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May 1995

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through primary processing?

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Preliminary material and interim research results circulated to stimulate
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ISBN 1 85864 033 4

May 1995

EXPORT-ORIENTED INDUSTRIALISATION THROUGH PRIMARY PROCESSING?

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Abstract

Recent research suggests that East Asia's manufactured export success is not replicable in other developing countries, with lower skill/land ratios. This conclusion, however, is based on a narrow definition of manufactured exports. The present paper asks whether the chances of export-oriented industrialisation in countries with low skill/land ratios seem better when the definition of manufactures is broadened to include processed primary products. The answer from its cross-country econometric analysis is "yes" for countries with moderately skilled labour forces (as in Latin America), but "no" for countries where levels of skill are low (as in Africa).

Annexes (available on request)

1. Resource-based industrialisation: literature review
2. Compilation of trade data
3. Membership of country groups
4. Further analysis of regression results
5. Correction for non-normality
6. Functional form problems
7. Exclusion of petroleum products
8. Alternative specification of skill
9. Specific natural resource indicators
10. Introducing regional dummy variables

Acknowledgements

The research on which this paper is based was financed by the UK Overseas Development Administration through its grant to IDS. The authors are most grateful to Gerhard Margrieter of UNIDO for supplying the trade data, to Barry Reilly for econometric advice, and to Cristobal Ridao for comments.

For the past decade, donor policy has been strongly influenced by the conventional interpretation that East Asia's spectacular success in the export of manufactures was a result of 'export push' trade policies. Thus trade policy reforms along these lines have been central to the structural adjustment programmes promoted by the World Bank and the IMF in many countries, most notably - and least successfully - in sub-Saharan Africa.

However, recent research (Wood and Berge 1994) raises serious doubts about the scope for other developing countries to follow East Asia down the road of export-oriented industrialisation. The problem is that many of these countries, particularly those in Africa and Latin America, do not have a comparative advantage in manufacturing, because they have the wrong resource endowments. More specifically, they have too low a ratio of human resources to natural resources, or, in other words, of skill to land, which causes their comparative advantage to lie instead in primary exports.

The econometric results which underpin these doubts are strong, but based on a particular dividing line between manufactures and primary products, namely that of trade statistics, which define manufactures narrowly. Correspondingly, primary products are defined broadly, including not only raw materials, but also many processed products, whose processing is undertaken in sectors which are defined as manufacturing in production and employment statistics - food canning and petroleum refining, for example.

The question addressed in this paper is whether, and to what extent, these doubts about the replicability of East Asian experience can be allayed by broadening the definition of manufacturing to include primary processing. Put another way, the question - debated in the development literature since at least the 1950s - is whether processing local raw materials can provide an alternative route to export-oriented industrialisation for countries without a comparative advantage in narrowly defined manufacturing.

Section I provides a fuller account of the recent doubt-creating research, gives a precise definition of processed primary products, and summarises the earlier literature on resource-based industrialisation. Section II, on data and methodology, presents some descriptive statistics, and discusses the cross-country econometric specification used. Section III reports the regression results, and section IV looks more closely at their regional

pattern. Section V summarises the conclusions and discusses their implications for policy. Supplementary information is contained in various annexes, referred to below and available from the authors on request.

I. Previous research

The analytical roots of Wood and Berge (1994) lie in Heckscher-Ohlin (H-O) trade theory, whose central insight is that countries export goods which use intensively the factors of production with which they are relatively abundantly endowed, and import goods which use intensively factors that are scarce at home. This insight has motivated many empirical studies, with mixed results (surveyed in Leamer 1992), but including several which, like Wood and Berge, argue that the influence of policy on the pattern of trade is usually exaggerated, and that of resource endowments understated (e.g. Winters 1987, Saxonhouse 1993).

A skill-and-land-only model

Wood and Berge focus on one specific aspect of the pattern of trade, namely whether a country has a comparative advantage in manufactures or in primary products. They explain this in terms of each country's relative endowments of two factors: skill (or human capital), and land (or natural resources). Capital and labour, the two factors which feature in most other H-O models, disappear into the background. Capital (financial or physical) is omitted on the grounds that it is now so internationally mobile as to be no longer a factor of production in the sense relevant to H-O theory (Wood 1994a). Labour is left out on the grounds that there is little difference in labour intensity between manufacturing and primary production (Wood 1994c).

What distinguishes manufacturing from primary production in the Wood and Berge model is another sort of difference in factor proportions, namely the ratio in which production of these two goods requires inputs of skill and land. In other words, the two sectors are similar in terms of their number of workers per unit of output, but the ratio of skill (per worker) to land (per worker) is always higher in manufacturing than in primary production. The reasons for this difference in factor proportions are largely obvious: one is that manufacturing needs much less space than agriculture; another is that even unskilled workers in manufacturing need a basic education.

Clearly, given this difference in factor proportions, what must determine a country's comparative advantage between manufactures and primary products in this model is its relative endowments of skill and land. In the absence of trade, the relative price of skill and land would vary among countries, depending on the relative scarcity of these two factors. For example, in a country with a lot of natural resources and few skilled workers, land would be cheap relative to skill. These variations in relative factor prices would cause corresponding variations in product prices: manufactures would cost more, relative to primary products, in a country with a low ratio of skill to land. Given the opportunity to trade, such a country will tend to export primary products and import manufactures - and vice versa for a country with a high ratio of skill to land.

Econometric results

The Wood and Berge hypothesis is thus that countries with high skill/land ratios tend to export manufactures, while those with low skill/land ratios tend to export primary products. This is tested by running a cross-country regression of the form:

$$(\bar{X}_m/\bar{X}_p)_i = a + b(\bar{h}/\bar{n})_i + u_i \quad (1)$$

where X_m and X_p are gross exports of manufactures and primary products, h is skill per worker (measured by average years of schooling), n is land per worker (measured as the land area of each country divided by its labour force), u is the error term, and the subscript i identifies the country. The ratios on both sides of the equation are expressed in natural logarithms (denoted by $\bar{\quad}$ over the variable concerned).

In dividing h by n , the per worker denominators of the two variables cancel out, so that h/n is simply the ratio of skill to land - more precisely, the number of person-years of schooling per square kilometre of land. To check that it is legitimate to exclude labour from the model in this way (which is equivalent to testing the assumption of no difference between the labour intensity of manufacturing and primary production), the regression was also run in the expanded form:

$$(\bar{X}_m/\bar{X}_p)_i = a + c.\bar{h}_i - d.\bar{n}_i + u_i \quad (2)$$

The results showed the coefficients c and d to be similar in absolute size. Hence, since by definition $\log(h/n) = \log(h) - \log(n)$, it is justifiable to replace the two separate variables h and n by their ratio, with a single coefficient, b ($= c = -d$).

Using data for all countries in the late 1980s, the regression has a highly significant slope coefficient, and an R^2 of 0.57 (Wood and Berge, Table 1). In other words, this simple regression explains nearly 60% of the variation among countries in the ratio of manufactured to primary exports. Little of the remaining variation, moreover, can be accounted for by cross-country differences in trade policies (Wood and Berge, Table 3). Essentially the same relationship emerges when the regression is applied to data for 1960 and 1975, but the fit is less close, suggesting that the influence of trade policy may have been greater in these earlier years, when many developing countries that now export manufactures had inward-oriented trade regimes.

These results refer to gross exports of manufactures and primary products, whereas H-O theory refers fundamentally to net exports (i.e. gross exports minus imports). However, Wood and Berge get similar results when the gross export ratio is replaced as the dependent variable by a net export ratio. The reason for the similarity is that the ratio of manufactured to primary *imports*, though it varies among countries, is uncorrelated with variations in their skill/land ratios, probably because imports are highly diversified among different specific types of manufactures and primary products.

The cross-country relationship between exports and resources is paralleled by a similar relationship across developing *regions* (Wood and Berge, Figure 3). Inter-regional differences in the manufactured/primary export ratio in the late 1980s are strongly correlated with inter-regional differences in the skill/land ratio. For example, the high share of manufactures in East Asia's exports reflects the region's combination of a lot of education and few natural resources. The much lower share of manufactures in the exports of Latin America is caused by that region's high level of education being offset by its abundant natural resources. And in sub-Saharan Africa, the

tiny share of manufactured exports is due to the combination of low levels of education and moderate amounts of natural resources.

