An explanation of differences in trade-product ratios among countries (*)

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This paper tries to explain differences in trade-product ratios (i.e. import or export of goods and services divided by national product : $\frac{M}{Y}$ ([1]) and $\frac{X}{Y}$) of 61 countries for the years 1954, 1958 and 1961. The greater $\frac{X}{Y}$ the more, *ceteris paribus,* an economy is influenced by inflationary or deflationary impulses from abroad ; the greater $\frac{M}{Y}$ the more domestic inflationary and deflationary impulses are transmitted to the rest of the world.

I. THE EXPLANATORY VARIABLES

The four following independent variables revealed generally significant in the regression analysis ([2]).

1. *Population* (*variable P*) : Obviously, the smaller its population, the more a country would tend to specialize in the production of a few goods and services and import the remaining bulk [2], [5], [6], [10].

2. *Product per head* (*variable* $\frac{Y}{P}$) : There exists a theory about the decline of the share of international trade with the growth of income

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([1]) We also made experiments with $\frac{M}{Y+M}$ instead of $\frac{M}{Y}$ but the results were less good. For a discussion on the relevance of these ratios see [9].

([2]) The values of all the dependent and independent variables in 1961 can be found in the table of the Appendix.

which has been first formulated by Werner Sombart [2], [4], [8], [11]. As will be seen, our findings tend to confirm that theory with some qualifications.

3. *Vicinity* (*variable V*) : If a country is close to the rest of the world, the impediment to trade constituted by transport and other costs (including psychological costs) will not play a great role so that one can expect, ceteris paribus, high trade-product ratios.

The average vicinity of a country to the rest of the world, was measured by following formula : $\sum_j \frac{X_j}{D_{i,j}}$ i.e. the weighted sum of the inverses of the distances between the country considered and all the trade partners, the weights being the total export of the partner ([3]).

Colum (5) of the table in the Appendix shows the values of vicinity for 61 countries in 1961, ranked in decreasing order of that variable, the three « nearest » countries being the Benelux-countries and the three « farthest » India, Japan and Australia.

4. *Preferential treatment* (*variable Pr*).

We also tried to estimate the advantage of preferential treatments enjoyed by numerous countries. We took into account :

([3]) This choice can be justified as follows : in a cross-section study of all the trade flows between 42 nations, J. TINBERGEN obtained approximately the following formula (viz. [15] and also [11], [13] and [14]) :

$$M_{i,j} = k \frac{Y_i Y_j}{D_{i,j}} \qquad (A) \qquad R^2 = 0{,}66$$

where $M_{i,j}$ stands for import of country i from country j, Y_i and Y_j the national products of i and j and $D_{i,j}$ the distance between both countries. Summing over j and dividing by Y_i :

$$\frac{M_i}{Y_i} = k \cdot \sum_j \frac{Y_j}{D_{i,j}} \qquad (B)$$

The sum-variable appearing on the right side of (B) would be nothing else, after division by $\sum_j Y_j$, than the weighted mean of the inverses of the distances, the weights being the national products of the different trading partners.

We used this sum-variable to stand for vicinity with two modifications :

— the inverses of distances were weighted by the export of the trading partner instead of its national product : we felt justified in doing so by the consideration that the import of a nation was made out of parts of the exports and not of the national products of the other countries.

— besides, we tried to measure economic rather than geographic distance. Therefore :
  - four kilometers by sea were considered as the equivalent of one kilometer by land;
  - every transshipment required in the transport of a good between two countries was taken into account as being equivalent to 50 land-kilometers.

Distance was usually (but not always) measured between the two capitals : so, in the case of the United States, distance from European countries was measured up to New York plus 250 land-kilometers and distance from Asian countries up to San Francisco plus 250 land-kilometers.

— the Benelux-agreement

— the Commonwealth preference

— the Franc Area preference

— the E.E.C. preference (for 1961)

— the E.F.T.A. preference (for 1961)

— the preference given by the U.S. to Cuba (for 1954 and 1958 but not 1961), to the Philippines and to Porto-Rico

— the preference existing in fact between Belgium and Congo (for 1954 and 1958 but not 1961).

