FACTOR ABUNDANCE AND KOREA'S COMPARATIVE ADVANTAGE IN INTERNATIONAL TRADE

Dong Young IM
Bachelor of Business Administration, Sung Kyun Kwan, 1974
Bachelor of Arts, Guelph, 1980

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the Department

of

Economics

ACCEPTED
F[redacted]E STUDIES
DEAN
DATE 1986-10-10

We accept this thesis as conforming
to the required standard

[redacted]
Dr. D. G. Ferguson

[redacted]
Dr. Izzud-Din Pal

[redacted]
Dr. William M. Ross

[redacted]

University of Victoria

August 1986

Supervisor: Dr. Donald G. Ferguson

ABSTRACT

Although the factor proportions theory is now the dominant theory of international trade, there has been considerable controversy over its empirical implications and how it should be applied. The objective of this thesis is to use the factor proportions theory to explain the commodity composition of Korea's trade and, in so doing, to assess the merits of alternate empirical approaches based on the theory.

The starting point is a regression model which employs the specification and interpretation introduced by Harkness (1978). This basic model is supplemented by alternate regression models and by various measures of the factor content of Korea's trade. The major conclusions are: that, under Harkness' interpretation, all of the regression models provide an explanation of Korea's trade which is consistent with the factor proportions theory; that, with imperfect data, the regression models provide a more consistent explanation than do other methods based on the measurement of the factor content of trade; and that, although the factor proportions theory is clearly important, other considerations do affect the commodity composition of Korea's trade.

Examiners:

[redacted]

Dr. D. G. Ferguson

[redacted]

Dr. Izzud-Din Pal

[redacted]

Dr. William M. Ross

[redacted]

Dr. Richard J. Powers

CONTENTS

TABLES

ACKNOWLEDGEMENT

I am greatly indebted to many people for their unique contributions to this study. First of all, I would like to thank Dr. D. G. Ferguson for his guidance, assistance and encouragement that were indispensable in writing this thesis. Thanks are also due to the help from other supervisors; Dr. I.-D. Pal, the Department of Economics, and Dr. W. M. Ross, the Department of Geography.

My appreciation should be extended to Dr. S. Earmme, the Ministry of Industry & Small Business Development, B.C., who provided most of the data used in this study, and Dr. W. Hong, the Department of Economics, Seoul University, who kindly sent his publications.

Finally, I wish to offer my gratitude to J. Bouchard for correcting errors of earlier draft, and to Kumhee, my wife, for her enduring patience and support, without which this study would not have been completed.

Chapter I

INTRODUCTION

Two competing trade theories have been used to explain the direction of commodity trade: the factor proportions theory (the Hecksher-Ohlin theory) and the 'neo-technology' theory.[1] The former views relative differences in factor endowments as the major cause of international trade, while the latter considers productivity differences as the fundamental cause of commodity trade flows. While 'neo-technological' explanations in international trade have received increasing attention, they tend to be descriptive rather than analytic and the factor proportion theory still dominates both theoretical and empirical analysis.

In the case of South Korea, which has experienced a phenomenal growth in trade (from 3% of GNP in 1960 to 30% in 1978), the factor proportions theory is the natural choice for an analytical framework. Because of its emphasis on a country's endowments of capital, natural resources and labor skills, it has been used extensively in the study of other newly industrialized countries and in the previous studies of Korean trade (see Hong (1976, 1978) and Lim (1976)).

---

1 The so-called 'neo-technology' theory contains two branches of trade studies: one is intra-industry trade studies which regards economics of scale as a determinant of international trade, the other is 'technological gap' or 'product cycle' studies which hypothesize knowledge of product and production technique as important determinants of the world trade.

Stated most generally, the objective of this thesis is to contribute to the understanding of the role played by factor endowments and proportions in explaining the composition of Korean trade. However, to give this objective a specific form it is necessary to recognize the controversy that exists over precisely what the empirical content of the factor proportions theory is. The recent reviews of the empirical literature by Stern (1975) and Deardorff (1984) cite a variety of distinct empirical models, all of which have at least some intuitive linkage to the theory but none of which has an unique claim to being the correct and the most useful.

In large measure this state of affairs can be attributed to the nature and weakness of the predictions when the theory is extended beyond the traditional textbook model of two commodities and two factors. Such an extension is desirable, not only because there are many commodities and factors, but also because the use of simplified models has sometimes led to results which are apparently at odds with the theory. In most instances, this phenomenon, known as the Leontief Paradox, has disappeared as the model was made more general.

In the present case it was decided to employ the regression model developed by Harkness (1978) and, within the confines of available data, to include as many factors as possible. The data is drawn from the 1978 input-output table for Korea and covers sixty industries and five primary factors (skilled labor, unskilled labor, self-employed labor, capital and natural resources). Although its theoretical foundations have been challenged, Harkness' model has proven to be remarkably successful in explaining the commodity composition of trade of other countries. Furthermore, the controversy surrounding the model has helped to clarify its nature, its limitations and its interpretation. This is particularly important since a full understanding of an empirical methods is necessary before it can be used to draw conclusions.

The thesis will address four primary issues. First, does the Korean data support Harkness' interpretation of his model? Second, does the specific form of Harkness' model have advantages over an alternate regression model which can be given the same interpretation? Third, based on Harkness' interpretation, what do this model and the alternate model reveal about the nature of Korea's comparative advantage? Fourth, can a simple extension to Harkness' model be used to demonstrate that the factor proportions theory does not offer a complete explanation of Korea's commodity trade?

Stated briefly, the answers obtained for the respective questions are: (i) yes; (ii) no; (iii) Korea has a comparative advantage in commodities which use unskilled labor and self-employed labor relatively intensively and a comparative disadvantage in goods which use capital, skilled labor and natural resources relatively intensively; (iv) yes. (A more complete description of the conclusions would require going into matters which can only be dealt with at length and which are the subject of the next two chapters.)

In the process of dealing with the primary issues, a number of secondary matters are raised. The principal one among these is understanding the consequences of the structural differences between Korea and her major trading partners (Japan and the United States). Many commodities imported by Korea can not be produced there and this has significant consequences in terms of the data that is required to properly apply the theory. It also has implications for the merits of alternate empirical methods. In the present study, it was not possible to obtain comparable data on the Japanese and American input-output structures and, as a result, it was necessary to treat all imports as if they could be produced in Korea. Under similar limitations the previous studies of Korean trade encountered anomalies when measuring the factor content of Korea's trade. Despite further evidence to this effect, both Harkness' model and the alternate regression model do not exhibit such anomalies. This suggests that regression models are better able to cope with data limitations than are the models based on measures of the factor content of trade.

The outline of the thesis is as follows. Chapter Two addresses the nature of the factor proportions theory and of the alternate empirical models based on it. Particular attention is given to Harkness' model and its relationship to the theory. Chapter Three discusses the data, its limitations and the methods used to construct the variables. The results and their interpretation are then presented in Chapter Four.

Chapter II

THE FACTOR PROPORTIONS THEORY AND ITS EMPIRICAL APPLICATIONS

2.1 Introduction

This chapter provides an overview of the factor proportions theory of trade determination and of its empirical applications. The chapter discusses the elementary form of the theory in section 2.2. The more general (multi-dimensional) version is presented in section 2.3 and the empirical applications are discussed in 2.4. The latter also summarizes the previous studies of Korean trade and places them in the context of other empirical studies and the controversies surrounding them. The conclusion draws on the previous discussion to show how each of the four primary issues mentioned in the introduction will be dealt with.

2.2 The 2x2x2 factor proportions model

The factor proportions theory offers an explanation of trade based on cross-country differences in relative factor supplies and cross-industry differences in the relative intensity with which factors are used. In the context of an elementary model involving only 2 factors, 2 commodities and 2 countries (the 2x2x2 model), it is possible to give precise meaning to the notions of relative factor abundance and relative factor intensities. For example, if we adopt the following notation

K = domestic capital supply; L = domestic labor supply

K^w = world capital supply

L^w = world labor supply

a_{Kj} = capital coefficient for the jth good

a_{Lj} = labor coefficient for the jth good

S_j = domestic output of the jth good

S_j^w = world output of the jth good

where $j = 1, 2$

we can say that the home country has a relative abundance of capital (scarcity of labor) if

$$K/K^w > L/L^w \text{ -----------------------(1)}$$

and that good 1 is relatively capital intensive if

$$a_{K1}/a_{L1} > a_{K2}/a_{L2} \text{ -----------------(2)}$$

As discussed in any undergraduate text on international economics, it is possible to demonstrate that if (1) and (2) hold, then under appropriate assumptions, at any common world prices for the two goods

$$S_1/S_1^w > S_2/S_2^w \text{ ---------------------(3)}$$

In words, the relations in (1), (2) and (3) state that a country will be a relatively large producer of the good which uses its relatively abundant factor relatively intensively.[2]

The conclusion itself is intuitively appealing. However, there are a number of critical assumptions, apart from the dimensionality of the model, which underly the validity of the conclusion. These include the assumptions of

(a) constant returns to scale in production (to exclude absolute factor supplies-country size-as a determinant of relative production levels.)

(b) identical technologies across countries (to exclude productivity differences as a determinant of relative production levels.)

(c) factor price equalization (to ensure that countries adopt the same production methods and hence to ensure that (2) can be used to refer to either country.)

(d) perfect competition (to exclude intersectoral differences in market power as a determinant of relative production levels.)

Although each of these assumptions can be relaxed while retaining the basic conclusion, this must be done in particular ways. For example, (b) may be replaced by weaker assumptions that allow for international differences in factor productivity, provided these differences do not significantly affect relative productivity across sectors. Correspondingly, (c) can be relaxed to allow for international differences in factor prices based on these productivity differences.

---

[2] This statement is due to the Rybczynski theorem: references include Rybczynski (1955), Jones and Scheinkman (1977) and Dixit and Woodland (1982).

To move from a statement about relative production levels to one about patterns of trade, it is necessary to say something about the nature of product demand. In this respect, to retain the focus on the role of supply considerations, it is conventionally assumed

> (e) preferences are homothetic and identical across countries.[3] (Homotheticity ensures that international differences in income levels do not affect relative product demands and the identity of preferences ensures that relative product demands will be the same across countries.)

Adopting the further notation

p_1 = the price of good 1

p_2 = the price of good 2

Y = domestic income

Y^w = world income

D_j = domestic demand for the jth good

D_j^w = world demand for the jth good.

g° = Y/Y^w: the domestic share in world income

this assumption (e) implies that domestic and world demands are proportionate to income levels and hence

$$D_j = g^\circ D_j^w \qquad (4)$$

The home country's net trade in good j is

---

[3] References for homotheticity are Katz (1970), Silberberg (1978, pp. 358-359), Dixit and Norman (1980, pp. 325-326), Woodland (1982, pp. 33-35), Ethier (1983, pp. 543-547).

$$T_j = S_j - D_j \quad (5)$$

with T_j positive or negative as the home country is a net exporter or importer. With the further requirements that

(f) world markets clear

$$D_j^W = S_j^W \quad (6)$$

(g) trade is balanced

$$p_1 T_1 + p_2 T_2 = 0 \quad (7)$$

it can be shown that (3) implies[4]

$$T_1 > 0 > T_2 \quad (8)$$

In words, (1) , (2), (3) and (8) state that a country will export (import) the good which uses its relatively abundant (scarce) factor relatively intensively. This is the Heckshar-Ohlin theorem.

2.3 The multi-dimensional model

The principal difficulty in extending the Heckshar-Ohlin theorem to cases involving more than two factors and goods is that there is no natural analogue to (2) for characterizing the relative intensity with which factors are used in produc-

---

4 An excellent exposition of deriving (8) is shown by Leamer (1984, Chapter One).

ing goods---ratios are inherently comparisons of two things. Moreover, no tractable alternative has been developed to take its place. Instead, following Vanek (1968) and Bertrand (1972), an effort has been made to recast the theory in a weaker form as a statement about covariations or correlations between the levels of commodity trade and factor intensities, with the sign of the covariation depending on the country's relative factor abundance.

To present the argument, the following notation will be adopted

S = (nx1) vector of final goods

K = (mx1) vector of supply of primary factors

D = (nx1) vector of final consumptions

T = (nx1) vector of net commodity trade

Y = GNP at factor costs

C = (mxn) matrix of the total factor cost shares, where C_{ij} denotes the total factor cost share of the ith factor in the production of the jth good.

where i = 1, 2, -----, m, and j = 1, 2, -----, n

with a superscript w being employed to represent the corresponding terms for the world as a whole. A country is said to have a relative abundance in factor i if

$$K_i/K_i^w > g^\circ \text{ ---------------------(9)}$$

and a relative scarcity if the inequality is reversed.

