Relative factor abundance and Australia's trade in a three-factor framework

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1. Introduction

IT IS generally recognised that Australia is relatively richly endowed with certain types of renewable and non-renewable natural resources. Even a cursory glance at Australia's merchandise export and import trade would reveal the importance of farm and fishery products and minerals on the export side, and manufactured products on the import side. However, direct exports and imports of a country do not tell the whole story. Natural resources are also processed into semi-manufactured and manufactured products and traded as such. It is necessary, therefore, to take into account both the intermediate and final use of natural resources to capture more accurately the natural resource content of a country's export and import vectors. That is one of the major objectives of this study.

The production of goods for final and intermediate use would, of course, require primary inputs such as labour and capital as well as natural resources, and the relative availability of these inputs would strongly influence the pattern of a country's trade. This study therefore also estimates the capital and the labour content of Australia's trade vectors.

Once these factor intensities have been worked out, it is possible to compare the factor contents of a country's exports with those of its imports, and rank its factor endowments as revealed in its trade pattern with the rest of the world. Such knowledge and information can be of use in several areas of decision making. For example, a country's strategy of industrialisation is more likely to be sustainable if it is in line with its

actual and/or potential comparative advantage. As industries intensive in the country's more abundant factor(s) are most likely to have such comparative advantage, a study such as this can assist in the selection of industrial strategies. Policy implications such as these provided the strongest motivation behind the study.

Section 2 briefly outlines aspects of the basic factor proportions model and one or two of its extensions that are of direct relevance to the study. The methodology for the empirical estimates is described in section 3, while section 4 introduces the data used in the estimates, and their limitations. The main findings and some of their implications are examined in section 5, and some concluding observations are made in section 6.

2. Factor endowments and trade: Theory and evidence

2.1 *The factor proportions model and some extensions*

The factor proportions model of trade, originally proposed by Heckscher (1919) and subsequently developed by Ohlin (1933) and Samuelson (1948, 1949) used a two-country, two-commodity, two-factor (2 x 2 x 2) framework. The theorem, based on the two observations of (a) different relative factor endowments of countries, and (b) different relative factor intensities of products, hypothesises that a country would have a comparative advantage in the production of the good that uses more intensively its most abundant factor. Together with the well known assumptions on the production side, the theorem also assumes that the consumption patterns in the two countries are 'uniform and homothetic' at each relevant commodity price ratio. This assumption requires that preferences in the two countries be not so dissimilar as to offset the cost advantages conferred by the relative factor endowments of the countries.

The extensions of the basic Heckscher–Ohlin–Samuelson (HOS) theorem have been along either the many-good, two-factor or the many-good, many-factor lines. The former, in turn, has evolved along two distinct paths—one based on the assumption of factor price equalisation, the other not; while the many-good, many-factor extension is based on the assumption that factor prices do equalise. Since the focus of this study is the factor content of trade, we discuss briefly only those extensions that are relevant to this theme.

The factor-content approach is perhaps best analysed in an empirical framework where its analytics have evolved.

2.2 The Leontief paradox and some suggested resolutions

The first—and the most celebrated—test of the HOS trade model was conducted by Leontief (1953). Aggregating the 1947 input–output table of the US economy into 50 sectors, and using two factors—capital and labour—Leontief estimated the factor requirements of a 'representative bundle' ($1 million dollars worth) of US exports and competitive imports. On the assumption that the US was the most capital abundant country in the world, Leontief's expectation was that US exports would be capital intensive relative to US import substitutes. His estimates showed, however, that the US import substitutes require 30 per cent more capital per worker than did US exports—an apparently paradoxical result. To eliminate the possibility that 1947 was an 'abnormal' year for the world economy, Leontief (1956) repeated his study using 1951 trade figures. US import substitutes were still found to be more capital intensive than US exports, although this time by only 6 per cent. The Leontief paradox was thus confirmed.

Moving away from the traditional capital–labour framework, a number of later studies used other factors such as natural resource, human-skill and influences such as scale economies in attempts to explain trade patterns more satisfactorily. One early attempt using natural resource as an input into US exports and imports was made by Diab (1956). This led to a possible explanation for the Leontief paradox—subsequently supported by Vanek (1959:63)—that US imports consisted largely of non-manufactured products that were, in the main, natural resource based. These products were found to use capital as a strong complementary input. Therefore, even if capital was an abundant factor in the US, the relative scarcity of natural resources made the US a net importer of products that used natural resource and capital as inputs.

Some support for this conjecture was provided by Leontief himself in his 1956 study mentioned above. By eliminating 19 natural resource products (i.e. by treating them as non-competitive imports), he was able to resolve the paradox that the US was exporting labour-intensive products.

2.3 The multi-factor extensions: the Leamer approach

Vanek's work extended the two-factor, many-good Leontief framework to the many-factor case. What has been called the Heckscher–Ohlin–Vanek (HOV) theorem hypothesises that a country exports the services of abundant factors. As Leamer (1984) put it: 'this way of re-expressing

the H–O theorem properly emphasises the point that it is factor services that are being exchanged through trade. Commodities serve only as a bundle within which factor services are wrapped.'