We measured the total advantage of mutual preferential treatments enjoyed by a country i by summing the $\frac{X_j}{D_{i,j}}$ values of the countries partaking in the agreement after giving the weight 1 to the « hard » agreements and 1/2 to the « soft » agreement (Commonwealth preference, E.E.C. and E.F.T.A. preference in 1961). For instance, the value of the variable for Belgium in 1961 was computed as the sum of the $\frac{X_j}{D_{i,j}}$'s of Luxembourg and the Netherlands plus half the sum of the $\frac{X_j}{D_{i,j}}$'s of the three remaining E.E.C. countries, i.e. France, Germany and Italy.

Countries who did not benefit of mutual preferential treatments were given — quite arbitrarily — the value 0,01 for that variable (and not 0 because logarithms were to be used).

From colums (5) and (6) of the table in the Appendix, one sees that some positive correlation exists between preferential treatment and vicinity (for instance, the Benelux-countries rank first according to both) : this is not surprising in view of the construction of the two variables. It is also defensible on *a priori* grounds : the closer a country to the rest of the world, the greater will be the real advantage conferred by preferential treatments.

A fifth variable, the area of the country, was used without success and was consequently dropped.

II. THE RESULTS

A. Import-product ratio.

All the variables being expressed in logarithm to the base 10, ordinary least-squares gave the following results (the value of the t variable, $\frac{\hat{\beta}}{s_{\hat{\beta}}}$, stands in brackets under the regression coefficients) :

For 1954 :

$$\text{(I)}\quad \log \frac{M}{Y} = \underset{}{-\ 0.55990} \underset{(t=-29.2)}{-\ 0.244 \log P} \underset{(t=-8.05)}{-\ 0.100 \log \frac{Y}{P}} \underset{(t=-1.71)}{+\ 0.355 \log V} \underset{(t=3.13)}{} + \underset{(t=3.94)}{0.066 \log Pr}$$

$$R^2 = 0.712$$

All the coefficients are significant at the 1 % level — except that of income per head (4). We tried to improve our results by correcting income per head for differences in the purchasing power of the different currencies [3] — but the effect of this refinement proved quite small :

$$\text{(II)}\quad \log \frac{M}{Y} = \underset{}{-\ 0.47873} \underset{(t=-25.0)}{-\ 0.245 \log P} \underset{(t=-8.07)}{-\ 0.125 \log \frac{Y\ corr}{P}} \underset{(t=-1.73)}{+\ 0.358 \log V} \underset{(t=3.14)}{} + \underset{(t=3,93}{0.066 \log Pr}$$

$$R^2 = 0.712$$

For 1958, we obtained :

$$\text{(III)}\quad \log \frac{M}{Y} = \underset{}{-\ 0.50250} \underset{(t=-28.8)}{-\ 0.260 \log P} \underset{(t=-9.52)}{-\ 0.117 \log \frac{Y}{P}} \underset{(t=-2.24)}{+\ 0.341 \log V} \underset{(t=3.40)}{} + \underset{(t=3.85)}{0.056 \log Pr}$$

$$R^2 = 0.757$$

And for 1961 :

$$\text{(IV)}\quad \log \frac{M}{Y} = \underset{}{-\ 0.35431} \underset{(t=-23.8)}{-\ 0.275 \log P} \underset{(t=11.99)}{-\ 0.130 \log \frac{Y}{P}} \underset{(t=-2.87)}{+\ 0.243 \log V} \underset{(t=-2.70)}{} + \underset{(t=4.23)}{0.053 \log Pr}$$

$$R^2 = 0.804$$

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(4) It can be pointed out that the errors of observation on the regressand, $\log \frac{M}{Y}$, and on the regressor $\log \frac{Y}{P}$ are negatively correlated as Y appears in the denominator of the former and in the numerator of the latter. This given rise to bias from zero in the regression coefficient which, we hope, could partly offset the bias towards zero due to the presence of errors of observation per se in P.

In these two equations, all the coefficients are significant at the 1 % level (except the coefficient of $\log \frac{Y}{P}$ in (III) which is significant only at the 5 % level).

Thus according to (IV), the import-product ratio has an elasticity of about —0.27 with respect to population, —0.13 with respect to income per head ([5]), 0.24 with respect to vicinity and 0.05 with respect to preferential treatment.