These results, though they lessen the force of some of the accusations of policy failure directed at Latin America and Africa, nonetheless appear to have rather discouraging implications for countries and regions with low skill/land ratios. The implications are particularly discouraging because exporting (and producing) large amounts of manufactures seems to contribute to learning and technological advance, as measured for example by total factor productivity growth (World Bank 1993: Table A6.3; Berge et al 1994: 10-20). Moreover, the obvious policy response, which is for the countries concerned to raise their skill/land ratios by improving the education and training of their workers, can be implemented, at best, only slowly.

Processed primary products

However, as noted at the outset, the results in Wood and Berge (1994) are based on the narrow definition of manufactures used by trade statisticians: categories 5-8 less 68 (non-ferrous metals) of the Standard International Trade Classification (SITC). Primary products are categories 0-4 plus 68. By contrast, production and employment statisticians use a much broader definition of manufacturing: category 3 (or in the latest version, division D) of the International Standard Industrial Classification (ISIC). Their definition of primary products is correspondingly narrower.

The difference between these two definitions of manufacturing consists of goods whose production, though undertaken in factories, uses large inputs of local raw materials. The main categories are: processed food, beverages and tobacco, refined petroleum, non-ferrous metals, leather goods, lumber, and pulp and paper. These goods are what will be defined in this paper as *processed primary products* (PP for short) - for example, canned tuna, beer, cigarettes, gasoline, and aluminium ingots. The goods in the overlapping part of the two definitions of manufacturing, or, equivalently, in the SITC definition, will be referred to as *narrow manufactures* (NM) - for example, garments, shoes, toys, pharmaceuticals, and aircraft. The ISIC definition, which is the sum of PP and NM, will be labelled *broad manufactures* (BM).

Since a firm grasp of these definitions will be essential to the reader's comprehension of the rest of this paper, it is worth dwelling on them here, with some algebra and a diagram (Figure 1), which simply restate the verbal content of the preceding paragraph in two alternative ways. Let the sum of manufactures and primary products be Q (trade and production statisticians more or less agree on its coverage). The basic accounting identity is:

$$Q = NM + PP + NP \quad (3)$$

where NM is narrow (SITC) manufactures, and PP processed primary products. NP (for *narrow primary*) refers to the narrow (ISIC) definition of primary products, which is confined to goods in the state in which they leave the farm or the mine - either raw or after a little on-site processing (such as threshing or husking grain). Two other identities can then be derived:

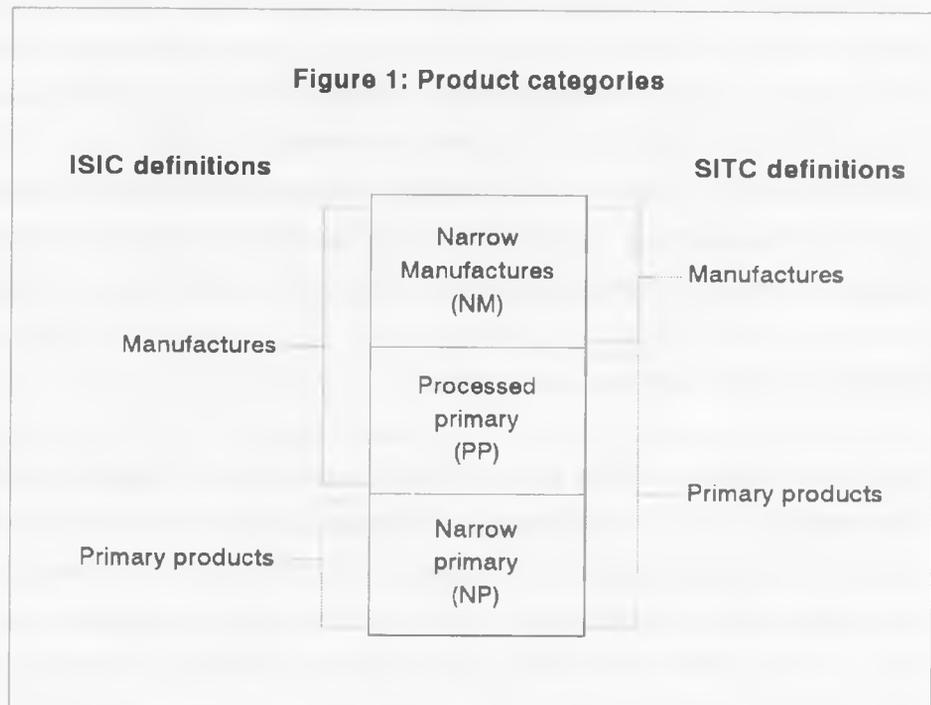
$$BM = NM + PP \quad (4)$$

which expresses the broad (ISIC) definition of manufactures as the sum of narrow manufactures and processed primary products; and

$$BP = NP + PP \quad (5)$$

in which BP (for *broad primary*) is the broad (SITC) definition of primary products, which includes both unprocessed (NP) and processed (PP) goods. Figure 1 then shows how the ISIC definitions of manufactures and primary products (on the left) relate to the SITC definitions (on the right), via a column in the middle which separates out processed primary products.

The definition of processed primary products used here is *statistical*, and thus precise and convenient for empirical analysis. But underlying this is an *economic* definition, based on transport costs. In theory, PP are goods made by manufacturing processes whose cost structure contains a high share of payments for raw materials, and where either the process is weight- or volume-reducing or the raw material is more fragile or perishable than the output. There is thus an economic incentive for the manufacturing process to be located close to the source of the raw material (Krueger et al 1981: 15). By contrast, narrow manufactures are footloose: for example, textiles



can be made anywhere, because ginned cotton is a small share of production costs, and cheap and easy to transport.

The exact position of the transport cost dividing line between PP and NM is in principle arbitrary. In practice, moreover, the statistical allocation of particular goods to one or other of these categories can be challenged - for example, petroleum refining, which falls in the PP category, is often done in countries which are not producers of crude oil. But in most cases there appears to be a close correspondence between the principles suggested by the economics of transport costs and the division of broad manufactures between these two categories in trade statistics.

Resource-based industrialisation

The main object of the rest of this paper is to find out whether the gloomy econometric results of Wood and Berge concerning the industrial prospects of developing countries with low skill/land ratios change for the better if the narrow SITC definition of manufacturing is replaced by the broad ISIC one. Can such countries industrialise through primary processing, even though they lack a comparative advantage in narrow manufacturing?

This question overlaps with another one, long discussed in the literature, concerning the benefits to developing countries of further processing their primary exports. Notable contributions to this debate on "resource-based industrialisation", which includes many case studies of particular products and countries, are Roemer (1977), Singer (1978), Wall (1987), Yeats (1991) and Londero and Teitel (1995). A fuller list of references and survey of the literature is contained in Annex 1 (available on request), but the main conclusions relevant to the present paper may be summarised as follows.

In some respects, primary processing differs from narrow manufacturing - as regards the importance of transport costs, and the volatility of primary commodity prices, for example. In general, however, most authors conclude that the similarities between these two sorts of manufacturing outweigh the differences. This applies on the benefit side: primary processing, like narrow manufacturing, provides opportunities to acquire new technologies and learn new skills, and can be an important new source of export revenue. It also, however, applies on the cost side: growth of primary processing is

constrained, like growth of narrow manufacturing, by protectionist policies in developed countries, and by shortages of skills and infrastructure in developing countries. Whether significant gains can be reaped from further processing of local raw materials thus varies, depending on the product and on the circumstances of the developing country concerned.

II. Data and methodology

The necessary information on exports and imports was created from the UNIDO data base, in which all the trade statistics have been converted from SITC to ISIC categories, to make them comparable with production and employment statistics. The UNIDO data show, for each country, exports and imports of broad manufactures, both in aggregate and broken down into 28 three-digit manufacturing industries. We divided these three-digit industries into two groups: those lying within the narrower SITC definition of manufacturing, whose trade flows were identified as NM, and those outside it, whose trade flows were taken to be PP. Exports and imports of narrowly defined primary (NP) products were estimated as the difference between BM trade and total trade, which is also available in the UNIDO data base.