Leamer argued further that in a multi-factor H–O model, a country abundant in (say) capital need not have its exports more capital intensive than its imports. It is also a possibility that a country, in a multi-factor trading world, could be a net exporter of both labour and capital services. In a net export situation such as this, Leamer suggests that a country's abundance in respect of a particular factor (capital, say) could be verified by testing if its capital-per-worker ratio is greater in net exports than in consumption. Formally, if $K_x, K_m, K_c; L_x, L_m$ and L_c are capital and labour embodied in exports, imports and consumption respectively, Leamer's argument implies that a country is capital abundant if

$$\frac{K_x - K_m}{L_x - L_m} \rangle \frac{K_c}{L_c}$$

The reasoning behind this expectation stems directly from the HOV version of the factor proportions model. A country's net exports must equal its production less its consumption. Its production embodies its own factor endowments, while its consumption will embody a fraction of world factor endowments equal to its share in world income (the homotheticity assumption). Thus, if the country is abundantly endowed with a particular factor in the sense that its share of the factor exceeds its share of world income, its exports must embody more of that factor than its imports. By estimating which factor a country is a net exporter of, one can therefore establish which factor it is relatively abundantly endowed with.

In a three-factor setting such as ours—with natural resource, capital and labour as the three factors—several comparisons are needed to establish a country's trade-revealed factor abundance. If natural resource is assumed to be the most abundant factor, then we would expect:

$$R_x > R_m \qquad (1)$$

(where R_x and R_m are the resource contents of a unit of exports and imports respectively).

In balanced trade, therefore, the country would be a net exporter of the services of natural resource. For further confirmation of the hypothesis concerning the nature of the country's factor abundance, the following inequalities should also obtain:

$$\left[\frac{R}{K}\right]_x \rangle \left[\frac{R}{K}\right]_m \tag{2}$$

$$\left[\frac{R}{L}\right]_x \rangle \left[\frac{R}{L}\right]_m \tag{3}$$

where K and L are respectively the capital and labour service content of a unit of exports or imports. By making one further comparison involving the factor intensities of exports and imports as used in (2) and (3) above, the trade-revealed relative availabilities of capital and labour can be obtained. For example, if:

$$\frac{\left[\frac{R}{K}\right]_x / \left[\frac{R}{L}\right]_x}{\left[\frac{R}{K}\right]_m / \left[\frac{R}{L}\right]_m} \rangle 1; \mapsto\mapsto, \frac{\left[\frac{L}{K}\right]_x}{\left[\frac{L}{K}\right]_m} \rangle 1 \tag{4}$$

then exports are found to contain more labour than capital services per unit than imports. Labour would then be more abundant in the country relative to capital. The necessary assumption regarding consumption is that it is roughly similar across countries. Strict homotheticity is not a necessary condition, although it is obviously a sufficient one.

3. The methodology

THE METHODS used to estimate the natural resource, labour and capital contents of Australia's exports and competitive imports are explained in this section. Extensive use is made of input–output analysis.

3.1 The estimation of natural resource content

Any attempt to quantify the natural resource content of a vector of commodities must first ask what is the economically appropriate measure of a natural resource. If land is used as a 'generic shorthand' for all natural resource, as Vanek (1968) has suggested, how does one measure land as an input in a production process? In a theoretical sense, economic rent, which arises from what Ricardo called the 'original and indestructible powers of the soil,' would give an almost perfect measure of the natural resource (land) embodied in a group of products:

> As a variable derived directly from the general equilibrium setting, economic rent is the truest possible measure of the particular type of land to which it is attached (Vanek, 1968, p. 750).

However, as it is impossible to measure economic rent in this pure form, the required statistical information for any empirical estimation of the natural resource content of a group of products does not exist. Consequently, Vanek adopted as an alternative the 'resource product content' of goods. Since it is a measurable concept, which has been used successfully by Vanek and others, it has been incorporated in this study.

The 'resource products' are defined to be 'commodities which are nearest to the initial stages of the productive process'. In all such commodities, natural resource is used as a major input. Therefore, activities such as farming, forestry, and mining fall into the category of 'resource industries', and their products are classed as 'resource products'. By contrast, activities such as housing, manufacturing and transportation, for example, are classed as non-resource industries. The input–output tables for the Australian economy contain sectors that fall into one or other of these industry-types, and it is with the help of those tables that the total (i.e. direct plus indirect) resource product contents have to be estimated.

The basic input–output (I–O) relationship can be expressed as follows:

$$Q = AQ + Y \qquad (5)$$

where Q is a vector of output, Y a vector of final demand, and A a square matrix of input–output co-efficients, a_{ij}. Equation (5) can be solved for Q to obtain:

(6)

$$Q = [I - A]^{-1} Y \quad (6)$$

where $[I-A]^{-1}$, (which we label B), is the inverse Leontief matrix, of which a typical element is b_{ij}.