The contribution of the four regressors to the explanation of the regressand can be measured e.g. by the « beta » coefficients [7]. These are nothing else than the regression coefficients obtained by using standardized regressors and regressand (i.e. expressing the variables as differences from their sample mean divided by their sample standard deviation). For 1961, we obtained (in decreasing order of the absolute values) :

— 0.742 for log P
0.282 for log Pr
0.220 for log V
— 0.216 for $\log \frac{Y}{P}$

The contribution of the first regressor is thus about three times that of each of the remaining three.

A comparison of the coefficients of (I), (III) and (IV) indicates that the estimated elasticities remained quite constant over time. However the constant term shows an important and very significant increase. This increase is probably attributable to the general trend towards freer trade, in the period under review, as a consequence of the G.A.T.T., O.E.C.D., I.M.F. and other institutions. The same reason probably accounts for the drop in the coefficient of Pr and also for the gradual rise of the determination coefficient because, as excessive protectionism in some countries was broken down, there appeared more conformity to the general « law ». Improvements in statistical data may also have played a role.

Moreover, separate regressions for developed and underdeveloped countries showed no significant difference in coefficients between both groups.

([5]) A. Maizels, interestingly enough, found higher elasticities for the share of equipment import in equipment investment : — 0.66 for population and — 0.38 for per capita income in a cross-section of 28 countries during the period 1957-59 [11a].

B. **The export-product ratio.**

The results with $\log \frac{X}{Y}$ as a regressand were :

For 1954 :

$$\text{(V)}\quad \log \frac{X}{Y} = -0.98969 - \underset{(t=-29.9)}{0.199 \log P} + \underset{(t=-3.81)}{0.038 \log \frac{Y}{P}} + \underset{(t=0.38)}{0.362 \log V} + \underset{(t=1.85)}{0.072 \log Pr} \qquad (t=2.49)$$

$R^2 = 0.437$

For 1958 :

$$\text{(VI)}\quad \log \frac{X}{Y} = -1.04904 - \underset{(t=-33.9)}{0.215 \log P} + \underset{(t=-4.45)}{0.056 \log \frac{Y}{P}} + \underset{(t=0.60)}{0.346 \log V} + \underset{(t=1.94)}{0.059 \log Pr} \qquad (t=2.26)$$

$R^2 = 0.480$

For 1961 :

$$\text{(VII))}\quad \log \frac{X}{Y} = -0.81250 - \underset{(t=-29.6)}{0.234 \log P} + \underset{(t=-5.55)}{0.034 \log \frac{Y}{P}} + \underset{(t=0.41)}{0.203 \log V} + \underset{(t=1.22)}{0.052 \log Pr} \qquad (t=2.29)$$

$R^2 = 0.518$

The fit is less good than with $\log \frac{M}{Y}$ as witnessed by the lower determination coefficient and the smaller number of significant regression coefficients. Only the constant term and the coefficient of log P are significant at the 1 % level ; the coefficient of log Pr is significant at the 5 % and that of log V only at the 10 % level.

However, a comparison of the estimated import and export functions, e.g. of (IV) with (VII), shows that the coefficients are very similar ([6]) except for the constant term and the elasticity with respect to product per head : the latter is (non significantly) positive in the case of export and (significantly) negative in the case of import. So this finding would bring about a qualification of Sombart's law : admittedly, the share of import tends to decrease, *ceteris paribus,* with rising per capita income but that of export tends to augment if anything.

Rich countries will thus usually have positive net export, financing transfers and capital export to the rest of the world. The effect of per capita income is important as witnessed by the following example :

([6]) Note, in both cases, the (non significant) decline of the coefficients of log V and log Pr over time reflecting probably lower relative transport costs and less discrimination.

take a rich country with population 10 million, product per head 1,500 dollars, vicinity 10 and preferential treatment 1 (these are roughly the figures corresponding to the case of Australia in 1961) : according to equation (IV), its import-product ratio will be 0.159 (in fact, it was 0.157 for Australia) and its export-product ratio 0.184 (it was 0.174) according to (VII), leaving an export surplus of 2,5 % of G.N.P. A country with the same characteristics except product per head, now at 150 dollars in lieu of 1,500 (this is roughly the case of Sudan) would show 0.215 for import (in reality, it was 0.250) and 0.175 for export (in fact, 0.144) i.e. a deficit representing 4 % of G.N.P.

