure 3. A slightly different dendrite arrangement of countries, due to the employment of alternative types of intensity measures, has been determined only for the year 1980 (either Czechoslovakia or Rumania were selected as the nearest partners of the GDR, forming with the latter country a first-order conglomeration). Generally,

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[8] In Figure 2 and following the figures in parentheses are taxonomic distance estimates determined as inverse geometric means of compatibility coefficients while the figures written above are arithmetic means of correlation coefficients.

T a b l e 3

Intensity of intra-CMEA trade in 1970, 1975, 1980 measured by correlation[a] and compatibility[b] coefficients (closed model)

×100

Importer / Exporter	Year	Bulgaria		Czechoslovakia		GDR		Hungary		Poland		Rumania		USSR	
		a	b	a	b	a	b	a	b	a	b	a	b	a	b
	1970			-5,1	57	-3,1	79	-4,6	51	-5,8	52	-2,0	72	11,6	130
Bulgaria	1975			-4,9	58	-4,7	67	-5,9	40	-6,0	50	-0,7	89	12,9	136
	1980			-6,1	50	-4,2	70	-5,7	44	-5,3	59	-0,5	93	12,1	127
	1970	-3,6	69			4,4	122	2,5	120	3,0	119	5,6	159	-6,5	87
Czechoslovakia	1975	-6,4	48			5,2	129	2,2	118	3,4	122	3,0	134	-4,7	90
	1980	-5,4	57			3,8	123	3,4	128	2,6	117	2,7	130	-3,8	93
	1970	-2,8	84	5,0	127			2,9	119	2,8	115	-0,9	92	-4,7	92
GDR	1975	-4,5	68	6,9	138			4,7	131	2,7	115	1,6	116	-6,5	88
	1980	-3,3	77	7,0	142			-2,4	82	1,0	106	3,7	137	-3,1	95
	1970	-5,6	33	3,2	127	0,5	104			-0,7	94	-0,7	90	0,9	102
Hungary	1975	-7,0	32	2,3	118	2,1	114			-3,7	72	1,1	116	2,4	106
	1980	-4,8	42	3,0	131	1,7	116			-1,4	86	2,0	135	-0,3	99
	1970	-4,9	54	2,5	117	0,1	101	-0,2	98			-0,7	92	1,0	102
Poland	1975	-4,4	65	4,8	130	2,2	112	-4,1	69			0,5	105	-0,3	99
	1980	-4,6	62	5,4	138	1,4	109	-1,9	84			0,9	110	-1,0	98
	1970	-3,5	47	4,0	144	-2,3	80	4,3	106	-2,1	77			1,8	106
Rumania	1975	-1,9	72	1,2	113	-0,3	97	1,5	121	-0,3	96			-0,1	100
	1980	-2,0	75	0,7	108	4,2	140	1,8	123	-0,3	97			-2,8	92
	1970	10,3	129	-5,4	89	-0,6	99	-1,3	97	0,2	100	-1,1	96		
USSR	1975	13,6	135	-6,8	86	-3,1	95	0,2	101	1,0	102	-3,3	88		
	1980	10,4	121	-5,8	90	-3,2	95	2,7	106	1,1	102	-4,8	86		

[a] Columns a.

[b] Columns b.

S o u r c e: Calculations based on the UN trade series "Bulletin Monthly..." (1982).

