

The Changing Pattern of Korean Comparative Advantage, 1965-1980

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I. Introduction

By liberalizing its trade regime and adopting an 'outward-oriented' strategy of economic development, the Republic of Korea (hereafter simply Korea) has dramatically changed both the volume and composition of its international trade. Between 1960 and 1980 the constant price value of exports increased nearly eighty fold, while imports increased by twenty times over the same period.¹ The export share in gross domestic product (GDP) grew from three percent to forty-three percent between 1960-1980, while the import share rose from twelve percent to fifty-one percent. This expansion of trade volume was accompanied by significant changes in trade composition, as the share of manufactured goods in total exports grew from fourteen percent in 1960 to ninety percent in 1980.² Because of its increasing importance in the international trading system, and its rapidly changing pattern of specialization, the Korean case is of substantial interest.

Few studies though, have investigated the determinants of Korean comparative advantage. Westphal and K. S. Kim (1982) adopted the Leontief method and used Korean direct factor coefficients to compute the physical capital and labor embodied in Korean exports and imports over the period 1960-1968. They calculated that the capital-intensity of Korean exports was greater than imports because the capital-intensity of Korea's primary product exports (mainly forest products) was far greater than its primary product imports (mostly food). When these were removed and only manufactured goods were

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¹ Figures one from World Bank, *World Tables*, Volume I, 1984.

² Balassa (1985), p. 152.

considered they found they found that Korean exports were less capital-intensive than imports and that this difference appeared to increase over the sample period.³ However, in another study of manufactures trade, Hong (1979), using the same technique, concluded that "The factor-intensity 'capital-labor ratio' of Korea's export commodity bundle grew steadily in capital-intensity during 1960–1975 . . . Consequently, although competitive imports were much more capital-intensive than exports during 1963–1968 . . . the difference became smaller subsequently and there seems to have been only slight differences in factor-intensities after 1970."⁴ In another study, Hong (1976) also investigated changes in human capital and concluded that it "did not exert an influence working to shift Korea's comparative advantage specifically toward more skill intensive sectors."⁵ Finally, C. Kim (1983) also using the Leontief method, found that the ratio of physical capital embodied in manufactured exports to physical capital embodied in manufactured imports rose from 0.42 in 1960 to 0.99 in 1974. In addition, Kim calculated that the same ratio for human capital had risen from 0.35 to 0.89 over the period.⁶

Leamer (1980), however, has demonstrated that the method employed in these studies is an improper test of the Heckscher-Ohlin (H-O) theorem. When a country is a net exporter (or net importer) of both factors, comparison must be made with the capital-labor ratio embodied in domestic consumption. However, even when the tests have been correctly reformulated, this approach has led to contradictory and unsatisfying results.⁷

In light of the apparent difficulties with the Leontief-Leamer method, in this paper, a different approach, which integrates information on net exports, industry factor-intensity, and national factor-endowments is adopted. The model is presented in Section II, and estimated for a sample of fifty Korean manufacturing industries over the years 1965–1980 in Section III. Korea is found to have accumulated physical and human capital at a faster rate than the rest of the world during the sample period. As a consequence, the capital-intensity of net exports increased over the sample period. These results are discussed in section IV.

³ Westphal and Kim, p. 263.

⁴ Hong (1979), p. 30.

⁵ Hong (1976), p. 125.

⁶ Kim, p. 83.

⁷ Leamer found that United States net exports embodied capital intensively relative to labor. Brecher and Choudhri (1982), however, restored the paradox by deriving other implications of the model which were inconsistent with Leamer's data. Most recently, Maskus (1985) performed a variety of Leontief-type tests on data for the U.S. and OECD for 1958 and 1972 and found that the H-O theorem was violated in nearly every case.

II. The Model

Deardorff (1982) demonstrated in a general model admitting any number of goods and factors, the absence of international factor-price equalization, and the existence of impediments to trade, that on average countries will be net exporters of these goods whose production is intensive in the countries' abundant factors. That is, the relationship between industry net exports, industry factor-intensity, and national factor-endowments is positive. Forstner (1985) extended Deardorff's analysis to the linear regression framework and showed that in factor-intensity factor-endowment interactional models, on average, the estimated regression coefficients would have the expected positive signs. Unfortunately, the definition of factor-endowment used in these models is based on unobservable autarky factor prices, which severely limits these models empirical applicability. The one method that approximates the Deardorff-Forstner models is the "Stages Approach" of Balassa (1979, 1986).

