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FACTOR CONTENTS CAN EXPLAIN WEST GERMANY'S FOREIGN TRADE*

by

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I. Introduction

A series of recent studies reveal a renewed interest in the explanation of international trade flows. Stern (1976), Steinherr and Runge (1977) and Wolter (1977) analyze West-Germany's foreign trade structure, Branson and Monoyios (1977) consider U.S. trade. These authors successfully test one form or other of the Heckscher-Ohlin hypothesis whilst incorporating aspects of the neo-technology approach.

The two methods which have been used until now to examine the factor proportions theory, viz., the Leontief approach and regression analysis, do not scrutinize the same hypothesis. A calculation of factor inputs in overall trade is a test of the Heckscher-Ohlin theory : a capital rich country should be a net exporter of capital. However, if one were to run a regression of the net trade of such a country on capital, the sign of the coefficient of the capital variable would yield no such information : a negative or statisticaly insignificant coefficient would not negate the Heckscher-Ohlin hypothesis. It could simply result from a situation where a large number of minor industries export labor-intensive goods even if one dominating export industry were to be capital intensive.

What regression analysis, as traditionally undertaken in our context, does test is whether variations of factor proportions across industries are strongly correlated with variations in their net trade. Nevertheless we believe it possible to use least squares fitting to test the Heckscher-Ohlin hypothesis, to test whether factor proportions have an explanatory power for overall trade,by properly transforming the data.

The paper is organized as follows. Data and methodological questions are discussed in section 2. The standard use of regression analysis in comparing net trade flows and factor intensities, is presented in section 3. Section 4 develops our contention that an appropriate weighting of variables allows the use of ordinary least squares to test the Heckscher-Ohlin hypothesis. We summarize our main findings in section 5.

2. Model Specification and Data

2.1 Specification

The general equation tested is some measure of trade flows as a function of factor proportions. One has to determine the specification and measurement of the dependent and independent variables, as well as the functional form.

Both, Stern (1976) and Branson and Monoyios (1977) estimate equations of the type :

$$X_i - M_i = a_o + a_1 K_i + a_2 H_i + a_3 L_i + \varepsilon_i \qquad (1)$$

where X_i = exports, M_i = imports, K_i = physical capital, H_i = human capital, i = the i-th industry, a_o is a constant term and ε_i is the residual. Branson and Monoyios also estimate exports and imports separately with the same explanatory variables as in (1).

Since factor proportions theory leads to the prediction of trade flows on the basis of *relative* factor endowments it is more consistently represented by the use of factor intensities :

$$X_i - M_i = a_o + a_1 \left(\frac{K}{L}\right)_i + a_2 \left(\frac{H}{L}\right)_i + \varepsilon_i \qquad (2)$$

When industry data are used (as compared to commodity data) net exports may be influenced by the size of industry. Stern (1976) therefore employs net exports deflated by gross production as dependent variable[1] :

$$\frac{X_i - M_i}{Q_i} = a_o + a_1 \left(\frac{K}{L}\right)_i + a_2 \left(\frac{H}{L}\right)_i + \varepsilon_i \qquad (3)$$

This method of scaling is, unfortunately, not neutral. Indeed, it incorporates a different hypothesis : not the absolute volume of net trade but rather the proportion of an industry's net trade relative to its production level is influenced by relative factor endowments.

Turning now to the explanatory variables the debate over the Leontief-Paradox[2] has rendered it obvious that human capital must be considered a factor of production. Some authors, such as Kenen (1970) and Lary (1968) aggregate physical and human capital, but it is by now well-accepted that it is proper to treat them both separately[3].

The human capital variable measures the skill factor. Any measure derived from earnings is, of course, only an approximation since observed earnings may not correspond to undistorted equilibrium levels. Moreover, some income differentials are due to disutility of work and similar factors and not to skill differentials. Keesing's (1965) approach of using statistics of employment by skill classes in each industry may therefore be preferable. It has the further advantage of using the structure of skills and not only an aggregate measure[4].

Neo-technology theory suggests, in contrast to the Heckscher-Ohlin theory, that production functions may in fact be different across countries, mainly due to technological innovation. Wolter adds therefore research and development expenditures as a proxy measure of technological innovation. Stern uses the ratio of engineers and technicians to total employment. Usually, industries that are intensive in human capital also have high R&D expenditures as well as a large staff of engineers, A high correlation between these variables may, therefore, be expected. The empirical question then is whether this correlation is high enough to make factor proportions alone sufficient.

In order to explain West-German trade patterns Wolter also introduces raw material intensity, measured as inputs from agriculture, forestry, fishery, and mining as a percentage of value added. He experiments successfully with a proxy variable for scale economies in each industry, measured as employment in establishments with 500 and more employees as percentage of the industry's total employment. It is however difficult to judge how conclusive his results are since the quality of some of the variables used are necessarily poor, the degrees of freedom pf the equations are rather low, and most variables are introduced alternatively so that there may be substantial overlapping.

The influence of protection is also taken into account in a number of studies of the West-German trade structure. Fels and Stern use tariffs and effective tariffs, Wolter introduces a measure of effective assistance that takes into account distortions other than tariffs such as industry subsidies. In Stern's study the variables have the wrong sign and are generally not significant. In Wolter's work the chosen variable has the expected (negative) sign and is significant in most estimations of net exports.

Introducing measures of protection this way is unsatifactory from a theoretical point of view. *Domestic* protection affects imports, whereas exports are influenced by protection in *foreign* countries. In an estimation of net exports the sign of the coefficient of domestic protection rates can therefore be either positive or negative. The sign obtained by Stern is therefore not necessarily "wrong". Since data on foreign protection is not available in suitable form we prefer not to take protection into consideration.