The product CS defines the domestic demand for factors and equilibrium in domestic factor markets implies

$$CS = K \text{ ------------------------(10)}$$

Similarly, for the world as a whole, we must have

$$CS^w = K^w \text{ ----------------------- } (11)$$

which states that the total amount of factors embodied in world production is equal to the amount available. From (4), (5), (6), (10) and (11), it then follows that

$$CT = K - g^\circ K^w \text{ ------------------ } (12)$$

which is referred to as the Heckshe-Ohlin-Vanek (Vanek-Bertrand) equation.

The ith equation in (12) is

$$\sum_{j=1}^{n} C_{ij}T_j = K_i - g^\circ K_i^W \text{ ----------------- } (13)$$

which can be interpreted as stating if a country is relatively abundant in a factor i ($K_i - g^\circ K_i^W > 0$), then there is a positive covariation (correlation) between the intensity with which the factor is used in producing goods (represented by the C_{ij}) and the net exports of the goods. Conversely, if a country is relatively scarce in the factor, then the correlation will be negative. This is sometimes also phrased as stating that, on average, a country will be a net exporter of the goods which use its relatively abundant factors relatively intensively, and a net importer of the goods which use its relatively scarce factors relatively intensively.

The assumptions discussed in the previous section also underly this result and, as in the simpler model, it is possible to relax all of them, at least to some degree. For a discussion of this, and of the multi-dimensional model in general, the reader is referred to Ethier (1982) and the references cited there.

For our purposes what is important is that the Hecksher-Ohlin-Vanek (Vanek-Bertrand) equation conveys much the same sense of trade determination as does the Hecksher-Ohlin theorem, but in a weaker form. In place of the earlier determinate outcome, we now have a statement involving covariations, correlations or tendencies dependence in how one choses to describe (13). Although the Hecksher-Ohlin-Vanek equations tell us that factor intensities and relative factor endowments matter for trade, it does not allow us to state the nature of this dependence in a form that is both tractable and definite. For example, if our interest lies in explaining the commodity composition T, then since the number of factors and commodities need not be the same, it is not possible to simply invert C and solve for T in terms of the country's relative factor abundance and the factor intensities of production.

Finally, before proceeding to a discussion of various attempts to apply the theory, it should be noted that (13) can also be interpreted as a statement about the amount of factors embodied in commodity trade. The left hand side of (13) yields the total amount of factor i embodied the country's trade and the equation as whole can be read as stating that a country will be a net importer (net exporter) of a factor's services, if it is relatively scarce (abundant) in that factor. This is referred to as the 'factor content' version of the factor proportions theory and the earlier interpretation is referred to as the 'commodity composition' version.

2.4 Empirical applications

2.4.1 Introduction

There have generally been three different methodologies adopted in most empirical studies of trade based on the Heckshher-Ohlin-Vanek equation expressed in equation (12). They are: (i) factor content studies which measure net commodity trade T, and factor intensities C, and infer factor supplies ($K-g^{\circ}K^{W}$) from CT; (ii) cross-sectional regression studies which use measures of T and C and infer ($K-g^{\circ}K^{W}$) from regression parameters; (iii) cross-country studies that measure T, K and K^{W}, and implicitly infer C^{-1}, the inverse of factor intensities. The remainder of section 2.4 is devoted to presenting an overview of the methods and the issues that have arisen from their application.

2.4.2 Factor content analysis

One of the most famous empirical applications was undertaken by W. Leontief (1953, 1958) who examined the validity of the basic two-factor Heckshher-Ohlin model. To explain the trade pattern of the United States in 1947, Leontief computed the capital and labor requirements for the production of $1 million worth of United States exports and import-competing products. The methodological procedure adopted by Leontief was a direct calculation of factor content in which he calculated the total factor requirements of exports and imports and compared the capital-labor ratio of exports with that of imports.

According to Leontief's calculations for 1947, capital requirements of exports and imports were $2,550,780 and $3,091,339, respectively, and labor requirements of exports and imports were 181.31 and 170.00 man-years, respectively. Thus, he found that the import-competing goods were relatively more capital intensive than the goods exported by the United States. This result apparently contradicted the prediction of the Hecksher-Ohlin theorem, and went against the general conviction that the United States was more capital abundant than the rest of the world. This finding became known as the Leontief Paradox and undermined the confidence that economists had in the standard two-factor version of the model.

Studies exist for other countries which also arrive at paradoxical results--- Tatemoto and Ichimura (1959) for Japan, Bharadwaj (1962) for India, Wahl (1961) for Canada and Roskamp (1963) for West Germany. For example, Tatemoto and Ichimura found that Japanese exports in 1951 were more capital intensive than imports. Bharadwaj reported that Indian exports were more capital intensive than imports, and Wahl found that Canadian exports were capital intensive while her imports were labor intensive. Roskamp's finding indicated that West German exports were more labor intensive than imports.

Leontief's findings have led to a number of explanations and criticisms.[5] Leontief (1958) explained the Paradox in terms of United States labor being three times more productive than foreign labor so that when factor supplies are expressed in efficiency units, the United States was in fact relatively labor abundant. Minhas (1962) found support for the possibility of factor intensity reversals. Other explanations have concentrated on extending and redefining the number of factors, particularly human capital and natural resources. The concept of human

[5] See more comprehensive explanations: Baldwin (1971).

capital was used by Keesing (1965, 1966) and Kenen (1965) who observed that United States export industries employed more skilled labor than the import-competing industries----the apparent labor intensity of exports reflecting the United States' abundance in human capital. Observing that the United States was in fact abundant in capital but scarce in natural resources, Vanek (1963) showed that the complementarity between abundant capital and scarce natural resources meant that the United States imports were relatively capital intensive.

Recently, Leamer (1980) has argued that it is theoretically incorrect to compare the factor content ratio as Leontief did, if a country is a net exporter (or importer) of both capital and labor. When a country has a large surplus (or deficit) in trade so that it exports (or imports) both capital and labor services, it is neither necessary nor sufficient to use Leontief's factor content ratio to infer the country's relative factor abundance. Leamer argued instead that the factor abundance should be inferred from a comparison of the ratio of net exports to consumption. Since the United States was a net exporter of both capital and labor in 1947, Leamer pointed out that, in fact, the United States was endowed with more capital than labor.[6] Brecher and Choudhri (1982), however, claimed that the Leontief Paradox still holds when labor abundance is compared with an average of all resources rather than capital.[7]

---

6 Leamer suggested that if both net capital and labor exports, K_t and L_t, are positive, a necessary and sufficient condition for capital abundance is that K_t/L_t is greater than K_c/L_c, where K_c and L_c are capital and labor consumption. According to the data given by Leontief (1953), the United States is capital abundant since $K_t/L_t = \$23{,}450/1.990 > K_c/L_c = \$305{,}069/45.28$. See reference; Leamer (1980, pp. 503, tables 2 and 3).

7 Brecher and Choudhri (1982) argued that $L_t > 0$ if and only if $L/L^W > Y/Y^W$. But United States income (expenditure) per worker was higher than the world income (expenditure) per worker in 1950's. Thus, the paradoxical phenomenon still continues.

The principal studies of the factor content of Korean trade are those of Hong (1976, 1978) and Lim (1976) both of which concentrated on the two factor model and both of which used data drawn from the 1968 input-output table for Korea. Hong found little difference between the relative domestic factor content of exports and competitive imports (those producible in Korea), however, using United States input coefficients he found non-competitive imports to be significantly more capital intensive than either of these. Similarly, Lim found that for all industries taken together a weak paradoxical result was obtained (exports relatively capital intensive), but when only the manufacturing (modern) sectors were included the paradox disappeared. In both instances, obtaining the results expected from the theory was dependent on recognizing that, due to its stage of development, the structure of the Korean economy did not match that of its trading partners. As in all developing countries, Korea has a traditional economy which exists alongside a modern economy. Since the factor proportions theory applies only to the latter, the type of adjustments made by Hong and Lim were appropriate.

In addition to Hong's and Lim's work, which dealt exclusively with Korea, two other papers have examined the factor content of Korea's trade as part of broader studies covering a number of countries. Hillman and Hirsh (1980) found no evidence for the paradox using Korean and United States input coefficients and, similarly, Clifton and Marxsen (1984) obtained results consistent with the elementary theory when using the ratio of profits to wages to measure the relative factor intensity of imports and exports.

2.4.3 Cross-sectional regression analysis

2.4.3.1 Baldwin's studies

A considerable number of the empirical studies conducted during the 1970's have departed from Leontief's method by applying cross-sectional regression analysis. The cross-sectional regression method explains interindustry variations in net exports (or imports) by factor-use ratios under the assumption that continuous variations of factors would cause continuous variations in industry production. Thus, most researchers indirectly infer the effect of factors on trade, using Ordinary Least Squares (OLS), by assuming that the regression parameters reflect a country's factor abundance. Although this is intuitively plausible, the Hecksher-Ohlin-Vanek equation is not stated in this form and, as we shall see below, the legitimacy of such inferences is dependent on further conditions being met.

The examination of the United States' comparative advantage by means of regression analysis was first undertaken by Baldwin (1971) who specified 'net exports' or 'net adjusted trade balance' as the dependent variable and various factors influencing the pattern of trade as independent variables (such as the capital-labor ratio, the percentage of the labor force in various skill groups, scale indices and industry concentration indices). He found that the volume of an industry's net exports was significantly and positively related to the capital-labor ratio, but the significance of the other variables could not be determined. Noting the existence of a complementary relation between natural resources and physical capital, he concluded that the United States' comparative advantage lay in abundant skilled labor rather than in physical capital.

Harkness and Kyle (1975) questioned Baldwin's application of OLS. They contended that the commodity version of the Hecksher-Ohlin theorem does not concern itself with either the share or the volume of net exports, but rather with whether or not a country is a net exporter (sign of net export vector). It was suggested, therefore, that logit (or probit) analysis instead of OLS should be used for the estimation of the factor proportions models. Their results, using Baldwin's data for 1962 trade and 1958 input- output data, contradicted his conclusions.

Baldwin (1979) objected to Harkness and Kyle's procedure, reasoning that their tests were based on the commodity version of the Hecksher-Ohlin theorem in the absence of factor price equalization. On the other hand, the factor content version of the theorem would conceptually hold whether or not factor prices are equalized. In line with Baldwin's claim, the work of Branson and Monoyios (1977), using OLS, confirmed the Leontief Paradox in the United States, and Baum and Coe (1978) could not find any reversed signs between logit and regression estimates for West Germany. In contrast, Stern and Maskus (1981) seemed to confirm Harkness and Kyle's argument that, using the probit model for 1967 and 1978 United States data, the coefficients on the capital-labor ratio were positive. However, their findings could not support all of Harkness and Kyle's conclusions.

In his 1979 paper Baldwin included a regression for the Korean economy along with those for a number of other countries. Upon regressing net exports on the capital-labor ratio he obtained a negative sign which is what would be expected for a country which is relatively labor abundant. As in the case of the factor content studies, the factor proportions explanation of Korea's trade is consistent with Baldwin's result.

2.4.3.2 Harkness' studies

In a paper which departed from his earlier work with Kyle, Harkness (1978) suggested that the relations in (13) could be revealed by estimating equations of the form

$$(T/S)_j = \sum_{i=1}^{m} \beta_i C_{ij} + \varepsilon_j \quad \text{------------(14)}$$

where $(T/S)_j$ refers to 'proportionate net commodity exports' (net trade divided by output) and ε_j represents the classical error term.

Harkness (1981) argued that each estimated regression coefficient, $\hat{\beta}_i$, must be viewed as a descriptive rather than a structural coefficient, measuring the factor intensity's contribution to net commodity trade while all output levels are held at unity. Accordingly, the proper interpretation of the $\hat{\beta}_i$s is summarized as "descriptive coefficients characterizing the average, partial associations across goods"[8] between factor intensities and the fraction of domestic outputs which are traded.

In addition, Harkness also suggested an analytical proposition regarding the ' complementarities'[9] among factors. Specifically, Harkness (1983) argued that that "if factor complementarities are not 'severe', the sign and rank order of the $\hat{\beta}_i$s will duplicate those of relative factor abundance".[10]

---

8 In Harkness' original paper (1978), he did not explicitly confine the range of inference of β. In later papers, the inference of β is clearly reduced by stating that " β is not a proposed structural parameter---, rather it is an OLS-computed descriptive statistic----." See Harkness (1981, pp. 1044).