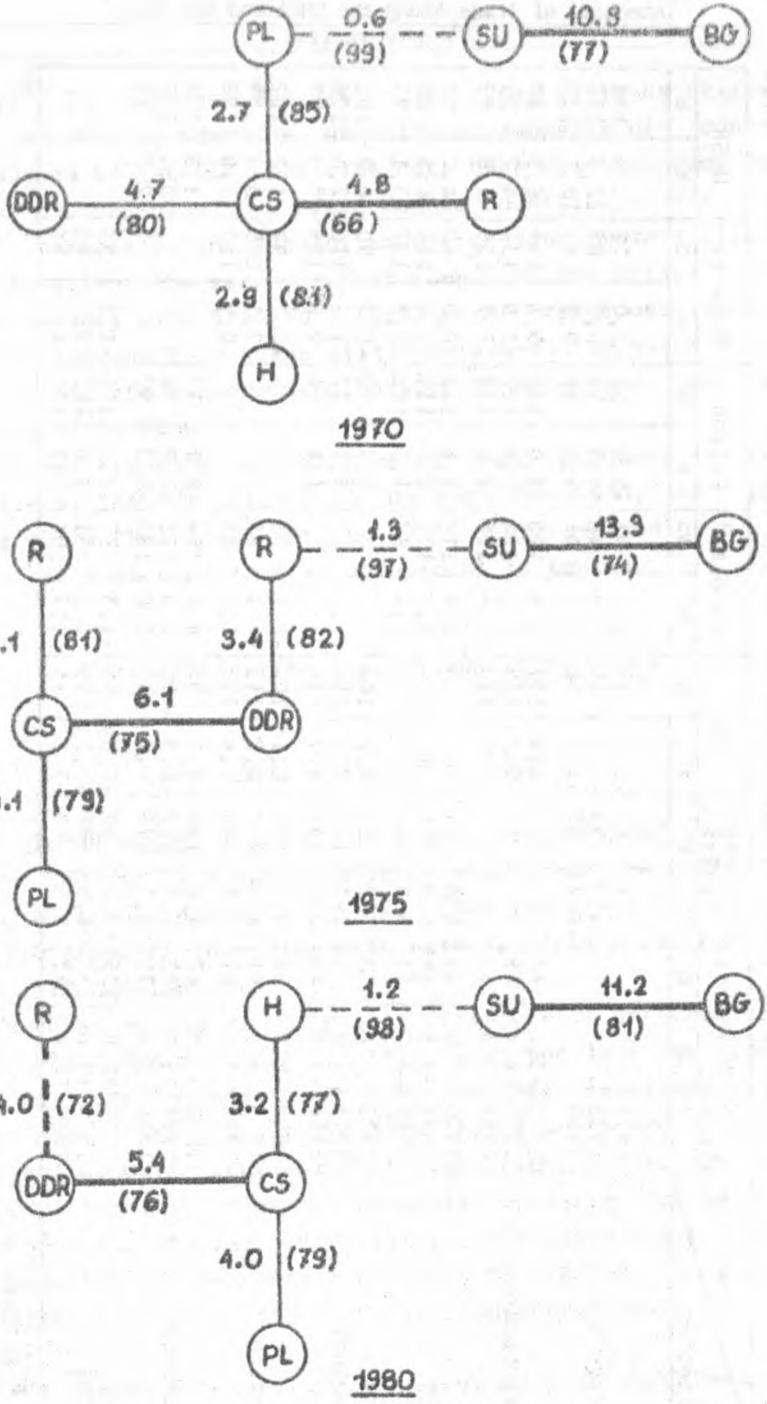

Fig. 3. Dendrite arrangement of the European CMEA member countries by distance in their intra-trade in 1970, 1975, 1980 (closed model)

structural trade interconnections within the CMEA revealed by the model adopted in this section are more diversified than those demonstrated earlier on the basis of an open model. The procedure utilized for calculation of the trade intensity indices eliminates the impact exerted by unequal total trade volumes of individual countries on levels of bilateral trade flows. The expected geographical distribution of trade is determined by actual export and import margins (hypothesis of origin-destination quasi-independence). Thus, for instance, a fact that the USSR is by far the largest exporter and importer of goods destined for and originated from the CMEA countries is automatically taken into account by the standardization procedure and it does not influence the level of relative trade intensity indices, and the compatibility coefficients in particular[9]. The latter depend only on deviations of actual from expected flows in the bilateral trade. The deviations computed on the basis of the closed model (Section 2) are positive and significant for all intra-CMEA trade flows. In view of the closed model actual flows within the CMEA are rather approached to their expected values, and the compatibility as well as the correlation coefficients oscillate obout their average levels, i.e. 100 and 0, respectively. It does not mean, however, that the distribution of trade among the CMEA countries is exactly biproportional to the trade margins. Some degree of relative concentration of the intra-CMEA turnover has been exposed also by use of a closed trade model.

In this case it was as well established that especially close trade links existed between the USSR and Bulgaria. In all years under investigation these two countries formed a first-order conglomeration (cf. Figure 3) as well as a separate subset within the CMEA. Another subset comprised the remaining five countries, of which other first-order conglomerations could be isolated: Czechoslovakia - Rumania in 1970, Czechoslovakia - GDR in 1975 and Czechoslovakia - GDR or GDR - Rumania in 1980 (in the latter case the classification depends on the employed measure of trade distance).

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[9] Correlation coefficients are, however, partly affected (by the weighting system).

As follows from the analysis of dendrites (Figure 3), Czechoslovakia has occupied a special position in the intra-CMEA trade. Her trade has been spread uniformly enough among the partners from the second subset (excluding the Soviet Union and Bulgaria). Hence Chechoslovakia emerged as a nearest trade partner for other three or four CMEA countries (including Poland) in the 1970-1980 period.

On the other hand the trade link between the USSR and Hungary (in 1975 and 1980) or between the USSR and Poland (in 1980) was the shortest trade connection between the two subsets of the European CMEA countries.

