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On unit prices and their use in the analysis of the international specialisation pattern within heterogeneous industries

by

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ON UNIT PRICES AND THEIR USE IN THE ANALYSIS OF THE INTERNATIONAL SPECIALISATION PATTERN WITHIN HETEROGENEOUS INDUSTRIES*

by Lennart Ohlsson

The main purpose of this paper is to present three new empirical variables, constructed so as to make possible a more thorough empirical analysis of the determinants of the intra-industry specialisation pattern in technologically heterogeneous industries. In the empirical analysis of the structure of a country's foreign trade the problems of a) more than two factors of production[1)], b) factor reversals between countries[2)], and c) new products[3)] are perhaps especially difficult to handle. The three variables presented here may suggest some alternative ways to tackle these problems.

The three variables are all based on unit prices (unit values on unit costs). Recently some work has been published on the use of unit prices that is similar to ours[4)]. The discussion of what unit prices measure has gained new interest following the publication of the the pathbreaking Kravis & Lipsey study of price competitiveness in world trade[5)]. By presenting a test on certain determinants of unit prices per metric ton the present paper contributes to that discussion. In addition it carries important implications for the possibility of constructing price indices for heterogeneous industries from observations on ton prices for individual commodity groups.

The hypothesis that unit prices per metric ton can be interpreted as a proxy variable for technological differences between products is tested for the Swedish engineering industry in the first two sections of this paper. By assuming that the main results of this test hold for other countries as well, and for a lower level of commodity aggregation, it is possible to illustrate how ton prices may be used to analyse possible determinants of the international pattern of specialisation in engineering exports[6)].

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1) - 6) See page 2.

1) The existence of more than two factors raises the problems of a) how should the factor intensities be empirically defined and b) what weights should be attributed to the different factor intensities in the construction of single index of comparative advantage for the set of products. One approach to this problem is to aggregate different types of capital (human, non-human, land) into one single measure. (On this point, see Johnson [1968] for a theoretical discussion. A recent empirical paper with a cost approach to aggregating human capital is Fareed, A.E. [1972].) An aggregation of different factors of production may, however, hide some important explanatory factors of the structure of foreign trade, and is in some cases unsatisfactory on both theoretical and empirical grounds (cf the discussion below on the Lary measure).

2) Minhas' [1962] original finding that factor intensity reversals did exist has been questioned on different grounds. A summary (and extension) of that discussion is given in the Addendum to the recent reprint of Bhagwati's survey article published in Bhagwati [1969] pp. 3-122. Recently Keesing [1971] has published a cross-country comparison of some skill intensities. A comparison of the rankings of these intensities shows a fairly wide range for many industries.

3) The importance of new products is, of course, of central [1966] importance in the product cycle theory as proposed by Vernon and Hirsch [1967]. The role of research and development, the prime factor behind new products, for the pattern of trade specialization, was first analysed by Keesing [1968 b] and then utilizing Keesing's data, reexamined by Kenen [1970].

4) Cf Hufbauer & O'Neill [1972] and Hufbauer [1970]. Grubel [1967] mentions (in a note) that he has tried to test the Burenstam Linder theory by utilizing implicit prices. No results are, however, reported there or - to our knowledge - elsewhere.

5) Cf Kravis & Lipsey [1971 a] especially chapter 8 and also [1971 b]. Estimation of price elasticities in foreign trade based on unit prices has a fairly long history. An early review article is Prais [1962]. A recent and methodologically ambitious study of price (and income) elasticities is Houthakker & Magee [1969].

6) The results of the paper are drawn from a forthcoming study on the determinants of the competitive position and international specialization of the Swedish engineering industry, Ohlsson [forthcoming]. The techniques and methods of construction variables developed for this study have also been used in the analysis of the Swedish fabricated metal product industry (Ohlsson [1973]) and chemical industry (Renck [forthcoming]).

Ton prices as a technology index - a first test

1. The hypotheses. Almost all modern trade theories include among the explanatory variables at least one variable indicating the technology embodied in different commodities[1]. However the available statistical sources limit the analytical possibilities due to

a. lack of data, or differences in data between countries, where many factors of production are concerned,

b) differences in industrial classification systems between countries,

c) insufficiently disaggregated industry data.

Data on exports and imports are in contrast rich in details, and in recent years also put together and published in a uniform classification system by the OECD and the UN. While at first glance these data do not seem to offer any explanatory variables of foreign trade other than tariff revenues, they do include both value and quantity data on exports and imports. In Swedish (and many other countries') trade statistics, most quantity figures are given in metric tons. By dividing the value by the quantity, the implicit price per metric ton, henceforth called the ton price, is obtained. The hypotheses to be tested for the Swedish engineering industry are that the ton price:

I. can be interpreted as a proxy variable for technology differences in intercommodity comparisons

II. is lower the more standardised the production methods of a commodity is compared to other commodities.[2]

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1) The exception being, of course, the Burenstam Linder theory (see Burenstam Linder [1961] and the discussion in Bhagwati [1969] and Hufbauer [1970]

2) The standardisation of production methods for (homogeneous) products depends on both the technological possibilities and the efforts taken to exploit these possibilities by "rationalising" production. They are to a large extent determined by the complexity of the products and the length of the production runs. It is in general easier to automate production the more simple the product is in terms of the number of manufacturing phases. Automatization tends also to be easier the longer the production runs are for the product or for some of its components. Given that the efforts to "rationalise" production are equally distributed among engineering products, the main determinant of differences in the automation of production between these products will be the technological possibilities In this paper the technology is regarded to be the more sophisticated the less the substitution of human - and especially technical human - skills for machinery in an intercommodity comparison. A highly automized production utilizing a sophisticated machinery but requiring little human skills is in this terminology called technologically unsophisticated.

