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FACTOR ABUNDANCE, TRADE SPECIALISATION AND LAGS IN ADJUSTMENT
- A CASE STUDY OF SWEDISH ENGINEERING TRADE

by

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Abstract

This paper investigates two problems almost neglected in the empirical analysis of the factor proportions theorem. One is the lack of empirical specification of the factor abundance of countries and the other the choice of testing only static versions of the theorem. By a stepwise testing procedure utilising a set of hypotheses differing in orders of superiority both static and various comparative static versions are tested here. This procedure also allows a more thorough testing of the factor abundance hypothesis for Sweden as regards both which factors are abundant and the stability assumption.

The results are similar to those obtained in some earlier studies in that factor intensities are found not to be powerful explanatory variables of the trade patterns of single years, in this case 1960 and 1970. However, they are powerful in explaining the changes in trade pattern between the two years. In consequence, the results generally indicate support rather than rejection of the factor proportions theory. More specifically, they are broadly consistent with the implications of a comparative static model involving factor accumulation and, perhaps, biased technological change.

FACTOR ABUNDANCE, TRADE SPECIALISATION AND LAGS IN ADJUSTMENT
- A CASE STUDY OF SWEDISH ENGINEERING TRADE *)

by Lennart Ohlsson

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Since the pathbreaking first attempt to test the factor proportions theorem by Leontief [1954], the factor proportions theory has developed towards a rather complex body of theories. However, its empirical counterpart does not seem to have reached a comparable maturity. Recent tests have much the same design as Leontief's original one.¹⁾ Leontief's own and some other tests of the simple Heckscher-Ohlin-Samuelson model seem to imply a rejection of the theory. But the test methodology used may not allow for a rejection of the H-O-S model.²⁾ In any case the modern factor proportions theory is still far from being tested in all its complexity and much of its basic assumptions are still left to be explored.

The purpose of this paper is to somewhat extend the empirical testing of the factor proportions theory by trying to analyse for Swedish engineering trade two possible shortcomings of earlier empirical tests. One is emphasized in Bhagwati's survey article [1969] in the following way: "... while factor intensities are carefully ascertained the factor abundance of the country in question is usually left uninvestigated, except tangentially and vaguely" (*ibid.* p. 27). That the lack of a thorough empirical foundation of the factor abundance of a country constitutes a serious shortcoming will be demonstrated for Sweden by examining its engineering trade pattern.

*) This paper rests on a study of Swedish engineering trade and production to be published by the Industrial Institute for Economic and Social Research (Ohlsson/[forthcoming]). An outline of the paper was presented to the trade seminar of the London School of Economics. Thanks go to H G Johnson, G C Hufbauer and B Carlsson.

1) Perhaps the best exception in this respect is Hufbauer's [1970] paper testing certain trade theories. It is outstanding in that the specific hypotheses tested on the trade pattern of different countries are based on empirical data on national endowments of factors of production.

2) Since studies of the factor content of a country's exports and imports are often at best based on assumptions of its factor abundance, it is difficult to interpret them as tests of the theory. Many of these studies are often meant to indicate no more than the net indirect flows of different factors across the border of a given country.

The second possible shortcoming is the testing of only the static models of trade theories. This shortcoming may be attributed to the emphasis in theoretical literature on the factor proportions theory as a static theory. (Cf. for instance Bhagwati [1969] and Chipman [1966]). The testing of static models relies on an empirical generalisation that the economy studied is basically adjusted to a free trade equilibrium in a given year. However, there are both theoretical and empirical objections to such an assumption. An implication of the simple versions of the theories underlying the tests is that relative factor prices are equalised in a free trade equilibrium. It is not only obvious that such a factor price equalisation has not in fact occurred. Even worse, if it had, the factor proportions theorem in its static version would no longer be valid, as Bhagwati [1972] recently pointed out. A comparative static formulation of the theorem does not have the latter shortcoming. Also it may be assumed to perform better in explaining trade in the post-war period, which is one of prolonged trade liberalisation starting from practically a no-trade-world in 1945. By analysing not only the trade pattern of 1970 but also that of 1960 and its changes between the years it is possible to test both the static and the comparative static formulations of the theorem.

1. Hypotheses on the factor abundance of Sweden

A formal test of the factor proportions theorem should as a first step include an empirical estimate of the factor abundance of Sweden. In the simplest text-book comparative static version of the H-O-S model, this factor abundance may be defined either from the relative factor endowment ratio, assumed to be exogeneously given, or from its pre-trade relative factor price ratio, assumed to be endogeneously determined. The factor abundance definition becomes much less self-evident, if the 2-2-2 model of perfectly tradable products is abandoned. However, in order to give the factor abundance hypothesis an empirical

1) As pointed out by Chipman [1966] more than two factors may make the factor abundance definition in terms of factor intensities too restrictive. Whether the country is found to be abundant or not in a given factor may furthermore depend on which factor is used in the denominator (see also Metcalfe & Steedman [1973]). - As noted by Bhagwati [1969] more than two countries give rise to four different definitions of factor abundance. Furthermore, allowing at the same time for at least three factors means that there is no simple factor abundance definition for any country. - Introducing non-tradable goods (or in general varying tradability of goods) means that factor abundance can no longer be defined from the factor endowments of the economies as a whole. Nor can it be defined from only the tradable goods sector. The domestic demand

foundation many of these difficulties have to be neglected in this first step of the analysis. Let us instead concentrate the discussion on how time will affect the factor abundance definition.

Earlier tests relying on static models seem implicitly to assume that the economies are adjusted to a free trade equilibrium for the year analysed. As noted initially the factor proportions theorem to be tested is then in many cases in conflict with the equilibrium assumed. A comparative static model may vindicate the theorem, albeit in its reformulation in terms of changes in trade patterns between two equilibrium points. Three different types of exogenous changes are usually discussed, namely changes in a) trade impediments, b) relative factor supplies and c) the technology of products. While for each type the factor abundance of the country is well defined in terms of the exogeneously given factor endowments, this is not always true in terms of initial factor prices. Given the postulated causality, the relative factor prices in both equilibrium points may be misleading when there has been a substantial change in relative factor supplies.