This procedure, which we applied to data for a single year (1989), is prone to inaccuracies arising from the rather coarse sectoral aggregation in the UNIDO data. More specifically, several of these three-digit industries are mixtures of NM and PP products, put together from four-digit or five-digit SITC trade data. Since the mixture varies from country to country, our initial mechanical application of the procedure generated various anomalies which had to be corrected by reassigning, in some countries, one or more of these mixed sectors from NM to PP or vice versa, using more detailed trade data. Details of these adjustments, and of other problems encountered in assembling the data, are contained in Annex 2 (available on request).

Descriptive statistics

Before embarking on the formal econometric analysis, it is worth looking at some simpler information on the relative importance of processed primary products. Table 1 is based on UNIDO data which aggregate across countries (in effect, these numbers are group averages weighted by country size - and unadjusted for mixed sectors). It shows that, for the world as a whole,

primary processing accounts for 20% of broad manufacturing employment, 23% of BM output, and 17% of BM exports. In developing countries, these shares are larger: 28% of BM employment, 33% of BM output, and 24% of BM exports.¹

Table 1: Processed primary share of broad manufacturing (% , late 1980s)

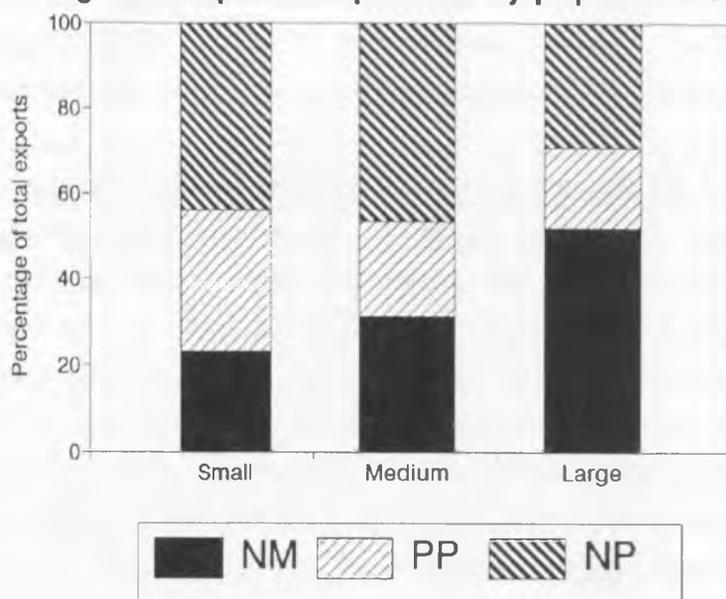
	Employment	Output	Exports
World	19.7	23.1	16.9
Developed countries	17.0	21.6	15.0
Developing countries	28.3	33.2	23.6

Source: UNIDO database (see text); 'output' is value added.

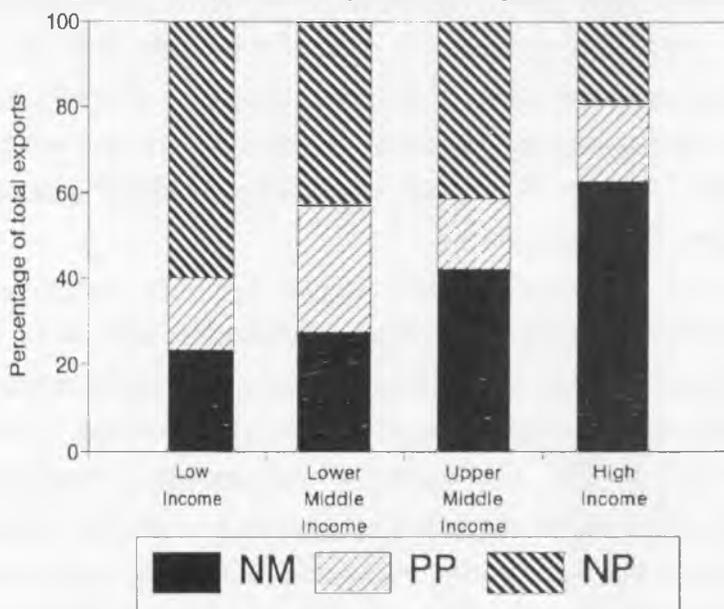
It may be noted that the PP shares of BM *employment* are smaller than the PP shares of BM *output* (which in this table is measured by value added). This implies that narrow manufacturing is more labour-intensive than primary processing. To be precise, these data imply that in developed countries, NM employs 34% more workers per unit of output than PP, and in developing countries, 26% more. The difference in labour intensity would seem bigger if output were measured in gross terms, because value added is generally a larger share of gross output for NM than for PP, due to the latter's large primary intermediate content. These figures thus confirm Roemer's (1977) conclusion that most PP activities are not especially labour-intensive.

Figures 2 and 3 provide further information on the composition of exports, using our adjusted UNIDO data (and unweighted averages of the countries in each group - listed in Annex 3, available on request). Figure 2 groups countries by population size: 'large' refers to those with a population over 25 million, 'medium' to those with a population less than 25 million, but over 1 million; and 'small' to those with a population less than 1 million. It shows that the ratio of NM to BP exports rises steadily with size - partly because of the disproportionate number of developed countries

1. As a share of all merchandise exports (manufactured and primary), PP are 14% for the world and 16% for developing countries. The unweighted average shares are 21% for the world and 26% for developing countries. This large difference between weighted and unweighted averages implies that processed primary products are relatively more important for 'small' countries (where size is measured by the total value of exports).

Figure 2: Export composition by population size

Source: UNIDO database (see text)

Figure 3: Export composition by income level

Source: UNIDO database (see text)

in the large group (28 percent, versus 14 percent in the medium group). There is also a steady increase with size in the ratio of NM to PP exports. However, the ratio of BM to NP exports, though highest in the large group, is similar in small and medium countries, reflecting the particularly high share (nearly one-third) of PP in the total exports of small countries.

Figure 3 groups countries by income level (following the *World Development Report*). The ratio of NM to BP exports rises monotonically with income, especially between the lower and upper middle, and between the upper middle and high income groups. In contrast, the ratio of BM to NP exports, though it increases between the low and lower middle income groups, and again between the upper middle and high income groups, is virtually the same in lower and upper middle income countries. This is because PP account for a larger share of total exports in lower middle income countries than in any of the other income groups.

Methodology

Exports of processed primary products are thus clearly large. The specific question addressed in this paper, however, is whether PP exports offer an alternative route to industrialisation for countries with low skill/land ratios, which do not have a comparative advantage in narrow manufactures. Our method of answering this question, in a nutshell, is to run regressions similar to those in Wood and Berge (1994), but with different dependent variables, chosen to permit comparisons between processed primary products and narrow manufactures.

The independent variables are exactly the same as in Wood and Berge - and subject to the same limitations, discussed further below. Skill per worker is measured by the average years of schooling of the adult (over 25) population in 1985 (from Barro and Lee 1993, supplemented in a few cases from the UNDP *Human Development Report*). Natural resources per worker are measured simply by total land area, divided by adult population (using data from the *World Development Report*). And, as before, the regressions are estimated for the largest possible number of countries with populations over one million (108), using trade data for 1989.

Using the notation developed above, the basic Wood and Berge regression can be rewritten as:

$$(\widehat{X_{nm}/X_{bp}})_i = a + b(\widehat{h/n})_i + u_i \quad (6)$$

where all that has changed is the dependent variable subscripts, which now make it explicit that the ratio concerned is that of *narrow* manufactured to *broad* primary exports. Similarly, the expanded Wood and Berge regression becomes:

$$(\widehat{X_{nm}/X_{bp}})_i = a + c.\widehat{h}_i - d.\widehat{n}_i + u_i \quad (7)$$

This specification, which, unlike equation (6), allows for the possibility of differences in the labour intensity of the two goods in the dependent variable ratio, is of particular interest in the present paper, because, as mentioned above, there is evidence that the labour intensity of processed primary products differs from that of narrow manufactures.