One possible test of the two hypotheses would be a regression analysis on a cross-section of commodities, the dependent variable being the ton price, and the independent ones being variables measuring the technology of production. Hypothesis I should be rejected if the ton price does not vary significantly with the latter variables. A test of hypothesis II is possible if the independent variables can be interpreted as measures of the degree of standardisation of production methods.

Due to shortcomings of the data the test can be carried out only for subsectors of industry (see section 2 below).[1] Results are presented here from a test on 40 subindustries of the Swedish engineering industry.

2. The dependent variable should ideally be the ton price of each subindustry's value added in manufacturing. Unfortunately it is impossible to obtain the ton price in net output. This shortcoming of the data limits the field of application of the ton price measure to industries or commodities having a similar raw material base.[2] It also suggests that a relatively large coefficient of determination is needed in order to rule out the possibility of a serious error in the ton price measure due to differences in ton prices of inputs.

In addition to errors in the dependent variable due to the use of gross rather than net figures for the ton prices, other errors are obtained by the use of export ton prices instead of ton prices of production.[3] The ton price of a given subindustry is calculated as $\sum_i x_i / \sum_i q_{x,i}$, where x_i = exports, fob (in thousands of Swedish crowns) of a commodity group i and $q_{x,i}$ = export quantity in metric tons. The summation is over all commodities included in the subindustry according to a key provided by the Swedish National Central Bureau of Statistics.

3. The independent variables. As measures of technological differences between the subindustries certain factor intensities of production are chosen. The choice of which factor intensities to use instead of input/ /output ratios is of course an arbitrary one, and is furthermore limited by the Swedish industrial statistics. The following original variables were tried in different forms:

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1) - 3) See page 5.

1) Such a test was only recently made possible by the re-classification of the Swedish industrial statistics to the so-called SNI-code, which is reported down to a 6-digit level and is equivalent to ISIC of 1968 down to the 4-digit level.

2) For each subindustry the following identity holds:

$$(1) \quad P_j O_j = P_{j,L} L_j + P_{j,K} K_j + P_{j,R} R_j$$

where the P:s denotes prices of output and inputs respectively, O_j the quantity of output in numbers of the commodity, L_j and K_j inputs of labour and capital respectively and R_j inputs of raw materials (and intermediate goods from other industries) in metric tons. But the value of $P_j O_j$ is equal to $P_{j,t} O_t$, where $P_{j,t}$ = price per ton of output and O_t = quantity of output in tons. Assume also that the price of (homogeneous) labour and (homogeneous) capital is the same for all subindustries, and there is no waste of raw materials, so that the weight of inputs from other sectors and that of the output is the same. Then expression (1) can be rewritten:

$$(2) \quad P_{j,t} O_{j,t} - P_{j,R} R_j = P_L L_j + P_K K_j.$$

If the raw material consists of a homogeneous good with a given price P_R (2) may be further simplified:

$$(2a) \quad P_{j,t} = P_L(L_j/O_{j,t}) + P_K(K_j/O_{j,t}) + P_R.$$

The variations between subindustries in the output price per ton is obviously determined by the variations in the required inputs of labour and capital per ton of output (or of raw material). But the raw materials of the engineering industry are not in fact homogeneous. If in contrast R_j is a vector of n different raw materials and $P_{j,R}$ the corresponding vector of raw material prices (2) may instead be written:

$$(2b) \quad P_{j,t} - \sum_{k=1}^{n} (R_{j,k}/O_{j,t}) P_{j,k,R} = P_L(L_j/O_{j,t}) + P_K(K_j/O_{j,t})$$

where $\sum_{k=1}^{n} (R_{j,k}/O_{j,t})$ is still for simplicity assumed to equal 1.

The most important inputs from other sectors of the engineering industries are metals and metal alloys (unfabricated and fabricated). There is good reason to assume that technologically relatively sophisticated engineering products usually require relatively sophisticated raw materials. For this cross section of products it may thus be suspected that the ton price of output is positively correlated with the weighted ton price of raw materials. The slope of this functional relationship must always be less than 45° since

$$P_{j,t} > \sum_{k=1}^{n} (R_{j,k}/O_{j,t}) P_{j,k,R}.$$

3) The latter ones are impossible to get due to the lack of quantity figures for many commodity groups. Another index was also tried in order to give an indication of the impact this error might have on the sign and significance of the regression coefficients. For each subindustry the ton price was approximated by the arithmetic mean of the average weighted ton prices in exports and imports respectively. The sign as well as the significance of the regression coefficients in the regressions using this latter dependent variable are the same as those reported in table 1. As table 2 shows, the correlation between the export and import ton prices in the cross-section of subindustries is as high as .94. These results may be interpreted to suggest that the results would not have differed much had the production instead of the export ton price been included as the dependent variable.