2.2. Data

West German data is used for 1962 and 1972. Comparison of the results for both years should allow us to discover whether important structural changes have occured during that decade. In another paper (Steinherr and Runge, 1977) Leontief indices were computed using the input-output tables for West Germany of the Deutsche Institut für Wirtschaftsforschung (DIW), Berlin, for 1962 and 1972. Labor, physical, and human capital are calculated as flows contained in commodities. In general equilibrium, flows and stocks are isomorphic so that both approaches are equivalent. In a non-competitive environment flows may be preferable since the equilibrium rate of interest that maps flows into stocks is generally unknown.

Unskilled labor income (L) was obtained as the product of the number of employed plus selfemployed in an industry and a minimum wage that is assumed to correspond to equilibrium pay of unskilled labor. For the minimum wage we have taken, alternatively, average wage incomes in each industry. The relevant wage is certainly at the lower end of that scale. Results obtained vary very little within, say, the fifteen lowest ranking industries. The remaining labor income is then considered as remuneration for human capital (H).

The construction of the physical capital variable (K) is more problematic. Data on gross income from capital and selfemployment is first purified of income from selfemployment. The remainder is one of our measures of physical capital. An alternative measure is depreciation. We prefer, in fact, the latter since it is less influenced by the business cycle. For details see Steinherr and Runge (1977). In Appendix II physical and human capital intensities are reproduced and ranked. To take account of raw material intensity a dummy variable (D_R) is used rather than the share of raw materials inputs since resource dependency has not only a quantitative but also a qualitative dimension.

To test whether the capital variables already account sufficiently for technological sophistication and innovation a dummy variable (D_T) was added. Technologically sophisticated industries receive a unit value, all others zero. The vectors D_R and D_T are reproduced in Appendix I.

Industry classification corresponds to the sectors of the input output tables. Of the 56 sectors 22 are eliminated either because trade is non existent or highly distorted. Among the sectors excluded are notably domestic private or public services, agriculture, electric power generation, retail and wholesale trade. The 34 industries in our sample account for 76.7 % of exports and 50.4 % of imports in 1962, and for 75 % of exports and 58 % of imports in 1972.

These data have the advantage of covering a much larger part of German foreign trade than previous studies. The degrees of freedom are also higher. However, there are also disadvantages.

First, trade data on a commodity basis would be preferable if it could be matched with data on factor proportions[5]. Within a given industry factor proportions and trade flows can vary substantially for different products.

Second, Fels, Stern, and Wolter have shown that it would be desirable to differentiate trade flows among industrialized countries from those to less developed countries. The explanatory power of the Heckscher-Ohlin theory is persistently higher in trade with less developed countries. We were unable to obtain a regional breakdown of trade flows for our industry classification.

Third, the previous argument suggests that trade among industrialized countries with similar factor endowments may have to be explained by a neo-technology argument. Data on economies of scale, and research and development expenditures are, however, not available for the input-output classification.

3. Factor intensities and the structure of trade

3.1 Spherical disturbances

Does net trade vary across industries according to relative factor content ? This question is examined by the use of regression analysis in the current literature and by us in this section. Our considerations concerning model specification lead us to formulate the most general (or maintained) hypothesis as follows :

$$(X-M) = \beta_1+\beta_2(\frac{K}{L})+\beta_3(\frac{H}{L})+\beta_4Q+\beta_5D_R.Q+\beta_6D_R+\beta_7D_T+\varepsilon \qquad (4)$$

where (X-M) represents net exports, Q is gross production of the industry concerned. The resource dummy (D_R) intervenes both additively as well as multiplicatively by affecting the slope of the production level variable.

The core of the model consists of the variables (K/L) and (H/L) with (X-M) as regressand . In order to discriminate among the other variables we set forth a series of more restricted models with regard to equation (4). These models present a certain nesting pattern. Both the list of models and the order of nesting are presented in Table I. The arrows indicate the direction of nesting.

Insert Table I

The models have been estimated for 1962 and 1972 ; the results are contained in Table II A and II B. We then apply a sequential testing procedure beginning with the maintained hypothesis and testing in increasing order of restrictiveness. Since each model is restricted with respect to only one parameter compared with the one in which it is directly nested, the individual tests are Student -t in nature. This procedure is to be preferred to its "reciprocal" which lies in beginning with the most restricted model. (Mizon, 1977).

TABLE I

List of models and order of nesting*

$$M1 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \varepsilon$$

$$M2 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \varepsilon$$

$$M3 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \beta_5\,(D_R.Q) + \varepsilon$$

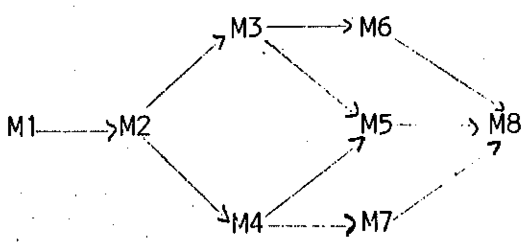
$$M4 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \beta_5\,D_R + \varepsilon$$

$$M5 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \beta_5\,(D_R) + \beta_6\,(D_R.Q) + \varepsilon$$

$$M6 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \beta_5\,(D_R.Q) + \beta_6\,(D_T) + \varepsilon$$

$$M7 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \beta_5\,(D_R) + \beta_6\,(D_T) + \varepsilon$$

$$M8 : (X\text{-}M) = \beta_1 + \beta_2\,(K/L) + \beta_3\,(H/L) + \beta_4\,(Q) + \beta_5\,(D_R) + \beta_6\,(D_R.Q) + \beta_7\,(D_T) + \varepsilon$$



* The disturbances are i.i.d. and normally distributed.

