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Taagepera, R
Hayes, JP

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How Trade/GNP Ratio Decreases with Country Size

REIN TAAGEPERA AND JAMES P. HAYES

University of California, Irvine

The ratio of a country's foreign trade (i.e., exports plus imports) to its GNP has a known tendency to decrease with country size. Previous studies have used a single year's data; but trade fluctuates greatly from year to year. This paper makes available a compilation of 1953-1972 export/GNP and import/GNP figures for 110 countries. The average import/GNP figure is found to correlate strongly with population size; the simple expression, $\text{Imports/GNP} = 40 P^{-1/3}$, applies, within a factor of 2, in 94% of cases. No correlation with development level can be seen. The United States data throughout its history (1799-1972) follow the same inverse cube root pattern, but with a constant of 20 instead of 40. Correlation is much poorer in the case of export/GNP ratio. Export and import figures are only marginally correlated to each other.

Small countries tend to export and import relatively more than do large countries. Thus the export (and import) figures of the United States, the Soviet Union, China, and India all represent less than 7% of their respective gross national products, while for Barbados, Gambia, and Luxembourg (with populations less than 500,000) exports (and imports) represent 30 to 90% of their GNPs.

This tendency, noted by Chenerey (1960) and Deutsch and Eckstein (1961), was more fully investigated by Deutsch, Bliss, and Eckstein (1962). The ratio of trade (i.e., exports plus imports) to GNP was considered for 73 countries for the single year of 1955. Differences in population size were found to account for 61% of the variation in Trade/GNP ratio, provided that one subdivided the countries into four groups based on per capita income levels and degree of sovereignty. Colonial territories tended to have relatively high ratios, and medium income sovereign states tended to have the lowest ratios, for equal populations. Total GNPs and literacy levels did not seem to have any effect. The best-fitting curve was given as

$$\log(\text{Trade/GNP}) = a' + 0.2068 \log P - 0.1334 (\log P)^2 \quad (1)$$

where P is the population in units of 100,000, and where the constant a'

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ranges from 1.6 to 1.85, for the four aforementioned subgroups. Note that Eq. (1) is equivalent (when $a' = 1.7$) to

$$\text{Trade/GNP} = 50 P^{(0.2068 - 0.1334 \log P)} \quad (2)$$

where Trade/GNP is in percent and P in 10^5 . The data which led to Eqs. (1) and (2), could also be expressed, with little loss in goodness of fit, by the simpler equation

$$\text{Trade/GNP} = 70/P^{1/3} \quad (\text{Trade/GNP in percent; } P \text{ in millions}). \quad (3)$$

Since 1962, the Trade/GNP ratio seems to have been studied only marginally, as part of wider correlational and factor analyses of sociopolitical data. Sawyer (1967) used 1955 data for 82 nations and found correlations with population size to be -0.61 for Trade/GNP, but only -0.39 for Exports/GNP. Russett *et al.* (1964) used mostly data for 1959 (but sometimes for other available years, from 1952 to 1960) for 81 countries, and found the following correlation coefficients for Trade/GNP: -0.69 with population, -0.54 with area, and -0.59 with the GNP of the country. Rummel's (1972) factor analysis of 1955 data isolated a trading dimension that is dominated by Trade/GNP and Exports/GNP ratios but which is found to be statistically independent of the country's size; however, he points out (1972, p. 242) that his is a linear analysis that would not detect curvilinear relationships. In fact, all of these post-1962 studies deal with linear correlations, with or without prior transformation (say, to log scale) the nature of which is often not clearly stated. As a result, the actual curvilinear relationships may go undetected or weakened. These studies also share the widely spread but deplorable habit of giving only correlation coefficients, but failing to report the actual best-fitting equations connecting the variables. What good is it to know that two variables are highly correlated if we are not given the means to estimate one of them when the other is given? Note that Deutsch *et al.* (1962) do give us the means [through Eq. (1)] to actually estimate the Trade/GNP ratio from the population size. The only later study to do so seems to be that of Dahl and Tufte (1973, p. 114) using 1965 data and finding a -0.69 correlation; their expression is equivalent to

$$\text{Trade/GNP} = 66/P^{0.29} \quad (P \text{ in millions, Trade/GNP in percent}). \quad (4)$$

It may be asked whether the correlations observed are not spurious because a ratio variable is used (see Schuessler, 1974). It is clear that regressing the Trade/GNP ratio on GNP itself would produce such a negative correlation for any random set of figures used for trade, because the GNP enters both variables. Since GNP is highly correlated with population, do we not have here a basically similar situation, comparing Trade/ $f(P)$ with P itself? The answer is that *both* GNP and trade volume depend heavily on population size. We are correlating a ratio of two

different functions of P — $g(P)/f(P)$ —to P itself. In such a case the sign or even the existence of a correlation is not spuriously imposed. In fact, since both the GNP and the trade volume are roughly proportional to population, one might expect that their ratio is not correlated with P . The contrary observation is thus not a spurious one.

The Trade/GNP ratio is a potentially important socioeconomic indicator. Once the effect of country size is accounted for, the residual variation could be traced to the degree of sovereignty (as seen above) and to a number of other geographic, economic, and political factors. Once the worldwide configurations are determined (on empirical and, preferably, also on theoretical grounds), the Trade/GNP ratio could be used to shed new light on the economy of a particular country. A worldwide increase or decrease in Trade/GNP ratios over time may tell us something about world integration. Deutsch and Eckstein (1961) found that the ratio has tended to decrease from 1890 to 1959. However, the effect of colonialism would have to be taken into account: colonies and their "mother countries" might be expected to have unusually high mutual trade. Another factor to be taken into account is the average transportation distance for goods which is technologically and economically optimal. If that distance should decrease, then all foreign trade would also tend to decrease. It will be shown in a subsequent paper (Taagepera, 1976) that the typical transport distance within a country can, in fact, be inferred from its Trade/GNP ratio.