In this paper the "Stages Approach" is adapted to a single country time-series cross-section framework. In the original formulation the econometric estimation of the model is carried out in two steps. First, a trade performance variable (net exports) was regressed against variables measuring industry capital-intensity (1). The estimated coefficients (β 's) indicate the factor-use pattern of specialization. In the second step, the correspondence between factor use and endowments is established by regressing country factor endowments on the estimated β 's (2). This is shown in equations (1) and (2),

$$NX_{ij} = \alpha_j + \beta_j k_i + u_{ij} \quad (1)$$

$$\beta_j = \gamma + \delta E_j + v_j \quad (2)$$

where NX is net exports, k is a measure of capital-intensity, E is a measure of endowments, α and γ are intercepts, u and v are disturbance terms; the subscripts i , and j , stand for industry and country, respectively. In the more recent paper, this procedure has been combined into one step by substituting (2) into (1):

$$NX_{ij} = \alpha_j + (\gamma + v_j)k_i + \delta E_j \cdot k_i + u_{ij} \quad (3)$$

Amemiya (1978) demonstrates the equivalence of the one- and two-pass procedures, under the assumption that u and v are uncorrelated with each other. The one-pass procedure will be adopted in this paper. The approach will be further generalized to include time-series analysis:

$$NX_{ijt} = \alpha_j + (\gamma + v_{jt})k_i + \delta E_{jt} \cdot k_i + u_{ijt} \quad (4)$$

In previous studies the variables have been scaled (usually by value of shipments) to account for intrinsic differences in industry size and heteroskedasticity. Since data on shipments was not available, the net export variable has been normalized $[-1, 1]$ by dividing net exports $(X - M)$ by total industry trade $(X + M)$. The normalized variable is an easily interpretable measure of trade position that avoids the potential problems created by changes in price levels or exchange rates.⁸

Following established practice, factor-intensity is expressed in terms of direct physical and human capital-labor ratios.⁹ Both stock and flow measures are utilized. The stock measure of physical capital per worker, PS , is simply fixed capital per worker. The flow equivalent, PF , is defined as non-wage value-added per worker. As Balassa has observed, "as far as physical capital intensity is concerned, the two measures will give the same result in risk-free equilibrium, provided that product, capital, and labor markets are perfect and non-wage value added does not include any items other than capital remuneration."¹⁰ He notes, however, that in reality the flow measure of physical capital will reflect a risk premium which varies across industries, and business cycle effects which vary over time. In turn, the stock measure ignores inter-industry differences in depreciation rates, and the valuation of capital at historical rather than replacement cost makes this measure susceptible to distortion, especially during periods of prolonged inflation. Since neither approach was clearly superior *a priori*, both were used.

Data on capital, labor, and wages are from the Economic Planning Board of Korea, *Report of the Mining and Manufacturing Census: 1970*, and the Korea Development Institute, *Estimates of Capital Stocks 1968-73*.

The stock measure of human capital intensity, HS , is the per capita discounted value of wages in excess of the unskilled wage

⁸ Balassa (1979) uses export revealed comparative advantage (RCA) as the dependent variable on the grounds that it would be less distorted by protection than net exports. However, unlike normalized net exports, export RCA does not always theoretically correspond to comparative advantage as indicated by pre-trade autarky prices (cf. Hillman). Further, in the case of Korea, it is quite possible that commercial policy has distorted the pattern of export specialization more than the pattern of import specialization. For these reasons, net exports are adopted as the dependent variable in this paper, as has been done in more recent work by Balassa (1986).