Given the vectors of exports and imports for a particular year, the calculation of their direct and indirect content of resource involves the following two steps:

i) Identify the resource product sectors in the I–O table: since the elements of the inverse matrix B give the direct and indirect requirements of an input i, summing the elements down the column j, using only the rows that correspond to what have been identified as resource products, will give the total resource product content per dollar increase in the final demand of all the sectors, when the final demand is of an unspecified kind.

ii) Obtain the inner product of B and the vector of exports, X, or of imports, M, as follows:

$$D_x = BX \quad (7)$$
$$D_m = BM \quad (8)$$

where D is a vector of which each ith element is the quantity of industry i's output used in exports or imports.

A further useful extension of this approach is to introduce a distinction between renewable and non-renewable resources, and obtain estimates of each type of resource required per unit of final demand. The method explained above, with appropriate changes to the summation requirements, would yield the renewable and non-renewable resource requirements per unit of final demand.

Of the 108 sectors in the 1977–78 input–output table of the Australian economy, and 109 sectors in the 1986–87 table, the following 12 have been identified as the 'resource products':

1. Sheep, Cereal; 2. Grains; 3. Meat cattle; 4. Milk cattle and pigs; 5. Poultry; 6. Agriculture n.e.c.; 7. Forestry and logging; 8. Fishing and hunting; 9. Ferrous metal ores; 10. Non-ferrous metal ores; 11. Coal, oil and gas; and 12. Minerals n.e.c.

Details of the classification of these products are shown in Appendix Table 1. The first eight of the resource products (nos. 1–8) are renewable resource products, while the remaining four (nos. 9–12) are non-renewable resource products. (The numbers in the list above are serial numbers only—they do not always correspond to the numbering used in input–output tables.) Given our methodology and presumption that Australia is a natural resource rich country, the first hypothesis to be tested is that:

> H.1: the natural resource intensity of Australia's exports is higher than that of its imports, i.e. $R_x > R_m$.

3.2 Introducing labour and capital: the hypotheses in a 3-factor context.

Following Leamer's approach (see section 2.3 above) in a three-factor framework, we would test the following two hypotheses:

H.2: The ratio of natural resource to labour is higher in Australian exports relative to Australian imports, i.e.

$$\left[\frac{R}{L}\right]_x \rangle \left[\frac{R}{L}\right]_m$$

H.3: The ratio of natural resource to capital is higher in Australian exports relative to Australian imports, i.e.

$$\left[\frac{R}{K}\right]_x \rangle \left[\frac{R}{K}\right]_m$$

Hypotheses 2 and 3 are essentially extensions of hypothesis 1 and the presumption that Australia is resource rich. Since factor abundance (scarcity) in the context of the factor proportions model is a relative concept, hypotheses 2 and 3 are based on the two sets of relativities or ratios with natural resource as the common factor in the numerator of both. Testing of these hypotheses should reveal the importance to the Australian economy of the natural resource factor, both in itself (hypothesis 1), and in relation to the other two factors (hypotheses 2 and 3). The

relative position of labour and capital with respect to each other will also emerge, although it does not appear possible to frame any clear-cut hypothesis regarding Australia's relative endowment of these two factors. The reasons for this will be discussed when interpreting the results in section 6 below.

3.3 *Estimating labour and capital contents*

$$\textit{Define:} \qquad n_j = \frac{l_j}{q_j} \rightarrow\rightarrow\rightarrow k_j = \frac{c_j}{q_j} \tag{9}$$

where l_j and c_j are labour and capital employment in the jth sector, and q_j its output in the year in question, so that n_j is the labour required and k_j the capital required per unit of gross output.

Pre-multiply the inverse input–output matrix $[I - B]^{-1}$ by a diagonal matrix N which has the co-efficients n_{ij} along the diagonal. Formally, each element l_{ij} of the matrix L, given by:

$$L = N[I - A]^{-1} \tag{10}$$

measures the employment created directly and indirectly in the ith sector when the final demand in the jth sector changes by one unit. The column sum Σl_{ij} would show the total employment generated in the economy when the final demand for the sector at the head of the column changes by one unit. Post-multiplying (6) by the vectors of exports and competitive imports, X and M, the required labour contents are obtained:

$$L_x = N[I - A]^{-1} X \tag{11}$$

$$L_m = N[I - A]^{-1} M \tag{12}$$

where L_x and L_m are column vectors showing the direct and indirect labour contents of a given vector of exports and competitive imports respectively. The column sum of the relevant vectors would show the total labour contents of exports or imports as a whole.

Likewise, to obtain the capital content of exports and competitive imports, first pre-multiply the inverse matrix $[I - A]^{-1}$ by a diagonal matrix k which has the coefficients k_{ij} along its diagonal:

$$K = k\,[I - A]^{-1} \qquad (13)$$

This will give the amount of capital required in each ith sector for a unit change in final demand in sector j. Post-multiplying (13) by the vectors of exports and competitive imports, the required capital contents are obtained:

$$K_x = k[I - A]^{-1}\ X \qquad (14)$$
$$K_m = k[I - A]^{-1}\ M \qquad (15)$$

where K_x and K_m are the column vector showing the direct and indirect capital contents of the given export and import vectors respectively. The column sum of the relevant vector would show the total capital content of exports or imports as a whole.

4. The data

THE INPUT–OUTPUT data used in this study are for the years 1977–78 and 1986–87. The latter year was chosen because it was the latest for which data were available at the time the work was begun. The earlier year should provide a benchmark for purposes of comparison.