9 These complementarities are represented by the off-diagonal entries in CC' which can be interpreted as the covariations in factor intensities across goods.

Harkness' paper provoked on exchange between himself (Harkness(1981)) and Anderson (1981) and Bowen and Leamer (1981). The exchange focused primarily on Harkness' model but, in the process, it also helped to clarify the relationships between the Hecksher-Ohlin-Vanek equation and all of the regression models. The nature of the conclusions can be indicated by considering the most commonly used model

$$T = C'\beta + \varepsilon \text{------------------------} (15)$$

which differs from Harkness' only in that the net export entries are not scaled by the respective industries' outputs. The OLS estimates of β are

$$\hat{\beta} = (CC')^{-1}CT \text{----------------------} (16)$$

Since $CT = K - g^{\circ}K^{W}$ from the Hecksher-Ohlin-Vanek equation, we then have

$$\hat{\beta} = (CC')^{-1}(K - g^{\circ}K^{W}) \text{---------------} (17)$$

From (17), it is evident that under suitable restrictions on the covariations between the factor intensities (the entries in CC'), the sign and ranking of the entries in $\hat{\beta}$ will correspond to those of the relative factor abundances $(K-g^{\circ}K^{W})$. These restrictions are precisely those that Harkness meant to impose with his complementarity condition. Consequently, in the context of equation (15) his conditional proposition is correct.

The exchange, however, did not clarify Harkness' reasons for scaling net trade by the sectoral outputs. To present his model, let D_S denote a diagonal matrix with the entries from S along the diagonal. Equation (14) can be restated as

---

10 See Harkness (1983, pp. 300, Theorem 3).

$$D_s^{-1}T = C'\beta + \varepsilon \text{------------------------------}(18)$$

with estimates

$$\hat{\beta} = (CC')^{-1}CD_s^{-1}T \text{----------------------}(19)$$

Since $CD_s^{-1}T$ will, in general, differ from CT it is not possible to use the Hecksher-Ohlin-Vanek equation, as stated in (12), to relate his estimates to the relative factor endowments. In addition, Harkness also chose to express the factor content of trade as a proportion of the total factor content of domestic production. Specially, he used

$$D_k^{-1}(K-g^\circ K^w) \text{---------------------------}(20)$$

where D_k is the diagonal matrix with K along the diagonal.

When first introducing the scaling matrix D_s^{-1}, Harkness stated that "we will assume as a first approximation that the proportion of any output value entering net trade is unaffected by this scaling".[11] This does not explain his procedure but it does indicate that further restrictions were necessary. Also, it is worth noting that in his 1981 response to Anderson he appears to assert that the Hecksher-Ohlin-Vanek equation could be restated as[12]

$$CD_s^{-1}T = D_k^{-1}(K-g^\circ K^w) \text{-----------------}(21)$$

---

11 See Harkness (1978, pp. 788).

12 See Harkness (1981, pp. 1045) equation (2).

If that were so then, premultiplying by D_k and using the Hecksher-Ohlin-Vanek equation, each equation in (21) could be written as

$$\sum_{j=1}^{n} C_{ij}T_jK_i/S_j = \sum_{j=1}^{n} C_{ij}T_j \text{ ---------------------(22)}$$

which will not, in general, be the case. Again, same further restriction is implied but its precise content is left unstated.

This does not dispute the possibility that the sign and rank of the estimated regression will match those of the country's relative factor abundance, but it does indicate that the conditions under which this is true are more severe with Harkness's specification (18) than with the more conventional specification (15). For this reason, Harkness' interpretation will be applied not only to equations with his specification but also to ones with the conventional specification.

Putting the issue of scaling aside, there is the further problem that, even if the coefficients of either (15) or (18) did have the same sign as the corresponding relative endowments,[13] independent estimates of relative factor endowments are simply not available. In his 1978 paper, Harkness proposed that

$$Z^\circ = D_k^{-1}CT \text{ -------------------------(23)}$$

or

$$EZ^\circ = D_k^{-1}C\hat{T} \text{--------------------------(24)}$$

could be used as proxies for a country's relative factor abundance.

---

13 See equations (12) and (20), respectively.

Since the Hecksher-Ohlin-Vanek equation implies

$$Z^\circ = D_k^{-1}(K - g^\circ K^W) \text{-------------------} (25)$$

he referred to Z° as the 'observed factor abundances' and since $\hat{T}$ would be obtained from the estimation of (18) he referred to EZ° as the 'estimated factor abundances'. More accurately, as (23) and (24) indicate, Z° and EZ° should be referred to as the 'observed' and 'expected' scaled factor content of net exports. Similarly, the unscaled 'observed' and 'expected' factor contents

$$\bar{Z}^\circ = CT \text{ ---------------------------} (26)$$

$$\bar{E}\bar{Z}^\circ = C\hat{T} \text{ ----------------------------} (27)$$

could be used as proxies for relative factor abundance under the conventional specification. In latter case, matters are made simpler since equation (16) implies that

$$\bar{Z}^\circ = \bar{E}\bar{Z}^\circ$$

In either case, however, Hong's results indicate that because of structural differences between Korea and her trading partners, measures of the factor content of her trade may be unreliable indicators of her true factor abundance.

2.4.4 Cross-country analysis

2.4.4.1 Baldwin and Hilton's studies

Leamer and Bowen (1981) interpreted (17) as stating that the sign and magnitude of the regression coefficients need not reflect a country's true factor abundance. Since then, several authors have sought to find alternative empirical approaches. Although they differ in model specification, these cross-country studies largely concern a specific group of commodities or industries across countries.

Baldwin and Hilton (1983) offered a 'revealed comparative cost' approach[14] which measures inter-country cost differences using estimated inter-country differences in relative factor prices for each industry. In bilateral trade, Baldwin and Hilton relate relative factor price differences with unit cost differences on the one hand, and unit cost differences with bilateral net trade flows on the other. Hence, by measuring the relevant factor shares and factor returns, they calculated the factor price differences between the United States and selected groups of countries, and inferred the United States comparative advantage from these relative factor price differences.

---

14 The formulation of Baldwin and Hilton's study is:

$$\nabla UC_j = \sum_{i=1}^{m} \theta_{ij} w_i$$

where ∇UC_j = the relative differences from the jth unit cost.
θ_{ij} = the ith factor share of the jth good.
w_i = the relative difference of return to the ith factor bilaterally.

Hilton (1984) attempted a slightly different method for estimating differences in factor prices, based on observable commodity trade. His argument is that the relative differences in production costs determine bilateral trade flows, and are a function of production requirements and relative factor returns. Hence, the estimated coefficients from a logit (or probit) analysis may be functions of the relative returns to the factors of production. The results of Baldwin and Hilton (1984) and Hilton (1984) have revealed remarkably similar results about the United States' comparative advantage.

2.4.4.2 Bowen and Leamer's studies

The Bowen (1984) and Leamer (1984) studies measured the net commodity trade vector T, and the factor supply vector K, from equation (12) by collecting world factor data.[15] Assuming that there is an approximately linear relation between T and K, they regress net exports on net factor supplies, and infer estimates of C^{-1}, the inverse of technologies. Bowen (1984), using 34 countries' trade in 7 commodities between 1963 and 1975, found a significant positive relationship between resources and trade, and a shift in United States trade toward less capital intensive goods. Leamer (1984) measured the profiles (indices) of 11 factors and

---

15 The basic foundation of Bowen's study is:

$$t_{ij} = \sum_{k=1}^{l} b_{jk} R_{ik}$$

where t_{ij} = net exports of the jth good by nation i.
R_{ik} = level of resource k in nation i.
b_{jk} = coefficients which indicates the impact on net trade of the jth good due to the augmentation of the kth resource.

of 10 commodities' exports and imports for 59 countries. He found that the R^2's were relatively high, and concluded that the Hecksher-Ohlin explanation of trade is 'accurate'. The principle drawback of both the Baldwin and Hilton and the Bowen and Leamer studies is the sheer magnitude of data required. Moreover, by their nature as cross-country studies, they necessarily conceal those country-specific features which affect trade and (or) limit the applicability of the theory to that country.

2.5 Conclusion

Of the various methods described above, none stands out from the others in terms of theoretical consistency, tractability and usefulness. Each fails in terms of one or more of these criteria. The decision to undertake a regression study in this thesis was made largely on the basis of the latter two criteria and also because this method allows us to incorporate some features which are particular to less developed countries.

The data used here is drawn from the 1978 input-output table for Korea and will be discussed in more detail in the next chapter. For the moment, however, it can be noted that it includes data on the amount of self-employed labor within each industry. For the most part this labor is concentrated in agriculture and other activities within the traditional economy. As a result, in the context of a regression model it can act to control for the structural differences between the traditional and modern parts of Korea's economy. This is particularly important since it was not possible to use data drawn from the United States and Japanese input-output tables to estimate the input requirements of those goods which can not be produced in Korea. To some extent this variable can also be used to control for structural differences between Korea and her trading partners.

The issue of structural differences between economies can also be dealt with by the inclusion of an output variable in each of the regression models (15) and (18). This yields the expanded models

$$T_j = \sum_{i=1}^{n} C_{ij}\beta_i + \beta_o S_j \qquad (28)$$

$$(T/S)_j = \sum_{i=1}^{n} C_{ij}\beta_i + \beta_o S_j \qquad (29)$$

The intent of doing so is to capture the effects on productivity and (hence trade) of economies of scale which are internal to an industry but external to individual producers.

As stated in the introduction there are four primary issues to be dealt with in this thesis. We are now in a position to indicate how each will be addressed. First, Harkness' proposition will be tested by comparing the estimated factor intensity coefficients in (15), (18), (28) and (29) with the corresponding observed and estimated factor contents of trade. The merits of the latter as 'proxies' for Korea's relative factor abundance will be judged by comparing them to an ordering based on a priori expectations. Second, the advantage of Harkness' specification ((18) and (29)) relative to the more conventional specification ((15) and (28)) will be judged by comparing the explanatory power of the equations and by examining the extent to which the estimated coefficients match Korea's relative factor abundance. Third, the nature of Korea's comparative advantage and its effect on the commodity composition of her trade will be addressed by examining the estimated coefficients in all four equations. Fourth, the completeness of the theory will be judged by examining the statistical significance of the economies of scale coefficient and of the intercept which, at least to some extent, will capture the effect of omitted variables.

Chapter III

DESCRIPTION OF DATA AND RELATED METHODOLOGY

3.1 Introduction

In this chapter, the statistical data base and methodological procedure underlying the estimation of equations (15), (18), (28) and (29) will be described. In general, three sets of data are required: (i) an input-output table; (ii) data on the commodity composition of trade; (iii) data on the total factor cost shares.

Several decisions were made with respect to the scope and degree of disaggregation of the primary factors. Given the limited availability of data, substantial adjustments had to be made in terms of the ways in which natural resources, skilled labor and unskilled labor are measured. Thus, a thorough understanding of the underlying rationale for such decisions is important in order to interpret the results of the study correctly.

3.2 The data

The major sources of data were originally retrieved from two 1980 publications of the Research Department of the Bank of Korea; the 1978 Input-Output Tables and the Compilatory Reports on the 1978 Input-Output Tables. While the former contains the various transaction tables, input-output coefficients, and the inverse matrices, the latter consists of an outline of compiling tables and a general description of the structure of the Korean economy.

3.2.1 Labor data

The data on employment and actual output were obtained from the above two publications. The data are gathered from various sources such as the Annual Report on the Economically Active Population by the Economic Planning Board, Population Censuses by the Economic Planning Board, Yearbook of Agriculture and Forestry Statistics by the Ministry of Agriculture and Forestry, Reports on Mining and Manufacturing Surveys by the Economic Planning Board, Labor Statistics Yearbook by the Bureau of Labor.

3.2.2 Capital stock data

There are two sources of capital stock figures: Estimates of Korean Capital and Inventory Coefficients in 1968 by Kee-Chun Han, and Trade, Distortion and Employment by Wontack Hong. In this study, the 'Sectoral Fixed Capital Stock' and 'Sectoral direct Capital Coefficients' collected and estimated by Hong (1978) were used.

Other relevant data concerning trade, exports, and imports by country were compiled in the Foreign Statistics Yearbook by the Korean Trade Association, and the Economic Statistics Yearbook by the Bank of Korea. Other auxiliary references, when necessary, were obtained from the 1975 Input-Output Tables and the Compilatory Reports on 1975 Input-Output Tables, published by the Bank of Korea.