⁹ Balassa (1985) argues that "direct factor-intensities . . . provide a more appropriate test of specialization according to comparative advantage than total (direct and indirect) factor-intensities, since intermediate products are tradable" (p. 161). This is especially true in the case of Korea since exporting firms had virtually unimpeded access to imported inputs. Westphal (1978) concurs noting that "the direct factor estimates are the most reliable as well as the most relevant, the latter owing to the fact that many important intermediate inputs are tradable" (p. 369).

¹⁰ Balassa (1979), p. 261.

$$HS_i = \frac{\bar{W}_i - W_i^U}{r} \quad (5)$$

where \bar{W}_i is the average per capita wage in industry i , W_i^U is the industry's unskilled wage, and r is the discount rate, traditionally set at 0.10. The flow measure of human capital-intensity, HF_i , is the difference between the industry average wage and the industry unskilled wage. Data on unskilled wages were taken from Industrial Development Institute, *Report on Wage Survey: 1970*.

Corresponding to the industry factor intensity variables are country factor endowment variables. These necessarily involve comparing domestic and foreign endowments to establish whether a country is relatively scarce or abundant in a particular factor.¹¹ In this paper, the relative factor endowment will be defined as the ratio of domestic per capita endowment to the world per capita endowment.¹²

A value of greater (less) than one would indicate that a country is abundant (scarce) in that factor. For example define the physical capital per capita endowment, GDICAP, of country j , as the value of a summed investment series where I is gross fixed investment, d is the depreciation rate, and n is the lifetime of capital, and L is population.

$$GDICAP_{jt} = \sum_{m=0}^n I_{j,(t-m)} (1-d)^m / L_{jt} \quad (6)$$

This is similar to the investment approach used in previous studies by Balassa, Bowen (1983), and Leamer (1984). Investment is calculated in constant value domestic currency then converted to dollars. In this study, capital is assumed to have a lifetime of fifteen years and depreciate at a rate of four percent annually. Data on exchange rates and gross fixed investment were found in World Bank *World Tables*, various issues.¹³

The relative physical capital endowment, PHYSCAP, is then expressed as the ratio of domestic and world endowments

¹¹ The necessity of comparing domestic and world endowments can be easily seen from the following example. Recall the second step regression in (2). Suppose there is an equiproportional doubling of factor endowments internationally. Neither the pattern of international specialization on comparative advantage will change, but the endowment coefficient would drop by one half. This is the difficulty with specifying endowments in levels—it is hard to disentangle economically meaningful changes from pure level effects.

¹² For the purposes of computing world factor endowments, the world factor endowments, the world is operationally defined as the 38 largest market manufacturing economies: Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Egypt, Finland, France, Federal Republic of Germany, Greece, Hong Kong, India, Ireland, Israel, Italy, Japan, Republic of Korea, Malaysia, Mexico, Morocco, The Netherlands, Norway, Pakistan, The Philippines, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, the United Kingdom, the United States, and Yugoslavia.

¹³ Data on Taiwan is from *Taiwan Statistical Data Book, 1983*, Council for Economic Planning and Development, Executive Yuan, Republic of China, 1983.

$$\text{PHYSCAP}_{jt} = \frac{\text{GDICAP}_{jT}}{\sum_j \text{GDICAP}_{jt} \cdot L_{jt} / \sum_j L_{jt}} \quad (7)$$

Likewise, the human capital endowment is expressed as the ratio of domestic to foreign endowments. The Psacharopoulos index of per capita educational capital, PIND, is defined as the average per capita expenditure on education embodied by workers in the labor force

$$\text{PIND}_{jt} = (Y1_{jt} \cdot A1_{jt} \cdot C1) + (Y2_{jt} \cdot A2_{jt} \cdot C2) + (Y3_{jt} \cdot A3_{jt} \cdot C3) \quad (8)$$

The variables $Y1$, $Y2$, and $Y3$ are the number of years spent in primary, secondary, and higher education respectively. $A1$, $A2$, and $A3$, are the percentages of the work force for which first, second, and third level education was the highest attained. The expenditure weights $C1$, $C2$, and $C3$ are average annual expenditure ratios derived by Psacharopoulos from a heterogeneous fourteen country sample; they are used to insure international comparability (Psacharopoulos (1973)). Educational attainment data was taken from UNESCO, *Statistics of Educational Attainment and Illiteracy 1945–1974*, and UNESCO, *Statistical Yearbook*, various issues. One problem with PIND is that it requires demographic data which, for most countries is only published every ten years. Deriving values for intervening years can be hazardous if there are dramatic changes in labor force participation rates on educational attainment between censuses. This problem is somewhat mitigated by the fact that the data is generally published for 5–10 year age cohorts which exhibit stable patterns over time. In the case of Korea, data is available for 1955, 1966, 1970, 1975, and 1980, and appears internally consistent.