The first stage in actualizing these potentialities is to establish firmly the dependence on country size, so that it can be normalized out of further studies. On the empirical level, previous findings have to be rechecked with data from years other than 1955, 1959, and 1965. On the theoretical level, a formal model has to be built that explains the observed trend on rational grounds. On the usability level, the more complex theoretical and empirical equations would have to be reduced to simpler forms which, though they have less explanatory power in a statistical sense, have more usable power because they are easy to visualize and use, e.g., compare Eqs. (1) and (3). This simplification stage is often neglected by scholars, but it is indispensable if the gist of the research is to become understandable and usable by the economic and political practitioners (and by less mathematically minded scholars!).

Theoretical models for size-dependence of Trade/GNP ratio are presented by one of us in a separate paper (Taagepera, 1976); they are based, respectively, on considerations of boundary conditions and entropy, and on uniform absorption properties of space. The main objective of the present paper is to offer a compilation of Trade/GNP data for more than 100 countries over 20 years (1953–1972), in order to check previous findings, to generalize, to determine trends in time, and to develop simple approximate equations. Factors other than population size are discussed

only briefly; none of them seems to have any clear-cut effect. Full statistical analysis is not part of our objectives, but the data collection presented offers a more solid basis for such an analysis than has been the case previously. It will be shown next that previous analyses have been, indeed, based on rather fluctuating data.

TRADE DATA COMPILATION (1953–1972)

Compared to the relative stability of population and even of GNP figures, the yearly trade figures are extremely fickle. Especially in smaller and less established countries, trade figures can be altered appreciably by a cash crop failure, a delay in trade negotiations, internal or external political manipulations, changes in currency conversion rates, and accounting errors. Trade and GNP data from different sources may inadvertently involve different units (e.g., 1957 dollars versus 1960 dollars), and the total effect on the Trade/GNP ratio is compounded by plain error at various stages of reporting and copying. This paper will not discuss the effect of issues such as whether exports and imports should be measured at the price of origin or destination, and what difference this might make. We will uncritically accept whatever scholarly or official data are available in U.S. dollars or other consistent currencies (i.e., both trade and GNP figures given in the same currency). As an example, Table 1 shows in detail our data compilation for Chile, a fairly stable (until recently) and not-so-small country. While we did not endeavor to obtain data for every year, we tried to cover the 20-year period fairly densely and uniformly. Note first that even for the same year some GNP values (1968) and export values (1969) differ by 10 to 20% depending on the source. As a result, the 1968 Trade/GNP ratio could be taken as low as 36 or as high as 39%. Throughout the period from 1958 to 1970, exports fluctuate, with little systematic trend, from 11 to 22% of GNP, while imports fluctuate only slightly less—from 12 to 17%. The combined Trade/GNP ratio varies from 24 to 39%, even when neglecting the 22% figure for 1960. Such variation is fairly typical for most countries on which we could find data. A statistical analysis based on a single year's single source values would be based on shaky grounds, and reporting the resulting regression coefficients with four significant figures would not be warranted.

The problem is aggravated when we extend Chile's series back to 1955: the export and trade ratios reported in two different studies are mutually fairly consistent, but differ so drastically from all of the subsequent values (more than double the 1958–1970 averages!) that we are inclined to discard them: Either the data are erroneous, or else the 1955 trade pattern was drastically different from that of the subsequent 15 years. Being lazy by nature, we tried to collect the least possible data necessary to test the aforementioned theoretical models, but we reluctantly came to the conclusion that nothing short of the scope sampled in Table 1 would do.

TABLE 1
Sample Data Sheet: Chile

Year	Population (millions)	GNP ^s (10 ⁹ \$)	Exports ^s (10 ⁹ \$)	Imports ^s (10 ⁹ \$)	Exp/GNP (%)	Imp/GNP (%)	Trade/GNP (%)
1972	9.2 ^b	—	0.86 ^a	—	—	—	—
71	—	—	0.96 ^a	0.98 ^a	—	—	—
70	8.7 ^e	7.8 ^b	1.25 ^{a,i}	0.93 ^a	16	12	18
	—	—	1.07 ⁱ	{ 0.91 ^{a,j}	{ 18 ^{i,i}	{ 15 ^j	{ 33 ^{i,i}
69	—	6.1 ^f	{ 1.00 ^{a,j}	{ 0.87 ^b	{ 16 ^f	{ 14 ^{i,b}	{ 31
	—	—	0.91 ^b	—	15 ^{f,b}	—	29 ^{i,b}
68	—	{ 4.3 ^h	{ 0.94 ^{a,i}	{ 0.75 ^h	{ 22 ^h	{ 17 ^h	{ 39 ^h
	—	{ 4.7 ^g	{ 0.93 ^h	{ 0.74 ^a	{ 22 ⁱ	{ 16 ^{a,a}	{ 36 ^{a,h,a}
67	—	[4.7] ^u	0.91 ^a	0.72 ^a	19	15	34
66	—	[4.7]	0.88 ^a	0.75 ^a	19	16	35
65	8.6 ^d	4.8 ^d	0.69 ^a	0.60 ^a	14	12	26
64	—	—	—	—	—	—	—
63	8.0 ^e	[4.6]	0.54 ^a	0.64 ^a	{ 12 ^a	14	{ 25
62	—	—	—	—	{ 9 ⁿ	—	{ 27 ^d
61	7.8 ^c	[4.5]	0.51 ^m	0.59 ^m	11	13	24
60	—	4.4	—	—	—	—	22 ^c
59	—	—	—	—	—	—	—
58	—	[3.3]	0.39 ^a	0.42 ^a	12	13	25
57	—	2.7 ^c	—	—	—	—	—
56	—	—	—	—	—	—	—
55	6.8 ^{a,a}	1.2 ^r	—	—	40 ^r	—	—
54	—	—	—	—	—	—	70 ⁿ
53	—	—	—	—	—	—	—

Averages			
1970 $\pm$ 2	18	15	33
1965 $\pm$ 2	16	14	28 ^v
1960 $\pm$ 2	12	13	24 ^v
1955 $\pm$ 2	(40) ^w	—	(70) ^w
Grand Average ^x	15.3	14.3	28.7 ^v

^a United Nations (1974).
^b Partington (1972).
^c Russett <i>et al.</i> (1964)
^d Taylor and Hudson (1972).
^e United Nations (1972).
^f Harth (1971).
^g Reader's Digest (1970).
^h Reader's Digest (1971).
ⁱ United Nations (1969).
^j World Almanac (1966).
^k World Almanac (1968).
^m Stark (1963).
ⁿ Vital (1967).
^o Deutsch and Eckstein (1961).
^p Deutsch <i>et al.</i> (1962).
^r Rummel (1972).
^s GNP, Exports, and Imports presumably are in billions of <i>current</i> U.S. dollars, but all sources do not specify it.
^t More weight is given to values based on GNP and trade figures from a single source.
^u Square brackets indicate values obtained by interpolation, a practice which seems to be relatively safe with GNP, but not with the more fluctuating trade figures.
^v Trade ratio differs from the sum of export and import ratios because of inclusion of direct trade ratio data (without underlying export-import data).
^w Parentheses indicate averages based on a single value.
^x Average of 1970, 1965, and 1960 averages, with a single value given half weight.

