Human Capital Formation and South Korean Agricultural Growth 1963-1977*

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I. Introduction

This paper deals with growth in the South Korean agricultural sector. Although overshadowed by the impressive growth in other sectors, annual growth in real value added in South Korean agriculture and forestry averaged over 4.5% for the fifteen year period 1963-1977. This was achieved despite little overall change in the area under cultivation, selective rural outmigration, and a land tenure system characterized by small, private, household farms.

The hypothesis of this study is that a major reason for the improvement in agricultural output was the South Korean farmer's willingness to innovate, to adopt new technology, and to increasingly participate in the market system. This is a reflection not only of the successful government extension work in the rural area; it is also indicative of the human capital formation that has taken place in the agricultural labor force.

A first order, autoregressive estimation procedure is used to test this hypothesis for the period 1963-1977, a time of rapid, export-led, economic development. In an attempt to capture the in-

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fluence of human capital formation in the agricultural sector, an index of educational attainment is constructed from farm household survey data. With the Cobb-Douglas specification and using annual survey data, this index is found to be statistically significant in explaining the variation in annual real agricultural income per labor hour, a measure of labor productivity. Physically capital intensity and land intensity are also found to be statistically significant regressors.

The index is then combined with the agricultural labor force, adjusted for average hours worked and sex composition, to obtain a measure of an effective labor input. Employing the Cobb-Douglas production function framework again, but with macro data, real value added in Korean agriculture and forestry is estimated for the same time period. The results suggest that human capital formation was a significant influence in the growth of South Korean agricultural output for 1963 to 1977.

II. Historical Background

Following the liberation from the Japanese in 1945, Korea undertook a series of land reforms designed to redistribute large landholdings among the indigenous farm population. The land reforms were an important asset redistribution and served to virtually eliminate tenancy.[1] The reforms, however, also created a land tenure system characterized by numerous, very small, private farms; a system that has changed little over the years (see Table 1).

After the Korean War, reconstruction efforts were focused on industrialization, and the agricultural sector was relatively neglected. Persistent and widespread poverty in the rural sector, a rapidly growing urban population, and the inevitable curtailment of United States foreign aid, demanded that agricultural development receive increased attention. Since the First Five Year Plan (1962-1966), increasing government assistance, in the forms of loans, investments, subsidization of farm inputs, price supports, and extension work, has been available to improve rural conditions and to augment agricultural output.[2]

1 For an overview of early Korean agricultural development, see Pal Yong Moon and Byung Seo Ryu (1977).

Table 1

DISTRIBUTION OF KOREAN FARMS BY SIZE, 1968 AND 1977

Farm Size	% of Farm Households		% of Cultivated Land	
	1968	1977	1968	1977
Landless	2.2	4.9	0	0
Under 0.3 hectare	15.9	13.3	3.6	3.2
0.3 to 0.5 hectare	17.4	16.5	8.2	7.9
0.5 to 1 hectare	31.8	34.5	27.0	29.8
1 to 2 hectares	26.0	25.1	40.3	40.3
2 to 3 hectares	5.2	4.4	14.2	12.2
Over 3 hectares	1.6	1.3	6.7	6.5

	1968	1977
Total Farm Households	2,578,526	2,303,930
Total Cultivated Land	2,277,948	1,954,675
Average Cultivated Land per Farm Household in Hectares	0.88	0.85

Note: Rounding error may prevent totals from summing to 100%.
From: Korea Statistical Yearbook 1974, Table 37, p. 76, and Korea Statistical Yearbook 1979, Table 43, p. 97.

2 Relevant to the thrust of this paper is the observation by Cole and Lyman:

> Between 1960 and 1966, the number of rural guidance or extension workers under the Office of Rural Development increased six fold, so that the average number of farm households served by each worker dropped from 2100 to 375. Of the new workers, over half had at least a junior college degree and more than a third were graduates of a four year agricultural college. This increased the flow of information on new farming technology to the farmers and contributed to the rapid adoption of better seeds, crop diversification, mixed fertilizer, spraying, and other measures to increase productivity. These workers were also involved in programs for expanding arable land.

From David C. Cole and Princeton N. Lyman (1971), p. 149.