TABLE II A

Estimates for 1962 of models listed in table I (O.L.S.)

stant erm	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	D_T	R^2	F
177 238)	-.157 (-.975)	.216 (1.476)	.186 (7.367)	41.166 (.077)	-.229 (-5.208)	-479.568 (-.965)	0.801	18.113
487 23)	-.288 (-1.301	.397 (2.008)	.103 (3.781)	-1602.317 (-2.686)	-	86.581 (.128)	0.602	8.470
956 359)	-.157 (-.994)	.218 (1.546)	.185 (8.123)	-	-.227 (-6.524)	-488.349 (-1.027)	0.801	22.541
324 795	-.101 (-.673)	.170 (1.228)	.179 (7.400)	158.595 (.306)	-.220 (-5.127)	-	0.795	21.717
.321 53)	-.300 (-1.509)	.407 (2.290)	.103 (3.939)	-1637.202 (-3.136)	-	-	0.502	10.966
936 844)	-.098 (-.663)	.175 (1.296)	.176 (8.439)	-	-.211 (-6.785)	-	0.794	27.944
.614 853)	-.517 (-2.439)	.491 (2.452)	.114 (3.841)	-	-	-	0.467	8.762
052 75)	-.629 (-2.493)	.649 (2.759)	-	-	-		0.204	3.972

stics are shown in parentheses.

TABLE II B

Estimates for 1972 of models listed in table I (O.L.S)

nstant term	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R.Q$	D_T	R^2	F
530.143 -1.889)	-.167 (-.525)	.401 (1.259)	.211 (7.368)	1298.410 (.880)	-.300 (-5.236)	-855.889 (-.601)	0.785	16.430
119.660 -1.137)	-.385 (-.876)	.625 (1.423)	.132 (3.888)	-2877.128 (-1.664)	-	691.343 (.356)	0.567	7.333
045.934 -1.682)	-.136 (.432)	.423 (1.340)	.203 (7.554)	-	-.273 (-5.682)	1387.230 (-.804)	0.780	19.739
793.777 -2.233)	-.098 (-.333)	.333 (1.132)	.205 (7.693)	1482.259 (1.039)	-.293 (-5.286)	-	0.782	20.088
888.872 -1.097)	-.448 (-1.131)	.687 (1.728)	.135 (4.202)	-3116.284 (-1.985)	-	-	0.565	9.417
311.684 -1.987)	-.036 (-.124)	.335 (1.139)	.193 (8.073)	-	-.258 (-5.863)	-	0.774	24.830
139.633 -1.870)	-.796 (-2.137)	.821 (2.000)	.149 (4.510)	-	-	-	0.506	10.243
553.047 -.743)	-1.018 (-2.165)	1.246 (2.445)	-	-	-	-	0.171	3.197

atistics are shown in parentheses.

In our case, the models are not totally ordered. However, various subsets of totally ordered models can be extracted. They are the following :

S1 : (M1, M2, M3, M6, M8)

S2 : (M1, M2, M3, M5, M8)

S3 : (M1, M2, M4, M5, M8)

S4 : (M1, M2, M4, M7, M8)

An illustration of the manner of testing will now be given using S1 and data from 1962. Testing the null hypothesis M6, (drop D_R) against the maintained hypothesis (keep D_R), one is led to accept the more restricted model, since the t-statistic corresponding to the coefficient of D_R in M8 is extremely low (0.077). One now examines M3, or D_T does not belong here, against M6 (D_T belongs here) and decides in favor of M3 because the t-value of D_T's coefficient in M6 is only (-1.027). If one now postulates M2 as null hypothesis, one is obliged to reject it because the coefficient attached to (D_R.Q) has a high t-statistic (-6.785). Consequently one decides for M3 in subset S1 for the year 1962. The significance level of the overall test is yielded by $\alpha = 1-\Pi_{i=1}^{n}(1 - \varepsilon_i)$ where ε_i is the significance level of the individual tests conducted and n the total number of tests, in this case 3.

In the case of subsets S1 and S2 our testing procedure results in the choice of M3 irrespective of the year under consideration. With S3, however, we proceed only one step stopping at M5, whereas with S4 we accept the maintained hypothesis, i.e. M8. We are, therefore, confronted with a choice among M3, M5 and M8. Fortunately, they present a nested sequence ; we finally end up with model M3.

The one model which prevails for both years is :

$$(X-M) = \beta_1 + \beta_2 \left(\frac{K}{L}\right) + \beta_3 \left(\frac{H}{L}\right) + \beta_4 (Q) + \beta_5 (D_R.Q) + \varepsilon$$

Table III contains its actual structure for 1962 and 1972 as well as separate estimates for exports and imports regressed on the same set of variables.

TABLE III

Preferred Model (O.L.S)

nstant term	$\frac{K}{L}$	$\frac{H}{L}$	Q	$D_R \cdot Q$	R^2	F	SSR
.936 (844)	-0.098 (-.663)	0.175 (1.296)	0.176 (8.439)	-0.211 (-6.785)	0.794	27.944	28864554.76
.189 (215)	-0.147 (-1.051)	0.232 (1.813)	0.250 (12.649)	-0.143 (-4.864)	0.873	49.837	
253 (42)	-0.049 (-.579)	0.057 (.733)	0.074 (6.166)	+ 0.068 (3.785)	0.763	23.341	
1.684 (987)	-0.036 (-.124)	0.335 (1.139)	0.193 (8.073)	-0.258 (-5.863)	0.774	24.830	232346124.4
5.842 (190)	-0.004 (-.014)	0.133 (.475)	0.307 (13.5)	-0.188 (-4.489)	0.877	51.963	
5.842 (41)	0.032 (.239)	-0.202 (-1.471)	0.114 (10.199)	0.070 (3.419)	0.841	38.347	

cs are in parentheses

The impact of relative factor intensities on exports, imports or their difference within the context of the preferred model is statistically insignificant, despite the very satisfactory nature of the R^2. On the other hand, the level of output is strongly linked with the three regressands. The actual manner, however in which industry size, as determined by gross production, affects foreign trade depends on whether the industry uses natural resources intensively or not. Industries that do not use raw materials heavily manifest a positive relationship between the level of production and exports, imports or net trade. Industries that are highly dependent on these materials show up a negative partial correlation between size and net trade. Whereas industries in this category tend to import more heavily than industries in the other group, their export performance are lower. This indicates that the class of industries concerned are directed essentially towards the interior market, either supplying inputs to other establishments or producing final goods for local consumption.