The Leontief inverse matrix, B, used in estimating all the factor contents—natural resource, labour and capital—was made available by the Australian Bureau of Statistics (ABS). Figures for exports and gross output are taken from Table 3 of the ABS publication *Australian National Accounts: Input–Output Tables*.

The estimation of the factor contents of imports requires some clarification. The input requirements (natural resource, labour and capital) for the import vector relate to the production of import competing goods in Australia. The resulting factor contents, therefore, are those of the vector of import substitutes produced domestically. The use of this procedure is based on the Heckscher–Ohlin assumptions of international identity of production functions and non-reversal of factor intensities. These assumptions require that the ranking of goods in terms of their

factor intensities merely be similar across countries. As the purpose of this study is to compare the factor intensities of Australia's exports with those of its imports, the use of Australian input–output tables for the purpose requires only that competitive imports be used. Complementary imports, by definition, are not produced in Australia, and their factor intensities cannot therefore be estimated with the help of Australian I–O tables. However, complementary imports into Australia are so few that omitting them is not likely to bias the results significantly.

We turn now to the measurement of the labour and capital inputs. The labour content of a vector of final demand ideally is measured either by the number of workers engaged in an activity, or by the number of hours worked by them to generate the given final demand vector. However, this requires employment data at the same level of disaggregation as for the input–output sectors. There are no regular publications giving such detailed employment figures, but fortunately, ABS was able to provide figures for the number of workers employed in the sectors covered in the 1986–87 table. These made it possible to estimate the labour content in Australia's export and competitive import sectors for that year.

In the absence of figures for actual employment for the year 1977–78, an alternative measure based on labour wages was used. The I–O tables give figures for the 'wages, salaries and supplements' paid to the primary input labour by sector. Dividing these figures by the corresponding gross output figures, labour employment figures per unit of gross output in these sectors are obtained. The value figures have the advantage of incorporating labour skills to a greater extent than the crude 'physical' data, since labour of higher skill would attract higher compensation in wages. However, in order for these figures to capture labour's contribution to the production process, it is necessary to assume that each factor is paid in accordance with its marginal revenue productivity, and that the marginal productivities bear a constant proportional relationship to the gross output of the sector in which the factor is employed. This last assumption implies that any change in output would cause an equi-proportional change in the factor employment, as measured by its share in output. These value-based employment figures are admittedly less than ideal as they ignore such institutional influences on labour wages as the degree of unionisation in a particular sector of the economy, or degree of competition in the market for the products that labour is producing. These

limitations must be borne in mind when interpreting the results.[1]

The estimates of the capital contents of exports and competitive imports too are based on value figures relating to what may be regarded as the return to the factor capital. The input–output tables contain figures for the gross operating surplus. This is 'estimated as a residual, after subtracting from the value of output all intermediate inputs, indirect taxes, the stock valuation adjustment and wages, salaries and supplements'. Adjustments are also made to 'exclude elements of non-operating income (such as interest, dividends, profits on sale of assets) and to add back elements of non-operating expenses (such as income tax, bad debts written off)' (ABS 1986–87, p. 14). The residual therefore must capture the returns accruing to capital, and may be said to measure that gross accounting profit which must reflect the use made of capital in the production process.

Ideally, one would like to measure capital intensity in terms of the actual use of physical capital in the production process. However, reliable estimates of such figures can come only from plant-level investigations. In the absence of such investigations, figures for the depreciation of fixed assets are often used. It is well known, however, that the depreciation figures reported in the economic statistics are often no more than 'accounting figures', and are therefore not reliable indicators of the use of fixed capital in the production process. The use of gross operating surplus as a measure of capital intensity therefore is unlikely to introduce a greater degree of distortion to the findings.

The returns to capital as reflected in the gross operating surplus figures are hopefully related to the marginal productivity of capital in given activities. Under conditions of perfect competition in both the factor and the goods markets, the marginal productivities of a factor will be equalised in different uses in equilibrium. Otherwise, free factor mobility ensures that a factor will move from a low to a high productivity use assuming, in keeping with the H–O trade model, that capital is not sector specific. A higher ratio of operating surplus to gross output in one sector relative to another must therefore reflect greater relative capital intensity.

Thus, our computations involving pre-multiplication of the inverse input–output matrices by the diagonal matrices of the ratios of operating surplus to gross output can be said to capture the capital-content of a unit of final demand. A further post-multiplication of this by the vectors of exports or competitive imports would yield the capital contents of these vectors.

5. The results

5.1 Natural resource contents: Renewables and non-renewables

Appendix Table 2 presents figures for the direct exports and competitive imports of resource products, together with the total (direct plus indirect) exports and competitive imports of resource products, of Australia in 1977–78. Table 3 shows the corresponding figures for 1986–87. Table 4 gives figures for the net foreign trade (i.e. export minus competitive imports) in resource products in the two selected years. Table 5 shows the total exports and competitive imports of resource products in absolute terms, as well as resource product contents per unit of the exports and of competitive imports.