Farm mechanization, land consolidation, irrigation and infrastructure development, the adoption of new seeds and technologies, and increased market orientation have all been extensively promoted by the Korean government. A comprehensive rural development strategy, the Sae Maeul (New Village) Movement was begun in the 1970's. The program was designed to expand rural non-farm employment through industrial relocation in the countryside, to further develop rural infrastructure, and perhaps most importantly, to initiate rural, collective, self-halp organizations.[3]

As Brown notes, "Korean farmers are mostly literate and relatively quick to adopt new practices."[4] It could be that it is this human factor, the desire for improvement, manifested in human capital formation and the willingness to change, which is responsible, as much as any other factor, for the growth in agricultural output in Korea.

III. Estimation of the Agricultural Sector

To attempt to capture the influence of human capital formation in the agricultural sector, an index of educational attainment is used. This index, described in detail in the Statistical Appendix, is designed to reflect the trend in the average level of education of the adult farm population. To investigate the significance of this variable, initially an indicator of labor productivity in the agricultural sector is estimated.

Using a Cobb-Douglas specification and micro data from the Korean Farm Household Economy Survey, real agricultural income per labor hour for the average farm household, y (a proxy for agricultural labor productivity), is regressed on four independent variables. The period of concern is 1963-1977.[5] The four regressors are: the physical capital and land intensities for the average farm household, k and r respectively; the farm adult

3 For descriptions of the new rural development strategy see Parvez Hasan (1976), Appendix. Sung Hwan Ban (1977).

4 Gilbert T. Brown (1973), p. 114.

5 Data considerations largely determined the period of investigation. For one, labor force data from the Korean Economically Active Population Survey were available only for 1963 and later years. For another, a consistent measure of the land input was available only up to 1977.

educational index, z; and a weather dummy variable, w. The human capital index, z, is modeled much like disembodied technical change. This reflects the supposition that the influence of human capital formation is diffuse, i.e. the productivities of the physical factors of production are enhanced when used in conjunction with human capital.[6]

The estimation results are shown in Table 2. In regression (2), the sex composition of the agricultural labor force was taken into consideration. Although both ordinary least squares (OLS) and a first order autoregressive process were used, only the latter estimations are presented below.[7]

The estimations show that both the physical capital and land intensities were highly significant in explaining the variation in real agricultural income per labor hour over the 1963-1977 period. The human capital index and the weather dummy also were statistically significant. Adjusting the labor input for the sex composition of the agricultural and forestry labor force did not markedly affect the results; if anything, the adjustment slightly improved some of the t-ratios.

Variables:

Y = Real agricultural income in thousand constant 1975 won (Household Average);

K = Real agricultural capital in thousand constant 1975 won (Household Average);

R = Cultivated land in danbo (Household Average);

z = Adult educational index (Household Average), (1963 = 1.00);

6 When the human capital index was modeled as a factor of production, i.e.

$$y = Ae^{bw} k^c r^d z^f$$

instead of in the diffuse sense,

$$y = Ae^{bw} e^{fz} k^c r^d$$

the empirical results were very similar. In the above equations:

e = base for the natural logarithm;

A, b, f, c and d = coefficients.

The time subscripts have been omitted for ease of exposition.

7 The first order autoregressive process used was the AUTOREG procedure in S. A. S. (Statistical Analysis System). Basically this procedure is a variant of the Cochrane-Orcutt method where the ordinary least squares (OLS) estimates are adjusted to reflect the autocorrelation of the error terms. Since autocorrelation appeared to be present (note the estimated coefficients and t-ratios of the first order autoregressive parameters shown in Table 2), the OLS results are not presented.

Table 2

ESTIMATION OF REAL AGRICULTURAL INCOME PER LABOR HOUR – HOUSEHOLD AVERAGE 1963-1977

Dependent Variable (R^2)	Constant	ln(k)	ln(r)	z	w	a_1
1) ln(y) (.992)	1.0260 (0.66)	0.2864 (7.69)***	0.7100 (3.59)***	1.7757 (2.97)**	0.0846 (2.97)**	0.4834 (2.14)
Dependent Variable (R^2)	**Constant**	**$\ln(k_s)$**	**$\ln(r_s)$**	**z**	**w**	**a_1**
2) $\ln(y_s)$ (.992)	1.1528 (0.77)	0.2852 (7.68)***	0.7266 (3.67)***	1.7359 (3.15)**	0.0863 (3.15)**	0.4841 (2.14)