3.2. Intra-EEC Trade

The trade intensity indices for the EEC region derived by use of a closed model for the years 1970, 1975 and 1980[10] are listed in Table 4. Dendrite arrangement of the EEC countries in their intra-regional trade is demonstrated in Figure 4.

Contrariwise to the patterns of the CMEA trade the graphs illustrating the structure of the EEC trade corresponding to the results of an open or a closed model are not substantially different. In Figure 4 the EEC countries are broken down into three subsets composed, respectively, of:

a) the United Kingdom, Ireland and Denmark (during the whole period 1970-1980);

b) the Benelux countries (1970) or the Benelux and the Federal Republic of Germany (1975 and 1980);

c) France, Italy and the FRG (1970) or France and Italy (1975), 1980).

Three first-order conglomerations within the EEC are composed of:

a) the United Kingdom and Ireland

b) Belgium-Luxemburg and the Netherlands

c) France and Italy.

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[10] Intra-regional trade matrices were compiled on the basis of the EEC Statistics.

Table 4

Intensity of intra-EEC trade in 1970, 1975, 1980 measured by correlation[a] and compatibility[b] coefficients (closed model)

Importer / Exporter	Year	Belgium-Luxemburg		Denmark		FRG		France		Ireland		Italy		The Netherlands		United Kingdom	
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Belgium-Luxemburg	1970			-4,9	44	-2,2	94	6,0	127	-5,4	15	-7,9	54	13,8	170	-7,2	54
	1975			-3,2	59	-2,1	93	5,5	125	-4,6	20	-7,6	52	11,5	163	-5,4	67
	1980			-2,9	59	-2,4	92	5,3	125	-5,0	22	-6,4	61	9,0	153	-1,8	89
Denmark	1970	-5,2	23			-1,2	90	-5,7	31	-0,5	81	-2,0	67	-4,1	43	22,7	499
	1975	-4,8	31			0,1	101	-4,7	44	-1,0	53	0,5	109	-3,6	49	14,9	343
	1980	-4,6	31			2,9	125	-3,8	54	-1,5	41	-1,0	85	-2,2	66	8,7	229
FRG	1970	-1,9	94	2,9	119			1,6	104	-7,8	30	5,6	119	4,9	114	-10,2	63
	1975	-2,8	91	4,8	134			0,2	100	-6,9	32	4,0	114	6,0	119	-7,6	74
	1980	-2,1	93	3,2	126			-0,6	98	-8,2	27	4,3	115	5,8	120	-5,0	83
France	1970	6,8	133	-4,6	53	0,2	101			-5,3	26	10,1	151	-8,8	61	-3,4	81
	1975	5,9	126	-5,4	45	-2,8	93			-4,2	40	10,7	155	-8,4	63	1,0	105
	1980	3,4	116	-4,5	48	-2,6	93			-5,0	38	12,9	164	-7,7	62	-0,7	97
Ireland	1970	-4,2	23	-2,4	7	-8,7	13	-5,2	23			-4,4	14	-5,1	13	38,0	917
	1975	-4,0	28	-2,0	18	-6,0	37	-4,4	35			-3,1	36	-4,1	27	27,5	658
	1980	-3,9	33	-1,6	36	-6,0	41	-2,7	63			-3,8	34	-2,7	51	22,4	481

Table 4 (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1970	-8,3	48	-2,8	62	8,2	129	7,3	137	-4,0	26			-7,2	58	-1,4	90
Italy	1975	-8,1	50	-3,1	55	7,4	127	8,5	144	-3,0	35			-8,0	50	-0,9	93
	1980	-8,1	48	-3,1	52	3,7	114	12,0	162	-4,5	25			-7,7	48	-0,3	98
	1970	7,2	139	-3,5	60	6,2	118	-7,9	66	-4,7	27	-6,8	61			3,7	124
The Netherlands	1975	7,8	138	-1,9	79	7,8	122	-8,3	67	-4,6	29	-6,9	62			-0,3	99
	1980	10,6	156	0,4	105	7,5	123	-7,9	66	-4,9	32	-7,7	58			2,3	88
	1970	-1,5	89	15,7	336	-10,0	61	-3,2	81	37,2	865	-1,9	86	-1,3	92		
United	1975	-0,6	96	10,0	260	-9,4	62	-1,0	94	33,1	825	-2,3	82	0,1	100		
Kingdom	1980	-1,4	92	6,6	194	-5,1	83	-4,4	79	32,3	595	-4,3	74	1,1	107		

[a] Columns a.

[b] Columns b.

S o u r c e: Calculations based on the EEC trade statistics (Mänedlige bulletin... (1976--1981).