The introduction of time gives, of course, also rise to the fundamental causality question. Can it at all be assumed that factor endowments (or factor prices) determine the structure of trade and production in an open economy? Are in fact factor endowments (or prices) more rigid for a small country than the structure of industrial output and product prices? As demonstrated by Stiglitz [1970] in a dynamic model the initial factor endowments may not be as important for trade specialisation tendencies over a long period of time as, for instance, savings functions (cf also Johnson [1971] and Oniki & Uzawa [1965]). Recognising time may obviously not only raise the problem of causality but also whether the factor abundance concept

1) cont. from p. 2: for NTG:s and substitution possibilities between NTG:s and TG:s will also affect the way in which factor abundance should ideally be defined. If the TG:s are in part sold to the NTG sector and if the TG sector buys NTG:s the commodity and factor prices respectively are possibly distorted. The NTG sector is in many countries a producer of human skills and has the power to influence capital formation, redistributing the production costs, determining directly or indirectly, the supplies of these factors. This affects the definition of factor abundance. In addition, the latter role of the NTG sector may bring about disequilibria in the factor markets. The factor abundance in terms of factor endowments may in extreme cases differ from that defined on the basis of factor prices. In any case it seems questionable whether factor endowments and/or factor prices should be treated as exogeneously given in a certain country.

should be defined in terms of a disequilibrium condition or even whether it is at all relevant.

An analysis of the basic assumptions of the factor proportions theorem in the time dimension needs to be done in a stepwise manner. As indicated in this short summary a reformulation of the factor proportions theorem and/or the factor abundance concept has to be done in leaving the static framework. Such a stepwise analysis requires hypotheses ranked according to different orders of superiority. In the present paper the order of superiority was chosen to correspond with the purpose of analysing how time may be taken into account in testing the factor abundance of Sweden and the factor proportions theorem. Throughout the paper two assumptions or hypotheses are therefore maintained.

I. Due to trade liberalisation in the post world war II period Sweden's international specialisation will eventually be determined by its comparative advantage.¹⁾

II. Sweden's comparative advantage is largely determined by its factor abundance as defined by its relative factor endowment and/or factor price ratios.²⁾

Ignoring in this paper the problems related to many factor, many countries and NTG:s³⁾ the following hypotheses with lower orders of superiority can be specified for the subsequent testing:

III. The factor abundance of Sweden has been stable in the long run.⁴⁾

1) By assumption hypothesis I rules out theories which advocate the importance for trade specialisation of product innovation, scale economies, technological or managerial gaps, R&D, quality differentiation etc. In Ohlsson [forthcoming] some of these arguments are directly or indirectly tested.

2) In Ohlsson [forthcoming] this hypothesis is also tested

3) In Ohlsson [forthcoming] some of the problems with many factors and NTG:s are tackled in testing the factor proportions theorem.

However, the existence of many countries is neglected almost completely.

4) This hypothesis means obviously that the changes in Sweden's relative factor endowments at least match some part of the factor price equalisation tendency that might come through trade.

IV. Vis à vis the rest of the world and relative to labour as a whole Sweden is abundantly endowed with a) certain raw materials, b) physical capital and c) human capital embodied in technical personnel and skilled workers.¹⁾

V. The factor intensities of the industries are internationally given throughout the period. The trade impediments existing throughout or disappearing during the period have not caused major shifts in trade specialisation compared with the pattern under free trade.

VI. The Swedish engineering industry had already in 1970 adjusted well to its comparative advantage.

The last hypothesis, which is the implicit assumption of earlier tests of the factor proportions theory, is first put to test using data for 1970. Since more than two factors and goods are admitted here (cf. hypothesis IV)²⁾ Leontief's original test method cannot be used. Before presenting the results of the tests, a discussion of how to test the factor proportions theorem therefore is needed.

2. On how to test the factor proportions theorem

Leontief's original study included three steps, the first one being the simple assumption that the USA was a capital rich country, i.e. employing a high capital/labour ratio. The second step defined an exportable and an importable and the third directly compared the factor intensities of exportables and importables as a test of the factor proportions theorem.

In a multicommodity framework the dichotomous nature of the dependent variable is lost. Since the size of exports and imports depends on the demand structure, and since exports and imports are reported for the same commodity categories, neither the two variables nor their absolute difference can be accepted to rank the commodities according to their comparative advantage, i.e. the likelihood for them to appear in the exports of the country.

1) The following major studies have been used for the formulation of this hypothesis: Carlsson & Ohlsson [1973], Hufbauer [1970], Keasing [1965, 1969 a and b], OECD [1970] and Ohlsson [forthcoming].

2) A multi commodity framework is justified by the necessity to minimize technological differences within, as compared to between the commodity aggregates. There are at least two reasons to leave the two factor models, the first one being the finding of earlier studies that human capital and raw materials play important roles in explaining the structure of trade. The second reason is suggested by the theory itself. According to the assumptions of the theory an aggregation of factor units into one variable is allowed only if all factor units are perfect substitutes. Even less strict aggregation rules probably make the proposition of Johnson [1968] to redefine factor concepts into two factor aggregates a dangerous one from the point of view of testing the factor proportions theorem.

The allowance for more than two factors destroys both the theoretical and methodological foundation of Leontief's third analytical step. The simultaneous influence of several factor intensities on the pattern of trade has to be estimated, which calls for the use of regression analysis or other econometric methods allowing for several independent variables.

Two alternative approaches have earlier been used, both explicitly recognising that exports and imports exist for practically all products and both using regression analysis. Baldwin [1971] used as dependent variable net exports adjusted in a way similar to that used by Leontief, while Branson & Junz [1972] used an adjusted net exports. The net exports measure depends, however, also on the demand for the commodities. In a test of the factor proportions theorem it should therefore be complemented with proper independent variables taking account of the demand side. Alternatively net exports should be normalized for the demand structure (cf. Carlsson & Ohlsson [1973]). This latter approach is followed in this paper, which uses as its dependent variable net exports divided by the sum of exports and imports, i.e. $(X-M)/(X+M)$, where X = exports, fob, and M = imports, cif. Apart from the fact that this measure is normalised for the structure of demand, it has an additional desirable property. It allows not only a classification of products as exportables and importables according to the sign; it also includes pure exportables and pure importables as extreme cases (+1.0 and -1.0 respectively). This property means that observations (industries) with net exports ratios near these extreme values will have a powerful influence in the regressions. Assuming the theory to be true for perfectly homogeneous commodities it is likely that such absolutely large net exports ratios will be obtained for relatively homogeneous subindustries with relatively large or relatively small values on the relevant factor intensities¹⁾. However, other dependent variables were also tried in Ohlsson [forthcoming].

1) A third method is used by Harkness & Kyle [1970] in an unpublished paper brought to my attention by Hufbauer. Departing from a similar criticism as above of net exports as the dependent variable they arrive at the conclusion that each observation (subindustry) should be given the same weight within the exportable and importable groups respectively. Given the dichotomous dependent variable they reject regression analysis on statistical grounds and use logit analysis instead. While their criticism of net exports is correct, their argument that consistency with the theory is maintained by only considering the sign of the net exports measure is not (p. 10). It rests on an earlier statement (p. 9) that "with a multi-factor model where there are more goods than factors, only the direction but not the volume of trade can be predicted by reference to relative factor intensities alone." Not even this can be predicted, but only a ranking of the commodities according

In summary the method used here is regression analysis for estimating the influence of factor intensities of production on the international specialisation of the engineering industry as measured by the net exports ratios of its subindustries.