As a capital intensity measure (K/L) the capacity of motive power (horsepower) per employee was used. One of the shortcomings of this measure is the exclusion of capital in building. The hypothesis according to proposition II above is that the ton price should be higher for subindustries with a low capital intensity than for those with a high one. The implicit assumption here is that the production process is more standardized the more capital that has been substituted for labour in production.

One of the variables indicating the human capital intensity is the technical skill intensity (L_T/L) defined as the ratio of technical personnel to the total number of employees. The assumption here is that a product is more sophisticated the higher this ratio. A positive regression coefficient for this variable is consequently expected.

Sweden has been found to have a large net export of skilled workers[1). The influence of the worker skill intensity on our ton price index was considered to be important since the field of application is the engineering industry. However, the only available measure of this intensity is the average wage (per hour) for workers[2)]

Some engineering products are sold without many sales personnel. Others require a relatively large number of salesmen. Such personnel could not on a priori grounds be considered important, and were consequently restricted to enter the regressions after the above mentioned variables. The hypothesis is, of course, that the regression coefficient for the selling skill intensity variable should be positive.

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1) As Keesing [1968 a] has shown this is perhaps the most distinguishing characteristic of Swedish foreign trade as far as skill intensities are concerned.

2) Measuring skills by income proxies is common in the human capital literature. The differences in hourly wages between skilled and unskilled workers are unfortunately probably smaller in Sweden than in many other countries. In the engineering industry as a whole the wage gap is so small that, for instance, regional wage differences might be as important a determinant of the inter-industry variations in average wages per hour as the worker skill intensity. The average wage per hour for skilled workers (having an pre-work education of at least 3 years) is 13-15 percent higher than that for all workers. This figure has been remarkably stable since the early 1920's (see Ohlsson [1973], chapter 2). A comparison of our skilled worker measure and the actual proportion of skilled workers for seven of the sub-industries led us, however, to accept our measure (see Ohlsson [1973], chapter 2).

The longer the production runs (for a given product) the greater the possibility is of a highly mechanized production, and for the development of economies of scale. Suppose that our subindustries consist of plants producing perfectly homogeneous products. Then a subindustry having small plants should be expected to be less mechanized than another one with larger plants. However, our subindustries are heterogeneous. The average plant size might then be misleading. Instead, the proportion of workers employed in small and medium sized plants (i.e. plants having at most 200 workers) to the total number of employed workers was used. This measure is supposed to take on higher values if either the economies of scale or the scale optimum points are relatively small. We expect to get a positive regression coefficient for our small plant intensity variable. This variable was also restricted to enter the regressions after the first mentioned three variables.

4. The regression results. The functional form for the relation between the technology index and some of the independent variables (the capital intensity, the technical skill and worker skill intensities) was first tried by using regression and plotting techniques. Some results are reported in table 1 (regressions 1, 2, 5 and 6). It was found that the technology index did not vary systematically with the worker skill intensity alone. Having picked out the better functional forms, the independent variables were then tried in multiple regressions. As table 1 indicates the linear forms give a better fit than the (double) log-linear ones. In the former case the labour/capital ratio gives much better explanatory values than the capital/labour ratio. The technology index seemed to be polynomially dependent on the technical skill intensity (cf regression 2).

The values of R^2 given in table 1 are quite high, the highest being .83. It is clear that proposition I above, which says that our ton price in an intercommodity comparison can be regarded as a proxy variable for production technology, cannot be rejected for the subindustries of the Swedish engineering industry.

The outcome of the test of proposition II can be discussed with regard to regressions 1-3. Since the hypothesis regarding the sign of the coefficients of our five independent variables cannot in any

Table 1. Some regression results indicating possible determinants to the technology index (T_x) in 40 subindustries of the Swedish engineering industry

Regression nr	Regression coefficients (with t-ratios) for							R^2 F-ratio (degrees of freedom)
	K/L	L/K	L_T/L	$(L_T/L)^2$	w_A	L_F/L	P_S	
Linear in all variables								
1	–	109.260	–	–	–	–	–	0.476
	–	(5.872)^{xx}	–	–	–	–	–	34.476^{xx}
								(1;38)
2	–	–	-285.913	2114.551	–	–	–	0.594
	–	–	(- 1.597)^{x}	(3.375)^{xx}	–	–	–	27.060^{xx}
	–	–	–	–	–	–	–	(2;37)
3	–	68.162	-211.483	1771.525	7.068	597.260	0.205	0.834
	–	(4.903)^{xx}	(1.464)^{x}	(3.537)^{xx}	(1.923)^{xx}	(1.851)^{xx}	(2.473)^{xx}	27.549^{xx}
	–	–	–	–	–	–	–	(6;33)
Linear in the logs of all variables								
5	-1.208	–	–	–	–	–	–	0.418
	(-5.228)^{xx}	–	–	–	–	–	–	27.334^{xx}
	–	–	–	–	–	–	–	(1;38)
6	–	–	0.850	–	–	–	–	0.263
	–	–	(3.678)^{xx}	–	–	–	–	13.529^{xx}
								(1;38)
7	-0.949	–	0.924	–	-0.738	0.032	0.211	0.628
	(4.183)^{xx}	–	(4.207)^{xx}	–	(-0.341)	(0.275)	(1.449)^{x}	11.474^{xx}
	–	–	–	–	–	–	–	(5;34)

x significant at the 10 percent level

xx " " 5 " " or more

T_x = the implicit price per metric ton (estimated from export ton prices)