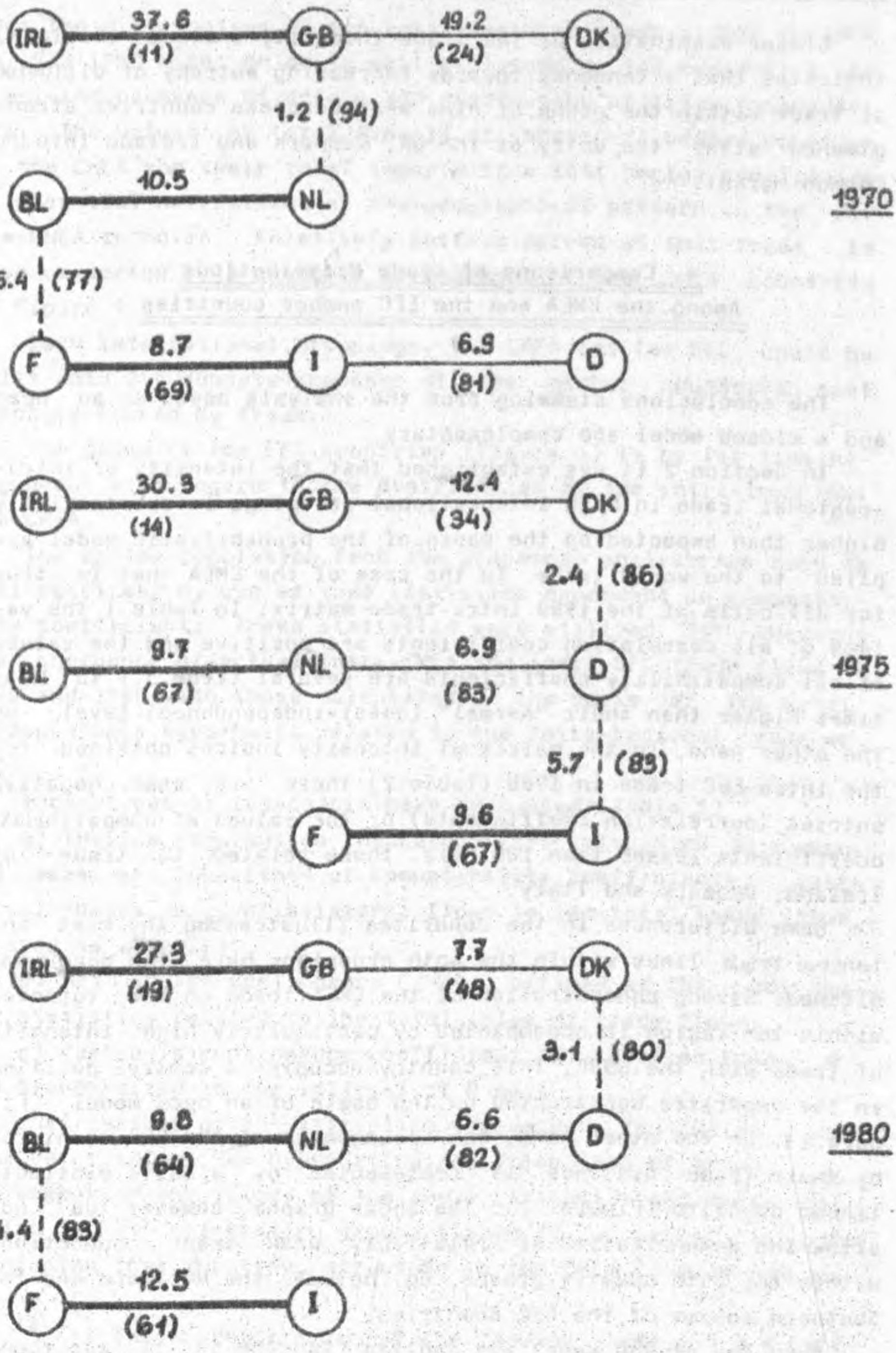

Fig. 4. Dendrite arrangement of the EEC member countries by distance in their intra-trade in 1970, 1975, 1980 (closed model)

Closer examination of the trade intensity indices (Table 4) indicates that a tendency towards increasing entropy or diffusion of trade within the group of nine West European countries strengthened after the entry of the UK, Denmark and Ireland into the Common Market.

4. Comparisons of trade distributions Among the CMEA and the EEC member countries

The conclusions stemming from the analysis based on an open and a closed model are complementary.

In Section 2 it was established that the intensity of intra-regional trade in both integrational groupings is substantially higher than expected on the basis of the probabilistic model applied to the world trade. In the case of the CMEA that is true for all cells of the 1980 intra-trade matrix. In Table 1 the values of all correlation coefficients are positive and the values of all compatibility coefficients are several (from 3.1 to 15.4) times higher than their "normal" (quasi-independence) level. On the other hand, in the matrix of intensity indices obtained for the intra-EEC trade in 1980 (Table 2) there are some negative entries (correlation coefficients) or the values of compatibility coefficients lesser than 100, viz. those related to trade of Ireland, Denmark and Italy.