Notes: Variables beginning with ln denote the natural logarithm of that variable. Approximate t statistics are in parentheses.
* = significant (approximately) at the 0.10 level.
** = significant (approximately) at the 0.05 level.
*** = significant (approximately) at the 0.01 level.

w = Weather dummy variable, 0 = if normal year, -1 = if year is considerably below or above average precipitation;

L = Agricultural labor hours (Household Average);

$(WAGE)_f$ = Female agricultural wage as a percentage of the male agricultural wage;

$(\%\ MALE)$ = Percantage of the labor force in agriculture and forestry that is male;

L_s = Sex-adjusted labor hours;

where $L_s = L\ [\ (\%\ MALE)\quad (100 - (\%\ MALE)\ )\ (WAGE)_f\ ]\ /100$

$$y = Y/L\ ;\quad y_s = Y/L_s$$

$$k = K/L\ ;\quad k_s = K/L_s$$

$$r = R/L\ ;\quad r_s = R/L_s$$

a_1 = first order autoregressive parameter.

As noted, the estimations above were based upon survey data. To estimate a national agricultural output function, a similar Cobb-Douglas specification will be used. The emphasis, however, will be on modeling the labor input. In particular, the effects of different measures of the labor input on real value added in Korean agriculture and forestry for 1963-1977 will be investigated.

There are essentially three versions of the labor input. The simplest is the physical labor force employed in agriculture and forestry adjusted for the length of the average work week, N_1. In the second version, N_2, the physical labor input N_1 is multiplied by the index of human capital formation, z, to obtain a measure of the effective input of labor. The third version models the influence of human capital formation as diffuse. That is, the human capital index, as a type of disembodied technical change, is used with the physical labor force in agriculture and forestry, N_1. In all three cases, the labor inputs are also adjusted to reflect the sex composition of the labor force.[8] These measures are denoted

8 In the adjustment of the physical labor force for the sex composition, female workers were given fractional weights-the fraction being determined by the ratio of female to male wages in agriculture. This adjustment implicitly assumes that the ratio of female to male wages in agriculture accurately reflects the relative labor productivities of the sexes. Over the fifteen year period under investigation, female wages varied between 62% and 72% of male wges.

with a subscript s. Thus, there are six different regression equations.

For the physical capital inputs, a measure of agricultural implements owned by farm households and chemical fertilizer consumption are used. With respect to agricultural implements, strong collinearity was evident among the various measures. As a result, one of the measures was selected as a proxy for farm equipment in general. The feasibility of the power tiller for Korean agriculture has been questioned by Harris.[9] The use of power insecticide equipment would seem to be closely associated with the use of purchased inputs like insecticides, herbicides and fertilizers. Other forms of less sophisticated capital may be employed at harvest time instead of power driven threshing machines. Given the smallness of the average Korean farm and the relative scarcity of irrigated, fertile farmland, the most appropriate measure for agricultural equipment might be the number of power water pumps owned by farm households. Annual chemical fertilizer consumption will be used as an indicator of purchased farm inputs.[10]

The measure for the input of land is cumulative land cultivated for food grains and cash crops. This takes into account the practice of multiple cropping. That is, the physical measure of farmland is multiplied by the intensity of cultivation. Finally, the weather dummy variable is present.

Table 3 presents the results of the regressions for real value added in agriculture and forestry based on the first order, autoregressive estimation process. Since it was inconclusive whether autocorrelation was a problem or not, ordinary least squares estimates for the same equations are given in Table 4. In general, the

9 See Randolph L. P. Harris (1979), Chapter 7, pp. 223-4. Harris notes that in Korea, power tillers are used mainly for transport purposes. In addtion, the weight of the power tiller requires two or three men to operate it in a day; whereas one man can till all day with a draft animal.

10 Harris (1979), p. 229-30, reports that fertilizer was subsidized by the Korean government until 1976. The relatively low prices for fertilizer meant that there was a chronic state of excess demand. As a result fertilizer was rationed. The rationed fertilizer, however, was in a pre-mixed form, and not always suitable for the specific needs of the Korean farmers. Total chemical fertilizer consumption dropped sharply in 1976 with the cessation of the subsidy.