When we tried to restrict ourselves to a couple of previous compilations, we all too often faced a set of values similar to Chile's Trade/GNP ratios of 22 and 27% from two editions of *The World Handbook of Political and Social Indicators* (Russett *et al.*, 1964; Taylor and Hudson, 1972), which could be averaged, plus 70% from Deutsch *et al.* (1962), which is too deviant to make any averaging meaningful.

Our data collection started with nearly 200 countries and territories for which there were some GNP or trade data available. For 181 of them, at least one year's Exports/GNP or Imports/GNP ratio could be determined; sometimes trade and GNP figures of contiguous years had to be used. For all possible years (or contiguous years), export, import, and trade ratios were calculated (see Table 1 for sample format). We then took the averages of these ratios over 5-year intervals centering on 1955, 1960, 1965, and 1970, eliminating values which so widely diverged from the country's general pattern that an error was highly likely. If there was only one value available for a given 5-year period, we considered it marginal and recorded it in parentheses. If there were two or more values to be averaged, we considered the result "strong." We then eliminated the countries with limited data, using the following criteria for inclusion in the final list: at least two periods "strongly" represented, or at least three periods "marginally" represented or, with populations of less than one million, at least two periods "marginally" represented. Thus, in general, we accepted only countries for which we had at least three Trade/GNP ratio values widely spaced in time, or at least four values rather closely spaced. Relaxed criteria were applied to very small countries because otherwise very few such countries would have remained on the list, and yet they are of special interest, if one wants to study the effects of population size. One further restriction was then introduced: All import and export figures had to be smaller than the GNP; this criterion eliminated Hong Kong, Singapore, and South Yemen. There is obviously something amiss when a country trades more than it produces. In some cases it may signal a gross error in data. In others (such as Hong Kong and Singapore) it is more likely to indicate that transit trade dominates in trade figures, and we would not expect transit trade to depend on territory size in the same way as other types of trade. Our criterion obviously has not eliminated all countries with considerable transit trade, but at least caught the extreme cases.

The final list thus culled includes 110 countries and territories, and is shown in Table 2. Hopefully, this list will enable several researchers to run different analyses and to test different theoretical models of trade *on the same data*, both cross-sectionally and in time series, especially when combined with Deutsch and Eckstein's (1961) data for 1890-1959. Table 2 shows separately the Exports/GNP and the Imports/GNP ratios; the trade ratio can be easily obtained by adding the two. However, the export and

TABLE 2
Export/GNP (Upper Line) and Import/GNP (Lower Line) Ratios, in Percent

Country	1955 ^a	1960	1965	1970	Average ^c	RI ^d
Afghanistan	(7) ^b (11)	— —	5.5 11	7.5 11	6.5 11	0.68
Algeria	— —	(21) (48)	26 25	29 31	26 32	1.83
Angola	— —	(45) (46)	42 41	31 30	38 38	1.64
Argentina	14 14	(11) (14)	8.7 7.0	9.7 9.0	9.8 10.0	0.69
Australia	— —	(13) (14)	14 14	14 17	14 15	0.85
Austria	19 —	(20) (23)	21 23	19 24	20 23	1.11
Barbados	— —	(50) (93)	41 74	33 77	40 79	1.24
Belgium	34 39	— —	35 36	40 40	38 38	2.01
Bolivia	49 —	(16) (25)	(18) (22)	19 18	18 21	0.85
Botswana	— —	— —	28 60	18 43	23 52	1.07
Brazil	— —	(6.9) (7.6)	8.3 7.2	7.6 8.3	7.7 7.7	0.84
Bulgaria	(11) —	(13) (13)	20 20	22 22	19 19	0.98
Burma	(23) —	(17) (19)	13 11	(6.2) (8.9)	12 12	0.91
Cambodia	— —	(12) (17)	10 12	6.2 9.0	9 12	0.54
Cameroon	— —	(25) (23)	20 21	26 23	23 22	0.97
Canada	20 23	(16) (16)	19 18	19 17	18 17	1.17
Cent. Afr. Rep.	— —	(14) (17)	17 19	18 19	17 19	0.52
Chad	— —	(16) (18)	12 15	13 20	13 18	0.66
Chile	(40) —	12 14	16 14	18 15	15 14	0.73
China (Mainland)	(0.7) —	— —	(2.0) (1.6)	2.8 2.8	2.4 2.2	0.49
Colombia	(14) —	(13) (11)	11 11	10 12	11 11	0.75

Continued

TABLE 2 (Continued)