III. A STUDY OF THE RESIDUALS

A look at the residuals of the regressions might prove promising. Table I below, shows the countries for which the absolute value of the residuals is 5 % or less of the observed import or export-product ratio (viz. also the last two columns in the Appendix) :

TABLE I

Countries for which the estimation error is small
($\leqslant$ 5 %)

Estimate of $\frac{M}{Y}$	Estimate of $\frac{X}{Y}$
1. Canada	1. Canada
2. Israel	2. Italy
3. Argentina	3. Switzerland
4. British Guiana	4. Chile
5. Korea	5. Colombia
6. Panama	6. Cyprus
	7. Jamaica
	8. Malta

The next table contains the countries for which the residuals represent 20 % or more of the value of the observed ratios.

It can be seen that the formula for $\frac{X}{Y}$ more frequently hits the bull's eye but does also more often under- or overshoot the mark by an appreciable percentage.

TABLE II

Countries for which the estimation error is important
($\geqslant$ 20 %)

Underestimation of $\frac{M}{Y}$	Underestimation of $\frac{X}{Y}$
1. Japan	1. Netherlands
2. Netherlands	2. Norway
3. United Kingdom	3. British Guiana
4. Algeria	4. Burma
5. Congo (Leopoldville)	5. Ceylon
6. Cuba	6. Congo (Leopoldville)
7. Ireland	7. Cuba
8. Fed. of Malaya	8. Fed. of Malaya
9. Porto-Rico	9. Ireland
10. Rhodesia	10. Peru
11. Trinidad	11. Porto-Rico
	12. Rhodesia
	13. South Africa
	14. Tanganyika
	15. Thaïland
Overestimation of $\frac{M}{Y}$	**Overestimation of $\frac{X}{Y}$**
1. France	1. France
2. Luxembourg	2. Israel
3. United States	3. United States
4. Barbados	4. Algeria
5. Brazil	5. Argentina
6. Costa Rica	6. Brazil
7. Ecuador	7. Greece
8. Guatemala	8. Honduras
9. Honduras	9. India
10. India	10. Korea
11. Malta	11. Mauritania
12. Mauritania	12. New Zealand
13. Philippines	13. Philippines
14. Turkey	14. Portugal
	15. Sudan
	16. Turkey

Regressing the residuals of the import regression, $\hat{u}_m$, on those of the export regression, $\hat{u}_x$, in 1961 yields the following results :

(IX) $\hat{u}_m = 0.381\ \hat{u}_x$ $\qquad r^2 = 0.491$
$\qquad\qquad (t = 7.62)$

About half the variance of the « unexplained » part of $\frac{M}{Y}$ would thus be accounted for by the « unexplained » part of $\frac{X}{Y}$. This confirms the belief that protectionism (liberalism) is correlated with unsuccessful (successful) export — although other factors, such as public or private transfers, autonomous capital movements and other factors also play an important role as witnessed by the fact that, in 10 cases, $\hat{u}_m$ and $\hat{u}_x$ have even different signs ([7]).

Finally the distribution of the $\hat{u}_m$'s and of the $\hat{u}_x$'s was tested for normality : the 61 values were distributed into 6 groups : the first comprising all the values between 0 and 0.5 the maximum likelihood estimator of the standard deviation, the second the values between 0.5 and 1.1 that statistic, the third all the values superior to 1.1 that statistic and similarly for the negative values. A X^2 test was used to test for conformity between theoretical and observed values.

In the case of $\hat{u}_m$, the normal hypothesis was never rejected (at the 5 % significance level). In the case of $\hat{u}_x$, it was rejected for 2 years out of 3 (1954 and 1961). This result must be brought in line with Michaely's [12] conclusion that countries tend to specialize much more in their export than in their import : numerous, independent small disturbances seem thus likely to be more at work for the latter than for the former.

IV. CONCLUSIONS

Four variables, population, per capita income, distance and preferential treatment could explain about four fifths of the variance of log $\frac{M}{Y}$ among countries and one half of the variance of log $\frac{X}{Y}$. It was found that Sombart's law needed a reformulation, in the sense that rich countries tend to have positive net export. Finally, it was confirmed that protectionism (liberalism) is correlated with unsuccessful (successful) export performances.