The simplest modification to these regressions is to replace their (common) dependent variable, X_{nm}/X_{bp} , with X_{bm}/X_{np} : the ratio of *broad* manufactured to *narrow* primary exports. This just shifts the position of the dividing line between manufactures and primary products, in effect by moving PP from the primary to the manufactures category. We will refer to equations with dependent variables of this type, based on a division of all goods into two categories, as 'broad ratio' regressions.

A more illuminating approach, however, is to acknowledge that we are now dealing not with two goods (manufactures and primary products), but with three distinct goods: narrow manufactures, processed primary products, and narrow primary products. Thus, instead of one broad ratio regression, we can run three 'single-good' regressions, with dependent variables X_{nm}/X , X_{pp}/X and X_{np}/X , where X is total exports ($= X_{nm} + X_{pp} + X_{np}$). Each of the dependent variables, in other words, is the share of the good concerned in total exports. To facilitate comparison between processed primary products and the other two goods, we also run two 'narrow ratio' regressions, whose dependent variables are X_{nm}/X_{pp} and X_{pp}/X_{np} respectively.

All these dependent variables refer to gross exports. In addition, we run similar regressions for imports and for net exports. For imports, the broad ratio dependent variables are M_{bp}/M_{nm} (as in Wood and Berge), and its counterpart M_{np}/M_{bm} . The three single-good import equations have as their dependent variables M_{nm}/M , M_{pp}/M and M_{np}/M , which are simply the shares of each of these goods in total imports. The dependent variables in the two narrow ratio import regressions are M_{pp}/M_{nm} and M_{np}/M_{pp} .

It should be noted that, with both the broad and the narrow import ratios, the subscripts of the numerator and denominator are the reverse of those in the export ratios: for example, the import ratio corresponding to X_{nm}/X_{bp} is M_{bp}/M_{nm} . This makes it easier to compare the export and import ratio regressions, because the expected signs of the coefficients are the same. For instance, countries with high skill/land ratios, and thus a comparative advantage in manufacturing, should have high ratios of *manufactured to primary* exports, and high ratios of *primary to manufactured* imports. (But in the single-good equations, the expected signs of the coefficients in the import regressions are the opposite of those in the export regressions.)

The gross export and import ratios are averaged (geometrically) to create net export ratios.² Thus, for instance, the net export ratio for the split between narrow manufactures and broad primary is:

$$NX_{nm/bp} = [(X_{nm}/X_{bp})(M_{bp}/M_{nm})]^{0.5} \quad (8)$$

This ratio is an increasing function both of the ratio of manufactured to primary exports and of the ratio of primary to manufactured imports, and so reflects comparative advantage on both sides of the trade account. If the shares of manufactures in exports and in imports are the same, implying no comparative advantage one way or the other, the net export ratio is unity (and its log is zero). For the single-good regressions, we use a different measure of net exports, namely the ratio of the gross export share to the import share. For example, for narrow manufactures,

2. This is an improvement on Wood and Berge (1994), where the averaging was arithmetic. Incidentally, none of these trade ratios would be useful if comparative advantage in one good meant zero imports of that good and zero exports of the other good: this would make all the ratios either zero or infinite. In reality, however, at this level of aggregation, all countries import and export both sorts of goods.

$$NX_{nm} = (X_{nm}/X) / (M_{nm}/M) \quad (9)$$

This ratio, too, is unity if the export and import shares are the same. If trade were balanced ($X = M$), it would be equivalent simply to the ratio of exports to imports of the good concerned (e.g. X_{nm}/M_{nm}).

It should be noted that these net export ratios differ from the measures of net exports used in most empirical work on H-O theory, which are based on arithmetic differences between exports and imports (e.g. $X_{nm} - M_{nm}$). These yield a number, in (say) millions of dollars, either positive or negative, for each good, which can be normalised, as Leamer (1994) has suggested, by division by the sum of the absolute values of net exports of all goods in the country concerned:

$$NX_j = (X_j - M_j) / \sum_j |(X_j - M_j)| \quad (10)$$

This normalisation is not usable if there are only two goods (the result is always \pm one-half): thus the Leamer measure cannot be applied to our coarse division of all goods into manufactures and primary products. However, it can be applied in our three single-good equations, although the regressions have to be run in unlogged form (because the dependent variable includes negative values). We tried this alternative approach: it did not greatly alter the results (as explained in Annex 4, available on request).

III. Regression results

The results are summarised in Tables 2-4 (additional results, mentioned at various points below, are contained in annexes, available on request). In discussing the results, we will first examine the gross export regressions in all three tables, then consider the results for imports and net exports, and finally discuss some possible criticisms of all these results.

Gross exports

Table 2 contains the broad ratio regressions, using the ratio specification of the independent variable (h/n). It also compares our results using the NM/BP split with those of Wood and Berge, who used the same split but a

Table 2: Broad ratio regressions

	Dependent variable	Constant term	Coefficient on independent variable h/n	Number of countries	R-squared
Gross Exports					
W&B	NM/BP	1.14 ***	0.73 ***	114	0.57
(i)	NM/BP	0.72 ***	0.61 ***	108	0.45
(ii)	BM/NP	2.24 ***	0.63 ***	108	0.45
Imports					
W&B	BP/NM	-0.89 ***	-0.02	112	0.01
(iii)	BP/NM	-0.60 ***	0.03	108	0.01
(iv)	NP/BM	-1.17 ***	0.45 ***	108	0.24
Net Exports					
W&B	NM/BP	0.15	0.37 ***	112	0.52
(v)	NM/BP	0.06	0.32 ***	108	0.45
(vi)	BM/NP	0.54 ***	0.54 ***	108	0.51

Notes: All regressions are estimated by OLS; all variables are in natural logs.

Definitions:

BP broad primary products

NP narrow primary products

BM broad manufactures

NM narrow manufactures

PP processed primary products

h average number of school years per worker

n land area (thousand square kilometres) per worker

*, **, *** significant at 10%, 5% and 1% levels respectively

W&B reproduced from Wood and Berge (1994, Table 1), except that the net export regression has been revised, using a geometrically rather than an arithmetically averaged dependent variable (see equation 8 and note 2 in the text).

Table 3: Single-good regressions

	Dependent variable	Constant term	Coefficients on independent variables		R-squared
			h	n	
Gross Exports					
(i)	NM	-0.54	0.40 ***	-0.39 ***	0.38
(ii)	PP	-2.72 ***	0.32 ***	0.10	0.07
(iii)	NP	-2.42 ***	-0.36 ***	0.38 ***	0.45
Imports					
(iv)	NM	-0.66 ***	0.04	0.04 ***	0.04
(v)	PP	-1.47 ***	-0.25 ***	0.01	0.32
(vi)	NP	-2.60 ***	0.76 ***	-0.23 ***	0.27
Net Exports					
(vii)	NM	0.12	0.37 ***	-0.43 ***	0.41
(viii)	PP	-1.25 ***	0.57 ***	0.10	0.20
(ix)	NP	0.19	-1.12 ***	0.61 ***	0.49

Notes: Gross export dependent variable is (log of) percentage share of good concerned in total gross exports; similarly for imports; net export dependent variable is (log of) ratio of export share to import share of the good concerned.

Number of countries = 108 in all regressions.

For other notes and definitions, see Table 2.

Table 4: Narrow ratio regressions

	Dependent variable	Constant term	Coefficients on independent variables		R-squared
			h	n	
Gross Exports					
(i)	NM/PP	2.18 ***	0.08	-0.49 ***	0.27
(ii)	PP/NP	-0.30	0.68 ***	-0.28 ***	0.28
Imports					
(iii)	PP/NM	-0.81 ***	-0.29 ***	-0.03	0.28
(iv)	NP/PP	-1.13 ***	1.01 ***	-0.24 ***	0.32
Net Exports					
(v)	NM/PP	0.68 ***	-0.10	-0.26 ***	0.25
(vi)	PP/NP	-0.72 ***	0.85 ***	-0.26 ***	0.48

Notes: Number of countries = 108 in all regressions.
For other notes and definitions, see Table 2.

different source of data (UNCTAD rather than UNIDO trade statistics) and a slightly larger number of countries. These two sets of results are very similar (in all three panels of the table, not only for gross exports).