Taking the direct components of exports and competitive imports first, one can see the importance of resource products in Australia's exports over its imports in both years. In 1977–78, the value of direct exports of these products was over 14 times larger than direct imports, while in 1986–87, they were over ten times larger. In 1977–78, the largest item of direct export was coal, oil and gas, followed by sheep, cereal, grains, ferrous metal ores and non-ferrous metal ores. Over the decade, most products had effectively maintained their positions relative to one another as well as to total direct exports. Non-ferrous metal ores experienced a stronger than average growth to improve their ranking from fifth largest in 1977–78 to third in 1986–87. Only poultry, and milk cattle and pigs experienced a decline in direct trade.

Direct imports of resource products were all modest in 1977–78. By 1986–87, their overall size had grown significantly, with a particularly sharp rise relative to total imports sometimes being registered. Coal, oil and gas and non-ferrous metal ores, for example, accounted for nearly one-half of the total competing imports in 1986–87, while their share had been less than a third in 1977–78.

The ratio of direct to total (direct plus indirect) exports was 67 per cent in 1977–78, rising slightly to 70 per cent by 1986–87. The ratio of direct to total imports, on the other hand, rose from a modest 33 per cent in 1977–78 to a moderately high 72 per cent by 1986–87.

Another ratio of interest to our investigations is that between renewable and non-renewable resource products exchanged through trade. In 1977–78, this ratio for direct exports was 86 per cent, falling to

66 per cent by 1986–87. The corresponding figures for direct imports were 108 and 71. Clearly, non-renewable resources became much more important in Australia's trade vector over the decade.

Turning now to total resource product exports and imports, it can be seen that, while total exports and imports have both roughly tripled over the period, the ratios of renewable to non-renewable resources have fallen from 95 to 75 per cent in respect of exports, and from 61 to 55 per cent in respect of imports. The growing importance of non-renewable relative to renewable resources is thus further confirmed, although in respect of imports, the decline this time is much more modest compared to the decline in direct trade.

The excess of exports over imports of resource products, both direct and total, confirms our hypothesis 1 that Australia is natural resource abundant relative to its trade partners.

Table 4 gives the item-wise breakdown of Australia's net exports (export minus import). With the exception of forestry and logging, net total export of every item was positive in both years. Net direct exports of 9 out of the 12 items were positive in both years, the exceptions being meat cattle, milk cattle, and forestry, which are all renewable resource products. However, although negative, the magnitudes of these net imports are relatively small. The most important of the renewable net exports were sheep and cereal grains, while non-ferrous metal, coal, oil and gas and ferrous metal ores were the most important non-renewable net exports in both years. The single largest net export in both years was coal, oil and gas.

However, significant as these figures are in indicating the relative natural resource intensities of Australia's exports and competitive imports, they need to be converted to a common base—by using one-million-dollar units for both exports and competitive imports—to aid comparison. The results are reported in Table 5, which also gives the total resource contents of Australia's export and competitive import vectors. The resource contents per unit of exports and of competitive imports clearly show the much higher resource intensity of exports over imports. At around 53 per cent, exports used over four times as much resource products as did imports in both years. Over the period, the resource content of exports declined marginally while that of imports rose

marginally.

The distribution of the resource products into renewable and non-renewable, and an item-wise breakdown of their use in Australia's exports and imports, are given in Table 6. Exports used around 26 and 22 per cent renewables, and around 27 and 30 per cent non-renewables, in the years 1977–78 and 1986–87 respectively. Imports, by contrast, used 4.5 and 4.4 per cent renewables and 7.3 and 8.0 per cent non-renewables in 1977–78 and 1986–87 respectively. Thus, non-renewable resources are more important in both exports and imports relative to renewable resources in both years. Moreover, the use of non-renewable resources per unit in both exports and imports increased, while that of renewables fell, over the period. These figures show that non-renewable resources are the more abundant resource, and that their importance is growing over time.

5.2 Labour and capital contents

The labour contents of exports and complementary imports have been estimated using both the value based measure of labour (wages and salaries paid) and the physical measure (number of workers employed). The capital contents have been estimated using the operating surplus measure.

Table 7 gives the labour and capital contents of total exports and competitive imports, together with the labour and capital shares of one million dollars' worth of exports and imports. The figures show that while total exports contain more labour and more capital relative to total imports in both years, exports per unit contain more capital and less labour relative to imports per unit. In 1977–78, the labour content (wage share) of a million dollars' worth of exports was 44 per cent, as compared to 49 per cent in the case of imports. The capital content of a unit of exports at around 40 per cent was significantly higher than that of a unit of imports, which was around 25 per cent. By 1986–87, the labour content of both the export and the import units had become smaller, and the capital content larger.

Quite why the share of labour fell and that of capital rose over the period by as much as they did (over 6 per cent) is difficult to explain. In terms of the methods used to estimate these figures, the explanations would lie either in a change in the input–output technology matrix—involving substitution of capital for labour—or a decline in the wage rate relative to operating surplus. But these two tendencies can only be

mutually conflicting: if labour wages become cheaper, substitution would be in favour of it, rather than away from it, as has happened. However, the present study being concerned primarily with the ranking of exports and imports in terms of their factor intensities, the observed changes to the absolute size of these intensities are of no direct interest as long as the rankings are not reversed. As Table 7 confirms, exports remained capital intensive relative to imports over the period.