([7]) This is the case of Algeria e.g. for which the explanation is straightforward : $\hat{u}_x$ was strongly negative in 1961 because of the war and $\hat{u}_m$ strongly positive for the same reason.

APPENDIX. — **Natural values of the**

Countries ranked in the decreasing order of the variable in (5)	Population (P) in millions	Nominal income per head $\left(\frac{Y}{P}\right)$ in $ per capita	Corrected income per head $\left(\frac{Y}{P}\text{ cor}\right)$	Vicinity (V)
(1)	(2)	(3)	(4)	(5)
1. Belgium	9,153	1,041	1,208	102.5
2. Luxembourg	0,314	1,216	1,398	98.5
3. Netherlands	11,480	838	1,198	86.0
4. France	45,542	1,047	1,241	59.8
5. Ireland	2,834	481	713	57.3
6. Germany	55,577	833	1,173	52.7
7. Norway	3,586	986	1,184	51.7
8. Switzerland	5,351	1,374	1,691	51.2
9. Denmark	4,581	932	1,164	51.1
10. United Kingdom	52,539	1,021	1,214	43.4
11. Sweden	7,480	1,112	1,301	42.7
12. Portugal	8,921	222	362	42.1
13. Finland	4,449	875	1,128	41.8
14. Algeria	11,020	279	438	38.2
15. Malta	329	382	565	36.1
16. Austria	7,081	697	1,093	34.2
17. Italy	49,361	469	633	33.5
18. Trinidad	844	413	612	33.3
19. Jamaïca	1,621	327	525	32.0
20. Barbados	232	223	358	31.9
21. Canada	17,814	1,508	1,358	31.1
22. Greece	8,327	336	541	29.5
23. British Guiana	567	178	305	29.3
24. Cuba	6,797	385	569	29.0
25. Cyprus	563	440	651	28.3
26. Israel	2,114	875	1,112	28.0
27. Colombia	14,132	164	280	26.3
28. Panama	1,055	325	482	25.3
29. Venezuela	7,524	876	1,007	24.8
30. Costa Rica	1,171	353	522	24.8
31. Mexico	34,923	243	412	24.6
32. U.S.A.	180,670	2,179	2,179	23.8
33. Guatemala	3,765	173	296	23.6
34. Honduras	1,883	168	289	23.6
35. Ghana	6,691	167	285	22.1
36. Nigeria	35,091	75	149	21.4
37. Ecuador	4,317	170	291	20.9
38. Turkey	27,561	288	462	20.9
39. Porto-Rico	2,361	555	763	20.4
40. Peru	10,857	126	229	19.5
41. Sudan	11,770	84	165	17.7
42. Brazil	65,743	167	248	17.5
43. Congo (Leopoldville)	14,150	78	141	16.7
44. Ceylon	9,896	121	219	16.3
45. Mauritania	639	56	111	16.3
46. Chile	7,340	368	544	16.3
47. Corea (South)	24,665	66	130	15.9
48. China (Taïwan)	10,612	126	228	15.4
49. Argentina	20,006	259	381	15.3
50. Philippines	27,500	201	343	15.0
51. Fed. of Malaya	6,909	315	467	15.0
52. Burma	20,662	91	108	15.0
53. Tanganyika	9,239	52	110	14.9
54. Rhodesia	8,330	130	237	14.8
55. Thailand	25,520	90	179	14.6
56. Indonesia	92,600	102	203	14.4
57. South Africa	15,780	379	520	14.4
58. New-Zealand	2,372	1,249	1,436	13.6
59. India	432,567	64	125	12.6
60. Japan	93,200	319	513	12.4
61. Australia	10,275	1,125	1,294	12.0