3. The engineering trade pattern of 1970

Given hypotheses I-VI in section 1 above the factor proportions theorem suggests that Sweden should be specialised in goods intensive in capital, technical personnel and skilled workers.¹⁾ The hypotheses to be tested on some 30 subindustries of the Swedish engineering industry are that the net exports ratio is positively related to these three factor intensities. Hypothesis I of a well adjusted engineering industry can be tested with the explanatory value of the regressions.

cont. 1) to their comparative advantage. In a theory with constant factor supplies, the direction of trade is not determined by comparative advantage alone but also by the demand determinants. Consequently, using a dichotomous dependent variable within a multi-factoral framework might in unfortunate cases lead to a rejection of a true hypothesis. If there is a large foreign demand for goods intensive in one of the abundant factors, some of the importables will be intensive in the scarce factors whereas other importables will be found intensive in the remaining abundant factors. One of the implications of this is that aggregate imports could be more intensive in the latter abundant factors than aggregate exports.

In a two-country model all trade pattern measures suggested in the empirical literature are dichotomous. In the case with more than two homogeneous products such measures cannot be used in principle as indices of comparative advantage, since these should be continuous variables.

If, on the other hand, the dichotomous property is avoided by using measures including production and/or consumption, such as shares of the home or total world markets, the theoretical basis for specific relationships with factor intensities is unclear. In addition they are far more difficult to obtain, and have for engineering goods proved to be very sensitive to the varying tradability of products.

Since it is impossible to use potential price differences in a pre-trade situation as a dependent variable it is doubtful whether the multi-commodity, multi-factor, two country model can be tested at all in a strict sense. Therefore, the choice of methodology has to be made in part on practical grounds. Since in practice exports and imports exist for all industries the heterogeneity should be considered important in choosing the dependent variable. It is then unfortunate to choose a dichotomous variable leading in the Harkness & Kyle case to an omission of 21 out of 79 industries on the ground that no net trade occurred in the former and with no indication of the values of the independent variables for the omitted observations. Also it must be questionable to abstain from the valuable information within the exportable and importable groups about how variations in factor intensities related to variations in the trade structure.

1) It was not possible to obtain statistical measures of raw material intensities. However, this is probably not an important shortcoming in analysing the specialisation pattern within the engineering industry.

Table 1 presents some regression results. The hypothesis of a positive regression coefficient for the skilled worker intensity is the only one which cannot be rejected. The current international specialisation of the Swedish engineering industry is neither positively nor negatively related to the capital and technical personnel intensities.¹⁾ The low multiple correlation coefficient suggests that the latter result is not due to any dominating influence for the skilled worker intensity. The hypothesis, (VI), that the engineering industry is adjusted to Sweden's factor abundance in 1970 has to be rejected. The static formulation of the factor proportions theorem may consequently be rejected. The hypotheses that Sweden has a long run and stable (III) abundance in capital and technical personnel (IV) need not to be rejected. It is possible that the earlier strong trade impediments or changes in the ranking of factor intensities between subindustries have led to an incomplete adjustment to comparative advantage. Substantial changes in technologies or tariffs may also explain a slow adjustment. In the following section, the hypothesis (V), that tariffs and/or factor intensity reversals over time might explain the pattern of changes in trade specialisation, is tested under the assumption that hypotheses I-IV are true. If this hypothesis cannot be rejected the next step would be to test this pattern against factor intensities and their changes.

1) These results were reaffirmed by tests with alternatively formulated independent variables, tests on the intra-subindustry specialisation patterns and tests where the simultaneous influence of factor intensities and tariffs were studied.

Table 1. Some regressions on determinants of trade specialisation in the Swedish engineering industry in 1970

Regression no	Dependent variable	Regression coefficients (with standard deviation) of				R^2	F-value (degrees of freedom)
		Constant	C/L	L_T/L	L_Y/L_A		
1	$\frac{X-M}{X+M}$	.021	.008 (.019)			.005	.174 (1;32)
2	"	.16		.430 (.812)		.009	.281 (1;32)
3*	"	-.127			.579 ^{a)} (.276)	.132	4.413 ^{b)} (1;29)
4*	"	-.134	.003 (.021)	-.129 (.923)	.590 ^{b)} (.312)	.134	.392 (3;27)

a)= significant at the 2.5 % level

b)= " " " 5 " "

*The number of observations here is 31, i.e. three less than in regressions 1 and 2. This is due to that the data on skilled workers is only reported down to the 5-digit level of the Swedish industrial classification system (SNI).

Legend:

$\frac{X-M}{X+M}$ = net exports ratio, where X denotes Swedish exports, fob, and M Swedish imports, cif

C/L = a measure of the physical capital intensity, where C is measured by the capacity of motive power (in horsepower) and L number of employees

L_T/L = the ratio of technical personnel to total employment (both measured in physical numbers)

L_Y/L_A = the ratio of skilled workers to total number of employed workers (measured in hours of work).

Sources: SOS (Official Statistics of Sweden published by the National Central Bureau of Statistics): Utrikeshandel part 2, 1970 and 1971, and Industripart 1, 1970. Data on hours of work for skilled workers and other workers were calculated from the wage statistics collected jointly by Sveriges Verkstadsförening and Svenska Metallindustriarbetareförbundet for 1972, 4th quarter. For a few of the subindustries the net exports ratio has been constructed on data for both 1970 and 1971, because of the occasional nature of deliveries of very large products or systems of products.

4. Changes in the pattern of trade specialisation between 1960 and 1970

Given hypotheses I-IV the results obtained in the preceeding section might in the simplest case be attributed to incomplete adjustment in 1970, at least in some subindustries. Then the pattern of changes would eventually bring about full adjustment to the factor abundance situation stated in hypothesis IV for Sweden. In order to investigate this possibility the pattern of changes in Sweden's trade specialisation from 1960 to 1970 can be analysed against the initial trade specialisation. In the simplest case, the liberalisation of trade should be expected to cause the net export ratios to cluster successively closer to its formal boundaries. In other words the lessening of price distortions would mean that products would tend to become pure exportables (net export ratio = +1.0) or pure importables (net export ratio = -1.0). Normally¹⁾ there would be a tendency for subindustries with positive net export ratios to increase their ratios and for those with negative ones to decrease them. Such a conclusion of a positive relationship between the changes in and the initial values of net export ratios presumes, however, that neither tariffs, nor technology changes, scale economies, technology gaps etc have shifted the specialisation pattern for individual subindustries. These latter causes of changes in specialisation may yield extreme observations disturbing or eliminating the expected positive relationship.