More surprisingly, there is also little difference between our gross export regressions (i), using the NM/BP split, and (ii), using the BM/NP split. The intercept of (ii) is larger, reflecting the fact that, for any country, BM/NP is bound to be greater than NM/BP.³ But the slope coefficients are virtually identical, which implies that a given proportional change in the skill/land ratio has the same proportional effect on a country's ratio of manufactured to primary exports, regardless of whether manufactures are defined narrowly or broadly. The two regressions also fit the data equally well (explaining nearly half the variation in the export ratio).

A more diverse pattern emerges, however, when we turn from these results, using rather aggregated variables on both sides of the regression equation, to Table 3, which contains our single-good regressions, and uses h and n as two separate independent variables. In the top (gross export) panel of the table, the results for *narrow manufactures* and *narrow primary* - regressions (i) and (iii) - are strikingly symmetrical. The pattern of signs on the independent variables is as expected: positive on h and negative on n in the NM regression, and vice versa in the NP regression. Thus a high level of skill per worker in a country raises the export share of NM and reduces that of NP, while a large endowment of land per worker does the opposite.

Moreover, all four coefficients are similar in absolute size - roughly 0.4 (as well as highly statistically significant). This implies that, for both these goods, the ratio specification of the independent variables (h/n) would be acceptable. It also implies that the proportionate effects of differences in skill and land endowments on the export shares of NM and NP, though opposite in sign, are of much the same magnitude. For instance, a 10% increase in a country's skill per worker would cause a 4% increase in the export share of NM and a 4% decrease in the export share of NP.

The single-good results for processed primary products (regression ii) are quite different from those for NM and NP. The coefficients on h and n are

3. The difference in intercepts (1.52) is almost the same as the difference in the means of the two dependent variables (1.48).

both positive (although that on n is smaller and less significant, and the fit of the regression is poor).⁴ This implies that primary processing, relative to total exports, requires *both* more skill and more land per unit of labour input (which, incidentally, would make it wrong to use the ratio specification of the independent variables). In other words, PP are both more skill-intensive and more land-intensive - and hence necessarily less labour-intensive - than the sum or average of NM and NP.

In order to compare PP with NM and NP *separately*, we turn to the two narrow ratio regressions in the top panel of Table 4.⁵ Regression (i), referring to NM/PP, permits comparison between processed primary products and narrow manufactures. The coefficient on h is small and insignificant, implying that differences among countries in levels of skill per worker (controlling for differences in land per worker) do not affect the relative size of NM and PP exports. This suggests that there is little difference in the skill (per worker) intensity of the two sorts of manufactures. By contrast, the coefficient on n is larger, highly significant, and negative, implying that countries with more land per worker (controlling for differences in skill per worker) have lower ratios of NM to PP exports. In other words, their exports of broadly defined manufactures contain a higher share of processed primary products. This suggests that PP are more land-intensive than NM.

Regression (ii), which refers to PP/NP, likewise permits comparison between processed and narrow primary exports. The coefficient on h is large and positive: countries with higher levels of skill per worker (controlling for differences in land per worker) have larger shares of processed products in their broadly defined primary exports. This suggests that PP are more skill-intensive than NP. The coefficient on n is significant and negative:

4. In the regression in Table 3, the coefficient on n is insignificant, but it becomes significant at the 5% level when the regression is corrected for non-normality, as shown in Annex 5 (available on request).

5. The results in Table 4 can be derived from those in Table 3 (as is shown algebraically in Annex 4, available on request). The coefficients on h and n in the narrow ratio gross export and import regressions are equal to the differences between (and in the narrow ratio *net* export regressions to *half* the differences between) the coefficients in the two corresponding single-good regressions. For instance, in regression (i) for the ratio NM/PP in Table 4, the coefficient on h (0.08) is equal to the h coefficient (0.40) in the NM regression (i) in Table 3, minus the h coefficient (0.32) in the PP regression (ii) in Table 3.

countries with more land per worker (controlling for differences in skill per worker) have fewer processed, and more unprocessed, primary exports. This suggests that NP are more land-intensive than PP.

The conclusions of these last two paragraphs concerning the relative factor intensities of the three goods are summarised in a simple way in Figure 4, whose axes measure skill per worker and land per worker respectively.⁶ NM and PP, being of similar skill intensity, are on the same horizontal line, while NP's lower skill intensity puts it on a lower horizontal line. Since the three goods vary in land intensity, they are all on different vertical lines: NP, the most land-intensive, lies furthest to the right, and NM, the least land-intensive, furthest to the left. PP is in between, being less land-intensive than NP, but more land-intensive than NM.

The skill/land input ratio for each good is measured in the diagram by the slope of a ray from the origin through the point concerned. Figure 5 shows the three rays: the skill/land ratio is obviously highest for NM and lowest for NP, with PP in between. Also shown, by dashed rays, are the skill/land ratios for broad manufactures (BM: a mixture of NM and PP, whose ray must lie between their two rays) and broad primary products (BP: a mixture of PP and NP, whose ray must likewise lie between their two rays).

Figure 5 thus helps to explain why, in the broad ratio regressions in Table 2, the coefficient on h/n is hardly altered by widening the definition of manufactures.⁷ This is fundamentally because the effect of moving PP, with its intermediate skill/land ratio, from the primary to the manufactures

6. The diagram takes relative factor prices as given: with a different set of factor prices, the general shape of the relationships between the points would remain the same, but the distances between them would alter. Another slightly different way of presenting the same information would be a Leamer triangle (Leamer 1987; Londero and Teitel 1995).

7. A fuller explanation, with algebra and numbers, is provided in Annex 4 (available on request). Table 1 in that annex also reveals that there is more of a difference between the two broad ratio export regressions when h and n are two separate independent variables, rather than combined into one ratio. The coefficients on n are similar in size, but the coefficient on h is larger for BM/NP than for NM/BP. This is consistent with Figures 4 and 5: shifting PP from primary to manufactures has little effect on the gap in land intensity between the two categories (since PP is of intermediate land intensity), but widens the gap in skill intensity (since PP is more skill-intensive than NP and just as skill intensive as NM).

Figure 4: Relative factor intensities

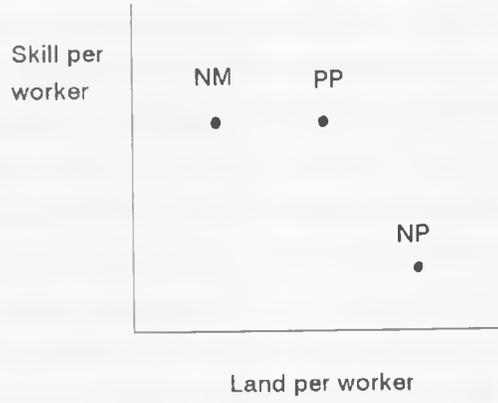
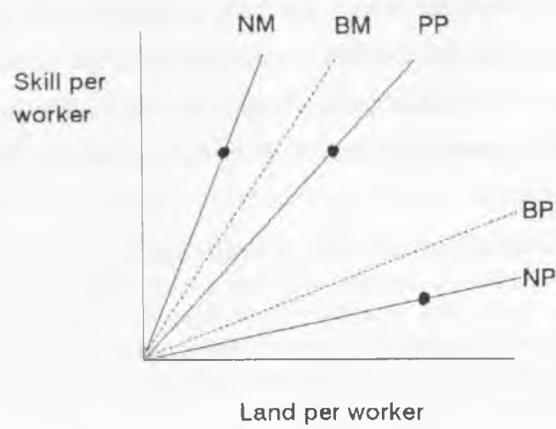


Figure 5: Skill/land input ratios



category is to reduce the skill/land ratios of *both* categories, and thus to leave the *difference* between their skill/land ratios (which is what matters in determining the composition of trade) much the same. In the figure, the BM ray is shallower than the NM ray, and the NP ray shallower than the BP ray: the difference in slopes between NM and BP is therefore similar to the difference in slopes between BM and NP.