3.3 Input-Output Analysis

3.3.1 Leontief system

The structure of the Korean input-output model is based on the Leontief system[16] which reveals the flow of goods and services through a given economy. The system assumes (i) linear production activities, (ii) no joint products, (iii) no substitution among factors, and (iv) a one-to-one relation between commodities and industries. These assumptions establish an equation for the demand by each industry for each commodity as a function of its own level of output.

The Leontief model assumes constant proportions among inputs and the outputs of each industry. The input coefficients are expressed as $a_{ij} = x_{ij}/S_j$, with

$$x = (I-A)S \text{----------------------------} (30)$$

where S and x represent the nx1 vectors of total output and final demand, respectively, $A = (a_{ij})$ is the nxn matrix of intermediate goods input coefficients, and x_{ij} is the flow of goods from sector i to sector j. The value version of the input coefficients is $\bar{a}_{ij} = p_i a_{ij}/p_j$, and the Leontief inverse matrix in value is $(I-\bar{A})^{-1}$, where

---

16 Further references include Chenery (1959), Miernyk (1965), and Kogiku (1982).

$\bar{A} = (\bar{a}_{ij})$.

For the purpose of estimating the equations in the previous chapter, the total factor cost share matrix

$$C = F \cdot (I-\bar{A})^{-1} \text{ --------------(31)}$$

will be used, where F is the matrix of direct factor cost shares. In $C = (C_{ij})$, each entry C_{ij} denotes the value of the total amount of factor i necessary to produce W1 (or \$1) worth of net output of good j.

Because all magnitudes in (31) are measured in terms of value, the matrix C has some special properties: first, all elements are non-negative and, second, if the primary factors in F are the only sources of value-added, then the column sums of C are equal to one. This last point is the reason for the omission of an intercept term in the regression models of the previous chapter. In practice, however, value-added does have other sources (net taxes and capital depreciation) and, as a result, the computed factor total cost shares sum to less than one. To account for this, an intercept term will be included in the regression models in the next chapter.[17]

---

17 As noted in Chapter Two, this intercept can also serve to capture the effect of omitted variables.

3.3.2 An Outline of the Korean input-output structure.

The 1978 Korean input-output tables consist of two transaction tables: one table at consumer's prices and another at producer's prices. The former is valued at consumer's prices including the trade margins and transaction fees while the latter is valued at the price of shipments from producers. Both are 'commodity-by-commodity' tables showing the transaction of goods and services.

The sector classifications are based on the Korean Standard Classification as well as the International Standard Industrial Classification (ISIS) of the U.N.. The number of intermediate sectors (industries) is 392 which is aggregated into 162 sectors and further aggregated into 60 sectors. To achieve comparability with other data, it is the 60 sector version which is used here.

The value-added sector is composed of four components:[18] (i) the compensation of employees; (ii) other value-added; (iii) consumption of fixed capital; and (iv) net indirect taxes. The compensation of employees is the total of wages and salaries of employees including social insurance payments. The consumption of fixed capital covers regular depreciation of physical capital. The depreciation of roads and other public facilities of governments are not included. Net indirect taxes are calculated by subtracting subsidies from indirect taxes. Custom duties and commodity taxes on imported goods are excluded from these calculations. Other value-added includes interest and profit along with self-employed income and rents that might accrue to national resources.

---

[18] Each country's value-added sector differs. For instance, the value-added sector of the United States input-output table consists of only other value-added. The value-added sector of Canadian input-output table has four components; the compensation of employees, commodity taxes, subsidies, other subsidies on indirect taxes and surplus.

As such, other value-added includes the income that would accrue to a number of productive factors---capital, self-employed labor and natural resources. Similarly, the compensation of employees category combines the income for various types of labor. One of the principal tasks of this chapter is to outline the way in which additional data can be used, first, to decompose employee compensation into separate categories for skilled and unskilled labor and, second, to decompose other value-added into parts corresponding to capital income, self-employed income and the return to natural resources. Needless to say the resulting figures are only estimates of the true values. The details will be given in section 3.5.

The Korean Input-Output Tables contain a number of coefficients.[19] Among them, there are two sets of input coefficients and their inverses: (i) the competitive input coefficient matrix, A, which represents the average input coefficients including both domestically produced goods and competitive imports; and (ii) the domestic input coefficient matrix A^d which depicts the average input coefficients excluding the use of competitive imports.

Since our objective is to measure the total factor content of both imported and domestically produced goods it was decided to use the matrix A. However, since a range of imported goods are not produced in Korea, the total factor content of such non-competitive imports can not be properly assesed using any one of the Korean input-output tables. As noted earlier, Hong dealt with this problem by using Japanese and American input-output tables to estimate the factor content of non-competitive imports. Unfortunately, these tables and the information necessary to achieve a correspondence with the Korean tables were not available. As

---

19 The published input coefficients except A and A^d are Import Input Coefficients (A^{cm}), Competitive Import Input Coefficients (A^{cm}), and Complementary Inport Input Coefficients (A^{nm}).

a result, it was decided to use the matrix A as if applied to all imported goods. In effect, it is being assumed that the structure of the Korean economy is the same as that of its principal trading partners. The consequences of this, and the means of controlling for it, were discussed Chapter Two and will also be discussed in Chapter Four.

3.4 The Commodity composition of Trade

Gross imports and exports in the 60 sectors of the Industry Transaction Table at producer's prices (competitive imports model) appear in the first and second columns of Appendix A. The export sector covers exports of goods and non-factor services excluding the transactions on factor incomes---receipts of wages, interests, dividends, freight and insurance premiums on exports. Exports are valued at Free on Board (FOB) prices. Meanwhile, the import sector pertains to imports of goods and non-factor services from abroad. Imports are valued at Customs, Insurance and Freights (CIF) prices. Customs duties and import commodity taxes are separated from the import sector and recorded as separate entries.

The import figures shown in Appendix A represent the gross amount of competitive and non-competitive imports. Korean trade is characterized by numerous non-competitive natural resource products that are not produced in Korea. While, in 1978, 74% of total imports were regarded as competitive imports, the remaining 26% were classified as non-competitive imports.[20] Dividing the non-

---

[20] See the third and fourth columns of Appendix A. The significance of 'non-competitive natural resource imports' in Korean trade is comprehensively discussed by Hong (1976, Chapter 7, pp. 57-62).

competitive imports by their characteristics, about 80% of them were comprised of non-competitive natural resource imports.

Another feature is that Korean trade is dominated by the United States and Japan. During 1978, approximately 20% of all Korean exports were bound for Japan and 30% were bound for the United States. Furthermore, about 40% and 20%, respectively, of her total imports came from Japan and the United States.[21] Considering the structural differences between Korea and her trading partners, one may argue that a bilateral trade analysis would be much more suitable for an empirical study. As noted above, because of the lack of additional data for both countries' input coefficients, this study will be conducted using only Korean data.

The last column of Appendix A presents the 'proportionate net exports', (T_j/S_j), defined in equation (14). A negative sign of (T_j/S_j) implies the importation of the jth good. On close examination, four out of the 60 sectors not only show a negative sign for (T_j/S_j), but their absolute values exceed unity.[22] These sectors are natural resource-oriented sectors such as forestry, non-metallic minerals and basic organic chemicals. In each of these cases, net imports exceed domestic production.

---

21 See Appendix B.

22 Conceptually, 'proportionate net exports' should not exceed unity. However, as mentioned here, four sectors exhibit this irregularity. This phenomenon may be explained by the fact that they are mostly imported as intermediate products and eventually reexported to foreign countries.

3.5 The primary factors and their direct factor shares

3.5.1 Introduction

This section focuses on the measurement of the direct factor cost shares for primary factors, expressed as the matrix F in equation (31). The basic question is how many factors can be identified and incorporated into the model. The present study considers five primary factors: skilled labor, unskilled labor, self-employed labor, physical capital and natural resources. The computational methods for each of the primary factors will be discussed.

The principle issues are: first, how to decompose the total employed labor compensation into separate categories based on skilled differences; second, how to decompose other value-added into separate parts corresponding to the contributions of capital, self-employed labor, and natural resources. The first issue is dealt with in section 3.5.2 and the second in sections 3.5.3 and 3.5.4.

3.5.2 Skilled and unskilled labor shares

Generally, economists agree that labor is a heterogeneous factor. This implies that simply identifying labor with man-hours embodied in goods regardless of skill, would result in a gross misspecification. The distinct roles of skilled labor (human capital) and unskilled (raw) labor as determinants of commodity trade was recognized by Leontief, and later became a prime focus in the empirical estimation of the Hecksher-Ohlin model. Such a contention has been theoretically established by Schultz (1962) and Becker (1962) and confirmed empirically later by Keesing (1965, 1966), Baldwin (1971) and others.

There are two procedures for estimating skilled labor. The first procedure is to treat skilled labor as human capital. Assuming that each worker's skill results solely from his investment in human capital and that wages represent the return on that capital, wage rate differences will be positively associated with skill differences. Consequently, an industry whose labor force is largely composed of skilled labor will tend to pay higher wages than an industry using less-skilled labor. Like the return on other investment in capital goods, wage differentials can be calculated and capitalized at some appropriate discount rate,[23] to arrive at estimates of the stock of human capital.

Other studies such as Kenen (1965), Keesing (1966), Baldwin (1971) estimated various levels of skill according to various labor categories. Bowen's (1983) calculation was based on the following methods; (i) skilled labor is number of professional/technical workers; (ii) semi-skilled labor is measured by multiplying a country's literacy rate times the number of workers not classified as professional/ technical; (iii) unskilled labor is measured by multiplying one minus a country's literacy rate times the total number of workers.

---

[23] The stock of skilled labor (human capital) is usually calculated by:

$$SK_j = (\bar{w}-w_j)L_j/.10$$

where $\bar{w}$ is the average annual wage and w_j is the median annual wage for all workers with eight years or less of education for industry j, and L_j is the jth industry employment. Such a formula is found in Branson and Monoyios (1977), Stern and Maskus (1981) and Aw(1981).

The present study, on the other hand, applies a 'weighted wage differentials' method. At first glance, this procedure looks similar to the first method, but it differs from prior methods in that the shares of skilled and unskilled labor are weighted instead of being capitalized at a fixed discount rate.[24]

The input-output tables provide data on total employee compensation and the purpose of this procedure is to use wage differentials across sectors to divide that compensation into separate parts for skilled and unskilled labor. Specially, the estimated skilled labor share of industry j is given by

$$F_j^{sk} = \bar{w}_x \frac{(w_j - \bar{w}_m)\, L_j}{(\bar{w}_x - \bar{w}_m)\, S_j} \qquad \text{----------(32)}$$

The unskilled labor share of industry j is measured by

$$F_j^{usk} = \bar{w}_m \frac{(\bar{w}_x - w_j)\, L_j}{(\bar{w}_x - \bar{w}_m)\, S_j} \qquad \text{----------(33)}$$

where: $\bar{w}_m$: the economy-wide minimum wage earnings

$\bar{w}_x$: the economy-wide maximum wage earnings

w_j: the average annual wage earnings in industry j

L_j: the total employed labor of industry j

S_j: the value of net output of industry j

---

24 In order to compute the stock of skilled labor shown in previous footnote, we must have data on educational levels of all labor and wage rates. Because there are no data for the educational level of workers in Korea, the 'weighted wage differentials' method is used.

There are two points to note about (32) and (33). First, when added they yield;

$$F_j^{sk} + F_j^{usk} = w_j L_j / S_j$$

which is total labor compensation per unit value of output. As a result, these measures are consistent with the directly observed labor share data. Second, for the sector in which the highest wage is paid $F_j^{usk} = 0$ and F_j^{sk} equals the total employed labor share, whereas for the sector in which the lowest wage is paid $F_j^{sk} = 0$ and F_j^{usk} equals the total employed labor share. In effect, it is being assumed that in the highest wage sector all labor is skilled and that in the lowest wage sector all labor is unskilled. For sectors between these extremes (32) and (33) divide labor between skilled and unskilled using weights which depend on the proximity of the sector's wage to the two extremes.

The average annual wage earnings for the 60 sectors, w_j, is calculated by dividing the compensation of employees by the number of employees and appears in the last column of Appendix C where w_j ranges from W0.485 million per man-year for the textile fabric industry to W7.181 million per man-year for the petroleum industry. The wide dispersion of w_j among industries is not surprising since highly educated and skilled labor tends to be employed in the petroleum industry whereas unskilled labor is mostly found in the textile industries. The estimated skilled and unskilled labor shares for the 60 sectors are shown in the first and second columns of Appendix D.