Some differences in the dendrites illustrating the most intensive trade links within the both groupings have also been established. Strong concentration of the CMEA trade on the turnover within the region is accompanied by particularly high intensity of trade with the USSR. This country occupies a central position in the dendrites constructed on the basis of an open model (Figure 1). On the other hand, the arrangement of the EEC countries by their trade distance is represented by a quite distinct, linear dendrite (Figure 2). The above graphs, however, do not allow for demonstration of relatively weak trade connections within the both country groups, eg. between the Northern and the Southern subset of the EEC countries.

When the closed model was applied (Section 3) is was found that the distribution of the intra-regional trade within the CMEA in 1970-1980 might be quite well explained by the hypothesis on quasi-independence of origin and destination of trade consignments. The values of total exports of individual member countries to the CMEA and their total imports from that region constituted an essential determinant of the geographical pattern in the intra-CMEA turnover. Relatively uniform spread of that trade is also reflected by a dendrite arrangement of the CMEA countries in Figure 5.

Both integrational groupings, the CMEA and the EEC, could be split into 2-3 subsets composed of the member countries most strongly linked by trade.

The group of the EEC countries (Figure 4) is by far less homogeneous with regard to the distribution of the intra-trade than the CMEA.

The latter conclusion from the graphical analysis has been as well confirmed by use of some statistics dependent on compatibility coefficients. These statistics were utilized for checking the congruence of actual intra-CMEA and intra-EEC trade flows in 1970 and 1980 with those calculated on the basis of the quasi-independence hypothesis related to the intra-regional trade models.

Three types of indicators have been used (Table 5)[11]:

a) Theil's information inaccuracy (I), calculated as a weighted mean of logarithms of compatibility coefficients (with actual shares, b_{ij}, of bilateral flows in the total trade value, T, used as weights),

b) Mean square contingency (Φ^2), defined as the chi-square statistics related to the total value of trade flows,

c) Pearson's contingency coefficient (C), derived from Φ^2 and standardized in the interval of 0 to 1.

Lower values of the statistics correspond to fuller congruence of actual and hypothetical distributions of trade.

Comparing the values of the above statistics and their evolution in both integration groups (Table 5), we arrive at the conclusion that the trade structure in the CMEA is much more con-

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[11] For fuller description of the results - see J. K o t y ń s k i (1984).

gruent than that of the EEC with the distribution expected on the assumption of quasi-independence, with the given trading capacities of member countries. The trade within the EEC is marked by a much stronger relative concentration. It evolves, however, towards more even geographic distribution.

Appendix A

A.1. Measures of Stochastic Dependence and Correlation as Indices of Trade Intensity

Given is a square matrix of transaction flows between n countries $A = [a_{ij}]$, with a main diagonal equal to zero ($a_{ij} \geq 0$; $a_{ii} = 0$; $i, j = 1, \ldots, n$). The total value of exchange (sum of flows) is equal to T:

$$T = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} \tag{1}$$

There are 2n random variables U_i, V_j with bevariate distributions defined on this matrix. We assume that $U_i = 1$ (with the ex ante probability P_i) when country i is an exporter in the given transaction chosen at random, and that $V_j = 1$ (with the ex ante probability Q_j) when country j is an importer in such transaction. In the remaining cases, the random variables U_i and V_j are equal to zero. Variables U_i, V_j ($i, j = 1, \ldots, n$) are quasi-independent if the total ex ante probabilities $P_{ij} = P(U_i = 1, V_j = 1)$ are defined by the formulas:

$$P_{ij} = P_i Q_j S \quad \text{for } i \neq j;\ i, j = 1, \ldots, n \tag{2}$$

$$P_{ij} = 0 \quad \text{for } i = j \tag{3}$$

where:

$$S = (1 - \sum_{i=1}^{n} P_i Q_i)^{-1} \tag{4}$$

T a b l e 5

Congruence statistics for the CMEA and the EEC regional trade matrices in 1970, 1980
(based on compatibility coefficients δ_{ij} - closed model, quasi-independence hypothesis)

Type of statistics	Formula[a]	CMEA[b]		EEC[c]	
		1970	1980	1970	1980
Structural discrepancy[d] (Theil's information inaccuracy)	$I = \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} b_{ij} \log \delta_{ij}$	0.008	0.007	0.052	0.035
Mean square contingency	$\varphi^2 = \frac{\chi^2}{T} = \sum_{i=1}^{n} \sum_{j=1}^{n} P_{ij} (\delta_{ij} - 1)^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} \delta_{ij} - 1$	0.030	0.031	0.368	0.213
Pearson's contingency coefficient	$C = \sqrt{\frac{\varphi^2}{1 + \varphi^2}} = \sqrt{\frac{\sum_{i=1}^{n} \sum_{j=1}^{n} P_{ij}(\delta_{ij}-1)^2}{\sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} \delta_{ij}}}$	0.169	0.172	0.519	0.419

[a] For denominations of explanatory variables - see Appendix A. [b] 7 European member-countries ($n = 7$). [c] 9 countries ($n = 8$) [d] In hartleys.