It should also be noted that, in spite of the statistically insignificant character of relative factor intensities over time, one can observe a switch in the signs of their coefficients in as far as the import equation is concerned. From being negative for physical capital relative to unskilled labour and positive in the case of human capital relative to labour it becomes positive in the former and negative in the latter case. Can one discern here a change in the structure of German imports ?

Finally, we remark that the technology variable does not figure in the prefered model. In fact, it is not significant in any of the models in which it figures.[6]

3.2 Analysis subject to heteroscedastic disturbances

Stern (1976) and Branson and Monoyios (1977), among others, suggest that scaling of some kind or other is necessary for the variance of the disturbances may depend on industry size. Stern corrects for this by introducing net exports relative to gross production as regressand We have already commented on this approach, maintaining that it transforms the underlying hypothesis. Branson and Monoyios explicitly introduce heteroscedastic disturbances. They first test for mis-specification when spherical errors are assumed, then estimate a heteroscedastic structure, and finally estimate their preferred model subject to the estimated error structure

Unfortunately, the logic of their final estimation procedure is difficult, if not impossible, to understand.[7]

We have chosen to postulate a given heteroscedastic structure of the error term and then calculate the minimum variance (and, subject to normality which we assume, maximum likelihood) estimator. We have supposed that the variance of the net exports of an industry is proportional to the square of that industry's share in total gross production of the industries included in the sample. Apart from the error structure, the models used are those listed in Table I. Our estimates are presented in Tables IV A and IV B for 1962 and 1972 respectively. We then apply the same sequential testing procedure as in the case of spherical disturbances using the same subsets of totally ordered nested hypotheses.

Once again for subsets S1 and S2 our preference goes to M3. However, for subsets S3 and S4, the situation is not as clear. For 1972 we choose M5 and M8, respectively ; and the problem becomes one of choosing between M3 (from S1 and S2), M5 (from S3) and M8 (from S4) ; since these models are nested we decide in virtue of t-statistics for M3. However, for 1962 the choice of the level of significance is crucial - in the previous cases the decisions were valid for very low significance levels. The choice of M5 for S3 and M8 for S4 implies relatively high significance levels for the overall test : slightly over 5 % in the former and 10 % in the latter case for decisions within the subsets. Combined with the second stage choice between M3, M5 and M8 the levels are higher. If one is willing to accept these levels then one's preference goes exclusively to M3 ; otherwise, one is left with M3 and M4.

The estimated structure of these models as well as the decomposition of net exports into exports and imports is to be found in Table V. The results are rather disparate in nature. It is not possible to draw any firm conclusions in general. If we consider model M3, we remark that the gross production variable, both alone and linked multiplicatively with the raw materials dummy, is always significant except for the import equation where the size of industry variable alone fails. Industries that use natural

TABLE IV A

Estimates for 1962 of models listed in table I (H.L.S.)

ant m	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	D_T	F	SSR
7	.177	-.118	.129	-422.839	-.146	36.927	13.275	118287
)	(3.128)	(-1.755)	(2.632)	(-1.395)	(-1.869)	(.205)		
3	.157	-.07	.06	-896.085	-	145.574	13.985	133597
2)	(2.705)	(-1.076)	(1.786)	(-5.149)		(.817)		
7	.201	-.117	.172	-	-.237	-26.425	15.033	126810
2)	(3.664)	(-3.273)	(4.452)		(-5.424)	(-.149)		
5	.171	-.114	.132	-407.197	-.151	-	16.485	118471
)	(3.697)	(-1.807)	(2.842)	(-1.412)	(-2.08)			
	.125	-.044	.061	-900.804	-	-	17.514	136784
)	(2.917)	(-.781)	(1.835)	(-5.208)				
4	0.207	-0.181	0.172	-	-0.235	-	19.441	126911
0)	(5.282)	(-4.28)	(4.558)		(-5.612)			

e t-statistics are in parentheses
e F-statistic is calculated according to Malinvaud E. (1970) pp. 178-84

TABLE IV B

Estimates for 1972 of models listed in table I (H.L.S.)

nt m	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	D_T	F
56	.110	.078	.133	- 290.732	-.184	-246.357	5.627
63)	(1.605)	(1.014)	(2.867)	(-.597)	(-2.715)	(-.728)	
11	.159	.094	.038	-1326.339	-	156.204	4.299
82)	(2.173)	(1.101)	(1.127)	(-3.949)		(.463)	
316	.091	.069	.150	-	-.216	-352.653	6.388
37)	(1.514)	(.925)	(4.329)		(-5.174)	(-1.240)	
304	.140	.071	.122	- 477.396	-.163	-	6.759
65)	(2.582)	(.942)	(2.802)	(-1.162)	(-2.688)		
89	.140	.100	.038	-1275.311	-	-	5.469
63)	(2.343)	(1.214)	(1.130)	(-4.074)			
984	0.127	0.044	0.152	-	-0.213	-	8.015
82)	(2.389)	(0.609)	(4.348)		(-5.072)		

e t-statistics are in parentheses.

e F-statistic is calculated as in Table IV A.