This consideration casts some doubt as to the appropriateness of the chemical fertilizer consumption variable used in the estimations for real value added in agriculture and forestry. Unfortunately, a better alternative was not available.

Table 3

ESTIMATION OF REAL GROSS DOMESTIC PRODUCT ORIGINATING IN AGRICULTURE AND FORESTRY 1963-1977 (First Order Autoregressive Process)

Dependent Variable (R^2)	Constant	Labor Inputs				z	ln(Land)	ln(Pump)	ln (Fertz)	w	a_1
		$\ln(N_1)$	$\ln(N_{1s})$	$\ln(N_2)$	$\ln(N_{2s})$						
1) ln(Q)	-2.6208	0.6852					0.4120	0.1997	-0.0821	0.0434	0.2300
(.955)	(-0.60)	(2.77)					(1.01)	(4.17)	(-0.85)	(1.43)	(0.92)
		**						***			
2) ln(Q)	2.5943		0.6907				0.4347	0.1958	-0.0907	0.0470	0.2790
(.961)	(-0.65)		(3.09)				(1.14)	(4.32)	(-1.01)	(1.62)	(1.13)
			**					***			
3) ln(Q)	-3.1034			0.6801			0.5557	0.1770	-0.1146	0.0348	0.3409
(.970)	(-0.90)			(3.84)			(1.61)	(4.30)	(-1.43)	(1.28)	(1.40)
				***				***			
4) ln(Q)	-2.7281				0.6615		0.5462	0.1745	-0.1159	0.0389	0.3810
(.974)	(-0.86)				(4.17)		(1.70)	(4.47)	(-1.54)	(1.51)	(1.60)
					***			***			
5) ln(Q)	-1.7716	0.3092				2.1808	0.5345	0.1333	-0.1008	0.0214	0.3641
(.979)	(0.52)	(1.13)				(2.38)	(1.73)	(2.99)	(-1.40)	(0.83)	(1.51)
						**		**			
6) ln(Q)	-1.6461		0.3176			2.0861	0.5268	0.1345	-0.1009	0.0240	0.3757
(.980)	(-0.51)		(1.23)			(2.25)	(1.77)	(3.06)	(-1.44)	(0.94)	(1.57)
						**		**			

Table 4

ESTIMATION OF REAL GROSS DOMESTIC PRODUCT ORIGINATING IN AGRICULTURE AND FORESTRY 1963-1977 (Ordinary Least Squares)

Dependent Variable (R^2)	Constant	Labor Inputs				z	ln(Land)	ln(Pump)	ln (Fertz)	w	D.W.
		$\ln(N_1)$	$\ln(N_{1s})$	$\ln(N_2)$	$\ln(N_{2s})$						
1) ln(Q)	−0.5605	0.5385					0.2284	0.1972	−0.0298	0.0407	2.22
(.932)	(−0.12)	(2.07)					(0.52)	(3.56)	(−0.28)	(1.32)	
		*						***			
2) ln(Q)	−0.3674		0.5299				0.2300	0.1939	−0.0316	0.0422	2.32
(.933)	(−0.08)		(2.14)				(0.53)	(3.52)	(−0.30)	(1.39)	
			*					***			
3) ln(Q)	−0.8089			0.5257			0.3229	0.1785	−0.0478	0.0356	2.46
(.941)	(−0.19)			(2.52)			(0.77)	(3.35)	(−0.47)	(1.23)	
				**				***			
4) ln(Q)	−0.5630				0.5140		0.3186	0.1760	−0.0486	0.0373	2.54
(.942)	(−0.14)				(2.57)		(0.77)	(3.30)	(−0.49)	(1.31)	
					**			***			
5) ln(Q)	−0.0939	0.1308				2.5893	0.4210	0.1181	−0.0646	0.0211	2.70
(.960)	(−0.02)	(0.48)				(2.40)	(1.15)	(2.12)	(−0.73)	(0.80)	
						**		*			
6) ln(Q)	−0.0340		0.1307			2.5701	0.4189	0.1179	−0.0646	0.0216	2.72
(.960)	(−0.01)		(0.49)			(2.35)	(1.15)	(2.13)	(−0.74)	(0.82)	
						**		*			

same patterns emerge in both sets of estimations. The major differences have to do with the size of the output elasticities. The output elasticities in the autoregressive estimations exceed those in the OLS estimations — particularly for the labor and land inputs. As a result, the sum of the output elasticities in the former case are from a third to a half again as large.