S o u r c e : The author's calculations published in J. K o t y ń s k i (1984), based on the UN the EEC statistics (Mänedlige bulletin... (1976-1981), Monthly Bulletin... (1982)).

P_{ij} means the ex ante joint probability (theoretical frequency) with which a transaction between two definite countries, i (the exporter) and j (the importer), is expected in the whole set of transaction.

Probabilities P_i, Q_j, P_{ij} (i, j = 1, ..., n) and parameter $S(S \geqslant 1)$ may be assessed for individual periods on the basis of the observed relative marginal frequencies (ex post probabilities) e_i, f_j, interpreted in this case as shares of the exports (6) and imports (7) of individual countries in the value of exchange, that is the frequency with which these countries emerge as exporters or importers. On the other hand, the ex ante joint probabilities (P_{ij}) correspond to the observed relative frequencies (ex post probabilities) b_{ij} (5), that is shares of the export of country i to country j in the total value of exchange:

$$b_{ij} = \frac{a_{ij}}{T}; \qquad i, j = 1, \dots, n \tag{5}$$

$$e_i = \sum_{j=1}^{n} b_{ij} = \frac{1}{T} \sum_{j=1}^{n} a_{ij}; \qquad i = 1, \dots, n \tag{6}$$

$$f_j = \sum_{i=1}^{n} b_{ij} = \frac{1}{T} \sum_{i=1}^{n} a_{ij}; \qquad j = 1, \dots, n \tag{7}$$

The above definitions show that observed frequencies e_i, f_j, b_{ij} - like probabilities P_i, Q_j and P_{ij} - are nonnegative and not greater than 1, and their sums are respectively equal to 1. The sum of elements in each row (i = 1, ..., n) of the ex ante probability destribution matrix P_{ij} is equal to the respective marginal frequency e_i while the sum in each column (j = 1, ..., n) is equal to marginal frequency f_j.

$$\sum_{j=1}^{n} P_{ij} = \sum_{j \neq i} P_i Q_j S = P_i(1 - Q_i)S = e_i; \quad i = 1, \dots, n \tag{8}$$

$$\sum_{i=1}^{n} P_{ij} = \sum_{j \neq i}^{n} P_i Q_j S = Q_j(1 - P_j)S = f_j; \quad j = 1, \ldots, n \quad (9)$$

On the other hand, marginal frequencies e_i, f_j differ from the respective ex ante probabilities P_i, Q_j, except when $S = 1$.

The basic assumptions of this model have been formulated by I. R. Savage and K. W. Deutsch (1960). The model includes two systems of non-linear equations (10) and (11), with $2n + 1$ unknowns which are P_i, Q_j $(i, j = 1, \ldots, n)$ and S, a parameter that is a function (4) of the ex ante probabilities sought at the same time:

$$SP_i^2 - (S + e_i - f_j)\, P_i + e_i = 0 \qquad i = 1, \ldots, n \quad (10)$$

$$SQ_j^2 - (S + f_j - e_j)\, Q_j + f_j = 0 \qquad j = 1, \ldots, n \quad (11)$$

The method of an iterative solution of these equations was proposed by S. S. Wagner (1970). Other, simpler algorithms are also applied.

Let us now define the measures of stochastic dependence and correlation between the random variables U_i, V_j introduced above. We shall next apply these measures to an estimation of the relative geographic concentration of trade within the EEC. In order to determine them it is enough to know the empirical distribution of exchange, that is frequency b_{ij} (5) for $i, j = 1, \ldots, n$. The marginal frequencies e_i (6) and f_j (7) obtained on this basis allow to assess parameters P_i, Q_j and S. They thus generate a distribution of joint probabilities P_{ij} (2), (3) which corresponds to the hypothesis on the stochastic quasi-independence of variables U_j, V_j. The observed distribution (5) of trade generally differs from a theoretical distribution thus defined. This applies to trade between individual countries and to whole matrices of transaction flows. The compatibility and correlation coefficients of variables U_i, V_j presented above measure individual deviations of the actual values of transaction flows from their theoretical values, for individual pairs of countries i,

j. They may be used, however, to build congruence tests for whole matrices of transaction flows.