Perhaps a more serious deficiency of the Psacharopoulos index is that by focusing exclusively on formal education, it ignores human capital accumulated in other ways. It has been argued that since much economically meaningful human capital is acquired through on-the-job training, measures of human capital based on formal schooling may be downwardly biased indicators of LDC human capital-endowment. It is sometimes asserted that this is particularly true of East Asian labor markets. Unfortunately, international data on on-the-job training does not exist, and alternative measures of human capital-endowment based on occupational data appear unreliable.¹⁴ The human capital endowment variable, HUMANCAP, based on PIND is defined analogously to PHYSCAP

$$\text{HUMANCAP}_{jt} = \text{PIND}_{jt} \cdot L_{jt} / \sum_j L_{jt} \quad (9)$$

¹⁴ See Balassa (1979), p. 262.

TABLE 1 Korean Factor Endowments

Year	PHYSCAP		HUMANCAP	
	Value	Rank	Value	Rank
1965	0.07	34	0.92	22
1980	0.29	28	1.21	16

Note: Values expressed as the ratio of domestic to world per capita endowment. Rankings are with reference to the thirty-eight country sample.

Sample end point values of PHYSCAP and HUMANCAP are reported in Table 1. These values indicate that Korea accumulated both physical and human capital at a more rapid rate than the rest of the world between 1965 and 1980. Relative physical capital endowment increased dramatically though Korea remained relatively scarce in physical capital. In the case of human capital endowment, Korea went from the borderline to human capital abundance over the sample period, which suggests that the possible underestimate of the Korean human capital endowment may not be severe.

III. Econometric Results

In this section, econometric estimates of models derived from (4) are reported.

$$NX_{ijt} = \alpha_j + (Y + v_{jt})k + \delta E_{jt} \cdot k_i + u_{ijt} \quad (4)$$

Several points are of particular interest. First, the β 's from (1) (the partial derivatives with respect to industry factor intensity) indicating the direction of net factor trade can be derived from (4).

$$\hat{\beta} = \hat{\gamma} + \hat{\delta} E_{jt} \quad (9)$$

The coefficients are of intrinsic interest themselves. In addition, their correlation with the endowment variables provides a test of the H-O theorem. The theorem states that the international trade of a particular country with the rest of the world will embody positive (negative) net exports of factors in which it is abundantly (scarcely) endowed. This means that the β 's should be positive (negative) for factors in which a country is abundantly (scarcely) endowed. In the case of Korea, this means that the β 's for physical (β_p) capital should be negative and that the β 's for human capital (β_h) should switch signs, going from negative to positive as the Korean HUMANCAP variable went from less than one, and Korea moved from twenty-second to sixteenth in the ranking. Finally, the time-series nature of the model enables us to examine how changes in the β 's are correlated with changes in endowments. If factor net exports are a positive function of

relative endowments, then the estimated β 's should change in a predictable manner. In the case of Korea they should become more positive over time.

The model was estimated for a sample of fifty three-digit Standard Industrial Trade Classification (SITC) industries from SITC manufacturing groups 5–8 for the years 1965–1980. (The industries are listed in the Appendix.) The regressions were initially estimated by the ordinary least squares (OLS) technique. Since first-order autocorrelation and heteroskedasticity were detected in the residuals, an estimated generalized least squares (EGLS) estimator was used to correct for these violations of the classical assumptions on the disturbance term. First, the degree of autocorrelation was estimated, then eliminated by the Cochrane-Orcutt transformation of the variables. Then, using the transformed values, the regression was reestimated. the estimated variance–covariance matrix was used to construct a modified Aitken GLS estimator with the properties of consistency, asymptotic efficiency, and asymptotic normality. The results of the regressions are reported in Table 2.