K/L= the capacity of motive power (in horsepower) per employee

L_T/L= the ratio of technical personnel to the total number of employees

w_A = the average wage per hour for workers, interpreted as a measure of worker skill intensity

L_F/L = the ratio of selling personnel to the total number of employees

P_S = the proportion of workers employed in plants having at most 200 workers employed

R = the multiple correlation coefficient

Sources: SOS Industri 1968 and Utrikeshandel del 2 1967.

case be rejected (at the 5 % significance level), proposition II cannot be rejected either for the Swedish engineering industry[1]. Our technology index receives higher values the lower the capital intensity and the higher the intensities of technical, selling and skilled worker personnel are in the sub-industries. It also tends to be higher the larger the proportion of small plants.

A comparison between the ton price index and Lary's value added per employee

In his study of U.S. imports of manufactures from less developed countries Lary [1968] proposed that the value added in manufacturing per employee could be used as a measure of the sum of human and non-human capital per employee in an inter-industry comparison. The properties of the two factor versions of the factor proportions theory can then be utilized, provided that the country to be analyzed has a comparative advantage in total capital (or in raw labour) in relation to raw labour (or capital respectively). The relative factor endowment of the USA compared to that of less developed countries obviously made such an assumption reasonable.

For other industrial countries such a simplified approach with only one explanatory variable is theoretically unsatisfactory if, for instance, they have relatively abundant supplies of one but not other kinds of capital.[2] In this case the ton price index may in some cases be preferable since human and non-human capital influence the index in opposite directions. It is thus in principle possible to distinguish the specialisation pattern of a country abundant in only

1) Even though a regression analysis has not been tried for the Swedish chemical industry a study of the variations in ton prices over its 13 subindustries and capital intensities and technical skill intensities give the same impression as for the engineering industry (see Renck [forthcoming]).

2) The argument here relates of course to the empirical problem of explaining the trade specialisation of a country. The Lary approach tried out for Swedish imports from less developed countries proved to be less successful than using the technical skill intensity alone. (Carlsson & Sundström [1973]).

one of these types of capital resources,[1] provided that the industry analysed has a rather homogeneous raw material base. Our technology index may furthermore be a complement to Lary's when the subindustries produce technologically quite different products. Then ton prices may be used in a study of intra-subindustry specialisation patterns.

In the above discussion the implicit assumption has been that the factor proportion theory in one version or another is the empirically relevant theory. Lately the product cycle theory has been much discussed. One of its most essential features is the substitution of physical for human capital over the life-time of a product. Within this theory our technology index apparently has good analytical properties in that it allows separate variations in the intensities of human and non-human capital.[2]

Certain industrial countries' technology specialisation in their exports of engineering products

In order to give an illustration of the analytical usefulness of the ton price measure, some results are presented from a simple correlation analysis of the international pattern of specialisation in exports

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1) As is clear from the correlation matrix of table 2 our measure is positively correlated with Lary's. The value added per employee has only a low positive correlation with the capital intensity measure, while our index has a strong negative correlation with the same intensity.

Another distinguishing factor between the two technology indices is that ours refer to production in all sectors back to raw material production, while the Lary index refers only to value added in a given industrial sector.

2) The product cycle theory, as it is usually formulated, has two important limitations as far as its usefulness for inter-commodity comparisons is concerned. It does not explicitly take account of the fact that new products initially differ as to their level of technical sophistication, factor intensities and so on. Secondly, it does not recognize that some products "grow old" faster in terms of factor intensities of production than others. A theory incorporating explanations of these two points facilitates inter-commodity comparisons. Time is here an even more essential variable than in the product cycle theory. In such a theory our technology index is useful as an explanatory variable. Such an approach has been pursued for the Swedish engineering industry (Ohlsson [forthcoming]), from which some results are presented below. However, the whole structure of assumptions and hypotheses behind such an analysis cannot be discussed here.