When labour content is measured in terms of the number of workers employed per million dollars of exports and imports, imports again turn out to be labour intensive relative to exports. Table 10 shows that 1,840 workers were needed for a million dollars' worth of exports in 1986–87, while for the same amount of competing imports, 1,940 workers were required. The two measures of labour intensity thus yield results that are consistent, suggesting that both measures capture equally the pattern of labour use.

Tables 8, 9 and 10 shed light on hypotheses 2 and 3, which are based on comparisons of natural resource to labour (H.2) and to capital (H.3) respectively. Table 8 shows that the natural resource intensities of exports relative to both labour and operating surplus are significantly higher than those of competing imports in both years.

Taking each of the three factors in turn, Table 9 shows the ratios of their use by units of exports and imports. Thus, exports used over four times as much natural resource per unit as did imports in both years. The use of capital per unit of exports was also around 50 per cent more than the use of capital per unit imports. In respect of labour, however, exports used around 10 per cent less than did imports in both years. Using the physical measure of labour somewhat changes the magnitude of the ratio of labour use in exports relative to imports, but does not reverse their rankings. As the bottom half of Table 10 shows, the labour intensity of exports is less than that of imports.

The findings thus support hypotheses 2 and 3. Relative to imports, Australian exports are natural resource intensive with respect to both capital and labour.

Australia is also found to be a net exporter of the services of both natural resource and capital, and a net importer of labour services in balanced trade conditions. It was observed in section 5.2 above that no

clearcut hypothesis in regard to Australia's endowment of capital relative to labour was evident. This is probably because Australia, in terms of its capital endowment, would rank 'somewhere in the middle' in relation to its major trade partners. With the possible exception of New Zealand, Australia's other major trade partners in the industrial world—Japan, the USA and the European Community—are likely to be capital rich relative to Australia. On the other hand, Australia's trade partners in the developing world would be labour rich relative to Australia.

In a two-factor setting, therefore, it would be difficult to predict Australia's trade pattern if the two factors were capital and labour. In a three-factor setting with natural resource as the third factor, a trade pattern in line with Australia's apparent natural resource abundance can be predicted. These expectations have been verified in this study.

The fact that Australia has also been found to be a net exporter of capital services probably has the same explanation as the one used by Diab and Vanek with respect to the US (see section 2.2 above) in seeking to resolve the Leontief paradox. As a net exporter of the services of natural resource, Australia must be using the services of capital as a strong complementary input. This results in putting capital services ahead of labour services as Australia's net exports to the rest of the world.

6. Concluding observations

THE RESULTS of the detailed empirical investigation relating to the factor contents of Australia's foreign trade establish Australia to be exchanging the services of its renewable and non-renewable natural resources, and the services of capital that these natural resources use as complementary inputs, for the services of the factor labour. The findings are largely in keeping with the general perception of Australia as a relatively resource-rich country. In particular, non-renewable resources were found to be playing an increasingly dominant role in Australia's export trade.

One implication of these findings is that any strategies of further diversification of the economy would require increased availability of capital, without which natural resources cannot be processed into exportables. A longer term consideration would be that as the supply of non-renewable resources depletes, their costs would rise, and their markets may become more limited. A strategy to use the available

renewable resources more effectively would obviously be a desirable one.

The drawbacks to which the data used in the study are subject have already been indicated. The findings based on them are therefore best treated as indicative only.

Note

1. The dual computations for the 1986–87 year enable a check on the reliability of the two measures of labour content. Any wide divergence would perhaps indicate that the two measures are not good substitutes.

Appendix

Table 1 **The composition of the 12 resource products**

Input–Output Industry Classification			Corresponding ASIC Industries	
I–O Sector No.	Code	Description	Code	Description
1.	01.01	Sheep	0182 (Part) 0184 (Part) 0185	Sheep-cereal grains Sheep-meat Cattle Sheep
2.	01.02	Cereal grains (including oil seeds n.e.c.)	0181 0182 (Part) 0183 (Part)	Cereal grains (including oil seeds n.e.c.) Sheep-cereal grains MeatCattle-cereal grains
3.	01.03	Meat Cattle	0183 (Part) 0184 (Part) 0186	Meat Cattle-cereal grains Sheep-Meat Cattle Meat Cattle
4.	01.04	Milk Cattle and Pigs	0187 0188	Milk Cattle Pigs
5.	01.05	Poultry	01245	Poultry
6.	01.06	Agriculture (n.e.c.)	0134-6 0143,4 0191-6	Fruit Vegetables Other agriculture
7.	03.00	Forestry and Logging	0303, 4	Forestry and Logging
8.	04.00	Fishing Hunting	0431-4 0440	Fishing Hunting and trapping
9.	11.01	Ferrous Metal Ores	1111, 2	Ferrous Metal Ores
10.	11.02	Non-Ferrous Metal Ores	1121-9	Non-Ferrous Metal Ores
11.	12.00	Coal; Oil and Gas	1201, 2 1300	Coal Oil and Gas
12.	14.00	Minerals n.e.c.	1401-4 1501-5	Construction materials Other Non-metallic minerals

Source: Adapted from the *Australian National Accounts, Input-Output Tables (1986–87).* Appendix B.