TABLE V

Estimates of preferred models (H.L.S)

stant erm	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	F	SSR
914	.207	-.181	.172	-	-.235	19.441	12691121.66
0)	(5.282)	(-4.281)	(4.558)		(5.612)		
366	.009	-.031	.167	-	-.107	9.427	8472210.01
3)	(.269)	(-.883)	(5.442)		(-3.120)		
280	-.198	.151	-.004	-	.128	10.148	11180524.07
7)	(-5.393)	(3.792)	(-.119)		(3.264)		
361	.125	-.044	.061	-900.804	-	17.514	13678442.97
8)	(2.917)	(-.781)	(1.835)	(5.208)			
849	-.026	.025	.117	-378.276	-	8.132	9058836.41
9)	(-.740)	(.549)	(4.336)	(-2.688)			
487	-.151	.069	.056	522.528	-	10.464	10981388.23
9)	(-3.927)	(1.370)	(1.891)	(3.372)			
984	.127	.044	.152	-	-.213	8.015	52475071.03
2)	(2.389)	(.609)	(4.348)		(-5.072)		
982	-.031	.008	.197	-	-.095	12.242	38793980.56
0)	(-.686)	(.133)	(6.538)		(-2.633)		
967	-.159	-.036	-.045	-	.118	7.104	56061916.89
1)	(-2.882)	(-.479)	(1.232)		(2.717)		

s as for Table IV

resources intensively yield a negative partial correlation between net exports and level of production : imports increase faster and exports grow slower than the other group of industries which show a positive link between net exports and output levels. The behaviour of relative factor intensities is inconsistant over time. Physical capital stays positively significant with respect to net exports whereas human capital becomes insignificant after manifesting a negative relationship. Their significance when present comes exclusively from the import equation : exports reveal no linear statistical relationship with factor intensities.

Model M4 did not withstand our testing procedure for 1972. Moreover, its structure for 1962 does not modify our reflexions at all. A general phenomenon is the important role played by industry size, favorable for net trade in industries that do not depend heavily on natural resources, unfavorable otherwise.

3.3 A likelihood comparison of the preferred models

The only model that survives for both years is M3 in its homoscedastic as well as in its heteroscedastic formulation. We may discriminate between these two hypotheses concerning the error structure by comparing the corresponding maximum likelihoods attained conditional to the given data matrix. The data will then be said to support the hypothesis that yields the higher likelihood. (Edwards (1972) p.30). Under certain conditions [8] we may equivalently compare the sum of squared residuals : the lower the sum, the higher the likelihood. Table VI contains the sum in question for each formulation. For both years, the heteroscedastic version of M3 yields a higher likelihood.

TABLE VI

Preferred Models

(with sum of squared residuals)

	1962	1972
O.L.S.	M3 (28864554.76)	M3 (232346124.4)
H.L.S.	M3 (12691121.66)	M3 (52475071.03)

3.4 Scaling the regressand

We shall now briefly examine Stern's method of treating the presence of heteroscedasticity which lies in taking net exports per unit of output as regressands. Our estimates are presented in Table VII A and VII B. The models perform poorly compared with those considered above. The natural resources dummy in additive form plays a crucial role ; the R^2 is stable at two different levels according as the dummy is present or not. Moreover, the preferred model in this case is M4 for both years. In this version, the variable reflecting level of production plays a statistically insignificant role which results from the fact of scaling the regressand. The factor intensities variables play a significant role in 1962 but none a decade later.

TABLE VII A

Estimates of models with scaled regressand (1962)

tant rm	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	D_R	R^2	F
.088 47)	.473 (1.827)	-.312 (-1.329)	.048 (1.188)	-3304.105 (-3.868)	.003 (.039)	-889.274 (-1.115)	0.517	4.817
.792 86)	.474 (1.890)	-.314 (-1.403)	.049 (1.598)	-3284.138 (-4.859)	-	-896.152 (-1.173)	0.517	5.994
.414 33)	.488 (1.541)	-.484 (-1.714)	.110 (2.404)	-	-.159 (-2.283)	-184.477 (-.194)	0.25	1.867
.183 44)	.577 (2.378)	-.399 (-1.79)	.036 (.91)	-3086.354 (-3.695)	.02 (.29)	-	0.495	5.489
.812 5)	.595 (2.579)	-.420 (-2.036)	.043 (1.397)	-2923.064 (-4.827)	-	-	0.494	7.078
514 96)	.511 (1.762)	-.500 (-1.889)	.106 (2.593)	-	-.153 (2.503)	-	0.249	2.404
499 08)	.207 (.726)	-.271 (-1.007)	.061 (1.533)	-	-	-	0.087	.953
.599 50)	.147 (.509)	-.186 (-.691)	-	-	-	-	0.015	.236

istics are in parentheses.

TABLE VII B

Estimates of models with scaled regressand (1972)

tant rm	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	D_T	R^2	F
.256 61)	.021 (.141)	.141 (.969)	.025 (1.887)	-1852.564 (-2.742)	-.012 (-.455)	-572.938 (-.878)	0.472	4.023
.900 39)	.012 (.084)	.150 (1.056)	.022 (1.967)	-2018.932 (-3.604)	-	-511.290 (-.813)	0.468	4.926
.122 468)	-.023 (-.145)	.109 (.676)	.037 (2.713)	-	-.051 (-2.075)	-202.034 (-.285)	0.326	2.709
.734 89)	.067 (.496)	.096 (.707)	.021 (1.697)	-1729.494 (-2.628)	-.007 (-.280)	-	0.457	4.713
.583 67)	.058 (.451)	.105 (.804)	.019 (1.825)	-1842.062 (-3.589)	-	-	0.456	7.078
.239 632)	-.005 (-.035)	.093 (.625)	.035 (2.931)	-	.048 (-2.166)	-	0.324	2.404
.919 .802)	-.147 (-1.072)	.184 (1.214)	.027 (2.233)	-	-	-	0.214	2.723
.226 .284)	-.188 (-1.298)	.261 (1.669)	-	-	-	-	0.084	1.421

ics are in parentheses

4. Factor content in foreign trade

Is W-Germany a net exporter or importer of goods that are relatively intensive (with respect to unskilled labour) in human capital or in physical capital ? It is our contention that in order to answer this question one may not use the same data as in section three without some preliminary transformation. If one is interested in the aggregative performance of a country, it is only reasonable to apportion to each industry its relative weight in the economy. We are therefore led to weigh our data matrix, multiplying the data point corresponding to each industry by the relative share of that industry in total gross production [9]. The data set is then ready for use in examining the factor contents hypothesis.