These figures also suggest an answer to the central question of this paper, which is whether primary processing offers an alternative route to export-oriented industrialisation for countries with low skill/land ratios. It is that this depends on whether the low endowment ratio (relative to all other countries) arises from a small numerator - a low level of skill per worker - or from a large denominator - a lot of land per worker. To produce PP requires more skill than NP, and more land than NM. Thus a country with a skilled labour force, whose skill/land ratio is low because it also has a large supply of land, will actually have a comparative advantage in primary processing. However, a country whose low skill/land ratio is the result of a low level of skill per worker, with a moderate or large amount of land per worker, has little chance of exporting PP. It will have the necessary raw materials, but not the labour force skills needed to process them.

Imports and net exports

This answer to our central question is based on an analysis of gross export data. The next few paragraphs ask whether it stands up to further analysis using data on imports and net exports. The relevant results are contained in the lower panels of Tables 2-4, which report on regressions identical to those in the upper panel, except that their dependent variables refer to imports and net exports rather than gross exports.

In each table, there is an arithmetic relationship between the coefficients in the net export regressions and those in the gross export and import regressions. (The underlying algebraic linkages are laid out in Annex 4, available on request.) In Tables 2 and 4, where the dependent variables are ratios, and the net export ratio is as defined in equation (8), each net export coefficient is half the sum of the corresponding coefficients in

the gross export and import regressions.⁸ In Table 3, where the dependent variables are shares, and the net export ratio is as defined in equation (9), each net export coefficient is equal to the corresponding gross export coefficient minus the corresponding import coefficient.⁹

The broad ratio regressions (iii) and (v) in Table 2, defining manufactures narrowly, confirm the findings of Wood and Berge (included in the table for comparison). There is no cross-country correlation between the composition of imports and the skill/land ratio. Thus, although the coefficient on h/n in the net export regression is still positive and significant, it is only half the size of that in the gross export regression. But with the broad definition of manufactures, the import regression (iv) becomes significant: moreover, the coefficient on h/n is almost as large as in the corresponding gross export regression (ii), and hence so is the coefficient in the net export regression (vi). This suggests that, for imports in particular, it makes more economic sense to divide the three goods into two categories on the basis of similar skill intensity (combining NM and PP) than on the basis of similar land intensity (combining PP and NP).

Of the single-good import regressions in Table 3, only that for NP mirrors the gross export results, with a significant positive coefficient on h and a significant negative one on n (meaning that the share of narrow primary products in imports is greater in countries with higher levels of skill and smaller amounts of land). By contrast, the NM import regression has little explanatory power, with a small coefficient of the expected sign (positive) on n , and an insignificant coefficient on h : thus differences in the share of narrow manufactures in imports are not strongly related to cross-country differences in either skill per worker or land per worker. The PP import regression has more explanatory power, but this derives entirely from the skill variable, whose negative sign is consistent with the positive sign in

8. For example, in regression (v) in Table 2, the coefficient on h/n (0.32) is half the sum of the h/n coefficients in regressions (i) and (iii): $(0.61 + 0.03)/2$. Similarly for the constant term: $0.06 = (0.72 + (-0.60))/2$. This arithmetic does not work exactly for the Wood and Berge regressions, because the gross export and import country samples differ slightly.

9. For example, in regression (vii), the coefficient on n (-0.43) is equal to that in regression (i) minus that in regression (iv): $(-0.39 - 0.04)$. Likewise for the coefficient on h (subject to a rounding error) and for the constant term $(0.12 = -0.54 - (-0.66))$.

gross export regression (ii): the imports of countries with more skill per worker contain a smaller share of processed primary products.

Given these results for imports, the single-good net export regressions in the bottom panel of Table 3 are qualitatively similar to the gross export regressions in the top panel. The NM and NP results remain symmetrical: higher levels of skill per worker raise net exports of narrow manufactures and lower net exports of narrow primary products, and vice versa for higher levels of land per worker. But the coefficients on both h and n are larger in the NP regression, where the import results reinforce the gross export results, than in the NM regression, where the weaker import results dilute the gross export results. For processed primary products, the net export regression (viii), like the gross export regression (ii), suggests that, relative to the sum or average of both other goods (NM and NP), comparative advantage in PP is conferred by high levels both of skill per worker and of land per worker, but that skill is more important than land.¹⁰

The narrow ratio regressions in Table 4 permit us once again to compare PP with each of the other two goods separately. Import regression (iv), where the comparison is with narrow primary products, has a significant positive coefficient on h , and a smaller negative coefficient on n . This simply confirms the inference from the corresponding gross export regression (ii), which is that primary processing is much more skill-intensive, and somewhat less land-intensive, than narrow primary production.

However, import regression (iii), which compares processed primary products with narrow manufactures, differs in two notable respects from gross export regression (i): the coefficient on h is significantly negative, rather than insignificant; and the coefficient on n , though still negative, is small and insignificant. In other words, the ratio of PP to NM imports is lower in countries with higher levels of skill per worker, and does not vary much with the level of land per worker (whereas the corresponding ratio of NM to PP gross exports is unrelated to skill per worker, and is markedly lower in countries with more land per worker).

10. Both in regression (ii) and in regression (viii), the coefficients on n in Table 3 are insignificant, but become significant at the 5% level when the regression is corrected for non-normality (as is shown in Annex 5).

There is no apparent *statistical* reason for these differences in the import ratio results (for example, the influence of outliers). They might thus be interpreted as telling a different story from the export results about the relative factor intensities of the two goods, namely that PP is more skill-intensive than NM (rather than equally skill-intensive), and that PP and NM are equally land-intensive (instead of PP being more land-intensive). But the import-based story about relative factor intensities is less plausible, in relation to general knowledge of the sectors involved, than the export-based story. So it is worth considering possible alternative explanations for the PP/NM import regression results.

The coefficient on n could be insignificant because PP imports are more diversified than PP exports across the many different specific goods within the processed primary category. Thus a country whose abundance of land of a particular type (say pasture), together with a skilled labour force, caused its exports to consist largely of one processed primary product (say canned meat), would not import this product, but would still need to import most other processed primary products - cigarettes, refined oil, aluminium, and so on. So the overall share of processed primary products in its broad manufactured *imports* would not be much lower than for a similarly skilled country with little land, even though processed primary products would be a much larger share of its broad manufactured *exports*.¹¹

An explanation for the negative coefficient on h (other than PP being more skill-intensive than NM) might be that the share of PP in expenditure on broad manufactures is lower in countries with higher per capita income (which is strongly correlated across countries with skill per worker).¹² The underlying reason for this could be that processed primary products

11. However, this explanation is not entirely satisfying. A country with more land is likely also to have a more diversified mixture of specific types of land, and thus to import fewer types of processed primary product. And to the extent that all countries have rather specialised endowments of land, one would expect to observe the same lack of relationship for narrow primary products, whose share of imports is in fact significantly lower in countries with more land (regression vi in Table 3).

12. Another conceivable explanation is 'tariff escalation' (higher tariffs in developed countries on processed than on raw material imports), but this is much less relevant to the PP/NM import ratio than to the NP/PP import ratio - where it may explain why the coefficient on h in import regression (iv) in Table 4 is larger than that in gross export regression (ii).

contain a higher proportion (than narrow manufactures) of "necessities", both for consumption (e.g. food) and for production (e.g. fuel oil). This variation in the structure of demand - contrary to the assumptions of most H-O models - could explain why PP are a larger share of broad manufactured imports in countries with lower levels of skill per worker.¹³

But, whatever may be the reasons for them, the unexpected results of this import regression are not powerful enough to overturn the results of the corresponding gross export regression. The net export regressions in the bottom panel of Table 4 tell the same story as the gross export regressions in the top panel about the relative factor intensities of the three goods. Processed primary products seem to be similar in skill intensity to narrow manufactures (the coefficient on h in regression v is insignificant), and much more skill-intensive than narrow primary products (the coefficient on h in regression vi is large). They appear more land-intensive than narrow manufactures, but less land-intensive than narrow primary products (the coefficients on n in both regressions are negative and significant).