With one exception, the signs of the coefficients are as expected. The exception is the coefficient of the fertilizer variable, which is consistently negative, although statistically insignificant. The cultivated land variable and the weather dummy are also not statistically significant.

Variables:

- Q = Real Gross Domestic Product originating in agriculture and forestry in billion won at 1975 constant factor cost;
- LAND = Cultivated land for food grains and cash crops, in thousand hectares;
- PUMP = Power water pumps owned by farm households;
- FERTZ = Consumption of chemical fertilizer in thousand metric tons;
- N_1 = Agricultural and forestry labor force adjusted for the average length of the work week, in thousand persons;
- N_{1s} = N_1 adjusted for the sex composition of the agricultural and forestry labor force;
- N_2 = Effective labor force in agriculture and forestry adjusted for the length of the average work week, in thousand persons;
- N_{2s} = N_2 adjusted for the sex composition of the agricultural and forestry labor force;
- w = Weather dummy variable, 0 = normal year, -1 = year is considerably below or above average in precipitation;
- z = Adult educational index (Household Average), (1963 = 1.00);
- a_1 = first order autoregressive parameter;
- D.W. = Durbin-Watson statistic;

Labor Input Calculations:

B = Index of average hours worked per week in agriculture, forestry and fishing (1963 = 1.00);

N = Persons employed in agriculture and forestry in thousands;

$(WAGE)_f$ = Female agricultural wage as a percentage of the male agricultural wage;

Labor Input Calculation (Cont.)

(% MALE) = Percentage of the labor force in agriculture and forestry that is male;

$N_1 = B \cdot N$

$N_{1s} = N_1\ [(\%\ MALE)\ (100 - (\%\ MALE))\ (WAGE)_f]/100$

$N_{1s} = z \cdot N_1$

$N_{2s} = z \cdot N_{1s}$

The proxy for agricultural implements, power water pumps owned by farm households, is very significant and rather robust in the first four regressions of each table. When the impact of human capital formation is modeled as diffuse, the output elasticity and the statistical significance of this variable decreases (see equations (5) and (6) in the two tables).

Concerning the various measures of the labor input, modeling the influence of human capital formation appears to improve the results. The output elasticity of the labor input changes little when the physical labor force is scaled up by the adult educational index; however, the statistical significance of the labor input as well as the overall level of explained variation (R^2) increase. (Compare equations (1) and (2) with equations (3) and (4) respectively.) In addition, using the effective factor formulation for the labor input increases the coefficient for the land variable.

Perhaps the most interesting results occur when the impact of human capital formation is modeled as diffuse. If these instances, the output elasticity of the labor input drops considerably. The physical labor force in agriculture and forestry loses its statistical significance. The human capital index, on the other hand, is statistically an important regressor.

With respect to returns to scale, as noted earlier, the sum of the output elasticities in the autoregressive estimations constantly exceed those in the OLS regressions. In the former, increasing returns to scale are indicated until the diffuse modeling of the human capital influence. Then the sum of the output elasticities appoximates unity. In the OLS regressions, constant returns appear to prevail until the diffuse representation of the human capital index. Then decreasing returns to scale are indicated. Given the binding land constraint on Korean agriculture, the OLS formulations appear to be more realistic in this regard.

Finally, adjusting the labor inputs for the sex composition of the agricultural and forestry labor force appeared to make little difference. Compare equations (2), (4) and (6) with equations (1), (3) and (5) respectively in both tables.

IV. Conclusion

Given the small number of observations, i.e. only fifteen years of data, the estimations presented above can only be suggestive. In addition, the validity of the constructed human capital index with respect to capturing the quality of the agricultural and forestry labor force is largely unconfirmed. The level of formal educational attainment might not be as important for labor productivity in the agricultural sector of developing countries as the combination of basic literacy and effective government extension work. As noted, South Korea had both of the latter elements; and the constructed adult educational index showed impressive gains over the fifteen year period.