Country	1955 ^a	1960	1965	1970	Average ^c	RI ^d
Congo (B)	—	—	(34)	26	29	
	—	—	(47)	45	46	1.09
Costa Rica	(27)	—	21	24	22	
	—	(27)	29	31	29	0.84
Cuba	(27)	(27)	19	(28)	23	
	—	(28)	38	(47)	38	1.87
Cyprus	—	(20)	(17)	20	19	
	—	(41)	40	43	41	0.87
Czechoslovakia	(14)	(15)	11	(17)	14	
	—	(17)	11	(17)	14	0.84
Dahomey	—	(13)	7	12	10	
	—	(15)	19	25	21	0.69
Denmark	29	30	27	23	27	
	35	31	31	27	30	1.25
Dominican R.	(23)	(20)	14	16	16	
	—	(20)	13	19	17	0.64
Ecuador	(13)	(18)	16	14	16	
	—	(14)	15	18	16	0.69
Egypt	(13)	(14)	10	11	11	
	—	(20)	15	11	14	1.11
Ethiopia	(7.2)	(7.8)	8.2	7.1	8	
	—	(9.0)	11	10	10	0.73
Finland	22	(23)	22	22	22	
	24	(21)	23	23	23	0.94
France	12	13	12	11	12	
	(13)	14	13	12	13	1.19
Gabon	—	—	(91)	82	84	
	—	—	(60)	48	52	1.00
Gambia	—	(55)	46	37	44	
	—	(50)	55	32	53	0.92
Germany (E)	(35)	(17)	10	8.4	11	
	—	(15)	10	8.8	10	0.66
Germany (W)	19	20	17	18	18	
	18	17	17	16	17	1.61
Ghana	—	24	14	19	19	
	—	22	19	18	20	0.97
Greece	(9.1)	(8.4)	7.6	7.0	7.5	
	—	21	18	21	20	1.02
Guatemala	(17)	(17)	16	16	16	
	—	(23)	19	16	19	0.76
Guyana	—	(47)	54	57	54	
	—	(57)	60	55	57	1.23

TABLE 2 (Continued)

Country	1955 ^a	1960	1965	1970	Average ^c	RI ^d
Haiti	(12) —	(11) (12)	10 10	10 12	10 11	0.46
Honduras	(23) —	(20) (19)	24 26	(26) (29)	24 25	0.81
Hungary	(16) —	(14) (13)	(14) (14)	9.3 8.8	12 11	0.60
Iceland	— —	(70) (91)	25 34	30 39	36 47	0.68
India	(4.7) —	(4.4) (6.4)	3.6 6.2	4.2 5.8	4.0 6.1	1.19
Indonesia	(9) —	(7.0) (4.9)	(7.0) (6.7)	(10) (10)	8.0 7.1	0.84
Iran	— —	(35) (27)	24 15	24 17	26 18	1.33
Iraq	(52) —	(57) (31)	41 21	38 15	43 21	1.03
Ireland	25 41	(23) (35)	27 (37)	27 41	26 38	1.37
Israel	(10) —	(10) (30)	(11) (22)	15 28	13 27	0.93
Italy	11 17	(10) (13)	14 18	15 16	14 16	1.51
Ivory Coast	— —	— —	29 25	34 25	32 25	0.98
Jamaica	— —	(27) (36)	27 36	24 30	26 34	1.02
Japan	10 15	11 12	11 12	9.8 9.1	11 11	1.27
Jordan	(8.0) —	(5.0) (48)	5.6 29	6.8 29	6.0 33	1.04
Kenya	— —	(17) (31)	16 28	13 24	15 27	1.43
Korea (S)	(1.0) —	(0.5) (12)	6.1 (16)	8.3 24	5.9 19	1.44
Kuwait	— —	— —	75 28	65 27	70 28	0.55
Laos	— —	(1.0) (31)	1.1 19	2.9 38	1.8 29	0.91
Lebanon	(8) —	(5) (36)	(6) (35)	(11) (40)	7.3 37	1.24
Lesotho	— —	— —	11 47	(7.7) (51)	9.4 49	1.16

Continued

TABLE 2 (*Continued*)

Country	1955 ^a	1960	1965	1970	Average ^c	RI ^d
Liberia	(21)	(41)	65	66	61	
	—	(29)	49	42	42	1.08
Libya	(13)	(20)	77	82	68	
	—	—	31	26	28	0.82
Malagasy R.	—	—	16	16	16	
	—	—	22	22	22	1.00
Malta	—	(8)	16	20	16	
	—	(67)	64	75	69	1.18
Mauritius	—	(41)	(34)	36	37	
	—	(42)	(40)	42	42	0.94
Mexico	(12)	(9.0)	8.5	4.8	7.1	
	—	(14)	(8)	7	9.0	0.79
Morocco	—	(24)	18	16	18	
	—	(20)	20	19	20	1.15
Mozambique	—	(17)	(21)	(9)	16	
	—	(27)	(33)	(16)	25	1.21
Netherlands	(35)	(35)	(33)	35	34	
	—	(39)	(39)	40	40	2.28
New Zealand	(27)	(24)	21	22	22	
	—	(28)	21	19	22	0.74
Nicaragua	(24)	(30)	25	21	24	
	—	(37)	29	25	29	0.87
Norway	20	(19)	(21)	20	20	
	33	(33)	(32)	29	31	1.19
Panama	(6.4)	(10)	13	13	12	
	—	(29)	33	35	33	0.88
Pakistan	(8.7)	(5.0)	4.7	5.2	5.0	
	—	(6.6)	8.9	7.7	8.0	0.96
Paraguay	(18)	(18)	12	10	12	
	—	(17)	11	12	13	0.40
Peru	(21)	(16)	16	15	16	
	—	(19)	17	11	15	0.86
Philippines	(9.4)	(10)	14	11	12	
	—	(11)	18	15	15	1.22
Poland	(7)	(8)	8.5	(10)	8.8	
	—	(9)	9.3	(10)	9.4	0.75
Portugal	(16)	—	19	15	17	
	—	—	30	23	26	1.36
Rhodesia	—	—	23	25	24	
	—	—	24	26	25	1.03
Romania	(7.2)	(7.2)	(7.5)	(9.5)	8.2	
	—	(7.4)	(7.3)	(10)	8.2	0.55

TABLE 2 (Continued)