3.5.3 Self-employed labor share

Trade economists have usually ignored the contribution of self-employed labor to production. In particular, for developing economies, self-employed labor in the traditional sectors is considered as 'disguised unemployment'. According to the 'Lewis-type' argument, this employment actually constitutes an 'unlimited supply of labor' whose marginal productivity is negligible.[25] The surplus of labor in the agricultural sector is a prime source of manufacturing sector's growth. Such an argument could explain the extensive labor migration over the last two decades in Korea. There is obvious evidence nevertheless against Lewis' argument. In Korea, other studies found that the change in farm income outpaced the change in income of industrial workers during the 1970's. Therefore, one cannot overlook the contribution of the self-employed to production. Moreover, in the present case, self-employed labor is being used to capture the effect of structural differences between Korea and her trading partners.

The principal difficulty in measuring the returns to self-employed labor lies in assessing its imputed price. In the present case the average annual wage earnings, w_j, are used as an approximation for the imputed wage rate of self-employed labor. Thus, the self-employed labor share is calculated as

$$F_j^{sml} = w_j \frac{SML_j}{S_j} \qquad (34)$$

25 See A. Lewis (1954) and G. Ranis and J. Fei (1961).

where SML_j is the amount of self-employed labor in the jth industry.[26] The estimates of F_j^{sml} appear in the third column of Appendix D.

3.5.4 The shares of physical capital and natural resources

After deducting the returns to self-employed labor, the remainder of other value-added in each sector represents the returns to physical capital and natural resources. To further divide the remainder into its component parts requires independent estimates of either the rent on natural resources or the return to capital. In the case of natural resources, it is reasonable to suppose that there is a negligible direct input into the manufacturing and service sectors.[27] Hence, for these sectors the remainder of other value-added is solely a return to capital.

In the case of the natural resources sectors (sectors 1-10) the 1975 capital stock estimates obtained by Hong (1978) are used in conjunction with his estimate of a 10% return on capital in agriculture to arrive at an estimate of the return to capital. The return to natural resources is then represented as the residual other value-added, after subtracting both self-employed earnings and the estimated returns to capital. The procedure just outlined is the one followed here and the resulting direct factor shares are given in the fourth and fifth columns of Appendix D.

---

26 See the third column of Appendix C.

27 Sectors 11-60 in the 60 sector input-output classification.

It should be pointed out that other estimates could be obtained even with the available data. For example, Hong's capital stock data could be used to estimate capital's share in all sectors with the residual in all sectors being attributed to natural resources. This method was in fact tried but the results corresponding to those reported in the next chapter, while qualitatively similar, did not offer as good as a fit to the trade data.

Any attempt to estimate capital's share and natural resources' share encounters several unavoidable difficulties. First, there are very few direct estimates of the natural resource content of production. Second, the capital markets in most developing countries are incomplete and subject to extensive interference from government policies promoting the growth of particular sectors. As a result, the sectoral rates of return on capital vary considerably and do not reflect the productive return on capital or its opportunity cost. Given these difficulties it is necessary to use approximate methods of the type described here.

3.6 Total factor cost shares

The calculation of total factor cost shares, in equation (31), is done by post-multiplying the Leontief inverse matrix, $(I-\bar{A})^{-1}$, with the direct factor cost share matrix F. The measured matrix C is often called the 'value-factor intensity' matrix as opposed to the 'physical factor intensity' matrix. Table 3.1 presents this matrix.

Table 3.1: Estimated Total Factor Cost Shares for Korea, 1978

no	sectors	SK	USK	SML	PK	NR
1	grain	.052	.071	.576	.083	.310
2	vegetables	.066	.045	.560	.095	.198
3	industrial crops	.116	.132	.487	.078	.197
4	livestock	.134	.084	.425	.155	.112
5	forestry	.103	.152	.430	.046	.243
6	fishery	.314	.109	.129	.165	.116
7	coal	.582	.118	.077	.139	.003
8	metallic ores	.304	.156	.053	.195	.108
9	non-metallic	.314	.157	.050	.124	.246
10	dairy	.155	.117	.309	.181	.140
11	seafoods	.306	.133	.173	.169	.078
12	grain polishing	.177	.248	.055	.414	.015
13	flours	.132	.123	.399	.266	.200
14	other foods	.151	.109	.252	.245	.112
15	beverage	.111	.072	.126	.216	.047
16	tobacco	.095	.067	.105	.185	.033
17	fibre	.169	.137	.176	.278	.064
18	textile fabrics	.186	.170	.116	.333	.044
19	fabricated textile	.133	.254	.127	.319	.038
20	leather	.208	.156	.156	.334	.055
21	lumber	.160	.153	.290	.174	.151
22	wood	.143	.253	.186	.249	.069
23	pulp	.246	.145	.093	.341	.034
24	printing	.301	.174	.084	.300	.022
25	organic chemicals	.234	.101	.073	.291	.091
26	inorganic chemicals	.252	.109	.004	.303	.097
27	fertilizers	.288	.105	.000	.296	.088
28	drugs	.260	.103	.099	.351	.031
29	resins	.225	.108	.082	.331	.054
30	other chemicals	.225	.120	.107	.341	.051
31	petroleum	.263	.119	.042	.185	.180
32	coal products	.467	.125	.070	.230	.009
33	rubber	.214	.166	.138	.271	.063
34	non-metallic mineral	.266	.131	.061	.307	.072
35	pig iron	.298	.105	.066	.321	.040
36	steel	.250	.103	.064	.363	.033
37	non-ferrous metal	.271	.114	.054	.362	.043
38	fabricated metal	.261	.124	.081	.340	.029
39	general machinery	.250	.130	.067	.384	.023
40	electronical machinery	.229	.112	.069	.325	.027
41	electronic comm.	.148	.193	.065	.354	.020
42	transportation equip.	.278	.121	.074	.349	.023

43	medical	.268	.169	.075	.329	.026
44	other manufacturing	.174	.195	.107	.363	.034
45	construction	.308	.136	.080	.304	.041
46	public work	.317	.145	.069	.311	.039
47	electric power	.250	.071	.051	.332	.071
48	water	.206	.113	.042	.406	.028
49	retail	.148	.086	.333	.394	.008
50	hotel	.103	.240	.136	.382	.012
51	transportation	.257	.126	.055	.333	.044
52	communication	.285	.074	.013	.369	.005
53	insurance	.335	.127	.031	.442	.006
54	real estate	.083	.050	.062	.586	.010
55	government	000	000	000	000	000
56	social services	.551	.132	.169	.100	.026
57	other services	.234	.147	.321	.159	.013
58	office supply	.243	.160	.137	.409	.030
59	business consumption	.135	.136	.179	.285	.050
60	unclassifiable	.171	.113	.201	.254	.102

***SK = skilled labor shares

***USK = unskilled labor shares

***SML = self-employed labor shares

***PK = physical capital shares

***NR = natural resource shares

Chapter IV

ANALYSIS OF EMPIRICAL RESULTS

4.1 Introduction

The purpose of this chapter is to present and analyze the results of applying the regression models outlined in Chapter Two. The data and the variable definitions are those described in the previous chapter. The nature of the models and their relation both to the factor proportions theory and to other empirical methods were discussed in Chapter Two.

To set the stage, the chapter opens with a brief review of Harkness' method and the proposed extensions to it. This is then followed by a presentation of the empirical results. The implications of the results and their limitations are discussed in the next section and summarized in the conclusion.

4.2 Some features of Harkness' model

There are several features which distinguish Harkness' model from other regression models. In contrast to most regression studies, which have used net trade as the dependent variable, Harkness scaled net trade by sectoral output.[28]

[28] Most previous regression studies used 'net trade' as the dependent variable: see Baldwin (1971), Branson and Monoyios (1977), Stern and Maskus (1981), and

Similarly, when representing trade in embodied factor services (the 'observed' and 'estimated' factor abundances) he choose to scale that trade by the domestic supply of the factor service.

While Harkness uses multivariate regression analysis, the estimated regression coefficients, $\hat{\beta}$, should not be regarded as 'structural' parameters. Instead, these parameters are to be viewed as 'descriptive' indicators whose meaning is dependent on their ranks and signs. The point of departure in the model is Harkness' proposition that if 'factor complementarities' are not severe, the estimated regression coefficients will indicate the ranks and signs of a country's relative factor abundances. In addition, the signs and rank orders obtained from the regression can be tested to compare them with those inferred from two alternative measurements, via equations (23) and (24). Since his model is not structurally related to the theory, his interpretation can also be applied to the alternate descriptive model with unscaled measures of net trade in goods and embodied factor services.

The 'observed' and 'estimated' factor abundances do not necessarily imply that the 'true' factor abundance ranking can be measured. A country's relative factor abundance ranking is not determinate unless world factor input data are available. In this regard, the 'observed' and 'estimated' relative factor abundances, represent 'effective' proxies for the true factor abundances. As such they are subject to error and since they are in fact based on measures of the factor content of Korean trade, the previous factor content studies can be used to assess their reliability.

Maskus (1983). Some studies used a normalized form as the dependent variable: see Baldwin (1971), Harkness (1978), Bowen (1983). Leamer (1984) used exports and imports separately as the dependent variables. Theoretically, the relationship between endowments (factor supplies) and factor contents predicted by the Hecksher-Ohlin-Vanek theorem is for net factor services.

4.3 The empirical results

The regression results are reported in Table 4.1. In the first two equations, the dependent variable is net exports per unit of output whereas, in the last two, it is simply net exports. In all instances the F statistic is significant at 99% except equation 3, indicating that the equations do explain Korea's trade. The R^2's, while less than those obtained by Harkness (1978) for his 17 factor model, are as large or larger than those obtained in other regression models with a small number of variables.[29] The t-statistics and their significance are reported, however, as noted above they are not central to much of the interpretation of the equations. In many instances, what is important is the relationship between the sign and rank of the coefficients and Korea's relative abundance in the factors as determined by the 'observed' and 'estimated' factor abundances.

Table 4.2 presents the values of Z°, EZ° and $\bar{Z}^{\circ}(=\bar{E}\bar{Z}^{\circ})$ for the corresponding equations. The = and ≥ signify that the signs are the same as or different from the corresponding coefficients in Table 4.1.

Finally, Table 4.3 presents the rankings of the regression coefficients, and of the 'observed' and 'estimated' relative factor abundance for each equation. The coefficients of rank correlation with the coefficient estimates are reported at the bottom of the factor abundance columns.

---

29 See, for example, Baldwin (1971, 1979), Stern and Maskus (1981) and Aw(1981).

Table 4.1: Regression Estimates (OLS)

	equation 1	equation 2	equation 3	equation 4
dependent variable	T/S	T/S	T	T
intercept	.1384 (.1366)	-.2003 (-.2017)	1.7796 (.3732)	-.5080 (-.1152)
skilled labor	-.9140 (-.6174)	-.3065 (-.2096)	-6.8689 (-.9863)	-2.7661 (-.4260)
unskilled labor	.1083 (.0454)	1.0839 (.4603)	20.1334 (1.7950)[b]	26.7217 (2.5555)[a]
self-employed labor	3.5369 (2.6769)[a]	3.4846 (2.7322)[a]	6.0422 (.9721)	5.6886 (1.0044)
physical capital	.2949 (.1545)	-.1698 (-.0925)	-6.3479 (-.7160)	-9.4856 (-1.1645)
natural resources	-9.3297 (-3.9772)[a]	-9.8804 (-4.3308)[a]	-30.2393 (-2.7399)[a]	-33.9560 (-3.3516)[a]
output	------	.0000 (1.9498)[b]	------	.0001 (2.9650)[a]
R^2	.379	.453	.270	.410
$\bar{R}^2$	.317	.365	.174	.314
F	5.01[a]	5.11[a]	2.81[b]	4.29[a]

*** T/S = proportionate net exports.

*** T = net exports (unit = ₩100,000).

*** a and b indicate 99% and 95% confidence level, respectively.

*** t-ratios are recorded in parentheses.

*** the number of observations is 44 sectors.

Table 4.2: Relative Factor Abundance Proxies

	equation 1		equation 2		equation 3	equation 4
dependent variable	T/S		T/S		T	T
	Z°	EZ°	Z°	EZ°	$\tilde{Z}^\circ = E\tilde{Z}^\circ$	$\tilde{Z}^\circ = E\tilde{Z}^\circ$
skilled labor	-.068	-.212	-.068	-.090	-.433	-.433
	(=)	(=)	(=)	(=)	(=)	(=)
unskilled labor	.013	-.135	.013	.016	.054	.054
	(=)	(≥)	(=)	(=)	(=)	(=)
self-employed labor	-.036	-.181	-.036	-.008	-.215	-.215
	(≥)	(≥)	(≥)	(≥)	(≥)	(≥)
physical capital	-.006	-.106	-.006	.028	-.052	-.052
	(≥)	(≥)	(=)	(≥)	(=)	(=)
natural resources	-.132	-.431	-.138	-.237	-.417	-.417
	(=)	(=)	(=)	(=)	(=)	(=)
number of sign changes	2	3	1	2	1	1

Table 4.3: Relative Factor Abundance Rankings

	equation 1			equation 2			equation 3		equation 4	
	$\hat{\beta}$	Z°	EZ°	$\hat{\beta}$	Z°	EZ°	$\hat{\beta}$	$\bar{Z}$° ($\bar{E}\bar{Z}$)	$\hat{\beta}$	$\bar{Z}$° ($\bar{E}\bar{Z}$)
skilled labor	4	4	4	4	4	4	4	5	3	5
unskilled labor	3	1	2	2	1	1	1	1	1	1
self-employed labor	1	3	3	1	3	3	2	3	2	3
physical capital	2	2	1	3	2	2	3	2	4	2
natural resources	5	5	5	5	5	5	5	4	5	4
rank correlation		.8[a]	.7[b]		.7[b]	.7[b]		.8[a]		.5

*** a and b denote 95% and 90% statistical significance, respectively.

*** the coefficient of rank correlation is based on Spearman's rho which is calculated by $\rho = 1-6\sum(|r(x_i)-r(y_i)|)/n(n^2-1)$, where $r(x_i)$ and $r(y_i)$ are the rank of x_i and y_i, and n is the number of observations.