Certainly more research into the theoretical and empirical links among formal education, informal training, labor quality and labor productivity is needed. Moreover, additional efforts to collect data on the demographic characteristics of agricultural labor forces in developing countries should be made.

This study should be viewed as a rudimentary attempt to model the influence of human capital formation on agricultural output growth for a particular development experience. The results, for the case of South Korea at least, are encouraging.

V. Statistical Appendix

For some time Korea has conducted an extensive survey of the agricultural economy. The Farm Household Economy Survey (FHES) was initially undertaken in 1952 by the Research Department of the Bank of Korea. Five hundred grain farmers were in the initial survey. The Ministry of Agriculture and Fisheries has been responsible for the survey since the early 1960's. The sample size has been periodically increased until by 1974, there were 2500 farm households in over 160 enumeration districts covered. Full time enumerators who keep in close personal contact with the farmers are utilized. The FHES is widely regarded as the best source of information on the conditions of the Korean farm economy.[11]

Based on data from the Farm Household Economy Survey, a farm educational index is constructed to illustrate the trend in human capital formation in the average farm household. The index is weighted arbitrarily, since the empirical relationships among educational level, human capital formation and labor quality are not well established. The selected weights are:

Illiterate	=	1.0
Literate Without Schooling	=	1.4
Middle School Education	=	1.8
High School Education	=	2.0
College Education	=	2.5

The index z attempts to measure the trend in the average level of education of farm adults, or those most likely to participate in the agriultural labor force. The calculation of the index is given below:

z_t = (1.0 · # ILLITERATE + 1.4 · # LITERATE WITHOUT SCHOOLING + 0.5 · 1.8 · # MIDDLE SCHOOL + 2.0 · # HIGH SCHOOL + 2.5 · # COLLEGE)/(# FARM HOUSEHOLD - # CHILDREN BEFORE SCHOOL AGE - # PRIMARY SCHOOL - 0.5 · # MIDDLE SCHOOL)$_t$

The index is in terms of number of persons in the average farm family. That is, # ILLITERATE and # MIDDLE SCHOOL would refer to the average numbers of persons illiterate and with a middle school education, respectively, in the sample farm

11 The information in this paragraph is from Moon and Ryu (1977). For a more detailed description of the Farm Household Economy Survey see Report on the Results of Farm Household Economy Survey (1976).

households for a given year. The implicit assumption is that those who are illiterate, literate without schooling, with a high school or college education are sufficiently old to participate in the agricultural labor force. In addition, it is assumed that fifty percent of those with a middle school education also fall into this category of potential agricultural workers.

This index then is used as a proxy for the trend and extent of human capital formation in the agricultural labor force. The base year chosen is 1963. It should be noted that the employment characteristics of the average farm household are fairly stable over the fifteen year period. That is, there is no discernible trend in the percentages of total farm workers, total family labor, total non-farm workers, or non-farm workers with other work in the average farm household. There is, however, a noticeable decline in the percentage of young farm children, a result of reduced rural fertility. The relative stability of the composition of employment in the average farm household adds credence to the human capital proxy.

Also from the Farm Household Economy Survey are data on agricultural income, agricultural capital, cultivated land, and labor hours for the average farm household. These variables are used in the regressions presented in Table 2.

Data on male and female wages for Korea are from the *Yearbook of Labour Statistics,* International Labor Office (various issues).

The weather dummy variable is based on average annual precipitation in three cities in Korea: Gwangju, Daegu, and Ulsan. For 1963-1977 the annual precipitation in the three cities averaged 1177 millimeters. For any particular year, the value of the dummy variable w was set equal to -1 if the average precipitation of the three cities fell outside the range of 1177 + 250 millimeters.

With the exception of the wage data, all of the above statistics can be found in the *Korea Statistical Yearbook* (various editions).

Data on agricultural and forestry employment, labor force characteristics and average hours worked are from the Economic Planning Board's Economically Active Population Surveys. This information, along with Gross Domestic Product originating in agriculture and forestry at constant factor cost is also available in the *Korea Statistical Yearbook*

Finally the data on agricultural implements, fertilizer consumption and cumulative cultivated land can be found in the *Handbook of the Korean Economy 1978* of the Economic Planning Board.

The time series used in the estimations along with additional details on the sources of the data are available upon request.

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