Note: For details of the classification of goods listed in the table, see the Australian Input-Output Commodity Classification (IOCC), ABS Catalogue

No. 5215.0.

Table 2 **Australia's foreign trade in natural resource products 1977/78 ($ millions)**

Serial No.	Resource Products	Exports		Competing Imports (CIF)	
		Direct[a]	Total[b]	Direct[a]	Total[b]
1.	Sheep (01.01)	920.0	1,129.516	29.0	58.109
2.	Cereal grains (including oil seeds n.e.c.) (01.02)	956.9	1,134.413	38.5	67.862
3.	Meat Cattle (01.03)	7.8	327.258	27.4	46.588
4.	Milk Cattle & Pigs (01.04)	1.1	205.017	8.8	30.178
5.	Poultry (01.05)	12.1	84.543	1.2	5.891
6.	Agriculture (n.e.c) (01.06)	84.1	391.691	30.4	94.516
7.	Forestry and Logging (03.00)	0.8	45.181	19.2	52.327
8.	Fishing and Hunting (04.00)	137.3	153.449	15.0	17.929
9.	Ferrous Metal Ores (11.01)	808.9	915.643	44.5	60.774
10.	Non-ferrous Metal Ores (11.02)	494.4	1,053.151	48.2	127.971
11.	Coal, Oil and Gas (12.00)	1,267.6	1,585.569	49.8	357.403
12.	Minerals (n.e.c.) (14.00)	56.5	86.169	14.8	60.035
TOTAL		**4,748.00**	**7,111.60**	**326.8**	**979.58**

Notes: [a] Direct exports (imports) refer to the exports (imports) of these products as such.

[b] Total exports (imports) refer to direct plus indirect, i.e. as inputs to other products, exports (imports).

The figures in brackets refer to the input-output code numbers of the industries.

Table 3 **Australia's foreign trade in natural resource products 1986–87 ($ million)**

Serial No.	Resource Products	Exports		Competing Imports (CIF)	
		Direct[a]	Total[b]	Direct[a]	Total[b]
1.	Sheep (01.01)	2,653.1	3,203.336	107.5	163.281
2.	Cereal grains (including oil seeds n.e.c.) (01.02)	2,089.2	2,562.586	104.9	192.012
3.	Meat Cattle (01.03)	57.6	1,017.817	71.5	135.885
4.	Milk Cattle & Pigs (01.04)	0.1	526.353	31.5	91.227
5.	Poultry (01.05)	6.9	225.514	4.2	20.223
6.	Agriculture (n.e.c) (01.06)	307.2	970.941	151.2	292.625
7.	Forestry and Logging (03.00)	2.1	123.961	44.5	148.719
8.	Fishing and Hunting (04.00)	191.9	256.486	60.5	79.352
9.	Ferrous Metal Ores (11.01)	1,280.0	1,497.563	78.5	170.680
10.	Non-ferrous Meal Ores (11.02)	2,525.1	3,733.741	248.0	466.649
11.	Coal, Oil and Gas (12.00)	5,153.6	6,104.869	404.8	1,148.845
12.	Minerals (n.e.c.) (14.00)	346.0	512.951	74.8	258.106
TOTAL		**14,612,8**	**20,736.118**	**1,382.2**	**3,167.604**

Sources: Own calculations, as explained in the text.
Notes: [a] Direct exports (imports) refer to the exports (imports) of these products as such.
[b] Total exports (imports) refer to direct plus indirect, i.e. as inputs to other products, exports (imports).
The figures in brackets refer to the input-output code numbers of the

industries.

Table 4 **Australia's net foreign trade in natural resource products 1977–78 and 1986–87 ($ million)**

Serial	Resource Products	1977–78		1986–87	
		Direct	Total	Direct	Total
1.	Sheep (01.01)	891.5	1,071.4	2,545.6	3,040.1
2.	Cereal grains (including oil seeds n.e.c.) (01.02)	918.4	1,066.6	1,984.3	2,370.6
3.	Meat Cattle (01.03)	-19.6	280.7	-13.9	881.9
4.	Milk Cattle & Pigs (01.04)	-7.7	174.8	-31.7	435.1
5.	Poultry (01.05)	10.9	78.7	2.7	205.3
6.	Agriculture (n.e.c.) (01.06)	53.7	297.2	156.0	678.3
7.	Forestry and Logging (03.00)	-18.4	-7.2	-42.4	-24.8
8.	Fishing and Hunting (04.00)	122.3	135.5	131.4	177.1
9.	Ferrous Metal Ores (11.01)	764.4	854.9	1,201.5	1,326.9
10.	Non-ferrous Metal Ores (11.02)	446.2	925.2	2,277.1	3,267.1
11.	Coal, Oil and Gas (12.00)	1,217.8	1,228.2	4,748.8	4,956.0
12.	Minerals (n.e.c.) (14.00)	41.7	26.1	271.2	254.9

Sources: Own calculations, as explained in the text.
Note: net trade = exports minus competing imports.