Recall from (9), that the β 's can be recovered from the regressions:

$$\hat{\beta} = \hat{\gamma} + \hat{\delta}E_{jt} \quad (9)$$

TABLE 2 Korean Net Export Regressions

	Coefficients	T-Statistics
Flow Variables:		
(2.1) ALPHA	5.698	(109.75)*
LKPF	−0.319	(− 31.26)*
LKHF	−0.741	(− 92.22)*
PHYSCAP · LKPF	0.281	(33.72)*
HUMANCAP · LKHF	0.005	(0.74)
		$\bar{R}^2 = .537$
Stock Variables:		
(2.2) ALPHA	7.369	(63.46)*
LKPS	0.144	(10.88)*
LKHS	−1.178	(− 35.84)*
PHYSCAP · LKPF	0.238	(35.56)*
HUMANCAP · LKHS	0.022	(4.87)*
		$\bar{R}^2 = .535$

Note: * denotes coefficient estimates significantly different from 0 at the 1% level using a two-tail test.

Legend: ALPHA = intercept (α).
 LKPF = log Korean physical capital flow-labor ratio (k).
 LKHF = log Korean human capital flow-labor ratio (k).
 LKPS = log Korean physical capital stock-labor ratio (k).
 LKHS = log Korean human capital capital stock-labor ratio (k).
 PHYSCAP = physical capital endowment (eq. 7) (E).
 HUMANCAP = human capital endowment (eq. 9) (E).

TABLE 3 **Estimated Betas**

Year	Physical Capital		Human Capital	
	Flow	Stock	Flow	Stock
1965	-0.299	0.161	-0.736	-1.158
1980	-0.238	0.213	-0.735	-1.151

Some sample values are reported in Table 3. The $\hat{\beta}_p$ derived from the flow equation (2.1) is negative and decreasing in absolute value as expected. The stock $\hat{\beta}_p$ however, is positive. Likewise, the $\hat{\beta}_h$'s take unexpected large negative values.

The difference between the stock and flow $\hat{\beta}_p$ estimates is due to the sensitivity of the stock estimates to the shifting trade patterns exhibited by a group of industries in the upper-tail of the physical capital-intensity stock distribution. The most physical capital-intensive industry according to the stock measure was paper and paperboard. As Kim points out, this industry benefited from the discovery of new sources of raw materials supply, and went from a net importer (1965–1972) to a net exporter (1973–1980).¹⁵ Similarly, of the next five most capital-intensive industries, four (textile yarn, iron and steel, plastics, and organic chemicals) are industries that the Korean government promoted in the 1970's.¹⁶ All exhibited declines in imports, and in two cases (textile yarn, iron and steel) switched from being net importing, to net exporting industries. The effect of these increases in net exports among outliers in the uppertail of the distribution was to raise the parameter estimates.

In contrast however, in the case of the physical capital flow variable, these industries tend to be ranked closer to the middle of the distribution and thus exert less influence on the coefficient estimates. In fact, of the five most physical capital-intensive industries according to the flow measure (textile yarn, paint, pharmaceuticals, cosmetics, and road motor vehicles), four exhibited net imports for the entire sample period. As a consequence, the flow estimates are much lower than the stock estimates which appear implausibly high. In addition to affecting the regression results reported here, the impact of government industrial policy provides a possible explanation for the diversity of conclusions about the factor pattern of Korean trade reached by previous studies.¹⁷

The surprisingly large negative estimates of $\hat{\beta}_h$ may be due to a deficiency of the sample. As Westphal, Rhee, et al. (1984) and Dahlman and Sercovich (1984) document, in the late 1970's Korea began exporting large amounts of project-related capital goods

¹⁵ Kim, p. 88.

¹⁶ See Westphal, p. 369, Krueger (1979), p. 196, Westphal and Kim, p. 263, and Balassa (1985), p. 173.