Table 2. A correlation matrix

	T_x	T_M	K/L	L_T/L	L_F/L	w_A	P_S	L/K	$(L_T/L)^2$	v/O	v/L
T_x	1.00										
T_M	0.94	1.00									
K/L	-0.52	-0.43	1.00								
L_T/L	0.69	0.63	-0.11	1.00							
L_F/L	-0.15	-0.23	-0.23	-0.37	1.00						
w_A	0.01	0.00	0.44	0.24	-0.39	1.00					
P_S	0.09	0.13	-0.31	-0.39	0.12	-0.27	1,00				
L/K	0.69	0.60	-0.80	0.35	0.10	-0.30	0.12	1.00			
$(L_T/L)^2$	0.75	0.72	-0.17	0.97	-0.43	0.18	-0.29	0.38	1.00		
v/O	0.06	-0.16	-0.21	-0.08	0.09	-0.12	0.12	0.11	-0.07	1.00	
v/L	0.30	0.39	0.09	0.42	-0.30	0.19	-0.08	0.10	0.38	-0.53	1.00
T_x/T_M	-0.33	-0.43	0.18	-0.22	0.25	-0.22	0.09	-0.29	-0.29	0.21	-0.17

T_x = the weighted average ton price in exports
T_M = " " " " " " imports
K/L = the capacity of motive power (in horsepower) per employee
L_T/L = the ratio of technical personnel to the total number of employees
L_F/L = " " " selling " " " "
w_A = the average wage per hour for workers
P_S = the propotion of all workers working in plants having at most 200 workers employed
v/O = the value added/gross output ratio
v/L = " " " per employee

Sources: Cf table 1.

of engineering products. In the analysis ton prices of OECD-Europe's exports[1] are assumed to reflect technological differences between commodity groups. It is furthermore assumed that the results of the regression analysis in table 1 also hold for this ton price measure as far as the signs of the regression coefficients are concerned. Commodity groups receiving relatively high ton prices in exports of OECD-Europe are thus regarded as being technologically sophisticated[2].

A simple measure of a country's specialisation in engineering exports is the correlation coefficient between its exports and the technology index. The interpretation of the results rests on the usual assumption that no intra-commodity-group specialisation invalidates the results obtained.[3] Specific hypotheses about the specialisation pattern of individual countries could not be formulated. However, the results obtained here can be compared to those found in other studies.

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1) In a few commodity groups quantity data were either lacking or given in other measurement units - especially for the U K. The choice of OECD-Europe instead of OECD as a whole was made necessary by the lack of quantity figures for the USA, Canada and Japan.

2) The empirical relevance of this assumption can not be assessed. More tests similar to the one reported in this paper (table 1) have to be made. The assumption rests on the signs of the regression coefficients obtained above not bring altered by a) going from one cross-section of 40 subindustries to another containing 112 commodity groups, and b)using ton price data from other European countries' exports as well. It is common in the international trade literature to assume the ranking of factor intensities of a given country to be internationally the same. Differences between countries in factor intensities are here in contrast, allowed for, but the relationship between the ton prices obtained on the world market and these factor intensities have been assumed essentially stable for all countries. The computer industry of the U K might thus be more intensive in technical personnel than that of Norway, but we have to assume that this also leads to technically less sophisticated products in the Norwegian as compared to the U K computer industry. Some correlation analyses suggest that the ton prices for a given set of commodity groups vary much the same in Swedish exports as compared to exports of other European countries,as well as in Swedish exports compared to Swedish imports. Apart from the lack of subindustry data, a comparison of the coefficient of variation in ton prices of commodity groups within these subindustries spoke in favour of a commodity group analysis. This comparison suggested that at least some subindustries were rather heterogeneous.

3) In a multiple regression analysis it is also possible to include a variable for the intra-commodity-group specialisation of a given country (cf the following section) as well as a variable constructed to reflect the heterogeneity of the commodity group. In contrast to a subindustry analysis the assumption of homogeneity can thus be avoided in an analytical framework of the above presented type.

The large differences in the size of commodity groups demand the use of a norm of comparison. The correlations between exports of OECD-Europe and OECD, respectively, and the technology index may be utilized for this purpose.

According to the results of table 3 Switzerland and the USA are the two countries with the strongest export concentration of technologically sophisticated engineering products. Norway, Sweden, West Germany and Italy have, on the other hand, specialised mostly in technologically relatively standardised engineering products in their exports. This country pattern seems reasonable with the possible exception of West Germany.[1)]

A comparison of similar correlations for certain subsectors of the engineering industry gives more information about the specialisation differences between countries. The USA, for instance, specialises in high technology groups within the non-electrical machinery, electrical machinery, and transport equipment sectors, but specialises in low technology groups within the fabricated metal products field.

West Germany, Great Britain, and Japan have a high concentration on technologically sophisticated products within the fabricated metal products sector, defined as SITC 69. If sanitary and plumbing equipment, instruments, and watches are added, Switzerland, followed by Japan, obtains the most positive correlation coefficient.[2)]

Apart from the U S A, Canada, Great Britain, the Netherlands and Belgium were found to have a strong high technology specialisation pattern in exports within the non-electrical machinery sector. A similar export position within the electrical machinery field was held by Canada, Denmark and the U S A as well as Switzerland and Sweden[3)]. In exports of transport equipment the big aircraft producing countries (U S A but also Great Britain and France) and some small countries (like

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1) See tables 1 and 2 of OECD 1970 and tables 2 and 3 in Keesing [1968 a]. These data suggest for instance that Sweden has an abundant supply of skilled workers but not of technical personnel. In Hufbauer [1970] table 4 Sweden is reported to have the highest proportion of skilled employees of all included countries. This result is unfortunately misleading since the Swedish figure also includes foremen, which is a relatively large labour category.