Country	1955 ^a	1960	1965	1970	Average ^c	RI ^d
Salvador	(21) —	(22) (21)	24 25	22 22	23 23	0.82
Saudi Arabia	— —	(78) —	90 (26)	78 27	83 27	1.26
Senegal	— —	27 (45)	19 24	18 24	21 28	1.07
Somalia	— —	(20) (30)	23 35	(32) (52)	24 38	1.29
S. Africa	(20) —	— —	(15) (21)	13 21	14 21	1.38
Spain	(6.0) —	(5.6) (10)	(5.5) (17)	6.8 15	6.2 14	1.13
Sri Lanka	(37) —	(31) (31)	27 22	17 20	24 23	1.28
Sudan	— —	(20) (27)	14 15	(15) (16)	16 18	1.10
Sweden	21 25	(20) (23)	(23) (25)	21 21	22 23	1.14
Switzerland	23 28	(21) (23)	25 33	24 28	24 29	1.32
Syria	— —	(17) (28)	18 22	13 24	16 24	1.05
Thailand	(16) —	(15) (19)	17 22	13 22	15 21	1.68
Togo	— —	(27) (23)	17 26	(23) (28)	21 26	0.75
Trinidad	— —	(77) (75)	64 69	57 54	64 64	1.58
Tunisia	— —	(23) (23)	(13) (27)	15 22	16 24	0.96
Turkey	(4.8) —	(4.4) (5.6)	4.9 6.3	4.5 6.8	4.6 6.4	0.50
Uganda	— —	(36) (21)	(27) (17)	26 16	29 18	0.86
USSR	2.3 2.2	(3.5) (3.6)	(2.6) (2.6)	2.5 2.3	2.8 2.7	0.41
UK	18 23	(16) (18)	17 19	17 19	17 19	1.79
USA	4.9 3.5	4.5 4.3	4.2 3.3	4.1 4.4	4.3 4.0	0.58
Uruguay	(12) —	(11) (12)	(12) (10)	12 11	12 11	0.38

Continued

TABLE 2 (Continued)

Country	1955 ^a	1960	1965	1970	Average ^c	RI ^d
Venezuela	(43)	(57)	35	28	37	
	—	(36)	15	16	20	1.01
Volta	—	—	6	8	7	
	—	—	14	18	16	0.68
Western Samoa	—	—	(22)	(35)	28	
	—	—	(42)	(59)	50	0.58
Yugoslavia	(5)	9	14	14	12	
	—	14	18	22	18	1.20
Zambia	—	(40)	62	58	56	
	—	—	37	36	36	1.41

^a Average of data available for 1955 $\pm$ 2. The same applies to other dates.

^b Parentheses indicate averages based on a single value.

^c Average of 1960, 1965, and 1970 figures shown, with values in parentheses given half weight; rounded off to 2 significant figures.

^d RI = Relative interaction index, as defined in Eq. (8), based on Average Imp/GNP. The second decimal, though given, has little significance.

Data Sources. See notes *a* to *r* of Table 1. It would be too space consuming to show the specific sources for each figure in the present Table—110 tables of the format of Table 1 would be needed.

import patterns are often seen to be so widely different (for reasons to be discussed later) that they should not be lumped together unquestioningly. A minor disadvantage of our form of presentation is that Table 2 does not include the previous compilations of Trade/GNP data by Deutsch *et al.* (1962), Russett *et al.* (1964), and Taylor and Hudson (1972), where exports and imports are not listed separately. There is usually fair agreement between our values and theirs; exceptions are shown in Table 3. In view of the wide year-to-year fluctuations, we have abstained from giving our ratios with more than two significant figures; extra decimals might impress the uninitiated with their apparent precision, but they would be devoid of any informational content. For the 5-year periods centering around 1965 and 1970, both export and import ratios are given for all 110 countries; for 1960, data are complete for 91 countries. The very incomplete data (17 countries) for 1955 is listed mostly for purposes of time series studies.

SIZE-DEPENDENCE OF TRADE

An inspection of Table 2 shows occasional large fluctuations in Exp/GNP and Imp/GNP ratios. Therefore, further smoothing was undertaken by weighted averaging of the 1960-, 1965-, and 1970-centered data—the values in parentheses (which are based on a single year's figure) were given half the weight of the other values (which are based on more than 1

TABLE 3
Major Disagreements in Trade/GNP Ratio^a

	Table 2 1955 $\pm$ 2	Deutsch 1962, 1955	Table 2 1960 $\pm$ 2	Russett 1964, 1959	Table 2 1965 $\pm$ 2	Taylor 1972, 1965
Algeria	—	69	69	—	51	66
Australia	—	34	27	26	28	14
Barbados	—	—	143	103	115	116
Bolivia	—	87	41	66	40	38
Bulgaria	—	—	26	—	40	68
Cameroon	—	—	48	63	41	43
Czechoslovakia	—	—	32	—	22	47
Egypt	—	30	34	38	25	33
Ethiopia	—	16	17	20	19	26
France	25	21	27	20	22	21
Germany (E.)	—	—	32	—	20	26
Hungary	—	—	27	—	28	40
Iceland	—	72	161	41	59	56
Indonesia	—	15	12	21	14	18
Israel	—	44	40	27	33	34
Italy	28	20	23	22	32	25
Kuwait	—	—	—	—	103	67
Lebanon	—	73	41	50	41	52
Morocco	—	54	44	33	38	34
Nicaragua	—	50	61	41	54	54
Rhodesia	—	—	—	66	57	79
Romania	—	—	15	—	15	32
Sudan	—	33	47	33	29	30
Turkey	—	12	10	14	11	12
Uganda	—	—	57	42	44	44
USSR	4.5	4	5.5	5	5.2	9.8
Uruguay	—	27	23	29	25	22
Venezuela	—	64	93	52	50	53
Yugoslavia	—	13	23	13	32	27

^a Only those countries are shown for which one of our 5-year averages differs by more than 25% from previous 1-year listings.

year's figures). The purpose of this smoothing is to reduce what could be called measurement error, from our macroscopic world-wide viewpoint. Sometimes smoothing data is dangerous in that it eliminates important substantive sources of variation. The choice depends on the scope of the problem envisaged. The various Trade/GNP ratios compiled in Table 1 should not be averaged if the purpose is to study Chile's economy, since from this more narrowly delineated viewpoint, the reasons for every change in trade volume could and should be described. However, for a comparison of Chile with all of the other countries of the world, such detail must be neglected as if it were random fluctuation. These smoothed values are plotted against the population size in 1965 (from Taylor and

FIG. 1. Imports/GNP ratio versus population, on log-log scale. Average (1958–1972) data from Table 2; population data (for 1965) from Taylor and Hudson (1972). The solid line shows the best fit with constants involving only one significant figure. Dashed lines delineate the zone where points deviate from the best-fit line by a factor smaller than 2. See Table 4 for abbreviations of deviating country names.