1) It is unlikely that the imposed tariffs have made importables out of otherwise exportable products and vice versa. The following simple correlation matrix for the cross-section of subindustries supports such a conclusion:

	C/L	L_T/L	L_Y/L_A
Nominal import tariff 1960	-.35	.38	-.20
Change in nominal import tariff 1960-70	.16	-.19	-.05

There is a significant negative correlation (at the 5% level) between tariffs and the 1970 capital intensity, which according to Lundberg/ forthcoming/ and Carlsson & Ohlsson [1973] holds also for Swedish industry as a whole and regardless of whether tariffs are measured in nominal or effective terms. Also there is a significant positive correlation between tariffs in 1960 and the technical personnel intensity. The fact that the tariff changes are not very highly correlated with either the factor intensities or the tariff structures of 1960 (the latter correlation is -.45), can be attributed to the car industry. Starting from almost the highest nominal tariff in 1960 (14.5%) it had almost the lowest decrease during the decade. The explanation to this is in part that EFTA affected only the British car industry, which has not substantially increased its market share or share of Swedish imports. In addition the Kennedy round did not much affect the tariffs for cars.

In Figure 1 the relationship between the changes in the net export ratio from 1960 to 1970 and the net export ratios of 1960 is presented. The hypothesis of a positive relationship has to be rejected but not on the ground of either extreme observations or the lack of a relationship at all. Instead a significant negative relationship is obtained, the sign of which excludes tariff changes in general as a main explanatory variable. The fact that the relationship is systematic precludes the possibility that it can be explained by peculiarities in changes of tariffs or technology. Furthermore, the relationship is inconsistent with the hypothesis of a long run stability in Sweden's factor abundance (hypothesis III above). But since the slope of the regression line is less than -1.0 the results may alternatively indicate either an evening out or a shifting tendency in the Swedish specialisation at the subindustry level.¹⁾ The former interpretation relies on the Burenstam Linder or other intra-industry trade theories (see Grubel [1970], Gray [1973] or Hufbauer [1970]). The same result interpreted instead as a tendency to a shift or reversal of the pattern of specialisation may be consistent with the factor proportions theory. A discrimination between these two explanations cannot be obtained by simply extending the period. Instead such a discrimination is strived at by proceeding along the lines suggested in hypotheses I-V above.

Hypothesis V states among other things irreversible factor intensities over time. This hypothesis cannot as a whole be tested for the subindustries analysed here because of the absence of published data in years earlier than 1967. However, it is in part testable as is shown in the following section.

5. Testing for major factor intensity reversals over time

The irreversibility assumption may in part be tested by utilising data for a somewhat different cross-section of 33 subindustries of the engineering industry and for the period 1959-1968 as regards the capital

1) It is interesting to note that almost exactly the same negative slope was obtained for a subsector of the engineering industry, namely the fabricated metal product industry, both at the subindustry and commodity group levels in 1960-1969 (cf Ohlsson [1974]).

and technical personnel intensities (from Du Rietz [forthcoming]). The test is a rather simple one relying on the same assumptions as those underlying the above used model of resource reallocation due to trade liberalisation. Specifically, the linear homogeneous production functions assumed to hold for each product are also assumed to remain unchanged over time. Changes in factor intensities are caused only by the endogeneously determined changes in factor price relations, thus leaving the factor intensity ranking unchanged. A normalisation for this general change in factor intensities can then be done simply by dividing each factor intensity of the given subindustry and year with that of the engineering industry as a whole. A stable ranking would then mean that, in a figure showing the relationship between the 1968 and 1959 factor intensity indices, all observations would lie on a positively sloped 45° line through the origin. The test of the strict hypothesis that the factor intensity ranking is perfectly stable could then be designed as a test of whether an estimated least square regression line for the 33 observations differs from this postulated 45° line. Assuming the usual normality properties of the distributions, the following F-distributed ratio could be used in a significance test

$$F(2;31) = \frac{[\Sigma (y-x)^2_{0,1} - \Sigma e^2] / (n_1 - n_2)}{\Sigma e^2 / n_2}$$

where $\Sigma (y-x)^2_{0,1}$ = residual sum of squares of a regression line with intercept postulated to be 0.0 and slope 1.0

Σe^2 = residual sum of squares of the estimated least square regression line

n_1 = degrees of freedom of the postulated regression line, i.e. 33

n_2 = degrees of freedom of the estimated least square regression line.

Figures 2 and 3 show the respective relationships for the capital and technical personnel intensities respectively. The F-values of the above formula is estimated to .84 and 27.79 respectively. At the 5 % level $F(2;30) = 3.32$. Consequently the stability hypothesis cannot be rejected for the capital intensity whereas it should be for the technical personnel intensity. However, even in the latter case there are no major changes in the factor intensity ranking. Instead the rejection of the hypothesis can be attributed to the fact that relatively technical

Figure 1. The relation between changes in the net export ratios 1960-70 and the net export ratio in 1960 in 34 engineering subindustries