The regression results with the appropriately weighted observations are contained in Table VIII. One does not need to proceed very far in the sequential procedure - the models are identical to those above - because only the resource dummy in additive form is insignificant ; and, at the next step, all the coefficients relevant to our choice of model are statistically non-null. Consequently, model M6 is decided upon, its estimated structure as well as separate equations for exports and imports are presented in Table IX.

The results are remarkable. The factor intensity coefficients are significant for net exports and possess acceptable signs. They indicate clearly that Germany is (1972) and has been (1962) a net exporter of goods that are rich in human capital but a net importer of physical capital. It points out that exports grow with higher intensities of human capital but decrease with heightened levels of physical capital - and that imports function conversely. The coefficient of Q, which is now the weighted average of production levels, is positive in all cases. However, the intensive use of raw materials by the country would reverse the situation for net exports, reduce the impact on exports and increase the influence on imports. The technology dummy incorporates the same nature of information as relative human capital intensities but on a qualitative level.

TABLE VIII

O.L.S. With Weighted Observations

...tant ...rm	$\frac{K}{L}$	$\frac{H}{L}$	Q	D_R	$D_R \cdot Q$	D_T	R^2	F
.506 (...95)	-1.162 (-5.322)	1.062 (5.979)	.194 (6.394)	1180.040 (.900)	-.305 (-5.304)	-2859.497 (-2.855)	0.960	108.000
.574 (...46)	-1.157 (-5.318)	1.094 (6.299)	.196 (6.531)	-	.266 (-6.969)	-3186.588 (-3.426)	0.959	130.985
.543 (...767)	-3.878 (-3.163)	4.351 (3.202)	.154 (2.303)	-203.291 (-.031)	-.272 (-1.952)	-12277.377 (-2.255)	0.887	35.323
.556 (...938)	-3.873 (-3.242)	4.341 (3.356)	.154 (2.345)	-	-.275 (-3.227)	-12215.158 (-2.456)	0.887	43.958

TABLE IX

Preferred model : weighted observations

nstant term	$\frac{K}{L}$	$\frac{H}{L}$	Q	$D_R \cdot Q$	D_T	R^2	F
-4.574 (-.446)	-1.157 (-5.318)	1.094 (6.299)	.196 (6.531)	-.266 (-6.969)	-3186.588 (-3.426)	0.959	130.985
-4.745 (-.417)	-1.002 (-4.110)	.980 (5.076)	.295 (9.301)	-.231 (-5.609)	-3171.530 (-3.725)	0.970	187.503
-.753 (-.185)	.105 (1.220)	-.089 (-1.298)	.094 (7.931)	.044 (2.893)	-184.784 (-.502)	0.974	209.785
-48.556 (-.938)	-3.873 (-3.242)	4.341 (3.356)	.154 (2.345)	-.275 (-3.227)	-12215.158 (-2.456)	0.887	43.958
-33.064 (-.658)	-2.789 (-2.405)	3.149 (2.509)	.290 (4.556)	-.228 (-2.754)	-9801.967 (-2.031)	0.946	98.104
15.491 (1.537)	1.084 (4.660)	-1.191 (-4.731)	.136 (10.665)	.047 (2.848)	2413.190 (2.492)	0.985	367.733

5. Conclusions

It was our intention to examine two hypotheses relative to West Germany's foreign trade : whether factor proportions played an important role in explaining sectoral variations in net trade, and whether factor content helped to understand the nature of Germany's commerce with other nations.

To the first question it was answered that factor proportions do not help to explain differences across industries of the extent of net trade but that the size of an industry and whether it used raw materials intensively or not was determinant. It was noticed that industries not depending heavily on natural resources tended to increase their net trade with size -though less than proportionally- but that the other group revealed a negative relationship on account of the depressing influence on exports and the greater impact on imports of belonging to this category of industries.

In order to reply to the second query we weighted our data matrix to give more importance to larger industries. This procedure was defended on the grounds of the aggregative nature of the hypothesis concerned. Our results go to show that W-Germany is indeed a net exporter of goods possessing an important content of human capital but a net importer of industrial products requiring larger amounts of physical capital.

Footnotes

[1]Fels (1972) prefers to deflate by employment in each industry. Wolter (1977) uses a measure of revealed comparative advantage as dependent variable and obtains excellent empirical results.

[2]For a survey see Bhagwati (1964).

[3]Baldwin (1971) raised the question whether physical and human capital should be aggregated. He included the capital variables both ways in his regressions and the results were statistically significant in either case. However, Branson has argued convincingly that both variables should not be aggregated, since they are neither perfect substitutes not perfect complements in production. The sign of the regression coefficients of both variables may therefore be opposite.

[4]Baldwin (1971) has extensively experimented with alternative measures of human capital and found that, in general, the skill-group measures had greater explanatory value than the human-capital measures.

[5]Branson and Monoyios could use such data compiled by Hufbauer (1970). For Germany such data does not exist.