The hypothesis on the quasi-independence of random variables U_i, V_j is verified by the compatibility (more precisely, quasi-compatibility) coefficient δ_{ij}:

$$\delta_{ij} = \frac{b_{ij}}{P_j Q_j S} = \frac{a_{ij}}{P_i Q_j ST} \qquad i, j = 1, \ldots, n \tag{12}$$

If the hypothesis is fulfilled then $\delta_{ij} = 1$. The export of country i to country j (a_{ij}, $i \neq j$) is then equal to its normative value ($P_i Q_j ST$), and the ex post probability (b_{ij}) of joint realization $U_i = 1$, $V_j = 1$ is given by the product of ex ante marginal probabilities $P_i Q_j$ and parameter S. If the bilateral trade links are stronger than those expected with the model adopted here, then $\delta_{ij} > 1$. Otherwise, $0 \leqslant \delta_{ij} < 1$.

A similarly defined measure (12) was applied by H. S a u t t e r (1974) (regionalization coefficient). We apply the denomination of this coefficient used here in view of its analogy with S. N. Bernstein's compatibility coefficient. The quasi-compatibility coefficient (12) comes, however, directly from I. R. S a v a g e and K. W. D e u t s c h (1960) who defined - only a differently scaled - Relative Acceptance Index (RA) as a measure of trade intensity, described on a flow matrix with a zero main diagonal:

$$RA_{ij} = \delta_{ij} - 1 \qquad i, j = 1, \ldots, n \tag{13}$$

The correlation (more exactly, quasi-correlation) of random variables U_i, V_j is measured by coefficient standardized in the interval $\langle -1, 1 \rangle$, introduced by J. K o t y ń s k i (1979)

$$r_{ij} = \frac{b_{ij} - P_i Q_j S}{\sqrt{P_j (1-P_i) Q_j (1-Q_j)}} = \left(\frac{b_{ij}}{P_i Q_j} - S\right)\sqrt{\frac{P_i Q_j}{(1-P_i)(1-Q_j)}} \tag{14}$$

or, after substituting (12) and further transformations:

$$r_{ij} = (\delta_{ij} - 1) S \sqrt{\frac{P_i Q_j}{(1-P_i)(1-Q_j)}}, \text{ for } i, j = 1, \ldots, n,\ i \neq j \tag{15}$$

Formulae (12) and (14), (15) get simplified when the theoretical distribution can be generated on the assumption of a (complete) stochastic independence of random variables U_i, V_j, that is when $S = 1$, $P_i = e_i$, $Q_j = f_j$ for $i, j = 1, \ldots, n$. The latter hypothesis abandons the assumption of a zero main diagonal in the theoretical flow matrix. The use of simplified instead of general formulas, particularly when the exchange between a few countries with different shares in the total exchange is investigated, may yield, however, substantially different results, leading to erroneous conclusions.

A.2. Score - Algorithm for Calculation on Theoretical Trade Distribution

The parameters determining the theoretical distribution of international trade can be estimated by use of a simple iterative procedure proposed by L. A. G o o d m a n (1964) 2n auxiliary variables (multipliers) u_i, v_j $(i, j = 1, \ldots, n)$ are first computed. (The symbols u_i, v_j introduced here have a different meaning than the random variables U_i, V_j of the para A.1). Their products form a matrix of expected trade shares (ex ante joint probabilities) p_{ij} (2):

$$p_{ij} = u_i v_j; \qquad i, j = 1, \ldots, n \quad i \neq j \tag{16}$$

Thus the multipliers u_i, v_j are sufficient for generation of theoretical trade shares. They allow as well for computation of the compatibility coefficients δ_{ij} (12) if the actual trade shares b_{ij} are also given.

The multipliers u_i, v_j are not however sufficient for computation of the quasi-correlation (or S-correlation) coefficients r_{ij} (15). For that purpose the estimates of the theoretical marginal probabilities P_i, Q_j and of the S-parameter are needed. The latter coefficients can be derived immediately once the multipliers u_i, v_j (or their l-th approximations) are computed.

The procedure presented here allows for simultaneous, iterative calculation of the u_i, v_j multipliers and the P_i, Q_j and S parameters. In this respect it differs from the L. A. G o o d m a n's algorithm (1964).