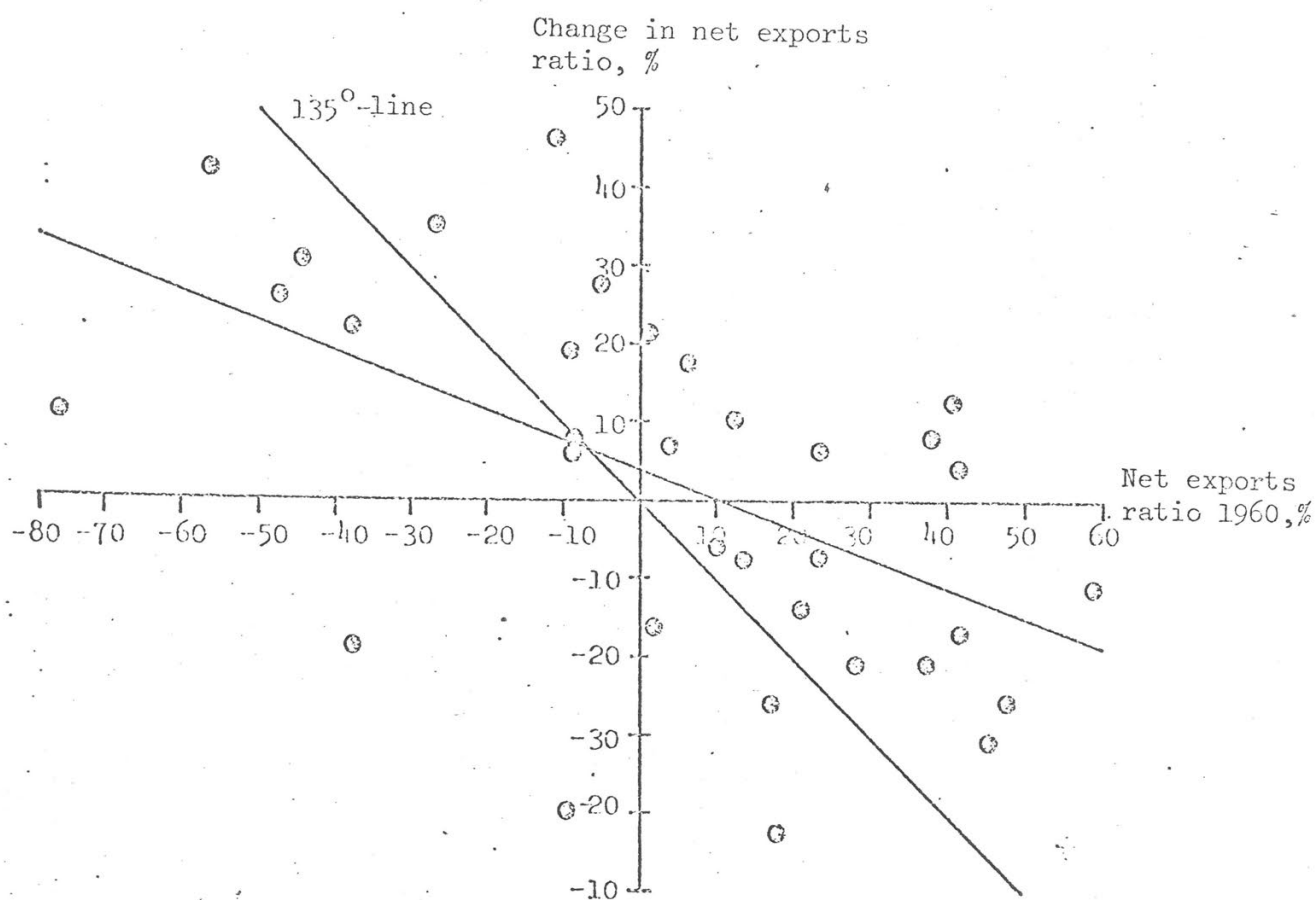
Regression:

$$y = 3,7 - 0,380x$$

(0,103)

$$R^2 = 0,297$$

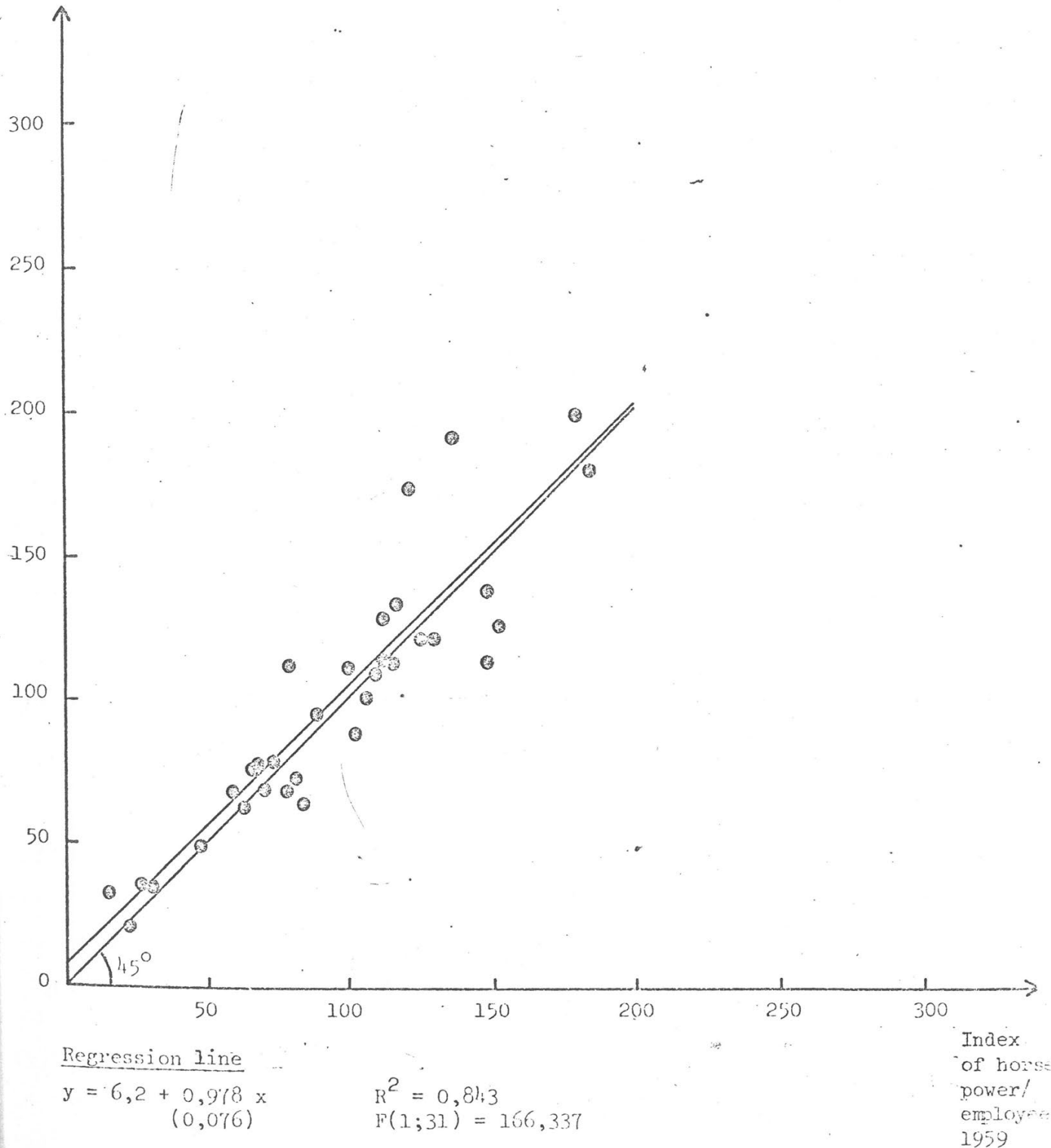
$$F(1;32) = 13,513$$



Sources: SOS (Official Statistics of Sweden published by the National Central Bureau of Statistics). Handel del I, 1960 and 1961 and Utrikeshandel del 2, 1970 and 1971.