Hudson 1972), in Figs. 1 and 2. Logarithmic scale is used on both axes, as done previously by Deutsch *et al.* (1962) and by Dahl and Tufte (1973). Our Trade/GNP ratios represent the averages of available values ranging from 1958 to 1972, and the reported population often changed by 20% or more during these years. Still, compared to variability in trade ratios, the population changes are minimal.

The striking observation in comparing Figs. 1 and 2 is that imports are visibly much better correlated with population size than are exports. In

FIG. 2. Export/GNP ratio versus population, on log-log scale. The comments underneath Fig. 1 apply.

Fig. 1, there is a clear linear correlation between $\log(\text{Imp/GNP})$ and $\log(\text{Population})$, yielding the approximate relationship

$$\text{Imp/GNP} = 40/P^{1/3} \quad (P \text{ in millions, Imp/GNP in percent}). \quad (5)$$

When the population figure is given, this equation would yield an Imp/GNP ratio which in 94% of cases is within a factor of 2 compared to the actual ratio. Separate plots for every 5-year period also fit Eq. (5), with only slightly wider scattering. There seems to be no systematic trend in time from 1955 to 1970.

On the other hand, the correlation between $\log(\text{Exp/GNP})$ and $\log(\text{Population})$ in Fig. 2 is quite blurred. The highest (Saudi Arabia) and the lowest (Laos) single values both occur in the middle of the population range. In addition to the drop in Imp/GNP for very large populations, there is also a hint of a drop for very small populations, which tempts one to carry out a parabolic analysis such as that of Deutsch *et al.* (1962)—cf. our Eq. (1)—instead of a linear one. As a very rough rule of thumb, one could describe the linear relation (of logarithms) by

$$\text{Exp/GNP} = 30/P^{1/3} \quad (P \text{ in millions, Exp/GNP in percent}). \quad (6)$$

The advantage of such a formulation is that the export and import ratios can be simply added to yield Eq. (3), which was first presented as an approximate Trade/GNP relation for previous 1955 data. Given the population, Eq. (6) yields an Exp/GNP ratio within a factor of 2 of the correct one in 77% of the cases only, while Eq. (3) achieves the same for the Trade/GNP ratio in 92% of the cases for our data, and in 87% of the cases for single year data from Taylor and Hudson (1972). Again, no clear trend in time is visible from 1955 to 1970.

We also considered 50 further countries not included in Table 2 but on which we had at least one trade ratio, and neither exports nor imports exceeded GNP. Some of these data are quite questionable so that a wider scattering is expected and observed: Only 74% of the import ratios and 44% of the export ratios are within a factor of 2 of the values given by Eqs. (5) and (6). Note that the imports again show a higher correlation with population; even if we included these questionable cases, 87% of Imp/GNP ratios would be within a factor of 2 of the value given by Eq. (5).

A particular data set could be fitted with more precision than is the case for Eqs. (3), (5), and (6). But the precise values of the constants would then vary depending on the particular data set selected. The advantage of giving the coefficient values with only one significant figure, as we have done here, is twofold: (i) The same equations apply to all data sets we have tried, from 1953 to 1972, within the limited range of precision implied; and (ii) estimates of trade ratios based on known population

figures are easy to calculate. Refined statistical treatment of our data may offer complementary advantages, as long as overprecise analysis of imprecise data is not thought to lead to precise results. But our own effort will be directed toward explanation of the main features described here, through formal models to be discussed in a subsequent paper.

We have used P in millions and Trade/GNP ratios in percent. However, Eqs. (3), (5), and (6) would remain unaltered if P were in number of people and the Trade/GNP ratios in fractions. This invariance occurs only when the exponent is $\frac{1}{3}$. Coefficients in Eqs. (1), (2), and (4) would change when units are changed.

For populations smaller than 27,000, Eq. (6) would yield exports larger than the GNP—an impossibility if we exclude transit trade. In general, the empirical Eqs. (3), (5), and (6) should not be used for populations much smaller than 100,000.

Are the inverse cube root Eqs. (5) and (6) a peculiarity of the last 20 years, or are they more durable? An answer could be given on two levels: (i) through a mathematically expressed conceptual model which explains why the relationship exists in the first place; and (ii) through analysis of extensive historical data. For the time being, we only present a sketchy version of the latter approach, using trade data compiled by Deutsch and Eckstein (1961) and easily available population figures. Figure 3 shows the Imp/GNP and Exp/GNP ratios for 14 countries, in 1928 and in 1958–1972. The overall picture does not seem to have changed or shifted. For the United States, values at 10-year intervals are shown, starting with 1799. The U.S. import ratio is seen to be consistently on the low side of the contemporary world average, by a factor of 2, thus proceeding on an inverse cube root path of its own, all the way from a population of a mere 5 million up to the present 200 million. The export ratio path consists of two segments: 1799–1869 when imports regularly exceeded exports, and 1879–1969 when the reverse was true. Within each segment, the inverse cube root relationship applies, and both segments are within the zone where contemporary worldwide data points are located. Data in Fig. 3 are obviously too limited for concluding that Eqs. (5) and (6) apply throughout history, but they suggest that this potentially exists and should be further investigated.

An approximate cube root relationship with population has previously been observed for the size of national assemblies (Taagepera, 1972); therefore, this size might be expected to be inversely proportional to Imp/GNP. The actual correlation is quite poor due to two factors: (i) The random deviations from the two cube root relationships cumulate upon elimination of P ; and (ii) assembly size correlates best with adult literate population rather than total population. Literacy level does not seem to affect the Trade/GNP ratios to any noticeable degree.

FIG. 3. Long-term changes in Imports/GNP and Exports/GNP ratios and population, on log-log scale. United States data are plotted at 10-year intervals. The arrow tip represents the 1958-1972 average, while the blunt end represents the 1928 data; arrow curvatures have no meaning. Best fit zones from Figs. 1 and 2 are also shown. Pre-1960 data from Deutsch and Eckstein (1961) for Trade/GNP and from World Almanac (1966, 71) for population. Later data as in Fig. 1. See Table 4 for country name abbreviations.