The ex ante marginal probabilities P_i, Q_j are derived by normalization of the u_i, v_j multipliers:

$$P_i = \frac{u_i}{\sum_{k=1}^{n} u_k} \qquad i = 1, \ldots, n \tag{17}$$

$$Q_j = \frac{v_j}{\sum_{r=1}^{n} v_r} \qquad j = 1, \ldots, n \tag{18}$$

The S-parameter is estimated either as a function (19) or (20) of the multipliers u_i, v_j, or as a function of the probabilities P_i, Q_j, defined earlier (4).

$$S = \left(\sum_{i=1}^{n} u_i\right)\left(\sum_{j=1}^{n} v_j\right) \tag{19}$$

$$S = 1 + \sum_{j=1}^{n} u_i v_i \tag{20}$$

The core of the problem is to estimate the values of the multipliers u_i, v_j, given the actual marginal shares (frequencies) e_i, f_j $(i, j = 1, \ldots, n)$. In successive iterations $(l = 1, \ldots, L)$ the values of the multipliers referring to exports $(u_{i(l)})$ and imports $(v_{j(l)})$ are estimated by use of recursive formulae (21) and (22):

$$u_{i(l)} = \frac{e_i}{\sum_{j \neq i} v_{j(l-1)}} \qquad i = 1, \ldots, n \tag{21}$$

$$v_{j(l)} = \frac{f_j}{\sum_{i \neq j} u_{i(l-1)}} \qquad j = 1, \ldots, n \tag{22}$$

As initial values of the multipliers the respective marginal export and import shares are introduced:

$$u_{i(0)} = e_i; \quad v_{j(0)} = f_j \quad i, j = 1, \ldots, n \tag{23}$$

(As initial value of S $S_{(0)} = 1$ is assumed).

In each iteration an estimate $S_{(l)}$ of the parameter S is computed, according to the formula (19) or (20), eg.:

$$S_{(l)} = \left(\sum_{i=1}^{n} u_{i(l)}\right)\left(\sum_{j=1}^{n} v_{j(l)}\right) \tag{24}$$

Next an absolute change in the S-estimate is calculated and compared with the assumed tolerance coefficient ε :

$$S_{(l)} - S_{(l-1)} \leq \varepsilon \tag{25}$$

The procedure stops if the result of the test (25) is positive (i.e. if the change in successive approximations of S is relatively small) or if the assumed maximum number of iterations (L) is implemented.

In each iteration l approximate values of marginal probabilities $P_{i(l)}$ and $Q_{j(l)}$ can also be calculated on the basis of the general formulae (17) and (18):

$$P_{i(l)} = \frac{u_{i(l)}}{\sum_{k=1}^{n} u_{k(l)}} \quad i = 1, \ldots, n \tag{26}$$

$$Q_{j(l)} = \frac{v_{j(l)}}{\sum_{r=1}^{n} v_{r(l)}} \quad j = 1, \ldots, n \tag{27}$$

Analogously, in each step the estimates of ex ante joint probabilities $P_{ij(l)}$ (theoretical trade shares) can be generated, according to the general formulae (16) or (2):

$$P_{ij(l)} = u_{i(l)} v_{j(l)} \quad i, j = 1, \ldots, n, \ i \neq j \tag{28}$$

or

$$P_{ij(l)} = S_{(l)} P_{i(l)} Q_{j(l)} \quad i, j = 1, \ldots, n, \ i \neq j \tag{29}$$

Obviously, the assumption (3) of a zero main diagonal is maintained in each iteration:

$$P_{ii(l)} = 0 \quad (30)$$

For intermediate steps the above part (26)-(30) of the SCORE algorithm is facultative as it has no influence on final estimates of the parameters. Thus the estimates of the probabilities P_i, Q_j (i, j = 1, ..., n) can be computed only in the final iteration by normalization (26)-(27) of the multipliers $u_{i(l)}$, $v_{j(l)}$ if condition (25) is fulfilled (or if l = L). Next the estimates of the joint probabilities, (28) or (29), are calculated.

L. A. G o o d m a n (1964) proved that the iterative procedure used for calculation of the u_i, v_j multipliers is convergent (formulae (21)-(23)). By the same the convergence of the whole SCORE algorithm presented above is also assured, since the remaining formulae express functional relationships between the multipliers u_i, v_j, on the one hand, and the parameters S, P_i, Q_j, P_{ij}, on the other.

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INTENSYWNOŚĆ HANDLU W RAMACH RWPG I EWG

Intensywność handlu między siedmioma europejskimi krajami RWPG i dziewięcioma EWG w latach 1970-1980 jest rozważana przy użyciu miar stochastycznych - współczynników korelacji i porównawczych, definiowanych na podstawie macierzy handlu. Rozkład

teoretyczny handlu jest wyprowadzony z probabilistycznego modelu Savage a-Deutscha opartego na hipotezie quasi-niezależności pochodzenie-przeznaczenie.

Ugrupowania integracyjne są podzielone na podzbiory wg relatywnych odległości handlu krajów-członków w stosunku do handlu globalnego, jak również do handlu wewnątrz regionu. Metody miar intensywności handlu pozwalają na kwantyfikację i porównanie koncentracji geograficznej obrotów RWPG i EWG w grupach towarów oraz tendencji dystrybucji tego handlu.