2) Obviously, it is Switzerland's and Japan's relatively large exports of instruments and watches that leads to this result.

3) For Sweden the relatively favourable position within the electrical machinery sector is due to the historically rooted lead Sweden has acquired in the electric power (ASEA) and the telecommunication (LM Ericsson) equipment fields.

Table 3. Correlation coefficients between the European ton price and the engineering exports of certain industrial countries in 1967

Exporting countries 1)	All engineering products (excl. ships and boats)	Fabricated metal products (SITC 69)	Fabricated and miscellenous products (SITC 69 812, 861, 864)	Non-electrical machinery (SITC 71, 725.01 725.02)	Electrical machinery (SITC 72 except 725.01 and 725.02)	Transport equipment (excl. ships and boats) (SITC 73 excl. 735)
USA	0.18	0.23	-0.03	0.14	0.25	0.47
West Germany	-0.09	0.43	0.05	-0.20	0.01	-0.11
Great Britain	0.06	0.49	-0.06	0.25	0.01	0.10
France	0.05	0.18	0.10	0.07	-0.04	0.12
Japan	0.00	0.44	0.34	-0.16	-0.02	-0.15
Italy	-0.08	0.10	-0.15	-0.13	0.09	-0.04
Canada	0.04	-0.01	-0.14	0.34	0.51	0.01
Switzerland	0.53	0.36	0.82	-0.12	0.18	0.65
Sweden	-0.10	0.34	-0.11	-0.11	0.15	-0.15
Belgium-Luxembourg	-0.05	-0.18	-0.23	0.14	-0.00	-0.08
The Netherlands	0.05	0.38	-0.11	0.18	0.10	0.51
Denmark	-0.06	0.24	-0.13	-0.08	0.31	-0.02
Norway	-0.12	-0.03	-0.18	-0.15	-0.01	-0.08
OECD-Europe	0.02	0.34	0.41	-0.04	0.05	-0.02
OECD	0.07	0.33	0.30	0.04	0.13	0.11
Number of commodity groups	112	26	41	34	18	19

1) The countries have been ranked according to the size of their engineering exports. The export figures used in the correlations are export values (fob).

Sources: OECD. Series C. Commodity trade statistics. Exports 1967.

Switzerland and the Netherlands) producing highly specialised transport equipment showed high positive correlations.

A product differentiation index?

So far it has been assumed that there is no intra-commodity-group specialisation between countries. In this section we shall relax this assumption. The analysis below is designed to reveal whether there is any systematic country pattern of intra-commodity group specialisation in engineering exports.

In table 4 the average ton prices of certain European countries' exports are presented.[1)] Since each commodity group has the same weight regardless of its size, a high average ton price for a given country may indicate either a systematically higher ton price for most commodity groups, or a very high ton price in a few groups. In the latter case a relatively high standard deviation will also be found.

The table shows substantial variations between the European countries export ton prices, indicating that a more systematic analysis might be fruitful. Therefore the ratio between the ton price in exports of a given country, and that of OECD-Europe, was calculated for all commodity groups and countries. For each country it is possible to study if and how the country systematically specialises within the commodity groups in the cross-section of groups. The specialisation might in principle follow two completely different lines, granted, of course, that it is systematic:

a. All commodity groups consist of technologically different products, and there are no quality differences within each product category. In this case the analysis is simply an analysis of the technology specialisation within the commodity groups of different countries. A relatively high ton price ratio is then an indication of a specialisation on high technology products within the commodity groups.

b. Technological differences exist only <u>between</u> the commodity groups, not within them. Each commodity group consists instead of technologically rather homogeneous products, which differ from each other only in quality. In this case the ton price ratio is a measure of the product

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1) Due to the lack of quantity figures in metric tons U S A, Canada and Japan could not be included in this analysis.

Table 4. Average ton prices in exports of engineering products from certain European countries in 1967

Exporting country	Average ton price(m) and standard deviation(s)	All engineering products	Fabricated metal products (SITC 69)	Fabricated and miscellaneous products (SITC 69, 812, 861, 864)	Non-electrical machinery (SITC 71, 725.01, 725.02)	Electrical machinery (SITC 72 except 725.01 and 725.02)	Transport equipment (excl ships and boats (SITC 73 except 735)
West Germany	m	6.31	1.41	9.74	6.22	6.14	6.18
	s	-	1.47	20.89	12.67	4.99	13.04
Great Britain 1)	m	(2.66) 80	(0.88) 22	(0.86) 25	(6.09) 32	(2.41) 6	(1.72) 12
	s	-	0.49	0.47	12.07	1.14	0.81
France	m	5.15	1.21	7.60	6.60	7.94	9.96
	s	-	1.31	17.28	12.75	7.74	23.91
Italy	m	6.40	1.15	8.31	5.73	6.87	7.17
	s	-	1.07	28.48	12.02	8.41	16.11
Switzerland	m	5.68	2.96	9.99	6.21	15.01	8.24
	s	-	3.04	18.66	10.23	16.91	15.64
Sweden	m	4.52	1.61	9.13	6.46	7.43	3.45
	s	-	1.65	16.89	10.79	12.84	4.35
Belgium-Luxembourg	m	6.00	1.35	10.21	8.28	7.91	5.60
	s	-	1.93	40.03	19.27	7.74	11.22
The Netherlands	m	6.09	1.52	9.55	6.08	6.46	7.01
	s	-	2.25	26.28	10.10	6.12	17.91
Denmark	m	4.06	1.68	8.48	4.36	10.97	3.46
	s	-	1.85	26.84	4.95	12.72	4.21
Norway 1)	m	(3.84) 40	(1.47) 25	(3.01) 33	(2.31) 2	(9.35) 5	-
	s	-	1.73	5.71	0.51	15.85	-