variables considered in 1961

Preferential treatment (Pr)	Import-product ratio $\frac{M}{Y}$	Export-product ratio $\frac{X}{Y}$	Calculated value of $\frac{M}{Y}$	Calculated value of $\frac{X}{Y}$	Indices of errors of estimate	
					$(11)=\frac{(9)}{(7)}$	$(12)=\frac{(10)}{(8)}$
(6)	(7)	(8)	(9)	(10)		
54.1	0.345	0.343	0.376	0.366	1.09	1.07
52.7	0.763	0.888	0.921	0.801	1.21	0.90
40.6	0.484	0.485	0.334	0.330	0.69	0.68
17.0	0.138	0.151	0.198	0.212	1.44	1.40
0.01	0.390	0.337	0.311	0.267	0.80	0.79
15.2	0.206	0.231	0.183	0.196	0.89	0.85
8.5	0.441	0.460	0.374	0.359	0.85	0.78
4.2	0.355	0.316	0.305	0.319	1.09	1.01
9.1	0.321	0.307	0.351	0.339	1.09	1.10
4.5	0.209	0.201	0.165	0.179	0.79	0.89
6.5	0.259	0.259	0.283	0.288	1.09	1.11
6.5	0.282	0.164	0.329	0.262	1.17	1.60
0.01	0.264	0.252	0.237	0.230	0.90	0.91
4.6	0.403	0.119	0.289	0.242	0.72	1.22
4.4	0.596	0.533	0.718	0.547	1.20	1.03
3.6	0.244	0.240	0.271	0.268	1.11	1.12
7.7	0.166	0.168	0.184	0.173	1.11	1.03
3.5	0.718	0.785	0.530	0.428	0.74	0.55
3.4	0.377	0.351	0.449	0.362	1.19	1.03
4.2	0.670	0.513	0.822	0.567	1.23	1.11
2.6	0.205	0.200	0.195	0.210	0.95	1.05
0.01	0.227	0.098	0.205	0.179	0.90	1.83
3.6	0.662	0.572	0.641	0.446	0.97	0.78
0.01	0.300	0.300	0.214	0.188	0.71	0.63
3.5	0.528	0.426	0.564	0.457	1.07	1.00
0.01	0.253	0.137	0.264	0.251	1.04	1.84
0.01	0.165	0.145	0.191	0.151	1.16	1.04
0.01	0.369	0.267	0.355	0.154	0.96	1.05
0.01	0.214	0.366	0.183	0.181	0.86	0.50
0.01	0.264	0.228	0.339	0.273	1.28	1.20
0.01	0.149	0.143	0.138	0.128	0.93	0.90
0.3	0.042	0.047	0.080	0.101	1.91	2.15
0.01	0.215	0.190	0.266	0.201	1.24	1.06
0.01	0.196	0.175	0.323	0.237	1.65	1.35
3.0	0.331	0.248	0.303	0.234	0.92	0.94
3.2	0.190	0.165	0.211	0.154	1.11	0.93
0.01	0.183	0.172	0.249	0.190	1.36	1.11
0.01	0.093	0.059	0.139	0.126	1.50	2.14
9.7	0.675	0.483	0.361	0.324	0.54	0.67
0.01	0.238	0.252	0.197	0.150	0.83	0.60
2.5	0.250	0.144	0.265	0.190	1.06	1.32
0.01	0.086	0.080	0.115	0.096	1.34	1.20
0.01	0.336	0.460	0.190	0.134	0.57	0.29
2.6	0.301	0.293	0.261	0.197	0.87	0.67
2.8	0.440	0.050	0.621	0.365	1.41	0.73
0.01	0.159	0.162	0.183	0.163	1.15	1.01
0.01	0.169	0.063	0.163	0.116	0.96	1.84
0.01	0.209	0.136	0.187	0.143	0.90	1.05
0.01	0.140	0.070	0.145	0.126	1.04	1.05
3.15	0.111	0.100	0.182	0.157	1.64	1.57
2.2	0.403	0.542	0.248	0.215	0.61	0.40
0.01	0.190	0.175	0.174	0.119	0.92	0.68
2.5	0.253	0.266	0.286	0.191	1.13	0.72
2.6	0.402	0.457	0.264	0.202	0.66	0.44
0.01	0.181	0.170	0.151	0.428	0.83	0.67
0.01	0.110	0.100	0.103	0.085	0.94	0.85
2.2	0.220	0.297	0.193	0.177	0.88	0.60
2.2	0.253	0.232	0.273	0.283	1.08	1.22
1.8	0.074	0.050	0.093	0.074	1.26	1.48
0.01	0.122	0.106	0.086	0.085	0.71	0.80
1.8	0.157	0.174	0.177	0.193	1.13	1.11

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