[6]With commodity data the technology variable is likely to be significant. Bodenhöfer (1976) carried out a rank-correlation analysis between research and development expenditures and exports and concluded that the explanatory value of that variable is high. However, in the presence of several explanatory variables a simple rank correlation does not allow such an inference.

[7]Consider the model : $Y = X\beta + \varepsilon$, $\varepsilon \sim N(0, \sigma^2\Omega)$. The minimum-variance (and maximum likelihood) estimator of β is $(X'\Omega^{-1}X)^{-1}X'\ \Omega^{-1}\ Y$. One manner of calculating this estimator lies in defining $S \equiv \Omega^{-1/2}$, premultiplying $[Y,X]$ by S ; and then performing ordinary least squares minimization with the transformed data matrix. What Branson and Monoyios do is to minimize the norm of $(SY - [i\ SX]\beta)$ where i is a vector of ones !

[8]Let $L_1 = \left[(2\,\Pi\,\hat{\sigma}^2)^T \det(\Omega)\right]^{-\frac{1}{2}} \exp(-u'\,\Omega^{-1}\,u/\,2\hat{\sigma}^2)$

and $L_2 = \left[2\,\Pi\,\tilde{\sigma}^2\right]^{-\frac{T}{2}} \cdot \exp(-e'e/2\tilde{\sigma}^2)$

Then $\log L_1 - \log L_2 = \frac{T}{2} \log \frac{e'e}{u'\,\Omega^{-1}\,u} - \frac{1}{2} \log \det(\Omega)$

when the sigma's are estimated by maximum likelihood. If Ω is normalized so that its determinant is one, a comparison of likelihoods is equivalent to a comparison of the (appropriately weighted) sum of squared residuals.

[9]We have taken the actual observations $[Y,X]$ where X contains no constant terms and premultiplied it by a diagonal matrix S with $S_{ii} = Q_i/\Sigma Q_i$. We have then regressed SY on $[i\ SX]$.

1. Baldwin, R.E., "Determinants of the Commodity Structure of U.S. Trade", *American Economic Review*, 61 (March, 1971), 126-46.

2. Bhagwati, J., "The Pure Theory of International Trade : A Survey", *Economic Journal*, 74 (March 1964), 1-84.

3. Bodenhöfer, H.J., "Technischer Fortschritt, Forschung und Entwicklung und Internationaler Handel : der Fall der Bundesrepublik Deutschland", *Jahrbücher für Nationalökonomie und Statistik*, 190 (März, 1976), 152-169.

4. Branson, W.H. and N. Monoylos, "Factor Inputs in U.S. Trade," *Journal of International Economics*, 7 (1977), 111-131.

5. Edwards, A.W.F., *Likelihood*, London, Cambridge University Press, 1972.

6. Fels, G., "The Choice of Industry Mix in the Division of Labour between Developed and Developing Countries", *Weltwirtschaftliches Archiv*, 108 (1972), Heft 1, 71-121.

7. Hufbauer, C.C., "The Commodity Composition of Trade in Manufactured Goods", in : R. Vernon (ed.), *The Technology Factor in International Trade*, New York, Columbia University Press, 1970.

8. Keesing, D., "Labor Skills and International Trade : Evaluating Many Trade Flows with a Single Measuring Device", *Review of Economics and Statistics*, 47 (August, 1965), 287-94.

9. Kenen, P.D., "Skills, Human Capital and Comparative Advantage", in : W.L. Hansen, ed., *Education, Income, and Human Capital*, (New York :Columbia University Press, 1970), 195-230.

10. Lary, H.B., *Imports of Manufactures From Less-Developed Countries*, (New-York : Columbia University Press, 1968).

11. Leontief, W., "Domestic Production and Foreign Trade : The American Capital Position Re-examined", *Proc. of the American Phil. Soc.*, 97 (Sept. 1953), 332-49.

12. Leontief, W., "Factor Proportions and the Structure of American Trade : Further Theoretical and Empirical Analysis", *Review of Economics and Statistics*, 38 (Nov. 1956), 386-407.

13. Malinvaud, E., *Statistical Methods in Econometrics*, Amsterdam, North Holland, 1970.

14. Mizon, G.E., "Inferential Procedures in Nonlinear Models : An Application in a U.K. Industrial Cross Section Study of Factor Substitution and Returns to Scale", *Econometrica*, 45 (July, 1977), 1221-42.

15. Roskamp, K.W., "Factor Proportions and Foreign Trade : The Case of West Germany", *Weltwirtschaftliches Archiv*, 95 (1963), 2, 319-26.

16. Roskamp, K.W., "Factor Proportions, Human Capital and Foreign Trade : The Case of West Germany Reconsidered", *Quarterly Journal of Economics*, 82 (February, 1968), 152-160.

17. Steinherr, A. and J. Runge, "The Evolution of West Germany's Structure of Foreign Trade from 1962 to 1972", Université Catholique de Louvain, mimeo.

18. Stern, R.M., "Some Evidence on the Factor Content of West Germany's Foreign Trade", *Journal of Political Economy*, 84 (February 1976), 131-142.

19. Wolter, F., "Factor Proportions, Technology and West German Industry's International Trade Patterns", *Weltwirtschaftliches Archiv*, 113 (1977), Heft 2, 250-67.