1) For Great Britain and Norway a relatively large number of commodity groups lack quantity figures in metric tons. The number of groups included are the number indexe to the parantheses. For all other countries at most a few commodity groups had to be sorted out as is clear from table 5 below.

Sources: Cf table 3.

differentiation of a given country. A relatively high ton price ratio then indicates a specialisation on high (or odd) quality product variants.

These alternatives are of course extreme cases. For some of the commodity groups one alternative is more reasonable than the other, and in others the opposite is the case. This fact is neglected here for the sake of providing a simple illustration of the method[1]. The two extreme alternatives above raise two different sets of hypotheses for individual countries which can be tested on our data:

a. Given the intra-commodity group technology differences, a similar intra-commodity group and inter-commodity group specialisation is in principle expected for all countries. Switzerland should, for instance also have a relatively high ton price ratio in its exports of most commodity groups.

b. Small advanced countries having narrow national markets should specialize in high quality or odd product variants. Such products have small markets also in large countries in relation to the standard product variants. Producers in large countries tend therefore to specialise in those of the latter kind of products which are suitable for large scale production.

A simple analysis of the second hypothesis would consist of a comparison between the average ton price ratios of small and large European countries. From table 5 we find that small countries have a higher average ton price ratio than large ones in exports of engineering products. However, small countries tend also to have a relatively high standard deviation for their ton price ratios. In other words it may well be that small countries are highly specialised only within a few commodity groups. The number of commodity groups having a value above 1.00 for this ratio provides further information on this point. Switzerland, Sweden, West Germany, Denmark and France in this order have the highest proportion of commodity groups with a ton price ratio exceeding 1.00. Obviously, intra-commodity group specialisation on products with high ton prices is not confined to small countries.

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1) Another difficulty is that differences exist between producers in a given country but here only systematic specialisation tendencies between countries are studied.

Table 5. Ton price ratios in exports of engineering products from certain European countries in 1967

Exporting country	Average ton price ratio(m) with standard deviation(s). Number of commodity groups having a ton price ratio above 1.00(n) out of total groups(N)	All engineering products	Fabricated metal products (SITC 69)	Fabricated and miscellaneous metal products (SITC 69, 812, 861, 864)	Non-electrical machinery (SITC 71, 725.01, 725.02)	Electrical machinery (SITC 72 excl 725.01, and 725.02)	Transport equipment excl ship and boats (SITC 73 except 735)
West Germany	m	1.10	1.16	1.16	1.06	1.07	1.04
	s	0.26	0.27	0.32	0.18	0.25	0.24
	n (N)	69(112)	18(26)	29(41)	23(34)	9(18)	8(8)
Great Britain	m	1.05	1.16	1.17	1.04	0.82	0.94
	s	0.29	0.38	0.37	0.22	0.13	0.19
	n(N)	38(75)	14(22)	17(25)	16(32)	0(6)	5(12)
France	m	1.08	1.02	1.00	1.10	1.22	1.10
	s	0.41	0.27	0.34	0.30	0.70	0.23
	n(N)	63(112)	12(26)	15(41)	23(34)	12(18)	13(19)
Italy	m	0.94	0.94	0.94	0.93	0.96	0.96
	s	0.37	0.21	0.51	0.23	0.26	0.25
	n(N)	39(111)	10(26)	13(41)	12(34)	7(18)	7(18)
Switzerland	m	2.06	2.83	2.43	1.44	2.91	1.59
	s	1.87	2.19	1.88	0.60	3.13	1.10
	n(N)	84(106)	21(24)	34(39)	25(33)	16(17)	9(17)
Sweden	m	1.48	1.59	1.56	1.50	1.63	1.12
	s	1.67	1.29	1.16	2.35	1.81	0.53
	n(N)	74(112)	17(26)	27(41)	20(34)	12(18)	15(19)
Belgium-Luxembourg	m	1.15	0.92	0.91	1.37	1.49	0.92
	s	1.49	0.37	0.45	2.40	1.35	0.42
	n(N)	43(111)	9(26)	13(41)	14(34)	9(18)	7(18)
The Netherlands	m	1.04	1.06	1.06	1.13	1.08	0.79
	s	0.42	0.35	0.38	0.42	0.51	0.26
	n(N)	48(110)	9(26)	22(41)	16(34)	8(17)	2(18)
Denmark	m	1.29	1.49	1.31	1.03	1.92	1.04
	s	1.11	1.02	0.90	0.43	2.09	0.56
	n(N)	64(107)	21(26)	29(41)	14(33)	14(18)	7(15)
Norway	m	1.29	1.39	1.35	-	1.06	-
	s	0.93	1.01	0.98	-	0.57	-
	n(N)	22(40)	16(25)	20(33)	0(2)	2(5)	-

Sources: Cf table 3.