Moreover, even if the unexpected import results were taken at face value, they would not alter the most basic policy conclusion from the gross export regressions, which is that primary processing offers an alternative route to industrialisation for land-abundant countries only if they also have moderate or high levels of skill per worker. For the import results (and the ghost of them that appears in the negative sign of the insignificant coefficient on h in net export regression v in Table 4), far from implying that processed primary products are *less* skill-intensive than narrow manufactures, suggest that they may be even *more* skill-intensive.

Robustness and reliability

Before discussing these results further, it is important to consider their vulnerability to technical criticism, and their sensitivity to changes in

13. A proper test of this hypothesis would require data on the composition of expenditure. In our data, the correlation between per capita income and skill per worker is too strong ($R = +0.69$) to allow their influence on the composition of imports to be disentangled. If both variables are included in the regression, the coefficient on per capita income is insignificant. If only one of them is included, per capita income has a highly significant negative coefficient, but explains less variance than skill per worker.

data and methods. After exploring a number of potential weaknesses of this sort, we are reasonably satisfied that our results are robust and reliable. Some of our checks have already been mentioned (e.g. use of an alternative measure of net exports, and unlogged rather than logged regressions.) The following paragraphs summarise the outcome of various other investigations: more details are contained in several annexes, available on request.

Diagnostic tests showed the residuals of almost all our regressions to be non-normally distributed - a potentially serious problem, which could cause significance tests to be misleading (in either direction). To check this, in every regression in Tables 2 and 3, we omitted countries in decreasing order of the size of their residuals until normality was restored, and then compared the results of the regression on this reduced sample with those on the full sample. As is explained at length in Annex 5, this rarely altered the sign, approximate size, or significance of the coefficients.

In some of our regressions, particularly those where the dependent variable involved the narrow definition of manufactures, the diagnostic tests also rejected our chosen log-linear functional form. In all these cases, as set out in Annex 6, we were able to solve the problem by including a squared or cubed skill variable without altering our results in any basic respect.

Refined petroleum accounts for a substantial share of all processed primary trade. We were concerned that it might dominate or distort our results, partly because crude oil is more tradeable than the raw materials of most other PP products (so that refined petroleum might be better classified as a narrow manufacture), and partly because petroleum refining is highly skill-intensive (so that its inclusion might exaggerate the skill intensity of primary processing). So we re-ran all the gross export regressions in Tables 2-4 with refined petroleum excluded from the PP category, and found that this did not greatly alter the results (as is described in Annex 7).

Our land variable (based simply on each country's surface area) is open to criticism as a measure of natural resource endowments. It is an *unbiased* measure, in the sense that what a country has, per square kilometre of its surface area, in terms of soil fertility, water resources, minerals, and so on, can be regarded as the outcome of a random draw. But it is clearly not an *ideal* measure, since in principle it could be greatly improved by

measuring the differences among countries in the composition and quality of their land. We tried to do this, using data on specific types of land (arable, forest, etc), on water resources, and on metal, oil, gas and coal reserves, but found, like Wood and Berge (1994), that this did not improve or otherwise materially alter our results (as described in Annex 9).

Our measure of skill (years of schooling) is deficient in two respects: it ignores both the quality of schooling - how much the student learned in the years concerned - and all other sources of skill acquisition (training and experience). Its explanatory power in our regressions is thus probably due in part to strong cross-country correlation between years of schooling and these other aspects of skill. In other words, countries with more years of schooling usually tend also to provide schooling of better quality, and to provide more classroom and on-the-job training. This should be borne in mind in considering the policy implications of our results: increasing the number of years children spend at school is a necessary but not sufficient condition for raising the skill level of a country's labour force.

We experimented with an alternative specification of the years of schooling variable (as described in Annex 8). Following Wood (1994b), we divided the labour force into three skill groups: NO-EDs (illiterates), BAS-EDs (with primary or junior secondary schooling), and SKILD (with upper secondary or tertiary education). From these, we derived ratios measuring two different dimensions of the skills of the labour force: $(\text{BAS-ED} + \text{SKILD})/\text{NO-ED}$, which is in effect the literacy rate; and $\text{SKILD}/\text{BAS-ED}$, which indicates the share of highly educated workers in the literate labour force. We then replaced the years of schooling variable in our regressions with these two new skill variables, which did not alter our basic results. Most of the explanatory power in the modified regressions comes from the literacy variable: the $\text{SKILD}/\text{BAS-ED}$ variable is less often significant, but some of the results suggest that narrow manufacturing requires a larger proportion of highly skilled workers than primary processing.

IV. Regional pattern

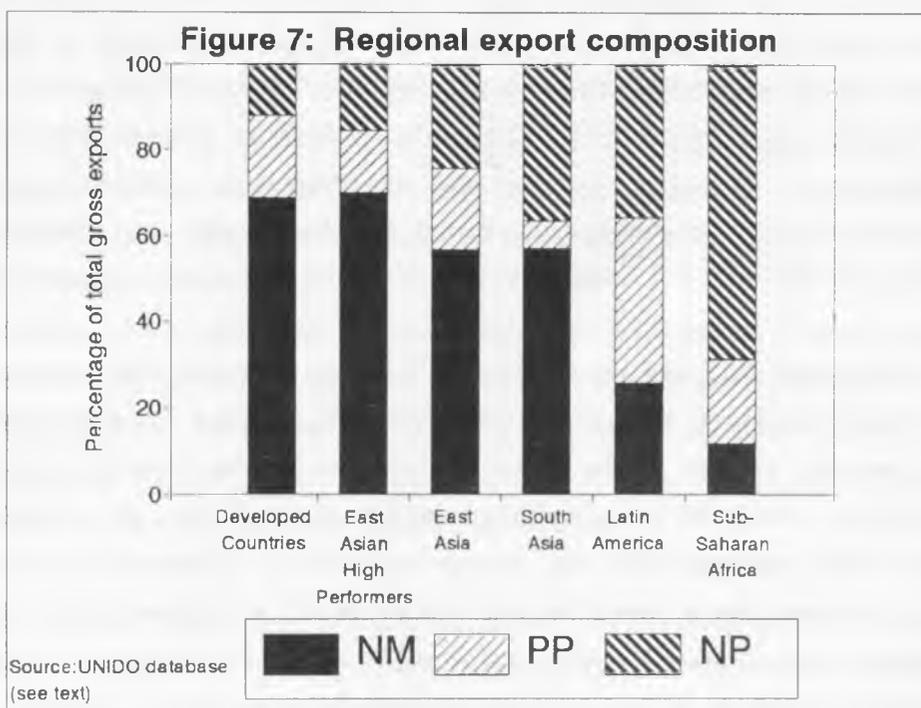
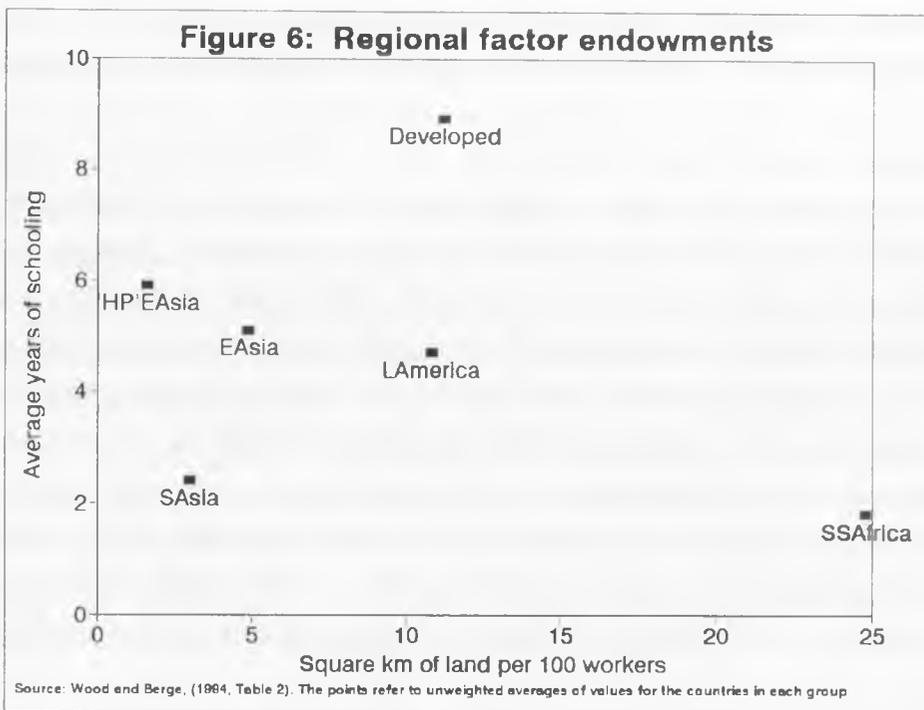
What can be learned from our results about the causes of variation in trade patterns among geographical regions of the world economy? Following Wood and Berge (1994, Table 2), we identify five groups of countries: developed

(high-income OECD), and the four principal developing regions (sub-Saharan Africa, Latin America, South Asia and East Asia). Within East Asia, we distinguish the sub-group of countries classified by the World Bank (1993) as 'high performing': Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan and Thailand. A sixth group, not analysed below, contains all other countries (the membership of each group is listed in Annex 3).