Table 5 **Total and per unit resource product requirements of Australia's exports and competing imports 1977–78 and 1986–87**

Year	Resource Product Requirements of: Exports ($ million)	Competing Imports ($ million)
	Total	*Total*
1977–87	7,111.60 (13,370.7)	979.58 (8,237.6)
1986–87	20,736.12 (39,482.9)	3,167.60 (25,441.7)
	Per Million Dollars	*Per Million Dollars*
1977–78	531,879.41	118,915.70
1986–87	525,192.30	124,504.42

Source: Own estimates.
Note: The figures in brackets are total exports (excluding primary input export categories) and total competing import (excluding imports allocated to final demand categories) for the corresponding years. These total figures obviously include both resource and non-resource products.

Table 6 **Renewable and non-renewable resource product content (direct & indirect) of Australia's trade 1977/78 and 1986/87**

Resource Products	Exports ($ million)		Competing Imports ($ million)	
	1977/78	1986/87	1977/78	1986/87
Renewable:				
1. Sheep (01.01)	1,129.52	3,203.34	58.11	163.28
2. Cereal grains (including oil seeds n.e.c.) (01.02)	1,134.41	2,562.59	67.86	192.01
3. Meat Cattle (01.03)	327.26	1,017.82	46.59	135.89
4. Milk Cattle & Pigs (01.04)	205.02	526.35	30.18	91.23
5. Poultry (01.05)	84.54	225.51	5.89	20.22
6. Agriculture (n.e.c.) (01.06)	391.69	970.94	94.52	292.63
7. Forestry and Logging (03.00)	45.18	123.96	52.33	148.72
8. Fishing and Hunting (04.00)	153.45	256.49	17.93	79.35
Total	**3,471.07**	**8,887.00**	**373.41**	**1,123.33**
~~Per Million Dollars~~	~~259,602.71~~	~~225,084.78~~	~~45,329.95~~	~~44,153.10~~
Non-Renewable:				
9. Ferrous Metal Ores (11.01)	915.64	1,497.56	60.77	170.68
10. Non-Ferrous Metal Ores (11.02)	1,053.15	3,733.74	127.97	466.65
11. Coal, Oil and Gas (12.00)	1,585.57	6,104.87	357.40	1,148.85
12. Minerals (n.e.c.) (14.00)	86.17	512.95	60.04	258.11
Total	**3,640.53**	**11,849.12**	**606.18**	**2,044.29**
Per Million Dollars	272,276.69	300,107.64	73,586.97	80,351.94

Source: Own Estimates

Table 7 **Direct and indirect primary input contents of Australian trade 1977/78 and 1986/87**

Primary Input	Total Exports ($ million)	Total Competing Imports ($ million)
	1977/78	
Wages, salaries supps. (WSS)	5,895.96	4,064.92
Operating surplus (OS)	5,299.90	2,062.18
	Exports Per Million Dollars	Competing Imports Per Million Dollars
WSS	440,961.20	493,459.26
OS	396,381.64	250,337.48
	1986/87	
	Total Exports ($ million)	Total Competing Imports ($ million)
WSS	14,709.95	10,985.57
OS	17,872.07	8,057.32
	Exports Per Million Dollars	Competing Imports Per Million Dollars
WSS	372,565.09	431,791.12
OS	452,653.43	316,697.39

Source: Own Estimates

Table 8 **Factor intensity ratios in the production of Australia's exports and competing imports 1977/78 and 1986/87**

	Exports		Competing Imports	
	1977/78	1986/87	1977/78	1986/87
Natural Resource Labour	1.2	1.4	0.2	0.3
Natural Resource Operating Surplus	1.3	1.2	0.5	0.4
Labour Operating Surplus	1.1	0.8	2.0	1.4

Source: Own Estimates

Table 9 **Natural resource products, labour and capital requirements per million dollars of Australian exports and competing import replacements 1977/78 and 1986/87**

	Exports		Competing Imports	
	1977/78	1986/87	1977/78	1986/87
Natural Resource Products	531,879.41	525,192.37	118,915.70	124,504.42
Wages, salaries, supp.	440,961.20	372,565.09	493,459.26	431,791.12
Operating Surplus	396,381.64	452,653.43	250,337.48	316,697.37

	1977/78 Exports/Imports		1986/87 Exports/Imports	
Natural Resource Products	4.5		4.2	
Wages, salaries, supp.	0.9	(.89)	0.9	(.86)
Operating Surplus	1.6		1.4	

Source: Own Estimates

Table 10 **Natural resource products, labour (actual employment) and capital requirements per million dollars of Australian exports and competing import replacement 1977–78 and 1986–87**

	Exports		Competing Imports	
	1977/78	1986/87	1977/78	1986/87
Natural Resource Products ($)	531,879.41	525,192.37	118,915.70	124,504.42
Labour (actual employment)	-	1,869.42	-	1,940.91
Operating Surplus ($)	396,381.64	452,653.43	250,337.48	316,697.37

	1977/78 Exports/Imports	1986/87 Exports/Imports
Natural Resource Products	4.5	4.2
Labour (actual employment)	-	0.96
Operating Surplus	1.6	1.4

Source: Own Estimates

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