Therefore hypothesis b has to be rejected as a generally valid hypothesis for all small industrial countries.

On the other hand the figures do not in general support the alternative hypothesis that intra-commodity-group specialisation is en fact a technology specialisation within commodity groups. While the results for Switzerland support such a conclusion, those for Sweden and West Germany do not.

In order to be able to draw stronger conclusions than are here possible, one would have to study how each country's ton price ratio relates to the technology index and to its concentration of exports in the cross-section of commodity groups. No analysis on this point is included in this paper, but table 2 above suggests some of the results that have been found for Sweden.

The correlation between T_x/T_M, i.e. the ratio of ton prices in Swedish exports and imports, and other variables indicate that the higher this ratio is: 1) the lower the technology index 2) the higher the capital intensity and 3) the lower the technical and worker skill intensities are[1).]

Sweden has an export structure within the engineering field that is very similar to the OECD total and to the large industrial countries. This export structure involves specialisation in commodity groups (and sub-industries) with small or average values for the technology index and a relatively large world market. In the Swedish engineering industry, this pattern is combined with a high quality or high technology specialisation within commodity groups (and sub-industries). A comparison with the Swedish chemical industry suggests that this is not a specialisation which is typical for the Swedish industry as a whole. The existence of historical backward and forward linkages to abundant or scarce raw materials in Sweden seem to play an important role for the specialisation pattern of the engineering and chemical industries (cf Carlsson & Ohlsson [1972], Ohlsson [1973] and [forthcoming], Renck [forthcoming]).

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1) Other results show that the differences in valuation between exports, fob, and imports, cif, are not important for this result.

A heterogeneity index

The above analysis indicates that there are differences in technology and/or quality within commodity groups. A high ton price ratio in a commodity group might thus be expected to depend on whether the technology or quality differences between the included products are large or small. A cross-section analysis of intra-commodity-group specialisation of the type carried out above may then be somewhat misleading. It would be desirable to normalize for the variations in the degree of heterogeneity between commodity groups. A rough measure of this degree was therefore constructed. Since we were only interested in the intercountry rather than the intra-country differences, the heterogeneity index was empirically defined for a given commodity group as the coefficient of variation of the ton prices in exports from the individual countries. This measure is not only suitable as a normalizer, but can also serve as an explanatory variable - especially in an analysis of structural changes over time.[1)] It turned out to be a powerful explanatory variable in the structural analysis of the changes in Swedish world market shares in the fabricated metal products industry (Ohlsson [1973]).

Summary and conclusions

In this paper three new variables have been presented. It has been argued that intercommodity group and interindustry variations in prices per metric ton can be attributed to technological differences in production. This is shown to be the case for the Swedish engineering industry on a subindustry level. Given these results the ton price measure has several theoretically nice properties.

It is preferable, for instance, to the value added per employee measure since, in some cases, human and non-human capital have opposite influences on the ton prices. Another advantage of this so called technology index is that it may be used on a very low level of commodity aggregation which makes the standard homogeneity assumption more reasonable. A limitation due to the existing statistical sources is, however, that it may only be used in comparisons between products of roughly the same raw material base.

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1) Since the analysis on this point rests on a more sophisticated theory and utilizes multiple regression methods, we must here abstain from presenting the empirical analysis of this variable.

By using ton prices it is possible to analyse the international pattern of inter-commodity-group specialisation. In addition, by utilizing the ton prices of individual countries, the pattern of intra-commodity-group specialisation of different countries may be studied as well. It can also be used to construct an index that roughly reflects the heterogeneity of various commodity groups.

It has been argued, although not actually shown, that the new variables facilitate new tests of some of the theories which have been used to explain the pattern of trade specialisation among countries. It is thus possible to test some of the propositions of the product cycle theory by using these variables. Another possible field of application is the study of factor intensity reversals between countries in certain heterogeneous industries. The new measures should be helpful in analysing whether factor intensity reversals in such industries can be attributed to differences in intra-industry specialisation, rather than to differences in technique of production.

Since the proposed variables are based on so-called unit prices which have been used to estimate price elasticities in exports and imports of different countries, the results of this paper also has implications for other fields of international economics. The conclusion is that unit prices, if constructed as prices per metric ton, cannot normally be assumed to measure prices. On the contrary, they seem more to reflect qualitative and technological differences. This conclusion agrees well to that reached by Kravis & Lipsey [1971 a] using completely different methods.

The estimation of production functions using time series data rests partly on the appropriateness of the price indices used. In Sweden and probably also in many other countries the construction of price indices is to a large extent based on ton prices. From the results of table 1 in this paper it is easy to imagine cases leading to serious biases in price indices for such a heterogeneous industry as the engineering industry.

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