Figure 6 shows the average factor endowments of each region (within each of which there is, of course, considerable variation). The level of skill per worker is high in developed countries, intermediate in East Asia and Latin America, and low in South Asia and Africa. Land per worker is low in Asia (East and South), intermediate in developed countries and Latin America, and high in Africa. If the Africa point were shifted to the left, to allow for the poor quality of much of its land, the four developing regions would thus lie in the four cells of a 2x2 matrix of (low and intermediate) skill and land per worker. The skill/land ratio of each region is measured by the slope of a ray from the origin through its point: high-performing East Asia obviously has the highest skill/land ratio, and Africa the lowest.

These regional differences in factor endowments, in conjunction with what our regression results suggest about the relative factor intensities of the three goods (summarised above in Figure 4), can be used to make predictions about regional comparative advantage, which can then be compared with the actual commodity composition of trade. Thus Figure 7 shows a breakdown of each region's gross exports into our three categories: narrow manufactures, processed primary products, and narrow primary products. (It would be more appropriate to show a breakdown of *net* exports, but also more complicated, and the pattern would be qualitatively similar.)

Processed primary products, we concluded, are more skill-intensive than narrow primary products and more land-intensive than narrow manufactures. In other words, primary processing is intensive both in skill and in land, relative to labour. It is thus not surprising to find that, among the four developing regions, the share of PP in exports is highest in Latin America, which is well endowed with both skill and land. Similarly, we predict, and observe, the share of PP in exports to be lowest in South Asia, which is poorly endowed with both skill and land. The other two developing regions



are well endowed with one of these factors, but not the other, so we expect their PP export shares to be somewhere in between, as indeed they are.

Narrow manufactures are of high skill intensity and low land intensity, and their labour intensity (with respect to the sum of skill and land) does not differ much from that of broad primary products. Comparative advantage in NM, as was shown by Wood and Berge, thus depends simply on a country's or a region's skill/land ratio.¹⁴ Figures 6 and 7 confirm this relationship for our developing regions: the shallower the ray through the relevant point in Figure 6, the smaller is the NM share of exports in Figure 7 (except that there is no difference in the export share between East and South Asia, whose skill/land ratios are quite close together, too). These figures also confirm Wood and Berge's finding that the NM export share of the developed group is much higher than would be predicted from its skill/land ratio.

The export share of broad manufactures (the sum of PP and NM) is thus large in developing regions which have *either* a relatively high skill/land ratio (East and South Asia) or a relatively high level of skill per worker (Latin America). Low skill per worker does not preclude a comparative advantage in broad manufacturing, provided that it is offset, as in South Asia, by an even lower endowment of land per worker, resulting in a high ratio of skill to land. But the combination, as in Africa, of low skill per worker and moderate or high land per worker, yielding a low skill/land ratio, causes a comparative disadvantage in broad manufacturing, or, looking at the other side of the coin, a comparative advantage in narrow primary production.

Another way of looking at Figure 7 is to ask how the addition of processed primary products to narrow manufactures affects inter-regional differences in export shares. The main change is in the relative position of Latin America, where NM is a small share of exports, and PP a large share. Using the broad rather than the narrow definition of manufactures eliminates the gap between Latin America and South Asia, and drastically reduces the gap between Latin America and East Asia. By contrast, the relative position of Africa, which also has a small NM export share, is not much affected by the

14. This Wood and Berge result is confirmed by our regression (i) in Table 2, and more particularly by the expanded version of this regression (ia in Table 1 of Annex 4), which shows the coefficients on h and n to be similar in absolute size.

addition of PP: in terms of broad manufactured exports, Africa is less far behind South Asia, but much further behind Latin America, and thus appears at even more of a comparative disadvantage relative to all other regions.

In summary, differences in comparative advantage among developing regions can plausibly be explained by differences in endowments of skill and land. Moreover, once skill and land are controlled for, few if any inter-regional differences in the pattern of trade remain to be explained. Specifically, we found, like Wood and Berge, that dummy variables for developing regions were insignificant in our regressions explaining the ratio of manufactured to primary exports, whether manufactures were defined narrowly or broadly. (The details are in Annex 10.) The only consistently significant dummy variable was that for developed countries, whose ratio of manufactured to primary exports, as already mentioned, is unusually high.¹⁵

V. Conclusions

Earlier research suggested that export-oriented industrialisation of the sort that has occurred in the successful countries of East Asia is unlikely to be replicated in other developing countries - particularly in Africa and Latin America - which have much lower ratios of skill to land (or of human to natural resources). This research, however, used a narrow definition of manufactured exports, which omitted *processed primary products* - industrial goods with a high natural resource content, such as canned food.

The question addressed in this paper is whether the prospects of countries with low skill/land ratios would look more favourable if the definition of manufactured exports were broadened to include processed primary products. Could primary processing, in other words, provide these countries with an alternative route to export-oriented industrialisation?

The answer that emerges from our statistical analysis is remarkably simple. Primary processing needs more local natural resources than narrowly defined manufacturing, but much the same level of skill - and a far higher level of skill than narrowly defined primary production (agriculture and mining). Thus whether the earlier conclusion is altered by the addition of processed

15. Wood and Berge (1994) present some evidence that this may be due to the longer period over which developed countries have been acquiring the skills needed for manufacturing through learning-by-doing.

primary products depends on whether the low skill/land ratio of the country concerned arises mainly from a small *numerator* (low skill per worker), or mainly from a large *denominator* (a lot of land per worker).

Put another way, our results suggest that whether a country with extensive natural resources can produce and export processed primary products depends on the skills of its workforce. If the level of skill per worker is high, the country will have a comparative advantage in primary processing; if the level of skill is low, its exports will be concentrated on narrowly defined (unprocessed or less processed) primary products.

This statistical answer is entirely consistent with common sense and casual observation. If, as appears to be the case, illiterate workers are not productive in shirt or shoe factories, why should things be different in asparagus canning factories or aluminium smelters? Our results are also consistent with the literature on 'resource-based industrialisation', which concludes that primary processing, apart from its need for more local raw materials, is fundamentally similar to other sorts of manufacturing.

The message of this paper for countries with low skill/land ratios, but moderate levels of skill per worker, epitomised by much of Latin America, is thus a positive one. Although they lack a comparative advantage in the sorts of manufactures in which East Asia specialises, these countries can, through primary processing, produce and export other sorts of manufactures. An important qualification, however, is that our results and other evidence also suggest that primary processing is less labour-intensive than narrowly defined manufacturing. Exporting processed primary products is thus likely to yield fewer of the distributional and social gains that East Asia reaped from massive expansion of manufacturing employment.

For countries which have both low skill/land ratios and low levels of skill per worker, epitomised by much of sub-Saharan Africa, the message of this paper is, alas, a negative one. Countries in this situation have no more of a comparative advantage in primary processing than in narrowly defined manufacturing. They thus have little chance of exporting large amounts of any sort of manufactures, unless or until they can raise the skill level of their workers (not just absolutely, but relative to the rest of the world),

which will require, first and foremost, large increases in the coverage and quality of basic education. This is bound to be a slow process.

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ISSN 1353-6141