4.4 Interpretation

The interpretation of the results focuses on the four primary issues raised in the introduction and discussed at the end of Chapter Two: (i) Harkness' conjecture that the estimated regression coefficients will have the same sign and rank as the corresponding 'observed' and 'estimated' factor abundances; (ii) the relative merits of Harkness' specification in equations 1 and 2 and the alternate specification in equations 3 and 4; (iii) the evidence concerning the nature of Korea's comparative advantage; and (iv) the completeness of the factor proportions explanation of Korea's trade.

4.4.1 Harkness' conjecture

On the face of it, the evidence concerning Harkness' conjecture is mixed at best. From Table 4.3, only one of the rank correlations is statistically significant at 95%. Moreover, in Table 4.2, equation 1 has a relatively large number of sign reversals between the estimated coefficients and the 'observed' and 'estimated' factor abundances. This issue to be addressed now is whether this indicates a failure of Harkness' interpretation or a failure in the proxies used for relative factor abundance.

When looked at as a whole, what is perhaps most notable about the results reported in Table 4.1 and 4.2 are the evident anomalies between the 'observed' and 'estimated' factor abundances on the one hand and, what would have been expected *a priori.* Korea is dramatically resource scarce and when compared with her principal trading partners (Japan and the United States), she is clearly relatively most abundant in unskilled labor and self-employed labor, with capital and skilled labor lying between these extremes. Each of the 'observed' and 'estimated' relative factor abundance orderings violates at least two of these presumptions and, as a result, little credibility can be given to them as proxies for the true relative factor abundance. By way of contrast, the signs and ranking of the coefficients in equations 2, 3 and 4 conform to this loose ordering in all respects and equation 1 violates it only with respect to the relative ranking of the capital and unskilled labor coefficients. The consequence is that Harkness' interpretation of the regression coefficients is strongly supported but his choice of proxies is not.

In Chapter Three it was noted that, since the input-output tables for Japan and the United States were not available, all imports, including those designated as non-competitive, were being treated as if they could be produced using the same methods as used in Korea. This clearly is not the case and the anomalies in the 'estimated' and 'observed' factor abundances can be attributed to the failure to use the actual foreign factor content of non-competitive imports when calculating the relative factor abundances. This conclusion is supported by the fact that both Hong and Lim also obtained anomalous results when estimating the factor content of Korea's trade before correcting for structural differences.

This raises the further question of why the regression coefficients do not appear to have been affected. The answer lies in the nature of regression models in general and the role of the self-employed labor variable in particular. In the context of the regression models that variable captures some of the effect of structural differences between the modern and traditional components of the economy and through its interaction with the other variables it can act to control for the effects of such differences.

What this suggests is that, within the confines of the data used here, the regression models have distinct advantage when applying the factor proportions theory. It also indicates the need for further work especially in the measurement of the factor intensities of non-competitive imports.

4.4.2 Alternate specifications

The comparison of Harkness' specification in equations 1 and 2 with the alternate specification in 3 and 4 again involves mixed evidence. As just noted, equation 3 conforms least to the a priori factor abundance ranking. On the other hand, the R^2 and F values for both of the Harkness equations exceed those for the corresponding alternate equations. Since the coefficients of neither set of equations are structurally related to the theory, the inconclusiveness of the results in this respect is not surprising.

4.4.3 Korea's comparative advantage

If it is accepted that the regressions in Table 4.1 do in fact control for structural differences and for factor complementarities then, taken as a whole, they provide a remarkably consistent depiction of Korea's comparative advantage. As indicated by the signs of the coefficients, her comparative disadvantage lies in resource and skilled labor intensive goods and her comparative advantage lies in goods which use unskilled labor and self-employed labor relatively intensively. Moreover, in all but the first equation the results indicate that she has a comparative disadvantage in capital intensive goods.

4.4.4 The completeness of the factor proportions explanation

In this respect, there are two matters to be examined; the intercept coefficient which may capture the effect of omitted variables and the coefficient of output in equations 2 and 4. Once again the evidence is mixed. In all four equations the intercept variable is not statistically significant and although the output variable is statistically significant in both equations, the size of the coefficient is small.[30] Nevertheless, this does provide some indication that other considerations should be taken into account.

4.5 Conclusion

The thrust of the preceding argument is that, despite the lack of a clear structural linkage to the theory, the regression models do yield results which are consistent with the theory. Moreover, with incomplete data, they appear to be more consistent with the theory than the attempts to measure the factor content of trade. In addition, although the results are largely consistent with Harkness'

[30] The zero coefficient in equation 2 is due to the regression program which reports coefficients only to four decimal places.

interpretation of trade regression models, they do not provide evidence for the superiority of his particular specification. The results also provide weak evidence for the role of explanations other than the factor proportions theory.

Perhaps the most important conclusion is that to properly understand the international trade of developing economies such as Korea, it is necessary to recognize their structural differences and to incorporate those differences into any empirical analysis.

BIBLIOGRAPHY

Aw, Ben-Y. "An Empirical Test of the Hecksher-Ohlin Theorem using ASEAN Data", Malayan Economic Review, vol. 71, 1981, pp. 25-38.

Aw, Ben-Y. "The Interrelation of Cross-section Regression Tests of the Hecksher-Ohlin Theorem with Many Goods and Factors", Journal of International Economics, vol. 14, 1983, pp. 163-167.

Anderson, James E. "Cross-Section Test of the Hecksher-Ohlin Theorem: Comment", American Economic Review, vol. 71, 1981, pp. 1037-1039.

Balassa, Bela "The Changing Pattern of Comparative Advantage in Manufactured Goods", Review of Economics and Statistics, vol. 61, 1979, pp. 259-266.

Baldwin, Robert E. "Determinants of Commodity Structure of U.S. Trade", American Economic Review, vol. 61, 1971, pp. 126-146.

Baldwin, Robert E. "Determinants of Trade and Foreign Investment: Further Evidence", Review of Economics and Statistics, vol. 61, 1979, pp. 40-48.

Baldwin, Robert E. and Hilton, S. R. "A Technique for Indicating Comparative Costs and Predicting Changes in Trade Ratios", Review of Economics and Statistics, vol. 66, 1984, pp. 105-110.

Baum, Christopher F. and Coe, D. T. "A Logit Analysis of the Factor Content of West German Foreign Trade", Weltwirtschaftlishes Achiev., vol. 114, 1978, pp. 328-337.

Becker, Gary "Investment in Human Capital: A Theoretical Analysis", The Journal of Political Economy, vol.70, 1962, pp. 8-44.

Bertrand, Trent J. "An Extension of the N-Factor Case of Factor Proportions Theory", Kyklos, vol. 32, 1972, pp. 592-596.

Bhagwati, Jagdish N. "The Pure Theory of International Trade: A Survey", Economic Journal, vol. 74, 1964, pp. 1-84.

Bhagwati, Jagdish N. "The Heckshner-Ohlin Theorem in the Multi- Commodity Case", Journal of Political Economy, vol. 80, 1972, pp. 1052-1055.

Bhagwati, Jagdish N. (ed.) International Trade: Selected Readings, Cambridge MA: M.I.T. Press, 1982.

Bhagwati, Jagdish N. Lectures on International Trade, Cambridge MA: M.I.T. Press, 1983.

Bharadwaj, R. "Factor Proportions and the Structure of Indo-U.S. Trade", The Indian Economic Journal, vol. 10, 1962, pp. 105-116.

Bowen, Harry P. "On the Theoretical Interpretation of Indices of Trade Intensity and Revealed Comparative Advantage", Weltwirtschaftlishes Achiev., vol. 119, 1983, pp. 464-472.

Bowen, Harry P. "Changes in the International Distribution of Resources and their Impact on U.S. Comparative Advantage", Review of Economics and Statistics, vol. 63, 1983, pp. 402-414.

Brecher, Richard E. "Minimum wage rates and the pure theory of international trade", Quarterly Journal of Economics, vol. 88, 1974, pp. 88-116.

Brecher, Richard E. and Choudhri, E. U. "The Leontief Paradox, Continued", Journal of International Economics, vol. 12, 1982, pp. 820-823.

Brecher, Richard E. and Choudhri, E. U. "The Factor Content of International Trade Without Factor Price Equalization", Journal of Political Economy, vol. 12, 1982, pp. 277-283.

Brecher, Richard E. and Choudhri, E. U. "New Products and the Factor-Content of International Trade", Journal of Political Economy, vol. 92, 1984, pp. 965-971,

Branson, William H. and Monoyios, N. "Factor Inputs in U.S. Trade", Journal of International Economics, vol. 7, 1977, pp.111-131.

Caves, Richard E. and Jones, R. W. World Trade and Payments, (3rd ed.), Boston: Little Brown, 1981.

Chang, Winston W. "Some Theorems of Trade and General Equilibrium with Many Goods and Factors", Econometrica, vol. 47, 1979, pp. 709-726.

Chenery, Hollis B. Interindustry Economics, New York: John Wiley & Sons Inc., 1959.

Chipman, John S. "A Survey of the Theory of International Trade", Econometrica, vol. 33, 1965, pp. 477-519; vol. 33, 1965, pp. 685-760; vol. 34, 1966, pp. 18-76.

Clifton, David S. and Marxsen, W. B. "An Empirical Investigation of the Hecksher-Ohlin Theorem", Canadian Journal of Economics, vol. 17, 1984, pp. 32-38.

Deardorff, Alan V. "The General Validity of the Law of Comparative Advantage", Journal of Political Economy, vol. 88, 1980, pp. 941-957.

Deardorff, Alan V. "The General Validity of the Hecksher-Ohlin Theorem", American Economic Review, vol. 72, 1982, pp. 683-694.

Deardorff, Alan V. "Testing Trade Theories and Predicting Trade Flows", in Jones, R. and Kenen, P. (ed.) Handbook of International Economics, Amsterdam: North-Holland, 1984.

Dixit, Avinash and Norman, V. Theory of International Trade, Digwell Place:Cambridge Univ. Press, 1980.

Dixit, Avinash and Woodland, A. "The Relationship between Factor Endowments and Commodity Trade", Journal of International Trade, vol. 13, 1982, pp. 201-214.

Ethier, Wilfred J. "Some of the Theorems of International Trade with many Goods and Factors", Journal of International Economics, vol. 4, 1974, pp. 199-206.

Ethier, Wilfred J. Higher Dimensional Issues in Trade Theory, Institute of International Economic Studies, Univ. of Stockolm: Seminar Paper No. 218, 1982.

Ethier, Wilfred J. Modern International Economics, New York: W.W. Norton, 1983.

Ferguson, Donald G. "International Capital Mobility and Comparative Advantage", Journal of International Economics, vol. 8, 1978, pp. 373-396.