¹⁷ Recall that Hong reached significantly different conclusions from Westphal-Kim when he extended the sample into the 1970's.

and related services, including manufacturing plants, overseas construction projects, and various information, technical, and managerial services. Westphal, Rhee, et al., calculate that the value of these exports totalled more than \$40 billion between 1977–1981.¹⁸ (For purposes of comparison, non-project related capital goods exports were roughly \$8 billion, and merchandise exports were approximately \$77 billion.) The vast majority of these earnings came from overseas construction projects. Since these activities tend to embody a high degree of human capital in the form of managers, engineers, and skilled workers, it is likely that the omission of these services effectively truncates the human capital-intensive tail of the sample distribution. As a consequence, the $\hat{\beta}_h$'s are probably biased downward, and understate the magnitude of secular changes in the β_h 's over the sample period as well. In addition, as discussed earlier, there is reason to believe that PIND may understate Korea's true human capital-endowment, further biasing the estimates in a downward direction.

IV. Conclusion

In this paper changes in Korea's comparative advantage over the period 1965–1980 have been analyzed in a time-series cross-section framework. Korea accumulated both physical and human capital at a more rapid rate than the rest of the world, and as expected, the capital-intensity of net exports increased. However, the estimated derivatives of the net export function with respect to industry capital-intensity ($\hat{\beta}$'s) did not always take theoretically expected values. In particular, the use of stock and flow measures of industry physical capital-intensity yielded widely differing estimates, with the flow results appearing preferable. Analysis of industry trade patterns suggest that estimates of both the physical and human capital β 's may be sample sensitive, with human capital estimates biased downward.

Two sources of difficulty were identified. First, in the 1970's the Korean government promoted certain heavy industries. This is particularly problematic since production or export subsidization, unlike import protection, can actually change the direction (sign) of net exports. Second, substantial export activity occurred in service sectors for which data was unavailable. This likely led to censored sample biases in the estimation.

These results suggest two avenues for further research. First, as Hong (1976) and Koo (1977) document, capital deepening and the attendant rise in industry physical capital labor ratios, occurred in Korea in the late 1960's and early 1970's. The development of industry level time-series data on capital-intensity might help to resolve some of the

¹⁸ Westphal, et. al., Abstract.

uncertainty as to the physical capital-intensity of Korean trade. Second, better data on international service transactions would facilitate the extension of the analysis to this increasingly important area of Korean, and world, trade.

APPENDIX

	<i>SITC</i> (<i>Revised</i>)
1. Textile Yarn and Thread	651
2. Cotton Fabrics	652
3. Non-cotton Fabrics	653
4. Special Textile Products	655
5. Textile Products, nes	656
6. Floor Coverings	657
7. Clothing, not of fur	841
8. Fur and Leather Clothing	842
9. Wood Manufactures, nes	632
10. Furniture	821
11. Paper and Paperboard	641
12. Articles of Paper	642
13. Printed Matter	892
14. Organic Chemicals	512
15. Plastic Materials	581
16. Medicinal Products	541
17. Soaps and Cleansers	554
18. Cosmetics	533
19. Paints	629
20. Rubber Articles, nes	629
21. Footwear	851
22. Leather	611
23. Leather Manufactures	612
24. Travel Goods, Handbags	831
25. Glass and Glassware	664-5
26. Clay, Refractory, and Building Products	662
27. Pottery	666
28. Iron and Steel	670-8
29. Non-ferrous Metals	68
30. Cultery	696
31. Tools	695
32. Nails, Nuts, etc.	694
33. Structural Metal Products	691
34. Agricultural Machinery	712
35. Textile, Leatherworking Machinery	717
36. Machines for Special Industries	718
37. Metalworking Machinery	715
38. Office Machines	714
39. Telecommunications Equipment	724
40. Electrical Power Generating Equipment	722
41. Electrical Equipment	721,729
42. Domestic Electrical Equipment	725
43. Road Motor Vehicles	732
44. Ships and Boats	735

45. Railway Vehicles	731
46. Scientific and Measuring Instruments	861
47. Watches and Clocks	864
48. Sound Recorders and Producers	891
49. Office Supplies	895
50. Miscellaneous Manufactures	899

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