Figure 2. The relationship between capital intensities of 1968 (= y) and 1959 (= x) in a cross-section of 33 engineering subindustries.
Index = 100 for the engineering industry as a whole in 1968 and 1959 respectively

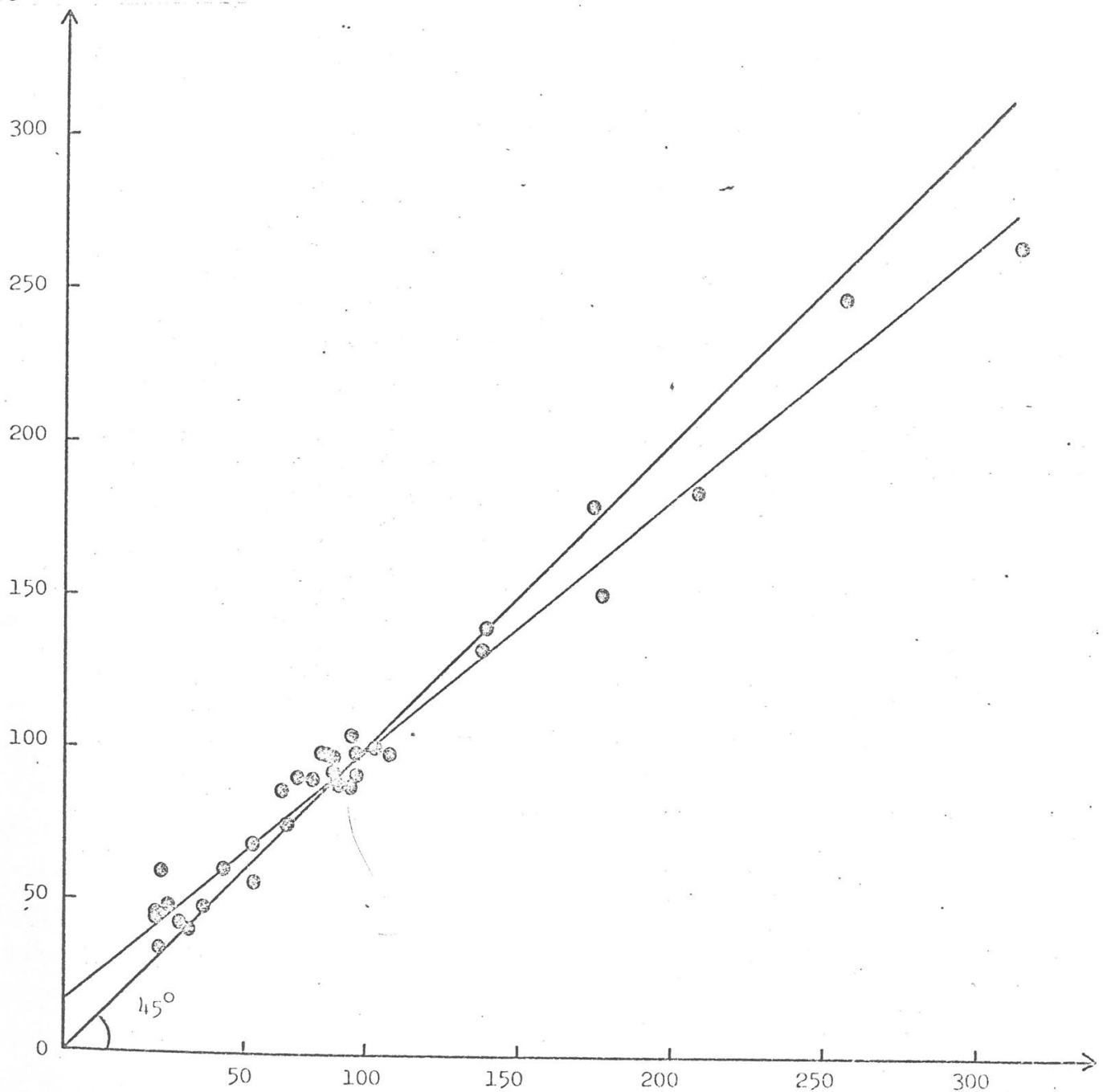
Index of horsepower/
employee 1968



Note: The same test has been made for the capital intensity measure electricity use/employee with the same outcome. In the cross-section of 34 subindustries there is a very strong relationship between the two alternative capital intensity measures. The results of some simple tests of these two measures did not allow a conclusion that one is preferable over the other, but cf. Moody [1974].

Figur 3. The relationship between technical personnel intensities of 1968 (= y)
and 1959 (= x) in a cross-section of 33 engineering subindustries.
Index = 100 for the engineering industry as a whole in 1968 and 1959
respectively

Index of technical
 personnel intensities,
 1968



Regression line

$$y = 16,7 + 0,824 x$$

(0,024)

$$R^2 = 0,975$$

$$F(1;31) = 1206,740$$

Index of
 technical
 personnel
 intensities
 1959

personnel extensive subindustries in 1960 have tended to increase their intensity more than average and vice versa for technical personnel intensive ones in 1960. Apparently, the earlier assumption of no technical change has to be rejected. The general increase in the technical personnel intensities, averaging 25 %, was accompanied by a biased technical change, which in the Johnson /1963/ terminology appears to be characterized by an intensive-factor-saving change in the technical personnel extensive subindustries and/or an intensive-factor-saving change in the technical personnel intensive ones.

Suppose that Sweden was abundantly supplied with technical personnel, that the bias in technological change was exogeneously determined and that Sweden being a small country could not affect its commodity price structure. Then a biased technological change of the kind indicated above suggests an import-biased growth in the sense that imports of earlier importables should decline relative to exports of earlier exportables but not as much as to lead to a reversal of trade direction.¹⁾ Such a relationship was found in figure 1 above, but so far the abundance hypothesis is contradicted for technical personnel by the results of table 1. If instead Sweden is scarcely supplied with technical personnel then the result should be interpreted to imply an export-biased growth similar to the growth pattern suggested by the Rybczynski theorem in the case of accumulation of the abundantly supplied factor.

In order to arrive at more decisive conclusions we have to reach more clearcut results about Sweden's true factor abundance. Since the results of figures 2 and 3 do indicate a major stability of the factor intensity rankings, it is possible to test the factor abundance hypotheses by regressing the changes in the specialisation pattern of the 1960's on the earlier used factor intensities of 1970.

1) Unless, of course, this bias continued to prevail for a sufficiently long time period.