Ferguson, Donald G. "Protection, Real Incomes and Aggregate Factor Substitution", 1983, mimeographed.

Findlay, Ronald. Trade and Specialization, New York:Penguin, 1978.

Hamilton, Cal and Svensson, E. O. "Should Direct or Total Factor Intensities be Used in Tests of the Factor Proportions Hypothesis?', Weltwirtschaftlishes Achiev., vol. 119, 1983, pp. 454-462.

Han, Kee-Chun Estimates of Korean Capital and Inventory Coefficients in 1968, Seoul:Yonsei Univ., 1970.

Harkness, Jon F. "Factor Abundance and Comparative Advantage: A Theoretic and Empirical Analysis", McMaster University Discussion Paper: 77-06, 1977.

Harkness, Jon F. "Factor Abundance and Comparative Advantage", American Economic Review, vol. 68, 1978, pp. 784-800.

Harkness, Jon F. "Cross-Section Tests of the Hecksher-Ohlin Theorem: Reply", American Economic Review, vol. 71, 1981, pp. 1044-1048.

Harkness, Jon F. "The Factor Proportions Model with Many Nations, Goods and Factors: Theory and Evidence", Review of Economics and Statistics, vol. 65, 1983, pp. 298-305.

Harkness, Jon F. and Kyle, J.F. "Factor Influencing United States Comparative Advantage", Journal of International Economics, vol. 5, 1975, pp. 153-165.

Helpman, Elhanan "The Factor Content of Foreign Trade", The Economic Journal, vol. 94, 1984, pp. 84-93.

Harris, John R. and Todaro, M. P. "Migration, unemployment and development: A two-sector analysis.", American Economic Review, vol. 60, 1970, pp. 126-142.

Helpman, Elhanan and Krugman, P.R. Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy, Cambridge: M.I.T. Press, 1985.

Hillman, Arye L. and Hirsh, S. "Factor Intensity Reversals: Conceptual Experiments with Traded Goods Aggregated", Weltwirtschaftlishes Achiev., vol. 115, 1980, pp. 272-281.

Hilton, Spencer R. "Commodity Trade and Relative Returns to Factors of Production", Journal of International Economics, vol. 16, 1984, pp. 259-270.

Hong, Wontack "Skill Intensity of Trade: The Case of Korea (1962-71)", The Development Economics, vol. 6, 1974, pp. 274-280.

Hong, Wontack "Distortions and Static Negative Marginal Gains from Trade", Journal of International Economics, vol. 6, 1976, pp. 299-308.

Hong, Wontack Factor Supply and Factor Intensity of Trade in Korea, Seoul:Korea Development Institutes, 1976.

Hong, Wontack Trade, Distortions and Employment, Seoul:Korea Development Institutes, 1978.

Horiba, Y. "A Note on the Factor-Proportions Theory in the N-Factor Case", Kyklos, vol. 24, 1971, pp. 339-343.

Hufbauer, G. C. "The Impact of National Characteristics and Technology on the Commodity Composition of Trade in Manufactured Goods", in Vernon, R. (ed.) The Technology Factor in International Trade, New York: Columbia Univ. Press, 1970, pp. 145-231.

Inada, Ken-ichi "A Note on the Hecksher-Ohlin Theorem", The Economic Record, vol. 43, 1967, pp. 270-280.

Johnson, Harry G. "Factor Endowments, International Trade and Factor Prices", The Manchester School of Economic and Social Studies, vol. 25, 1957, pp. 270-280.

Jones, Ronald W. "Factor Proportions and the Hecksher-Ohlin Theorem", Review of Economic Studies, vol. 24, 1957, pp. 270-280.

Jones, Ronald W. "Distortions in factor markets and the general equilibrium model of production", Journal of Political Economy, vol.79, 1971, pp. 437-459.

Jones, Ronald W. "The Small Country in a Many-Commodity World", Austrian Economic Papers, vol. 13, 1974, pp. 225-236.

Jones, Ronald W. "'Two-ness' in the Trade Theory: Costs and Benefits", Princeton Univ. Special Paper No. 12, 1977.

Jones, Ronald W. and Scheinkman, L.A. "The Relevance of the Two-Sector Production Model in Trade Theory", Journal of Political Economy, vol. 85, 1977, pp. 909-935.

Katz, Amoz "Comments on the Definition of Homogeneous and Homothetic Functions", Journal of Economic Theory, vol. 2, 1970, pp. 310-313.

Keesing, Donald B. "Labor Skills and International Trade: Evaluating Many Trade Flows with a Single Measuring Device", Review of Economics and Statistics, vol. 47, 1965, pp. 287-293.

Keesing, Donald B. "Labor Skills and Comparative Advantage", American Economic Review, vol. 56, 1966, pp. 249-255.

Kemp, Murray (ed.) Three Topic in the Theory of International Trade, New York: North-Holland, 1976.

Kenen, Peter B. "Nature, Capital and Trade", Journal of Political Economy, vol. 73, 1965, pp. 437-460.

Kmenta, J. Elements of Econometrics, New York:MacMillan Pub. Co., 1971.

Kogiku, K.C. Microeconomic Models, Florida: Robert E. Krieger Co., 1982.

Krueger, Anne O. Trade and Employment in Developing Countries, vol.I, II and III. Chicago: Univ. of Chicago, 1981, 1982, 1983.

Lary, H.B. Imports and Labor-Intensive Manufactures from Less Developed Countries, New York: National Bureau of Economic Research, 1968.

Leamer, Edward E. "The Commodity Composition of International Trade in Manufactures: An Empirical Analysis", Oxford Economic Papers, vol. 26, 1974, pp. 350-374.

Leamer, Edward E. "The Leontief Paradox, Reconsidered", Journal of Political Economy, vol. 88, 1980, pp. 495-503.

Leamer, Edward E. Sources of International Comparative Advantage: Theory and Evidence", Cambridge: M.I.T. Press, 1984.

Leamer, Edward E. and Bowen, H.P. "Cross-Section Tests of Hecksher-Ohlin Theorem: Comment", American Economic Review, vol. 71, 1981, pp. 1040-1044.

Leontief, Wassily W. "Domestic Production and Foreign Trade: The American Capital Position Re-Examined", Proceeding of the American Philosophical Society, vol. 97, 1953, pp. 332-349.

Leontief, Wassily W. "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis", Review of Economics and Statistics, vol. 38, 1956, pp. 386-402.

Leontief, Wassily W. "Theoretical Assumptions: Non-Observed Facts", American Economic Review, vol. 71, 1971, pp. 1-7.

Lewis, A. "Economic Development with Unlimited Supplies of Labor", The Manchester School of Economic and Social Studies, vol. 22, 1954, pp. 139-191.

Lim, Youngil "Capital, Labor and Skill Contents of Trade: South Korea", Southern Journal of Economics, vol. 42, 1976, pp. 416-423.

Maddigan, R. "The Measurement of Vertical Integration", Review of Economics and Statistics, vol. 63, 1981, pp. 328-335.

Magee, Stephen P. International Trade and Distortions in Factor Markets, New York:Marcel Decker, 1976.

Maskus, Keith E. "Evidence on Shift in Determinants of the Structure of U.S. Manufacturing Foreign Trade: 1958-1976", Review of Economics and Statistics, vol. 65, 1983, pp. 415-422.

Melvin, James R. "Production and Trade with Two Factors and Three Goods", American Economic Review, vol. 58, 1968, pp. 1248-1268.

Melvin, James R. "Empirical Tests of the Pure Theory of International Trade:Some Methodological Questions", Univ. of Western Ontario, 1983, mimeographed.

Miernyk, William H. The Elements of Input-Output Analysis, New York: Random House, 1965.

Minabe, Nobuo "The Stolper-Samuelson Theorem, The Rybczynski Effect, and the Hecksher-Ohlin Theory of Trade Pattern and Factor Price Equalization: The Case of Many-Commodity, Many-Factor, Country", Canadian Journal of Economics, vol. 33, 1967, pp. 401-419.

Minhas, B.S. "The Homophyballagic Production Function, Factor Intensity Reversals and the Hecksher-Ohlin Theorem", Journal of Political Economy, vol. 62, 1962, pp. 138-156.

Morrison, D.F. Multivariate Statistical Methods, New York: McGrow-Hill, 1967.

Mundell, Robert A. "International Trade and Factor Mobility" American Economic Review, vol. 47, 1957, pp. 321-335.

Pindyk, Robert S. and Rubinfeld, D. Econometric Models and Economic Forecasts, New York: McGrow-Hill, 1981.

Postner, Harry H. Factor Content of Canadian International Trade: An Input-Output Analysis, Ottawa:Economic Council of Canada, 1975.

Ranis, G. and Fei, J. "A Theory of Economic Development", American Economic Review, 1961, pp. 533-565.

Roskamp, K.Y. "Factor Proportions and Foreign Trade: The Case of West Germany", Weltwirtschaftlishes Achiev., vol. 91. 1963, pp. 319-326.

Ruffin, Roy J. "A Note on the Hecksher-Ohlin Theorem", Journal of International Economics, vol. 7, 1977, pp. 403-405.

Rybczynski, T. M. "Factor Endowment and Relative Commodity Prices", Economica, vol. 22, 1955, pp. 336-341

Samuelson, Paul M. "International Factor Price Equalization Once Again", Economic Journal, vol. 49, 1949, pp. 181-197.

Samuelson, Paul M. "Prices of Factors and Goods in General Equilibrium", Review of Economic Studies, vol. 21, 1953, pp. 1-20.

Sato, Ryzo and Tetsunori, K. "The Production Function and the Theory of Distributive Shares", American Economic Review, vol. 63, 1973, pp. 484-489.

Schultz, T. "Reflection on Investment in Man", The Journal of Political Economy, vol. 70, 1962, pp. 1-8.

Silberberg, Eugene The Structure of Economics, New York: McGrow-Hill, 1978.

Stern, Robert M. "Testing Trade Theories". in Kenen, P.E. (ed.), International Trade and Finance: Frontiers for Research, New York: Cambridge Univ. Press, 1975.

Stern, Robert M. "Some Evidence on the Factor Content of West Germany's Foreign Trade", Journal of Political Economy, vol. 84, 1976. pp. 131-141.

Stern, Robert M. and Maskus, K.E. "Determinants of the Structure of U.S. Foreign Trade, 1958-76", Journal of International Economics, vol. 2, 1981, pp. 207-224.

Stigler, George J. Capital and Rates of Return in Manufacturing Industries, New Jersey: Princeton Univ. Press, 1963.

Takayama, Akira International Trade, New York: Holt, R. & W., 1972.

Tatemoto, M. and Ichimura, S. "Factor Proportions and Foreign Trade: The Case of Japan", Review of Economics and Statistics, vol. 41, 1959, pp. 442-446.

The Bank of Korea, 1975 Input-Output Tables (I), 1978.

The Bank of Korea, 1975 Input-Output Table (II), 1978.

The Bank of Korea, Compilatory Report on '75 Input-Output Tables, 1978.

The Bank of Korea, 1978 Input-Output Tables (I), 1980

The Bank of Korea, 1978 Input-Output Tables (II), 1980.

The Bank of Korea, Compilatory Report on '78 Input-Output Tables, 1980.

The Bank of Korea, Economic Statistic Yearbook, 1981.

The Korean Traders Association, Foreign Trade Statistics, 1981.

Travis, William P. The Theory of Trade and Protection, MA: Cambridge, 1964.

Vanek, Jaroslov The Natural Content of United States Trade, 1870-1955", MA: Cambridge, 1964.

Vanek, Jaroslov "The Factor-Proportions Theory: The N- Factor Case", Kyklos, vol. 21, 1968, pp. 749-759.

Wahl, D. "Capital and Labor Requirements for Canada's Foreign Trade", Canadian Journal of Economics, vol. 27, 1961, pp. 349-358.

Williams, James R. "The Resource Content in International Trade", Canadian Journal of Economics, vol. 10, 1970, pp. 111-122.

Woodland, Allan D. International Trade and Resource Allocation, Amsterdam: North-Holland, 1982.