IMPORTS VERSUS EXPORTS

In retrospect, previous studies of size-dependence of trade omitted the most promising component—the imports—and either concentrated on exports, or on total trade, which included the confusing scattering of export data. The aforementioned Sawyer's (1967) finding of relatively high correlation for Trade/GNP but low correlation for Exp/GNP should have lead to the conclusion that the other trade component (Imp/GNP) might be even more highly correlated with size than total trade is. But such hints are best noticed in hindsight. The reasons for an export-oriented approach (which this paper's authors shared until data forced them to switch) merit further discussion because they may shed light on our general economic thinking.

We may subconsciously tend to take it for granted that, at least over the long run, exports and imports of a country must be balanced, and that exports are the active component: A country first looks at how much it

TABLE 4
Country Abbreviations Used in Figs. 1 to 4

Abbreviation	Country	Abbreviation	Country
Af	Afghanistan	La	Laos
Al	Algeria	Ln	Lebanon
An	Angola	Lr	Liberia
Ba	Barbados	Ls	Lesotho
Be	Belgium	Ly	Libya
Bo	Botswana	Ma	Malta
CA	Central African Republic	Ne	Netherlands
Ca	Cambodia	No	Norway
Ch	China	Pg	Paraguay
Cn	Canada	Pn	Panama
Cu	Cuba	Ro	Romania
Cy	Cyprus	SA	Saudi Arabia
Da	Dahomey	Sd	Sweden
De	Denmark	SK	South Korea
Fi	Finland	Sp	Spain
Fr	France	SU	Soviet Union
Ga	Gabon	Sz	Switzerland
Gr	Greece	TT	Trinidad & Tobago
Ha	Haiti	Tu	Turkey
Id	Ireland	Ug	Uganda
Iq	Iraq	UK	United Kingdom
Ir	Iran	Ur	Uruguay
Is	Israel	US	United States
It	Italy	Ve	Venezuela
Ja	Japan	Vo	Volta
Jo	Jordan	WG	West Germany
Ke	Kenya	WS	Western Samoa
Ku	Kuwait	Za	Zambia

exports, and then adjusts its imports accordingly. Countries unable to spend all the money they earn from exports may be seen as negligible aberrations, and the same goes for countries which go in debt or find ways other than exports to pay for imports. However, exports chronically tend to amount to less than imports for the majority of world countries. Table 5 shows that two-thirds of countries fail to break even, and that the median export/import ratio tends to be less than 0.90 rather than close to 1.00 as expected in case of balance. The trend toward more balance is slow, if there is any. Figure 4 shows the detailed picture, with weighted averages of export and import ratios plotted against each other. Logarithmic scales are used on both axes, in order to make equal *relative* deviations from trade balance appear as equal distances on the plot. The three straight lines shown correspond, respectively, to trade balance, and to 50% export excess or deficiency relative to imports. The scattering of points is about as wide as in Fig. 2. Note that the deviant high export cases in Fig. 4 also

TABLE 5
Most Countries' Import Figures Exceed Export Figures

Countries	1950	1960	1965	1970
All countries in Table 2				
Percentage with Exp < Imp	76	70	65	66
Median Exp/Imp ratio	0.84	0.89	0.89	0.84
Countries with no blanks in Table 2 (N = 15)				
Percentage with Exp < Imp	73	73	67	60
Median Exp/Imp ratio	0.84	0.92	0.92	0.94

tend to be high in Fig. 2 (exports versus population) but not in Fig. 1 (imports vs population). The same can be said about the especially low points. These deviant points will be investigated next, in order to find out why imports are more size-dependent than exports.

Countries with systematic heavy trade surpluses ($\text{Exp}/\text{Imp} = 1.4$ or more—see Table 6) tend to have a high concentration of export commodities. Even the lowest concentration index for this group (Gabon) is above the world median. The converse is not true: some other high concentration countries have considerable trade deficits, as shown by examples at the bottom of Table 6. The heavy surplus countries typically have relatively small populations combined with an unusually rich deposit of an exportable mineral resource: oil, copper, iron. Because of the

FIG. 4. Exports/GNP versus Imports/GNP, on log-log scale. Average (1958–1972) data from Table 2. See Table 4 for country name abbreviations.

TABLE 6
Countries with Large Export/Import Ratio

Country	Exp/Imp ratio ^a		Export concentration ^b		Main export commodities ^c
	Rank	Value	Rank	Index	
Saudi Arabia	1	3.1	—	—	Oil
Kuwait	2	2.5	5	0.88	Oil
Libya	3	2.4	1	0.99	Oil
Iraq	4	2.1	—	—	Oil
Venezuela	5	1.9	—	—	Oil
Uganda	6	1.6	36	0.36	Coffee, Copper, Cotton
Gabon	7	1.6	44.5	0.29	Wood, Oil
Zambia	8	1.5	3	0.92	Copper
Liberia	9	1.4	11	0.59	Iron
Iran	10	1.4	6	0.78	Oil
Median:	55.5	0.87	51	0.25	
Mauritius	53	0.89	2	0.96	
Mauritania	—	—	4	0.89	
Cuba	91	0.61	7	0.75	
Barbados	96	0.51	8.5	0.64	

^a Exp/Imp ratios based on Average values of Exp/GNP and Imp/GNP ratios in Table 2.

^b Export concentration indices (from Taylor and Hudson, 1972, pp. 366–368; see pp. 346–348 for definition) reflect the degree of a country's dependence on a few major export commodities. It is not clear in the source whether the index shown is Σp_i^2 (as given in p. 366) or the square root of it (as given in p. 347); p_i is the proportion of total value of exports accounted for by the i th commodity.

^c Major commodities from Harth (1971) and Partington (1972).

smallness of the population, the import absorption ability is limited although funds are available. Exports themselves depend little on national population size, since only a small part of the territory and of the population is usually involved with the export mineral. Therefore, for countries with heavy trade surpluses, little relation between Exp/GNP ratio and population size should be expected.