Appendix I

The 34 sectors of the DIW input-output table*	Resource dummy (D_R)**	Technology dummy (D_T)**
10. Iron and steel	1	0
11. Iron & steel foundries	0	0
12. Steel drawing and cold rolling mills	0	0
13. Non-ferrous metal	1	1
14. Chemicals	0	1
15. Mineral oil refining	1	0
16. Rubber and asbestos manufactures	1	0
17. Sawmills and timber processing	1	0
18. Cellulose and paper	1	0
19. Constructional steel	0	1
20. Machinery	0	1
21. Vehicles	0	1
22. Aerospace	1	1
23. Shipbuilding	0	1
24. Electrical engineering and electronics	0	1
25. Precision engineering and optics	0	1
26. Steel forging	0	1
27. Hardware and metal goods	0	1
28. Fine ceramics	0	0
29. Glass	0	0
30. Timber manufactures	1	0
31. Musical instruments, toys, jewelry & sport articles	0	0
32. Paper and board manufactures	1	0
33. Printing & duplicating	0	1
34. Plastic manufactures	0	1
35. Leather	1	0
36. Textiles	1	0
37. Clothing	0	0
38. Grain milling	1	0
39. Edible oils and margarine	1	0
40. Sugar	1	0
41. Brewing & malting	1	0
42. Tobacco manufactures	1	0
43. Other food and beverages	1	0

*Sectors 1-9 and 44-56 are disregarded in the regression sample.

**Both are identical for 1962 and 1972.

Appendix II

1962 :

Ranking of net exports per unit of output, physical and human capital intensity*

Rank	(X-M)/Q	Sector	K/L		H/L	Sector
34	-0.832549	22	0.045128	22	0.000000	37
33	-0.317371	13	0.062751	37	0.103332	35
32	-0.269719	18	0.075574	31	0.130641	36
31	-0.269549	17	0.089161	35	0.133401	32
30	-0.249218	39	0.103405	32	0.144296	28
29	-0.117987	43	0.106077	30	0.178749	31
28	-0.095770	36	0.123077	19	0.197303	34
27	-0.072597	15	0.123397	34	0.212838	30
26	-0.044937	35	0.126391	24	0.214630	25
25	-0.025593	37	0.136175	25	0.216314	17
24	-0.001495	30	0.143843	20	0.231960	42
23	0.002781	40	0.145619	27	0.235284	43
22	0.008440	42	0.151216	16	0.281746	23
21	0.009555	32	0.152715	26	0.300654	27
20	0.011974	34	0.164835	33	0.304187	29
19	0.018457	11	0.171821	36	0.318146	24
18	0.018965	41	0.181504	28	0.360770	26
17	0.020171	33	0.183150	29	0.361997	33
16	0.045183	38	0.183432	42	0.413223	16
15	0.054105	16	0.230769	11	0.458689	22
14	0.059805	19	0.232601	23	0.463257	12
13	0.082824	31	0.249750	17	0.472232	13
12	0.090330	10	0.266484	13	0.477597	20
11	0.104841	26	0.307692	21	0.512783	19
10	0.108940	29	0.313374	43	0.516002	38
9	0.110764	24	0.328671	39	0.546832	41
8	0.116692	27	0.342030	10	0.547877	18
7	0.152229	14	0.388889	12	0.549829	21
6	0.159490	12	0.425898	14	0.600468	11
5	0.198130	28	0.427767	18	0.601399	39
4	0.223931	21	0.555831	41	0.670118	10
3	0.225484	20	0.593407	38	0.735761	14
2	0.305839	23	0.789744	40	0.856410	40
1	0.309342	25	0.923077	15	0.881899	15
Spearman rank coefficient with (X-M)/Q			-0.444		0.033	
σ			0.403		0.426	

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*(assumed annual income of unskilled labor : DM 6.500)

1972 :

Ranking of net exports per unit of output, physical and human capital intensity*

Rank	$\frac{X-M}{Q}$	Sector	$\frac{K}{L}$	Sector	$\frac{H}{L}$	Sector
34	- 0.512263	22	0.096592	37	0.000000	37
33	- 0.298105	18	0.144180	31	0.109609	35
32	- 0.233451	17	0.147556	35	0.165956	31
31	- 0.222782	35	0.155256	19	0.179225	36
30	- 0.216911	13	0.160667	24	0.297032	25
29	- 0.156753	31	0.162586	30	0.316677	34
28	- 0.156074	36	0.169103	25	0.335904	43
27	- 0.139964	39	0.176458	20	0.341387	32
26	- 0.133787	37	0.189362	26	0.342011	28
25	- 0.121489	43	0.199798	27	0.383745	17
24	- 0.085422	15	0.210210	22	0.386381	27
23	- 0.014253	30	0.211166	23	0.411567	30
22	- 0.006180	29	0.217172	32	0.441333	22
21	- 0.004900	38	0.225708	34	0.446798	42
20	0.003985	42	0.227366	28	0.481481	26
19	0.015685	41	0.229101	16	0.486068	12
18	0.017056	32	0.240123	33	0.490495	24
17	0.024814	11	0.277453	36	0.503751	16
16	0.030834	33	0.291358	29	0.511196	11
15	0.034434	16	0.303704	39	0.517898	29
14	0.037246	19	0.340035	11	0.565373	13
13	0.053382	34	0.353086	42	0.586602	20
12	0.060878	10	0.355834	43	0.615457	23
11	0.062547	40	0.364444	13	0.620882	33
10	0.064919	23	0.375091	21	0.629630	40
9	0.074741	27	0.410256	12	0.662887	38
8	0.090088	12	0.451977	17	0.677697	18
7	0.090774	24	0.583562	14	0.694736	19
6	0.090801	26	0.607407	38	0.703849	21
5	0.100994	28	0.665509	18	0.723140	10
4	0.139903	14	0.682202	10	0.733545	41
3	0.161298	25	0.838164	41	0.828172	14
2	0.269782	20	0.940171	40	0.974074	39
1	0.313289	21	1.331881	15	1.273057	15

Spearman rank coefficient with (X-M/Q) :	- 0.059	0.207
σ	0.371	0.120

*(assumed annual income of unskilled labor : DM 13.500)