6. Is there a factor proportions explanation to the changing specialisation pattern?

While table 1 ruled out the possibility that the static formulation of the factor proportions theorem was a powerful explanation of the 1970 specialisation, figure 1 illustrating changes in the specialisation pattern constituted a contradiction either to the factor proportions theory in general or to the hypothesis of a long-run stability in Sweden's factor abundance.¹⁾ Here the latter alternative is tested by regressing the change in the net export ratio on the 1970 intensities of capital, technical personnel and skilled workers. The basic assumption behind this test is that Sweden's factor abundance may have been misspecified in terms of its stability (hypothesis III) but not in terms of which factor intensities should be included in the analysis. Since there is no way of estimating directly the specific nature of the change in Sweden's factor abundance, hypothesis IV of Sweden being abundantly supplied in the 1960's with capital, technical personnel and skilled workers, is temporarily maintained but now subject to testing. In consequence, this factor abundance must at least in part be assumed to have been gained (instantaneously) in 1960 or during the 1960's. The implication is, of course, that the pattern of specialisation in 1960 is adversely related to at least one factor intensity as compared to same relationship for the trends in specialisation between 1960 and 1970. Specifically, the following three hypotheses are to be tested:

A. The capital intensity hypotheses. 1. Between 1960 and 1970 there was an increased Swedish specialisation in capital intensive subindustries. 2. In contrast, this specialisation was capital extensive initially.

B. The technical personnel intensity hypotheses. 1. Between 1960 and 1970 there was an increased Swedish specialisation in technical personnel intensive subindustries. 2. In contrast, this specialisation was technical personnel extensive initially.

C. The skilled worker intensity hypotheses. 1. Between 1960 and 1970 there was an increased Swedish specialisation in skilled worker intensive subindustries. 2. In contrast, this specialisation was skilled worker extensive.

1) For simplicity we are here among other things neglecting the fact that the biased technical change in figure 3 may in some cases explain the relationship observed in figure 1.

In order to test these hypotheses the two different patterns of specialisation were regressed on each factor intensity, separately as well as in simultaneously. In addition the 1960 net exports ratio was tried as an independent variable in regressions on the change in the net exports ratio between 1960 and 1970 in order to investigate whether and how this inclusion affected the regression coefficients for the factor intensities.¹⁾

Table 2 presents the regression results. The rather high and significant explanatory values of most regressions on the change in the specialisation pattern makes it reasonable to conclude that there is a factor proportions explanation for this change. As much as around 40 percent of the change is in this way explained by the theorem.²⁾ It seems fair to conclude that the adjustment process in Swedish trade during the 1960's is consistent with one or another version of the factor proportions theorem.

It is also obvious from table 2 that the negative relationship of figure 1 should be interpreted as part of a reversal of Sweden's pattern of engineering specialisation. The outcome of the tests of hypotheses A, B and C gives evidence on this point.

Hypothesis A can be rejected as a whole. Instead of a positive relationship between the change in the net exports ratio and the capital intensity (hypothesis A1) a significant negative one is obtained. Also, instead of the expected negative relationship with the initial net exports ratio a positive one is received. Obviously the three patterns of specialisation studied in tables 1 and 2 are consistent with a hypothesis that Sweden was earlier abundantly supplied with capital visavis labour but has lost this abundance around 1960 or during the following decade. It is impossible to judge whether this change has meant nothing more than a lost advantage or even developed to become a comparative disadvantage in capital intensive products since the period does not cover the whole adjustment process.

1) There may, of course, be other reasons for including the net export ratio of 1960 as an independent variable for instance trying for other functional forms of the relationship, avoiding too much influence for initially extreme ratios which are bounded to move in one direction only and testing for other explanations behind the initial ratios than factor proportions ones.

2) If two more independent variables are included as in Ohlsson /forthcoming/ the R^2 -coefficient increases to more than 60 %. One of the variables, the change in nominal tariff rates, receives a highly significant positive coefficient. The other one, the percentage change in domestic consumption used in a test of either a Burenstam Linder-type or a product life cycle type basis for Sweden's comparative advantage, receives a significant negative coefficient. The latter result may be interpreted as a rejection of these two demand oriented approaches to explaining Sweden's comparative advantage since all a priori information points at a positive relationship.

Test of hypo- thesis	Regres- sion no.	Dependent variable	Constant	Regression coefficients (with standard deviation of variable)				R^2	F-value (degrees of freedom)
				C/L	L_T/L	L_Y/L_A	$(\frac{X-M}{X+M})_{60}$		
A 1	1	$\Delta(\frac{X-M}{X+M})$	.190	-.031 ^{a)} (.014)				.125	4.559 ^{b)} (1;32)
A 2	2	$(\frac{X-M}{X+M})_{60}$	-.168	.038 ^{b)} (.021)				.096	3.380 ^{c)} (1;32)
A 1,2	3	$\Delta(\frac{X-M}{X+M})$	.133	-.018 ^{c)} (.013)			-.366 ^{a)} (.107)	.335	7.795 ^{a)} (2;31)
B 1	4	$\Delta(\frac{X-M}{X+M})$	-.102		1.087 ^{b)} (.639)			.083	2.888 ^{c)} (1;32)
B 2	5	$(\frac{X-M}{X+M})_{60}$	.118		.656 (.950)			.015	.477 (1;32)
B 1,2	6	$\Delta(\frac{X-M}{X+M})$	-.059		.850 ^{c)} (.552)		-.361 ^{a)} (.102)	.347	8.228 ^{a)} (2;31)
C 1	7	$\Delta(\frac{X-M}{X+M})$	-.078			.300 ^{c)} (.222)		.059	1.828 (1;29)
C 2	8	$(\frac{X-M}{X+M})_{60}$	-.049			.278 (.336)		.023	.686 (1;29)
C 1,2	9	$\Delta(\frac{X-M}{X+M})$	-.097			.407 ^{a)} (.187)	.383 ^{a)} (.102)	.374	8.372 ^{a)} (2;28)
A 1, B 1, C 1	10	$\Delta(\frac{X-M}{X+M})$	-.018	-.024 ^{c)} (.015)	.821 (.680)	.235 (.230)		.216	2.479 ^{c)} (3;27)
A 2, B 2, C 2	11	$(\frac{X-M}{X+M})_{60}$	-.115	.274 (.241)	-.950 (1.073)	.355 (.362)		.116	1.180 (3;27)
A 1,2; B 1,2;	12	$\Delta(\frac{X-M}{X+M})$	-.056	-.015 (.014)	.507 (.600)	.353 ^{b)} (.203)	-.331 ^{a)} (.106)	.429	4.885 ^{a)} (4;26)

cont. table 2

a = significant at the 2.5 % level

b = " " " 5 " "

c = " " " 10 " "

Legend complementing that of table 1:

$\Delta(\frac{X-M}{X+M})$ = change in net exports ratio 1960-70

$(\frac{X-M}{X+M})_{60}$ = net exports ratio in 1960

Sources: cf table 1 and figure 1.