Countries with systematic heavy export deficits (Exp/Imp = 0.6 or less—see Table 7) usually make it up through foreign aid, or by rendering various international services: receiving tourists (Barbados), exporting temporary labor who send money back home (Botswana), leasing military bases (Malta), profiting from special banking (Lebanon) or transport (Panama) facilities, or contributing heavily to international shipping (Greece). Worldwide export figures tend to be more erratic (for given population size) and generally lower than import figures because this “export of services” is not included in the export figures. Services seem to be disproportionately sold by smaller states (where it may represent a

TABLE 7
Countries with Low Export/Import Ratio

Country	Exp/Imp Ratio ^a		Major methods of compensating for trade deficit ^c
	Rank ^b	Value	
Laos	1	0.06	Foreign aid > Imports
Jordan	2	0.18	Arab and Western subsidies
Lesotho	3	0.19	Foreign aid > Imports; labor export (10% of population)
Lebanon	4	0.20	Banking, tourism, emigrant remittances
Malta	5	0.23	Lease of military bases, entrepôt services
South Korea	6	0.31	Foreign subsidies and investment
Greece	7	0.38	International shipping
Panama	8	0.38	Canal Zone services
Volta	9	0.43	Foreign aid > Imports
Botswana	10	0.44	Labor export (13% of labor force)
Spain	11	0.44	Labor export, lease of military bases, tourism
Cyprus	12	0.46	"Invisible earnings" (Partington, 1972, p. 68)
Israel	13	0.47	Foreign aid
Dahomey	14	0.50	Foreign aid = Imp - Exp
Barbados	15	0.51	Tourism
Western Samoa	16	0.56	Foreign aid = Imp - Exp
Kenya	17	0.56	Tourism and foreign aid?
Afghanistan	18	0.59	Foreign aid $\approx$ Imports

^a Ratios based on the average values in Table 2.

^b Rank counted from the lowest values. $N = 110$.

^c Based on data in Harth (1971) and Partington (1972).

considerable part of total trade) and bought by larger states (where it does not affect total trade appreciably). In a sense, even foreign aid received is equivalent to international services in the form of strategic, military, diplomatic, and commercial concessions by the recipient.

The GNP figures do include international services (other than intangible services in return for foreign aid), sometimes as a major factor: labor remittances from South Africa represent 40% of Lesotho's GNP; tourism receipts and banking represent 75% of Lebanon's GNP; 38% of Malta's and Greece's GNPs are in services. In calculating the Exp/GNP ratio, we are thus including such services in the denominator but not in the numerator.

One form of international services that affects imports and exports equally (and thus produces no deviations in Fig. 4) is transit trade. While we eliminated the clear transit trade cases of Singapore and Hongkong, several others may have stayed in our collection. The unusually high Imp/GNP ratios of Belgium, Netherlands, and United Kingdom (in Fig. 1) may be at least partly due to high transit trade.

RELATIVE INTERACTION INDEX (RI)

When studying the effect of country size on the relative share of international trade, we should ideally consider all the disposable income (GNP plus foreign aid); we should also subtract transit trade and add international service bought and sold. Then exports and imports would be essentially balanced, and the modified Trade/GNP ratio would be

$$\left(\frac{\text{Trade}}{\text{GNP}}\right)' = 2 \left(\frac{\text{Imp}}{\text{GNP}}\right)' = 2 \left(\frac{\text{Exp}}{\text{GNP}}\right)' \quad (7)$$

$$= \frac{\text{Trade} - \text{Transit Trade} + \text{Import of Services} + \text{Export of Services}}{\text{GNP} + \text{Foreign Aid}}$$

In the absence of such data, Fig. 1 suggests that the uncorrected Imp/GNP data may come closest to being an international interaction indicator which depends primarily on the country's size. Once the size is normalized out, a size-independent relative interaction index is obtained; using Eq. (5),

Index of relative degree of international trade interaction

$$= \text{RI} = \frac{\text{Actual Imp/GNP ratio}}{\text{Expected Imp/GNP ratio}} = \frac{(\text{Imports}) (\text{Population})^{1/3}}{40 \text{ GNP}} \quad (8)$$

where imports and GNP must be in the same units, and the population is in number of people (*not* in millions). The actual RI values are shown in Table 2. The RI index has the value 1.00, if the country considered has the medium Imp/GNP ratio for countries of its size. A deviation from unity expresses the residual variation in import intensity, when the size effect has been accounted for. As seen in Fig. 1 and Table 2, 94% of countries have RI values of more than 0.5 and less than 2.0. The RI has no obvious relationship with any other country characteristics. In particular, there seems to be no correlation with per capita GNP or with the duration of independence. The next challenge is to explain this non-size-dependent residual variation in Imports/GNP ratios.

CONCLUSIONS

We have found that the Imports/GNP ratio of a country is approximately proportional to the inverse cube root of its population. This simple relation (Eq. 5) holds, within a factor of 2, for more than 90% of contemporary countries, provided that the import figures used are the averages of at least 3 or 4 years. For each country, we can then obtain a "relative interaction index" (RI) which is the ratio of actual imports to those

expected for a country of given GNP and population size. These RI values are observed to range from 0.41 to 2.3, with most values close to unity, and they have no clear correlation with development level or any other sociopolitical characteristics.

The Exports/GNP ratio is less well-correlated with population size, although an inverse cube root relationship still may help to visualize the overall trend. Export figures as a rule fall short of import figures because they omit the export of labor and services; thus they fail to include export forms which depend directly on population size. On the other hand, export figures also include "windfall" profits by some lucky countries which happen to have desirable mineral deposits and have not yet depleted them; thus they include nondurable export items which depend little on the population size.

It would seem that countries do not, as a rule, adjust their imports to balance their exports of material goods. They rather tend to import by an amount which befits their population size and GNP, as determined by Eq. (8) with RI set equal to unity, and then proceed to make up the deficit by labor export, by offering international services, or by asking for (and apparently usually getting) foreign aid. If there is, on the other hand, a large export surplus, the difference tends to be saved, spent, or invested abroad rather than used to increase imports which apparently soon reach a saturation point.

In a brief inquiry into the past, we found that the United States Imports/GNP ratio has tended to decrease according to the inverse cube root pattern ever since it was a nation of 5 million, 170 years ago. The relationship thus might have more than passing significance.

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