Appendix A

COMMODITY COMPOSITION OF TRADE FOR KOREA, 1978

no	sectors	EX	IM	COIM	NCIM	NEX
1	grain	9155	266358	266358	0	-.089
2	vegetables	8118	13407	12037	1370	-.003
3	industrial crops	79062	55648	28208	227440	.076
4	livestock	5643	46454	17555	28898	-.046
5	forestry	22588	376167	78802	297374	-1.073
6	fishery	201986	13452	13452	0	.253
7	coal	16	9857	7542	2314	-.045
8	metallic ores	14255	47398	46911	496	-.725
9	non-metallic	25485	1113853	19773	1095079	-4.481
10	dairy	47143	159401	159401	0	-.156
11	seafoods	105513	9773	9773	0	.443
12	grain polishing	0	0	0	0	-
13	flours	59	1688	1688	0	-.010
14	other foods	29557	147807	40107	107699	-.107
15	beverage	14764	12392	12392	0	.002
16	tobacco	332	73	73	0	-.001
17	fibre	176602	35704	22079	13624	.119
18	textile fabrics	396570	111917	111917	0	.237
19	fabricated text.	1164229	33415	33415	0	.584
20	leather	273713	92434	82949	9484	.349
21	lumber	210655	4293	4293	0	.367
22	wood	28662	2814	2814	0	.242
23	pulp	22391	110197	54905	55291	-.188
24	printing	7724	9617	9617	0	-.008
25	organic chemicals	33424	309693	233292	76401	-1.087
26	inorganic chemicals	8755	55306	43867	11439	-.190
27	fertilizers	76602	13791	12495	1295	.206
28	drugs	10812	28553	23003	5549	-.038
29	resins	78823	223098	208518	14579	-.146
30	other chemicals	9647	127221	115232	12088	-.324
31	petroleum	82742	222188	218628	3560	-.086
32	coal products	4377	61005	59286	1719	-.201
33	rubber	269908	8790	8790	0	.476
34	non-metallic min.	117343	52692	52692	0	.081

35	pig iron	5125	145495	145495	0	-.210
36	steel	273850	449988	449988	0	-.141
37	non-ferrous metal	27490	181962	181554	407	-.668
38	fabricated metal	264118	56548	56548	0	.326
39	general machinery	64779	1213067	1104630	19446	-1.766
40	electronical machi.	83893	249624	249212	412	-.213
41	electronic comm.	572816	449175	447429	745	.104
42	transportation equip.	474199	531061	441258	89812	-.042
43	medical	82182	139325	136723	1602	-.252
44	other manufact.	369689	46288	46113	175	.573
45	construction	0	3018	3018	0	-.001
46	public work	10331	0	0	0	.007
47	electric power	3295	1915	1915	0	.002
48	water	64	281	281	0	-.004
49	retail	439705	25380	25380	0	.098
50	hotel	61202	13975	13975	0	.069
51	transportation	681938	117439	117439	0	.231
52	communication	24709	18596	18596	0	.018
53	insurance	40982	35124	35124	0	.006
54	real estate	2275	852	852	0	.001
55	government	000	000	000	0	-
56	social services	57	1259	1259	0	-.001
57	other services	4862	5669	5669	0	-.001
58	office supply	534	62	62	0	.010
59	business consumption	5310	23921	23821	0	-.023
60	unclassifiable	84378	109585	109585	0	-.121
	total	7703998	7793998	5715597	2077301	

***EX = exports

***IM = imports

***COIM = competitive imports

***NCIM = non-competitive imports

***NEX = proportionate net exports

***unit = W million

***all the data EX, IM, COIM and NCIM were obtained from '78 Input-Output Tables, pp. 24, 47 and 55, The Bank of Korea, 1980.

***proportionate net exports (NEX) is measured by (EX-IM)/OUT, where OUT is sectoral output levels

***IM = COIM + NCIM

Appendix B

EXPORTS AND IMPORTS BY MAJOR TRADING COUNTRIES, 1978

countries	exports	imports
Japan	5232014	5981487
Saudi Arabia	717031	1280673
Hong Kong	384686	50601
Taiwan	103182	152619
Singapore	98442	61225
Kuwait	248463	746533
West Germany	662884	490905
United Kingdom	393027	211497
France	59187	442377
Netherlands	307287	46954
Italy	117840	442377
United States	4058343	3042950
Canada	327173	204033
Others	496998	759282
total	12710642	14971930

***sources: Economic Statistic Yearbook, The Bank of Korea, pp. 208-211, 1981.

***unit = in thousand U.S. dollars

Appendix C

LABOR AND CAPITAL DATA

no	sectors	EMP	COEMP	SELEMP	CAP	WAG
1	grain	182090	121100	2077470	1098567	.665
2	vegetables	77330	77257	737340	756600	.999
3	industrial crops	68260	62223	167580	167580	.765
4	livestock	60390	80398	142926	423100	1.331
5	forestry	95440	71789	174150	58534	.752
6	fishery	115100	208645	32990	440608	1.812
7	coal	49500	126832	90	114493	2.562
8	metallic ores	11490	14149	140	25721	1.231
9	non-metallic	70750	91981	2410	95025	1.300
10	dairy	71650	59492	8740	162515	.830
11	seafoods	23230	27762	8920	84535	1.195
12	grain polishing	50550	35965	4670	19652	.711
13	flours	5120	7972	130	28755	1.557
14	other foods	99490	98848	6140	192402	.993
15	beverage	46730	50750	2090	163167	1.086
16	tobacco	27760	35581	0	76916	1.281
17	fibre	115290	77035	380	904338	.668
18	textile fabrics	182250	133717	2130	531368	.733
19	fabricated text.	598640	290433	35310	476707	.485
20	leather	63540	62320	3620	80521	.980
21	lumber	54150	56448	2400	133935	1.042
22	wood	35439	18420	6030	21916	.519
23	pulp	52850	59353	1620	137080	1.123
24	printing	46740	54214	1520	93270	1.167
25	organic chemicals	8070	13682	30	105013	1.695
26	inorganic chemicals	14920	22363	70	146329	1.498
27	fertilizers	9840	24173	0	200219	2.456
28	drugs	34670	65053	90	59740	1.875
29	resins	57760	72021	420	390784	1.246
30	other chemicals	30320	33988	770	134191	1.120
31	petroleum	5400	38781	0	22779	7.181
32	coal products	17820	20165	730	34207	1.131
33	rubber	73890	71910	80	158565	.972
34	non-metallic min.	97810	121832	3090	471890	1.245

35	pig iron	17260	32020	0	393556	1.855
36	steel	42360	46548	300	610321	1.098
37	non-ferrous metal	15500	23894	270	90683	1.541
38	fabricated metal	62680	75165	6730	209914	1.197
39	general machinery	76600	86235	3550	259526	1.125
40	electronical machi.	57350	74636	520	195322	1.301
41	electronic comm.	183300	111180	340	485911	.606
42	transportation equip.	118320	183331	2930	548331	1.549
43	medical	30160	31576	710	36357	1.043
44	other manufact.	129370	75863	11820	116460	.596
45	construction	391300	605268	1700	90349	1.546
46	public work	238990	344338	1410	216664	1.435
47	electric power	18570	76098	0	3166761	4.087
48	water	8180	8473	0	355352	1.035
49	retail	560160	680781	1059060	815562	1.194
50	hotel	301720	171016	131270	132597	.566
51	transportation	397170	517410	15040	12190923	1.302
52	communication	49700	100626	0	536887	2.024
53	insurance	205810	320052	1510	363522	1.555
54	real estate	55100	47385	59040	12071451	.859
55	government	0	971881	0	0	-
56	social services	418910	976020	62030	3014837	2.329
57	other services	271850	298692	286600	1215114	1.098
58	office supply	0	0	0	0	-
59	business consumption	0	0	0	0	-
60	unclassifiable	0	1305	0	0	-
	total	11670390	8257216	5454760	47246600	-

***EMP = number of employees per man-year.

***COEMP = compensation of employees (unit = W million).

***SELEMP = number of self-employees per man-year.

***CAP = fixed capital stock (unit = W million)

***WAG = wage rate.

***EMP, COEMP, SELEMP are obtained from '78 Input-Output Tables and Compilatory Reports on '78 Input-Output Tables, The Bank of Korea, 1980.

***CAP is estimated on the basis of the estimated direct capital coefficients measured by W. Hong (1978). He estimated the 117 sectoral direct capital coefficients for Korea in 1975, which appear in Trade, Distortions and Employment, pp. 393-398. The capital stock for 117 sectors is calculated by multiplying the capital coefficients and the level of outputs from '78 Input-Output Tables. These figures are aggregated into 60 sectors in order to correspond with the present study, assuming that these coefficients being held constant during 1975-1978.

***WAG = COEMP/EMP.

Appendix D

ESTIMATED DIRECT FACTOR COST SHARES FOR KOREA, 1978

no	sectors	SK	USK	SML	PK	NR
1	grain	.012	.030	.483	.038	.260
2	vegetables	.027	.022	.479	.049	.162
3	industrial crops	.066	.103	.417	.029	.117
4	livestock	.062	.029	.217	.048	.020
5	forestry	.083	.135	.397	.017	.228
6	fishery	.220	.060	.080	.059	.075
7	coal	.513	.077	.001	.053	-.036
8	metallic ores	.201	.108	.003	.056	.081
9	non-metallic	.254	.124	.012	.039	.225
10	dairy	.036	.045	.010	.022	.058
11	seafoods	.081	.046	.049	.009	000
12	grain polishing	.113	.218	.030	.324	000
13	flours	.037	.013	.001	.069	000
14	other foods	.049	.040	.005	.088	000
15	beverage	.034	000	.002	.096	000
16	tobacco	.039	.020	000	.116	000
17	fibre	.019	.046	000	.078	000
18	textile fabrics	.040	.070	.001	.104	000
19	fabricated textile	000	.150	.008	.087	000
20	leather	.065	.055	.007	.115	000
21	lumber	.057	.042	.004	.079	000
22	wood	.012	.060	.029	.080	000
23	pulp	.077	.049	.003	.101	000
24	printing	.148	.098	.007	.086	000
25	organic chemicals	.041	.012	000	.074	000
26	inorganic chemicals	.066	.025	000	.128	000
27	fertilizers	.068	.011	000	.052	000
28	drugs	.112	.028	000	.150	000
29	resins	.048	.025	000	.083	000
30	other chemicals	.057	.036	.002	.101	000
31	petroleum	.024	000	000	.079	000
32	coal products	.044	.027	.002	.083	000
33	rubber	.070	.060	000	.059	000

34	non-metallic mineral	.100	.053	.004	.141	000
35	pig iron	.138	.010	000	.063	000
36	steel	.022	.015	000	.077	000
37	non-ferrous metal	.076	.027	.001	.134	000
38	fabricated metal	.075	.042	.012	.073	000
39	general machinery	.081	.051	.006	.139	000
40	electronical machinery	.064	.031	000	.086	.000
41	electronic comm.	.020	.073	000	.099	000
42	transportation equip.	.100	.035	.003	.095	000
43	medical	.081	.060	.003	.076	000
44	other manufacturing	.024	.109	.012	.133	000
45	construction	.169	.060	.001	.118	000
46	public work	.177	.072	.001	.126	000
47	electric power	.103	.006	000	.196	000
48	water	.089	.067	000	.250	000
49	retail	.103	.058	.301	.318	000
50	hotel	.038	.211	.109	.291	000
51	transportation	.142	.069	.008	.202	000
52	communication	.257	.058	000	.329	000
53	insurance	.275	.098	.002	.369	000
54	real estate	.018	.021	.043	.517	000
55	government	000	000	000	000	000
56	social services	.476	.084	.092	.007	000
57	other services	.149	.100	.263	.041	000
58	office supply	000	000	000	000	000
59	business consumption	000	000	000	000	000
60	unclassifiable	000	000	000	000	000

***SK = skilled labor shares

***USK = unskilled labor shares

***SML = self-employed labor shares

***PK = physical capital shares

***NR = natural resource shares

VITAE

Surname: IM

Given names: Dong Young

Place of Birth: Korea

Date of Birth: Jan. 24, 1948

Educational Institutions Attended:

Sung Kyun Kwan University, Korea;1970-74

University of Guelph, Ont.; 1977-80

University of Victoria, B.C.; 1981-

Degrees, Diplomas, Etc., Awarded:

B. of Business Admini.	1974	Sung Kyun Kwan University
B.A.	1980	University of Guelph

Honor and Awards:

Graduate supplements, 1982/83

Publications:

Partial Copyright License

I hereby grant the right to lend my thesis (the title of which is shown below) to users of the University of Victoria Library, and to make a single copies only for such users or in response to a request from the library of any other university, or similar institution, on its behalf or for one of its users. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by me or a member of the University designated by me. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Title of Thesis:

Factor Abundance and Korea's Comparative Advantage in International Trade

Author

Signature

[redacted]

Dong Young Im

August 28 / 1986

Date