Hypothesis B1 cannot be rejected since the regression coefficients obtained for the technical personnel intensity in regression 4 and 6 are significant. This conclusion can be drawn in spite of the insignificant regression coefficients of regressions 10 and 12. The exclusion of either the technical personnel or the skilled worker intensities in regression 10 turns the coefficient of the remaining intensity into significance. The following correlation matrix between the independent variables shows that this is due to the high positive correlation between the technical personnel and skilled worker intensities:

	1	2	3	4
1. C/L	1.00			
2. L_T/L	.22	1.00		
3. L_Y/L	.10	.36	1.00	
4. $(X-M)/(X+M)$	.27	-.16	.15	1.00

A comparison between regressions 1 and 10 shows that the inclusion of both almost doubles the explanatory value but decreases the F-value. In addition, the inclusion in regression 10 of a variable measuring changes in tariff rates of Swedish imports¹⁾ makes the regression coefficient for the technical personnel intensity significant and increases the significance also for the capital intensity coefficient.

While it seems safe not to reject hypothesis B.1, hypothesis B.2 of a negative relationship between the 1960 net exports ratio and the technical personnel intensity has to be rejected. A comparison of the specialisation patterns of 1960, 1970 and 1960-70 seems to suggest that Sweden might have obtained an abundance in technical personnel in the 1960's but too late or too small to have had a major impact on the 1970 pattern.

Hypothesis C.1 cannot be rejected. There is a significant positive relationship between specialisation trends and the skilled worker intensity. In contrast, hypothesis C.2 of a negative impact on the 1960 pattern of specialisation has to be rejected since there is no significant relationship at all in regression 8. The conclusion regarding the abundance in skilled workers is that Sweden has been abundant in skilled workers after 1960 and strongly enough to make the engineering industry specialised accordingly in 1970.

1) Cf. also footnote 2 page 18.

In summary, the results are consistent with a comparative static factor proportions theorem with factor accumulation. They allow a partial rejection of the initially formulated factor abundance hypothesis (hypothesis IV) as well as a complete rejection of the hypothesis of a long run abundance stability (hypothesis III). The results are those expected according to the Rybczynski theorem if Sweden has had an internationally strong accumulation of technical personnel and skilled workers relative to capital and other labour.

7. Further comments on the biased technical change

The more clearcut conclusions about Sweden's factor abundance makes it possible to discuss the biased technical change in terms of the technical personnel intensity of section 5. Two major problems may be discussed, the first one being whether the bias was exogeneously or endogeneously determined. The second problem is whether and how the bias affected the nature and speed of the adjustment process.

In section 5 above the technological bias was assumed to be exogeneous. However, a change in comparative advantage of the kind derived here gives the following adjustment incentives for firms with an earlier strong but worsened comparative advantage position:

1. to change the product mix in order to comply better with Sweden's new comparative advantage,
2. to alter the production methods of a given product mix to obtain the same thing,
3. to rationalise production methods and thus increase the over-all efficiency.

All three adjustments require a relatively large increase in the output of technical personnel. The first type is the one suggested by the factor proportions theory if the possibility of developing new products is disregarded. The second type of adjustment is successful only if major factor intensity reversals are obtained and this possibility was contradicted by the results of section 5. The third type of adjustment is insufficient in the long run in the factor proportions theory. All three adjustments may, however, require more technical personnel per employee. In consequence, the tendency of a more than average increase in the technical personnel intensity of technical personnel extensive subindustries may well be endogeneously determined

and thus be part of the adjustment process. Such a conclusion is more likely since the production factor discussed is itself an instrument for facilitating adjustments.

Having concluded that the bias in changing technical personnel intensities is more likely to be endogeneously than exogeneously determined, it is time to discuss its impacts on the nature and speed of the adjustment process. An exogeneously determined similar bias would have worked against the effects of the new comparative advantage in technical personnel intensive products. However, given that the tendency was weak it would only have slowed down the readjustment necessary in the long run.

If the technological bias was endogeneously determined, it would be even more likely that this bias could at most slow down, not alter the otherwise required readjustment. But if instead the excess increase in technical personnel (per employee) was largely an investment in type 1 changes, i.e. in product mix changes, it may alternatively have speeded up the adjustment process. Consequently, a firm conclusion cannot without further information be reached on how such a bias may have affected the nature and speed of this process.

8. Summary and Conclusions

This paper investigates two problems almost neglected in the empirical analysis of the factor proportions theorem. One is the lack of empirical specification of the factor abundance of countries and the other the choice of testing only static versions of the theorem. By a stepwise testing procedure utilising a set of hypotheses differing in orders of superiority both static and various comparative static versions are tested here. This procedure also allows a more thorough testing of the factor abundance hypothesis for Sweden as regards both which factors are abundant and the stability assumption.

The results derived for the Swedish pattern of engineering specialisation indicate that static models of the factor proportions theory do not explain much of the patterns prevailing in 1960 and 1970. In contrast, a comparative static model allowing for reversals of comparative advantage over time seems to be successful in explaining the trends in trade specialisation between the two years. The weak factor proportions specialisation in these years might then be attributed to the adjustment period being so long that the observed decade covered only a part of this period. Such an interpretation is supported by a

negative relationship between the changes in the specialisation measure and its initial values, the slope of which showed that a general reversal in specialisation had not occurred within the period.

Consequently, for the purpose of model building this paper is encouraging for the modern factor proportions theory. This conclusion can be drawn although, like many earlier tests, it does not support the empirical generalisation of a well adjusted economy in a given year necessary in testing the static models of this theory. The results are, as far as the factor proportions theorem is concerned, broadly consistent with the implications of a comparative static model with factor accumulation and perhaps also a biased-technological change. However, it neglects two fundamental empirical problems of such models, the first one being whether a country's factor abundance actually explains its international specialisation, or whether the direction of causality is the opposite. If the former is the case, a second fundamental problem is to assess whether a factor abundance of a country is determined by its factor endowments or its factor prices. Both problems apparently raise the question whether a comparative static framework really is sufficient or whether a dynamic one is necessary (cf. Ohlsson [forthcoming]).

One of the major policy conclusions of this paper is that altering the specialisation pattern of an economy with a very large foreign trade sector requires a fairly long adjustment period. Another policy conclusion is that the comparative advantage of a country is undergoing changes. If these two conclusions hold for other and larger countries, it may greatly enhance the possibilities of explaining international adjustment problems connected with, for instance, persistent balance of payment difficulties and the time and industry pattern of foreign direct investments.

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